BUSAN TECHNO PARK

TESTING REPORT

1. Client

Name : HANLA IMS Co., Ltd.

Address : #115, Hwajeonsandan 1-ro, Gangseo-gu, Busan, 618-280, Korea

2. Test overview

Title : Efficacy test of EcoGuardian™ Ballast Water Management System (Type approval, shipboard scale)

Model : EcoGuardian™

Manufacturer : Same as client's

Name of ship : CHANG YAHNG

3. Test standard/method : The provisional regulation for type approval of Ballast Water Management System by Ministry of Oceans and Fisheries of the Republic of Korea(PR. No. 2013-56) and IMO BWM convention regulation D-2

The test results attached herewith contained apply only to the test sample(s) supplied by the named applicant, and this test report will not be reproduced in full or in part without the prior written approval of the Busan Techno-Park in advance.

Approved by

Seo, Hyo-Jin

Seo, Hyo-Jin

Busan Techno-Park

Summary of test results

Test	Test site		Test Standard	Results
	Ballasting / date	Deballasting / date		
1st	Tolo (Hong Kong) / 2013.12.8~9	-	The provisional regulation for type approval of BWMS by the MOF [b)] and IMO BWM convention regulation D-2	Invalid[a)]
2nd	Kaohsiung (Taiwan) / 2014.5.22	-		Invalid
3rd	Gamcheon (Korea) / 2014.5.28	Donghae (Korea) / 2014.5.30		Satisfied D-2
4th	Gunsan (Korea) / 2014.6.22	-		Invalid
5th	Tolo (Hong Kong) / 2014.7.21	Tolo (Hong Kong) / 2014.7.23		Satisfied D-2
6th	Gunsan (Korea) / 2014.9.16	Gamcheon (Korea) / 2014.9.18		Satisfied D-2

a) Invalid, test water condition as stipulated in D-2 not met.

b) MOF, Ministry of Oceans and Fisheries

Contents

1. Introduction 1

1.1 Introduction of the developer(Hanla IMS) 1

1.2 Description of the EcoGuardian™ 1

1.3 System operation (Flow of BWMS in ballasting/de-ballasting) 2

2. Test ship and methods 3

2.1 Test ship information 3

2.2 Test method 4

2.2.1 Water parameters measurement 4

2.2.2 Biological efficacy test 4

3. Test results 10

3.1 Summary of the test results 10

3.1.1 Test 1 11

3.1.2 Test 2 12

3.1.3 Test 3 13

3.1.4 Test 4 16

3.1.5 Test 5 17

3.1.6 Test 6 21

3.2 Summary of the BWMS operating records 24

4. Attachment(Test reports and raw data) 25

1. Introduction

1.1 Introduction of the developer (Hanla IMS)

Since starting business in marine equipment industry in 1989, “Hanla IMS” have supplied reliable products to customers for over 24 years. Based on these 24 years experiences, Loading Computer, Valve Remote Control System, Deck Machinery, LED Lighting, Ballast Water Management System (BWMS) have been developed by their own technologies and they have been continuously growing up to become the best company in this field.

In this EcoGuardian™, they have put all of their efforts, technologies and experience to provide their customers with a perfect BWMS. Their practical knowledge and understanding of total ballast system ling up through supplying valve control system and ballast gauging system will help their customers choosing reliable and well-built BWMS.

Hanla IMS is seeking the type approval from the Korean administration for its proprietary - EcoGuardian™ Ballast Water Management System (BWMS). This approval is being sought in accordance with the *Guidelines for Approval of Ballast Water Management Systems* (G8) as adopted by Res. MEPC 174(58) (2008) of the International Maritime Organization (IMO) and the provisional regulation for type approval of Ballast Water Management System (PR. No. 2013-56) by the Ministry of Oceans and Fisheries, respectively.

1.2 Description of the EcoGuardian™ system

The EcoGuardian™ BWMS is designed by Hanla IMS Co. Ltd. The system consists of three main units - a filter unit, an electrochlorination unit and a neutralization unit.

Filter unit removes particles over 50 μm only during ballasting and has automatic backflushing function to prevent the clogging of filter mesh. Electrochlorination unit generates sodium hypochlorite in situ by means of an electrochlorination process only during ballasting. And neutralization unit adds a sodium thiosulfate solution to the treated ballast water during de-ballasting to neutralize the residual TRO.

- Maximum dose concentration of 9 mg/L TRO as Cl_2
- Maximum allowable discharge concentration (MADC) is 0.2 mg/L TRO as Cl_2

1.3 System operation (Flow of BWMS in ballasting/de-ballasting)

During ballasting operation, EcoGuardian™ removes aquatic organisms more than 50 μm through automatic backflushing filter unit. Secondly sodium hypochlorite is applied as a disinfectant which is generated at the electrolysis unit using the side-stream of the main ballasting line. During de-ballasting operation, the treated ballast water from the ballast tank is discharged through neutralization unit.

Mode	Process
Ballasting	Sea Chest → Ballast pump → Filter(50 μm) → Electrolysis(side-stream) → Ballast Water Tank
De-ballasting	Ballast Water Tank → Neutralization(sodium thiosulfate) → Ballast pump → Overboard

The schematic process diagram of the EcoGuardian™ system is shown in Figure 1.

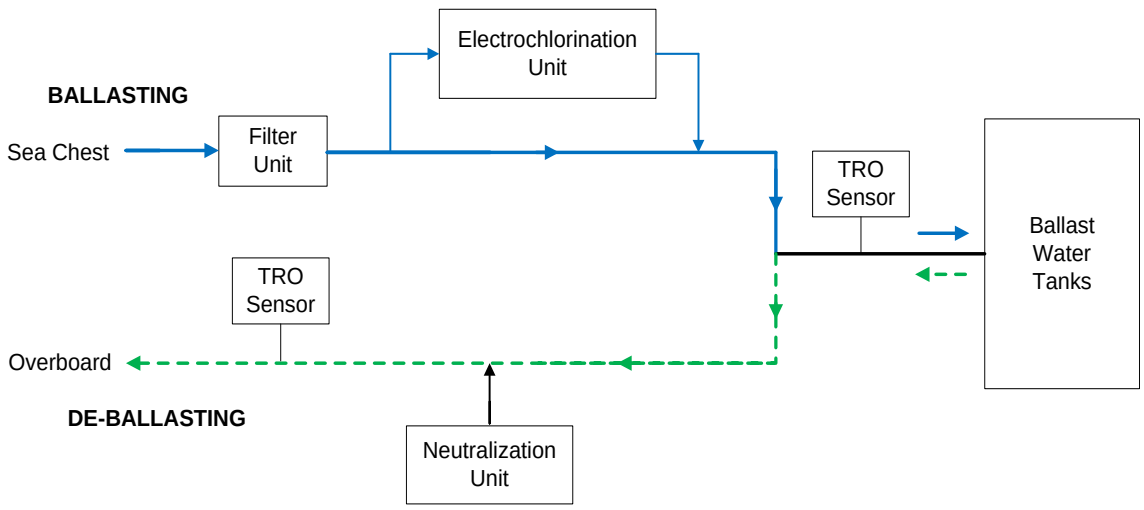


Figure 1. Schematic process diagram of the EcoGuardian™ system

2. Test ship and methods

2.1 Test ship information

Table 1. Introduction of the test ship

Ship Name	CHANG YAHNG
Ship Owner	SSANG YONG SHIPPING
Ship Builder	SHINA SHIPBUILDING
Hull No.	SAS380
IMO No	9121027
Ship Type	Bulk Carrier 10K
Ballast Pump Capacity	350 m^3 / h × 20 m
Class	KR

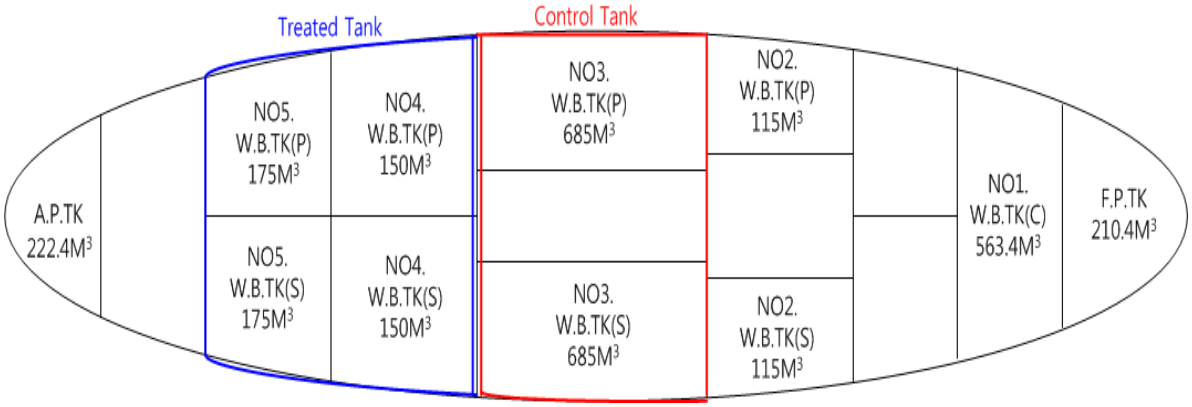


Figure 2. Test tank (Ballast Tank in CHANG YAHNG)

Table 2. Tank capacity

Tank	Tank number	Capacity
Treated Tank	No.4 WBT(S)	150 m^3
	No.4 WBT(P)	150 m^3
	No.5 WBT(S)	175 m^3
	No.5 WBT(P)	175 m^3
	Total	**650 m^3**
Control Tank	No.3 WBT(S)	685 m^3
	No.3 WBT(P)	685 m^3
	Total	**1370 m^3**

* Because of saftey, it selected the two tanks as a control tank and the four tanks as treated tank. It is to aim at ballasting or deballasting at the same time by using the port side and starboard.

2.2 Test method

2.2.1 Water parameters measurement

1) Water parameters (temperature, pH, DO, salinity, turbidity) of samples at Field (SSANG YONG CHANG YAHNG) are measured using YSI according to BTP-BW-QI-01~04, 22.

2) Water parameters (TRO) of samples at Field (SSANG YONG CHANG YAHNG) are measured using Pocket colorimeter II according to BTP-BW-QI-06.

3) Water parameters (DOC, POC) of samples at BTP lab are measured using Vario TOC cube according to BTP-BW-QI-20~21.

4) Water parameter (TSS) of samples at BTP lab is measured according to SOP-BWMS-005.

2.2.2 Biological efficacy test

1) ≥ 50μm organism

① Concentration

• Sample can be concentrated with 32 μm net.

• Concentrated sample transfer into beaker and fill up to 250 ~ 2000 mL with filtered seawater.

② Analysis

• General method

- Analysis under stereo microscope with dark field (alive: movement /dead: lack of movement).
- 1~20 mL of concentration sample place on a counting chamber (sedgewick-Rafter cell or Bogorov counting chamber).
- The number of observations must be more than three.(control samples)
- Treated ballast water samples are observed all volume of concentrated sample.

2) 10 μm - 50 μm organism

① Concentration (Treated samples)

• Sample can be concentrated with 5 μm net. (If necessary, samples can be filtered by 150 μm plankton net.)

• Concentrated sample transfer into beaker and fill up to 250 ~ 2000 mL with filtered seawater.

② Analysis

• General method

- 0.1~1 mL of sample place on a counting chamber (sedgewick-Rafter cell).
- Waiting for 1~5 minutes for cell sinking.
- The number of observations must be more than three.

• Process of staining

- Making of FDA Stock Solution (Made in BTP lab)
- 1 mL of 100 % DMSO solution inject to a 5 mg of FDA, which keep frozen until use.
- Making of Working Solution (Made in BTP lab or field)

Prepare by diluting the primary DMSO solution 100 times with stock solution.

- Each sample stained by adding 0.1 mL of the working solution to 3 mL sample.(Final concentration: 1.7 μL / mL FDA)
- Dyed sample place on a counting chamber.
- Waiting for 5~10 minutes for cell staining.

- Turn on mercury burner of microscope and apply to a fluorescent filter.
- Viable cells represent green color.
- Sample could be saved for up to 90 minutes without risking significant fluorescent degradation.

3) Heterotrophic bacteria

• SOP : SOP-BWTS-009

• Medium : 3M petrifilm - Aerobic Count Plate

• Method : Lift top film. Place 1 mL of sample onto center of bottom film. Release top film. Place spreader on top film over innoculum. Gently apply pressure on spreader.

• Sample volume : 1 mL

• Dilution water : Distilled water or filtered natural seawater (Autoclaved)

• Incubation : 35°C, 24hours.

• Data analysis : Select the plate with the number of colonies in the acceptable range and count all colonies on selected plates promptly after incubation. And calculate count per 1 mL.

4) *Escherichia coli*

• Standard : EPA 1603 [*Escherichia coli (E. coli)* in Water by Membrane Filtration Using Modified membrane - Thermo tolerant *Escherichia coli* Agar (Modified mTEC) : 2006]

• SOP : SOP-BWTS-010

• Medium : Modified mTEC agar (DIFCO, Cat No 214880)

• Method : Filter sample using 0.45 μm membrane filter and then place filters on the top of plate.

• Sample volume : 10 mL ~ 1L

• Dilution water : Distilled water(Autoclaved) or filtered natural seawater(Autoclaved)

• Incubation : Incubate 35°C ± 0.5°C for 2 ± 0.5 hours.Transfer the plates to incubate 44.5°C ± 0.2°C for 22 ± 2 hours.

• Data analysis : Select the plate with magenta or red colonies, and calculate the number of *E. coli* per 100 mL

• Report results as *E. coli* CFU per 100 mL of sample.

5) *Enterococcus faecalis*

• Standard : EPA 1600 [*Enterococci* in Water by Membrane Filtration Using membrane-*Enterococcus* Indoxyl-β-D-GlucosideAgar (mEI): 2006]

• SOP : SOP-BWTS-011

• Medium : mEI agar (DIFCO, Cat No 214881)

• Method : Filter sample using 0.45 µm membrane filter and then place filters on the top of plate.

• Sample volume : 10 mL ~ 1L

• Dilution water : Distilled water or filtered natural seawater (Autoclaved)

• Incubation : 41°C ± 0.5°C, 24 ± 2 hours

• Data analysis : Select the plate with colonies (regardless of colony color) with a blue halo. Calculate the number of enterococci per 100 mL

• Report results as enterococci per 100 mL of sample.

6) *Vibrio cholerae* O1, O139

• SOP : SOP-BWTS-012

• Medium : TCBS agar (DIFCO, Cat No 265020)

• Method

(1) Filter sample using 0.45 µm membrane filter and then place filters on the top of plate. Incubate the plates, protected from light at 35°C ± 1°C for 24± 2 hours.

(2) Each yellow sucrose fermenting colonies are placed on Non-salt Alkaline Pepton water. Incubate the plates at 36°C ± 1 °C for 6-18 hours.

(3) Presumptive positive colonies are performed using slide agglutination assays by O1 and O139 antiserum for serological identification.

• Sample volume : 10 mL ~ 1L

• Dilution water : Distilled water(Autoclaved) or filtered natural seawater(Autoclaved)

• Data analysis: Select the colonies with agglutinationO1 and O139 antiserum. Calculate the number of *Vibrio cholerae* per 100 mL

• Report results as *Vibrio cholerae* O1, O139 per 100 mL of sample.

※ Sample volume information

Test No.	Sample type/ volume		Water parameters	DOC, POC, TSS	≥ 50 μm sized organisms	10 ~ 50μm sized organisms	Bacteria
1st test	Uptake and control water	Volume	3~5 L	2 L	1,000 L	1 L	2 L
		Concentrated volume	-	-	250 mL	-	-
2nd test	Uptake and control water	Volume	3~5 L	-	1,000 L	1 L	-
		Concentrated volume	-	-	250 mL	-	-
3rd test	Uptake and control water	Volume	3~5 L	1~2 L	1,000 L	1 L	2L
		Concentrated volume	-	-	1,000 mL (control : 250mL)	-	-
	Treated water	Volume	3~5 L	1~2 L	1,000 L	10 L	2L
		Concentrated volume	-	-	250 mL	500 mL	-
4th	Uptake	Volume	3~5 L	-	1000 L	1 L	2L

test	and control water	Concentrated volume	-	-	500 mL	-	-
5th test	Uptake and control water	Volume	3~5 L	1~2 L	1000 L	1 L	2L
		Concentrated volume	-	-	250 mL	-	-
	Treated water	Volume	3~5 L	1~2 L	1000 L	10 L	2L
		Concentrated volume	-	-	250 mL	500 mL	-
6th test	Uptake and control water	Volume	3~5 L	1~2 L	1000 L	1 L	2L
		Concentrated volume	-	-	250 mL	-	-
	Treated water	Volume	3~5 L	1~2 L	1000 L	10 L	2L
		Concentrated volume	-	-	250 mL	500 mL	-

3. Test results

3.1 Summary of the test results (Efficacy test)

Table 3. Summary of the test results

Test	Test site		Results
	Ballasting	Deballasting	
1st	Tolo (Hong Kong)	-	Invalid [a)]
2nd	Kaohsiung (Taiwan)	-	Invalid
3rd	Gamcheon (Korea)	Donghae (Korea)	Satisfied D-2
4th	Gunsan (Korea)	-	Invalid
5th	Tolo (Hong Kong)	Tolo (Hong Kong)	Satisfied D-2
6th	Gunsan (Korea)	Gamcheon (Korea)	Satisfied D-2

a) Invalid, test water condition as stipulated in D-2 not met.

3.1.1 Test 1 (Ballasting : Tolo Harbor, Deballasting : -)

The shipboard tests were carried out following the guideline of G8. All measurements were tested more than three times and were analyzed as soon as possible after sampling. The water quality of test 1 is summarized in Table 4 and 5. The organism larger than 50µm was from 35,250 ± 1,768 to 60,000 ± 4,950 inds/m^3 and the organism between 10µm and 50µm was from 17 ± 11 to 53 ± 21 inds/mL in Table 6. The test water not met the requirements as stipulated in regulation D-2 of the BWM Convention, test 1 was invalid.

Table 4. Water parameters of test1 (Uptake water)

Date	Sample ID	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
2013.12.08 (Day0)	HL-S01UW-B	8.11±0.00	21.15±0.00	32.17±0.01	10.29±0.03	1.2±0.0	-
	HL-S01UW-M	8.12±0.00	20.98±0.01	32.20±0.00	10.39±0.04	1.0±0.1	-
	HL-S01UW-E	8.12±0.00	20.94±0.01	32.09±0.01	10.35±0.05	1.0±0.1	-

Table 5. Results of DOC, POC, TSS(Uptake water)

Date	Sample ID	TOC (mg/L)	DOC (mg/L)	POC (mg/L)	TSS (mg/L)
2013.12.08 (Day0)	HL-S01UW-B	3.595±0.090	1.075±0.021	2.521	3.0±0.2
	HL-S01UW-M	3.706±0.038	1.043±0.029	2.662	3.3±0.3
	HL-S01UW-E	3.694±0.029	1.070±0.020	2.625	2.4±0.3

Table 6. Biological efficacy of "EcoGuardian™" at test 1 (Uptake water)

Date	Sample ID	50µm< (inds/m^3)	10~50µm (inds/mL)	Heterotro. Bacteria (cfu/mL)	*E. coli* (cfu/100mL)	*Enterococci* (cfu/100mL)	*V. cholera* (cfu/100mL)
2013.12.08 (Day0)	HL-S01UW-B	35,250 ± 1,768	53 ± 21	267 ± 115	1 ± 1	0 ± 0	N.D[1)]
	HL-S01UW-M	60,000 ± 4,950	52 ± 15	333 ± 115	0 ± 1	0 ± 0	N.D

	HL-S01UW-E	39,000 ± 4,243	17 ± 11	533 ± 231	5 ± 3	1 ± 1	N.D
	Acceptability	Acceptable (≥10^2inds./m^3)	Unacceptable (≥10^2inds./m^3)	-	-	-	-

1) N.D : Not detected

3.1.2 Test 2 (Ballasting : Kaohsiung, Deballasting : -)

The shipboard tests were carried out following the guideline of G8. All measurements were tested more than three times and were analyzed as soon as possible after sampling. The water quality of test 2 is summarized in Table 7. The organism larger than 50µm was from 7,883 ± 493 to 11,200 ± 589 inds/m^3 and the organism between 10µm and 50µm was from 7 ± 3 to 9 ± 2 inds/mL in Table 8. The test water not met the requirements as stipulated in regulation D-2 of the BWM Convention, test 2 was invalid.

Table 7. Water parameters of test 2 (Uptake water)

Date	Sample ID	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
2014.05.22 (Day0)	HL-S02UW-B	7.88 ± 0.00	28.87 ± 0.02	34.30 ± 0.46	5.55 ± 0.35	10.1 ± 0.0	-
	HL-S02UW-M	7.91 ± 0.01	28.97 ± 0.05	33.93 ± 0.15	5.59 ± 0.04	10.1 ± 0.0	-
	HL-S02UW-E	7.92 ± 0.00	28.98 ± 0.12	33.74 ± 0.03	5.52 ± 0.11	10.1 ± 0.1	-

Table 8. Biological efficacy of "EcoGuardian™" at test 2 (Uptake water)

Date	Sample ID	50µm< (inds/m^3)	10~50µm (inds/mL)	Heterotro. Bacteria (cfu/mL)	*E. coli* (cfu/100mL)	*Enterococci* (cfu/100mL)	*V. cholera* (cfu/100mL)
2014.05.22	HL-S02UW-B	11,200 ± 589	7 ± 3	267 ± 58	116 ± 17	23 ± 4	N.D[1)]

(Day0)	HL-S02UW-M	10,283 ± 671	9 ± 2	250 ± 87	136 ± 18	1 ± 1	N.D
	HL-S02UW-E	7,883 ± 493	9 ± 1	200 ± 0	67 ± 10	3 ± 1	N.D
	Acceptability	Acceptable (≥10^2inds./m^3)	Unacceptable (≥10^2inds./m^3)	-	-	-	-

1) N.D : Not detected

3.1.3 Test 3 (Ballasting : Gamcheon, Deballasting : Donghae)

The shipboard tests were carried out following the guideline of G8. All measurements were tested more than three times and were analyzed as soon as possible after sampling. The water quality of test 3 is summarized in Table 9 and 10. The organism larger than 50µm was from 2,767 ± 115 to 4,233 ± 231 inds/m^3 and the organism between 10µm and 50µm was from 181 ± 17 to 201 ± 27 inds/mL in the uptake water (Table 11). The test water satisfied the criteria of G8 requirements and after being treated by "EcoGuardian™", results of efficacy test of test 3 satisfy the standard as stipulated in regulation D-2 of the BWM Convention.

Table 9. Water parameters of test 3

Date	Sample ID	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)
2014. 05.28 (Day 0)	HL-S03UW-B	8.29±0.01	19.42±0.10	33.25±0.13	4.37±0.13	4.9±0.8
	HL-S03UW-M	8.31±0.01	18.90±0.24	33.01±0.34	3.89±0.01	5.7±0.0
	HL-S03UW-E	8.34±0.01	19.76±0.06	33.32±0.09	5.49±0.58	3.9±0.3
2014. 05.30 (Day 2)	HL-S03CD2-B	8.21±0.01	19.19±0.23	33.37±0.02	5.31±0.25	3.3±0.3
	HL-S03CD2-M	8.26±0.01	19.90±0.06	33.44±0.02	4.58±0.03	6.5±2.4
	HL-S03CD2-E	8.29±0.01	20.56±0.04	33.37±0.07	5.98±0.10	3.2±0.2
	HL-S03TD2-B-1	8.36±0.02	18.07±0.06	33.42±0.05	5.84±0.32	2.4±0.2

	HL-S03TD2-B-2	8.34±0.00	18.14±0.07	33.40±0.11	5.61±0.24	2.0±0.1
	HL-S03TD2-B-3	8.29±0.01	18.19±0.03	33.42±0.03	5.00±0.08	2.3±0.3
	HL-S03TD2-M-1	8.26±0.01	18.29±0.05	33.43±0.07	4.59±0.10	2.6±0.6
	HL-S03TD2-M-2	8.27±0.01	18.37±0.04	33.45±0.06	4.38±0.02	2.0±0.3
	HL-S03TD2-M-3	8.26±0.01	18.48±0.09	33.41±0.03	4.20±0.07	3.5±0.2
	HL-S03TD2-E-1	8.26±0.01	18.52±0.07	33.39±0.08	4.12±0.08	3.3±0.1
	HL-S03TD2-E-2	8.27±0.00	18.49±0.10	33.44±0.09	4.09±0.03	2.6±0.1
	HL-S03TD2-E-3	8.27±0.01	18.43±0.06	33.37±0.05	4.11±0.01	11.6±0.2

Table 10. Results of DOC, POC, TSS

Date	Sample ID	TOC (mg/L)	DOC (mg/L)	POC (mg/L)	TSS (mg/L)
2014. 05.28 (Day 0)	HL-S03UW-B	4.157 ± 0.067	2.171 ± 0.073	1.986	7.6 ± 2.6
	HL-S03UW-M	4.663 ± 0.215	2.119 ± 0.285	2.465	7.5 ± 1.2
	HL-S03UW-E	4.852 ± 0.072	2.486 ± 0.111	2.366	14.0 ± 12.1

Table 11. Biological efficacy of "EcoGuardian™" at test 3

Date	Sample ID	50μm< (inds/m^3)	10~50μm (inds/mL)	Heterotro. Bacteria (cfu/mL)	*E. coli* (cfu/100mL)	*Enterococci* (cfu/100mL)	*V. cholera* (cfu/100mL)
2014. 05.28 (Day 0)	HL-S03UW -B	3,733 ± 451	191 ± 11	83 ± 29	52 ± 9	39 ± 2	N.D[1)]
	HL-S03UW -M	2,767 ± 115	201 ± 27	67 ± 58	68 ± 4	37 ± 5	N.D
	HL-S03UW -E	4,233 ± 231	181 ± 17	33 ± 29	33 ± 9	8 ± 1	N.D
	Acceptability	Acceptable (≥10^{2}inds./m^3)	Acceptable (≥10^{2}inds./m^3)	-	-	-	-

		m^3)					
	HL-S03CD2-B	1,242 ± 63	62 ± 6	73 ± 21	16 ± 4	18 ± 5	N.D
	HL-S03CD2-M	1,375 ± 150	61 ± 10	63 ± 6	15 ± 6	20 ± 4	N.D
	HL-S03CD2-E	2,133 ± 38	73 ± 6	87 ± 21	14 ± 3	17 ± 5	N.D
	Acceptability	Acceptable (≥10 ind./m^3)	Acceptable (≥10 ind./mL)	-	-	-	-
2014. 05.30 (Day 2)	HL-S03TD2-B-1	3	<1	70 ± 20	N.D	N.D	N.D
	HL-S03TD2-B-2	N.D	<1	40 ± 10	N.D	N.D	N.D
	HL-S03TD2-B-3	N.D	<1	13 ± 12	N.D	N.D	N.D
	HL-S03TD2-M-1	N.D	<1	57 ± 6	N.D	N.D	N.D
	HL-S03TD2-M-2	N.D	<1	40 ± 17	N.D	N.D	N.D
	HL-S03TD2-M-3	N.D	<1	20 ± 10	N.D	N.D	N.D

	HL-S03TD2-E-1	N.D	<1	33 ± 29	N.D	N.D	N.D
	HL-S03TD2-E-2	N.D	<1	50 ± 0	N.D	N.D	N.D
	HL-S03TD2-E-3	N.D	<1	10 ± 10	N.D	N.D	N.D
	Acceptability	Acceptable (<10 ind./m^3)	Acceptable (<10 ind./mL)		Acceptable (<250 CFU/ 100 mL)	Acceptable (<100 CFU/ 100 mL)	Acceptable (<1 CFU/ 100 mL)

1) N.D : Not detected

3.1.4 Test 4 (Ballasting : Gunsan, Deballasting : -)

The shipboard tests were carried out following the guideline of G8. All measurements were tested more than three times and were analyzed as soon as possible after sampling. The water quality of test 4 is summarized in Table 12. The organism larger than 50µm was from 6,233 ± 306 to 8,167 ± 252 inds/m^3 and the organism between 10µm and 50µm was from 21 ± 8 to 28 ± 12 inds/mL in Table 13. The test water not met the requirements as stipulated in regulation D-2 of the BWM Convention, test 2 was invalid.

Table 12. Water parameters of test 4 (Uptake water)

Date	Sample ID	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
2014.06.22 (Day0)	HL-S04UW-B	8.07 ± 0.00	21.95 ± 0.05	33.03 ± 0.01	8.01 ± 0.17	4.9 ± 0.1	-
	HL-S04UW-M	8.13 ± 0.05	22.12 ± 0.01	33.15 ± 0.06	5.34 ± 0.00	5.9 ± 0.6	-
	HL-S04UW-E	8.19 ± 0.01	21.63 ± 0.01	33.22 ± 0.01	5.48 ± 0.01	4.6 ± 0.1	-

Table 13. Biological efficacy of "EcoGuardian™" at test 4 (Uptake water)

Date	Sample ID	50µm< (inds/m^3)	10~50µm (inds/mL)	Heterotro. Bacteria (cfu/mL)	*E. coli* (cfu/100mL)	*Enterococci* (cfu/100mL)	*V. cholera* (cfu/100mL)
2014. 06.22 (Day0)	HL-S04UW-B	8,167 ± 252	28 ± 12	-	-	-	-
	HL-S04UW-M	7,333 ± 586	24 ± 11	-	-	-	-
	HL-S04UW-E	6,233 ± 306	21 ± 8	-	-	-	-
	Acceptability	Acceptable (≥10^{2}inds./m^3)	Unacceptable (≥10^{2}inds./m^3)	-	-	-	-

3.1.5 Test 5 (Ballasting : Tolo harbor, Deballasting : Tolo harbor)

The shipboard tests were carried out following the guideline of G8. All measurements were tested more than three times and were analyzed as soon as possible after sampling. The water quality of test 5 is summarized in Table 14 and 15. The organism larger than 50µm was from 14,583 ± 1,909 to 27,000 ± 500 inds/m^3 and the organism between 10µm and 50µm was from 135 ± 5 to 164 ± 13 inds/mL in the uptake water (Table 16). The test water satisfied the criteria of G8 requirements and after being treated by "EcoGuardian™", results of efficacy test of test 5 satisfy the standard as stipulated in regulation D-2 of the BWM Convention.

Table 14. Water parameters of test 5

Date	Sample ID	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
2014. 07.21 (Day 0)	HL-S05UW-B	8.38±0.16	29.47±0.04	29.73±0.03	5.64±0.19	7.5±0.1	-
	HL-S05UW-M	8.51±0.01	29.47±0.13	29.84±0.06	5.94±0.54	7.7±0.2	-
	HL-S05UW-E	8.52±0.01	29.44±0.04	29.86±0.01	5.61±0.10	7.4±0.3	-

2014. 07.23 (Day 2)	HL-S05CD2-B	8.27±0.08	30.43±0.20	30.35±0.81	2.53±1.26	6.6±1.5	-
	HL-S05CD2-M	8.26±0.11	30.22±0.06	29.66±0.07	3.36±0.40	7.7±0.9	-
	HL-S05CD2-E	8.30±0.07	30.30±0.05	29.56±0.22	2.92±1.53	6.9±0.2	-
	HL-S05TD2-B-1	8.27±0.00	30.20±0.0	29.58±0.00	2.27±0.04	7.3±1.5	0.04±0.02
	HL-S05TD2-B-2	8.40±0.00	30.06±0.03	29.69±0.01	3.15±0.00	6.1±0.1	-
	HL-S05TD2-B-3	8.40±0.00	30.02±0.01	29.71±0.01	3.49±0.04	5.0±0.3	-
	HL-S05TD2-M-1	8.43±0.00	30.03±0.01	29.76±0.03	3.64±0.07	6.5±0.1	0.05±0.03
	HL-S05TD2-M-2	8.42±0.00	30.04±0.01	29.66±0.03	3.85±0.49	4.9±0.1	-
	HL-S05TD2-M-3	8.43±0.00	30.08±0.01	29.59±0.00	3.73±0.25	6.7±0.2	-
	HL-S05TD2-E-1	8.43±0.00	30.12±0.01	29.73±0.04	3.41±0.01	4.8±0.0	0.06±0.02
	HL-S05TD2-E-2	8.43±0.00	30.06±0.03	29.69±0.02	3.36±0.01	5.6±0.0	-
	HL-S05TD2-E-3	8.43±0.00	30.12±0.01	29.75±0.04	3.34±0.05	5.7±0.1	-

Table 15. Results of DOC, POC, TSS

Date	Sample ID	TOC (mg/L)	DOC (mg/L)	POC (mg/L)	TSS (mg/L)
2014. 07.21 (Day 0)	HL-S05UW-B	3.200±0.085	1.793±0.033	1.793	2.4±0.4
	HL-S05UW-M	3.241±0.126	1.726±0.124	1.726	2.4±0.2
	HL-S05UW-E	2.948±0.179	1.759±0.110	1.759	3.0±0.2

Table 16. Biological efficacy of "EcoGuardian™" at test 5

Date	Sample ID	50μm< (inds/m^3)	10~50μm (inds/mL)	Heterotro. Bacteria (cfu/mL)	*E. coli* (cfu/100mL)	*Enterococci* (cfu/100mL)	*V. cholera* (cfu/100mL)
2014. 07.21 (Day 0)	HL-S05UW-B	14,583 ± 1,909	164 ± 13	67 ± 14	128 ± 39	N.D[2)]	N.D
	HL-S05UW-M	21,333 ± 1,443	155 ± 12	25 ± 0	145 ± 10	N.D	N.D
	HL-S05UW-E	27,000 ± 500	135 ± 5	N.D	84 ± 24	N.D	N.D
	HL-S05CD2-B	Acceptable (≥10^{2}inds./m^3)	Acceptable (≥10^{2}inds./m^3)	-	-	-	-
2014. 07.23 (Day 2)	HL-S05CD2-M	11,875 ± 433	34 ± 4	TNTC [1)]	4 ± 2	0 ± 1	N.D
	HL-S05CD2-E	10,583 ± 402	31 ± 2	TNTC	10 ± 3	N.D	N.D
	HL-S05TD2-B-1	12,792 ± 764	29 ± 4	TNTC	39 ± 3	N.D	N.D
	HL-S05TD2-B-2	Acceptable (≥10 ind./m^3)	Acceptable (≥10 ind./mL)	-	-	-	-
	HL-S05TD2-B-3	N.D	<1	78 ± 4	5 ± 5	N.D	N.D
	HL-S05TD2-M-1	N.D	<1	50 ± 1	1 ± 1	N.D	N.D

	HL-S05TD2-M-2	N.D	<1	69 ±7	N.D	N.D	N.D
	HL-S05TD2-M-3	N.D	N.D	40 ± 4	1 ± 1	N.D	N.D
	HL-S05TD2-E-1	N.D	N.D	44 ± 3	N.D	N.D	N.D
	HL-S05TD2-E-2	N.D	N.D	60 ± 2	N.D	N.D	N.D
	HL-S05TD2-E-3	N.D	<1	37 ± 10	2 ± 1	N.D	N.D
	HL-S03TD2-E-2	N.D	N.D	66 ± 5	N.D	N.D	N.D
	HL-S03TD2-E-3	N.D	N.D	83 ± 5	N.D	N.D	N.D
	Acceptability	Acceptable (<10 ind./m^3)	Acceptable (<10 ind./mL)		Acceptable (<250 CFU/ 100 mL)	Acceptable (<100 CFU/ 100 mL)	Acceptable (<1 CFU/ 100 mL)

1) TNTC : Too numerous to count

2) N.D : Not detected

3.1.6 Test 6 (Ballasting : Gunsan, Deballasting : Gamcheon)

The shipboard tests were carried out following the guideline of G8. All measurements were tested more than three times and were analyzed as soon as possible after sampling. The water quality of test 6 is summarized in Table 17 and 18. The organism larger than 50µm was from 2,283 ± 104 to 3,117 ± 325 inds/m^3 and the organism between 10µm and 50µm was from 114 ± 7 to 123 ± 9 inds/mL in the uptake water (Table 19). The test water satisfied the criteria of G8 requirements and after being treated by "EcoGuardian™", results of efficacy test of test 6 satisfy the standard as stipulated in regulation D-2 of the BWM Convention.

Table 17. Water parameters of test 6

Date	Sample ID	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
2014. 09.16 (Day 0)	HL-S06UW-B	7.91±0.19	24.42±0.01	30.06±0.27	6.19±0.17	7.8±0.2	-
	HL-S06UW-M	8.10±0.04	24.43±0.01	30.15±0.14	6.06±0.08	7.3±0.2	-
	HL-S06UW-E	8.12±0.05	24.43±0.02	29.99±0.23	6.02±0.15	6.6±0.1	-
2014. 09.18 (Day 3)	HL-S06CD3-B	7.81±0.30	24.46±0.07	30.33±0.03	5.34±0.10	6.2±0.2	-
	HL-S06CD3-M	7.95±0.16	24.44±0.05	30.25±0.05	5.76±0.17	6.6±0.4	-
	HL-S06CD3-E	8.03±0.11	24.47±0.04	30.25±0.04	5.66±0.12	6.4±0.2	-
	HL-S06TD3-B-1	8.06±0.12	24.67±0.08	30.58±0.09	5.94±0.06	8.0±0.4	0.11±0.02
	HL-S06TD3-B-2	8.19±0.11	24.58±0.03	30.57±0.09	6.03±0.07	6.8±0.2	-
	HL-S06TD3-B-3	8.16±0.16	24.59±0.03	30.59±0.06	5.92±0.08	6.8±0.2	-
	HL-S06TD3-M-1	8.14±0.18	24.60±0.03	30.58±0.09	5.86±0.43	6.8±0.2	0.09±0.01
	HL-S06TD3-M-2	8.26±0.05	24.62±0.09	30.46±0.32	5.68±0.06	6.8±0.3	-
	HL-S06TD3-M-3	8.21±0.05	24.61±0.03	30.59±0.06	5.87±0.08	7.0±0.1	-
	HL-S06TD3-E-1	8.06±0.08	24.59±0.03	30.62±0.01	5.88±0.05	7.4±0.2	0.07±0.02
	HL-S06TD3-	8.03±0.11	24.61±0.04	30.57±0.09	5.92±0.09	9.7±2.2	-

	E-2						
	HL-S06TD3-E-3	8.10±0.10	24.63±0.04	30.61±0.02	6.19±0.13	9.2±1.4	-

Table 18. Results of DOC, POC, TSS

Date	Sample ID	TOC (mg/L)	DOC (mg/L)	POC (mg/L)	TSS (mg/L)
2014. 09.16 (Day 0)	HL-S06UW-B	2.840 ± 0.16	1.737 ± 0.03	1.103	76.8±1.1
	HL-S06UW-M	2.690 ± 0.13	1.682 ± 0.16	1.008	78.4±1.2
	HL-S06UW-E	2.911 ± 0.04	1.791 ± 0.03	1.120	75.5±1.4

Table 19. Biological efficacy of "EcoGuardian™" at test 6

Date	Sample ID	50μm< (inds/m^3)	10~50μm (inds/mL)	Heterotro. Bacteria (cfu/mL)	*E. coli* (cfu/100mL)	*Enterococci* (cfu/100mL)	*V. cholera* (cfu/100mL)
2014. 09.16 (Day 0)	HL-S06UW-B	2,283 ± 104	114 ± 7	0 ± 0	18 ± 7	2 ± 1	N.D[2)]
	HL-S06UW-M	2,333 ± 257	123 ± 9	33 ± 29	31 ± 5	7 ± 3	N.D
	HL-S06UW-E	3,117 ± 325	123 ± 9	100 ± 50	52 ± 10	22 ± 5	N.D
	Acceptability	Acceptable (≥10^{2}inds./m^3)	Acceptable (≥10^{2}inds./m^3)	-	-	-	-
2014. 09.18 (Day 3)	HL-S06CD3-B	2,000 ± 87	18 ± 3	317 ± 52	3 ± 1	2 ± 2	N.D
	HL-S06CD3-M	2,017 ± 126	15 ± 1	108 ± 14	3 ± 2	3 ± 2	N.D

	HL-S06CD3-E	2,667 ± 189	17 ± 2	150 ± 43	1 ± 1	1 ± 1	N.D
	Acceptability	Acceptable (≥10 ind./m^3)	Acceptable (≥10 ind./mL)	-	-	-	-
	HL-S06TD3-B-1	N.D	<1	TNTC [1)]	N.D	N.D	N.D
	HL-S06TD3-B-2	N.D	<1	TNTC	N.D	N.D	N.D
	HL-S06TD3-B-3	N.D	<1	TNTC	N.D	N.D	N.D
	HL-S06TD3-M-1	N.D	<1	TNTC	N.D	N.D	N.D
	HL-S06TD3-M-2	N.D	<1	199 ± 15	N.D	N.D	N.D
	HL-S06TD3-M-3	1	<1	148 ± 6	N.D	N.D	N.D
	HL-S06TD3-E-1	N.D	<1	TNTC	N.D	N.D	N.D
	HL-S06TD3-E-2	N.D	<1	TNTC	N.D	N.D	N.D
	HL-S06TD3-E-3	N.D	N.D	TNTC	N.D	N.D	N.D
	Acceptability	Acceptable (<10 ind./m^3)	Acceptable (<10 ind./mL)		Acceptable (<250 CFU/ 100 mL)	Acceptable (<100 CFU/ 100 mL)	Acceptable (<1 CFU/ 100 mL)

1) TNTC : Too numerous to count

2) N.D : Not detected

3.2 Summary of the BWMS operating records

Table 20. Operating records of "EcoGuardian™"

Test	The operating records				Remark
	Ballasting		Deballasting		
1st	-		-		Invalid [a)]
2nd	-		-		Invalid
3rd	C	TRC[b)](m^3/h) : 349±5	C	TRC (m^3/h) : 345±14	**Conformity** Backflushing : None
	T	TRO[c)](mg/L) : 7.89±1.17 TRC(m^3/h) : 345±7	T	TRO[c)](mg/L) : 0.09±0.02 TRC(m^3/h) : 345±4	
4th	-		-		Invalid
5th	C	TRC(m^3/h) : 346±12	C	TRC(m^3/h) : 334±23	**Conformity** Backflushing : 20 times
	T	TRO(mg/L) : 8.06±0.50 TRC(m^3/h) : 336±18	T	TRO(mg/L) : 0.09±0.0 TRC(m^3/h) : 345±7	
6th	C	TRC(m^3/h) : 342±8	C	TRC(m^3/h) : 344±9	**Conformity** Backflushing : 34 times DPD indicator solution of TRO analyzer [d)] was changed by new one.
	T	TRO(mg/L) : 8.13±1.32 TRC(m^3/h) : 333±15	T	TRO(mg/L) : 0.07±0.07 TRC(m^3/h) : 336±36	

a) Invalid, test water condition as stipulated in D-2 not met.

b) TRC : Treatment Rated Capacity

c) TRO : Total Residual Oxidant

d) TRO analyzer : Online TRO and chlorine monitor(Model : CLX-XT)

Ballast water management system was of a capacity and concentration within the range of the Treatment Rated Capacity (TRC) and of the concentration of Total Residual Oxidant (TRO) for which it is intended. And the tests including invalid tests were to span a trial period of not less than six months and it was done to perform three consecutive test cycles that comply with regulation D-2.

4. Attachment

4.1 Test 1 report and raw data

4.2 Test 2 report and raw data

4.3 Test 3 report and raw data

4.4 Test 4 report and raw data

4.5 Test 5 report and raw data

4.6 Test 6 report and raw data

4.7 Operating Data (Written by HANLA IMS)

4.1 Test 1 report and raw data

Test Report

Project name	EcoGuardian™
Test number	SET-13-001
Port	Tolo (Hongkong)-Ballasting
Title	Efficacy test of EcoGuardian™ Ballast Water Management System (shipboard scale)

BUSAN TECHNO PARK

Statement of Quality Assurance

Data were reviewed by Quality Assurance Unit of BTP to assure that the study was performed in accordance with protocol and standard operating procedures (SOP) of Busan Techno-Park(BTP). The report was an accurate reflection of the raw data generated at the BTP. Inspection of the routine and repeated procedures that constitute the study was carried out as a continuous major phase at or about the time this study was in progress.

Inspection Phase		Date		
		Inspection	Report to Testing manager	Report to Project director
Test plan		December 02, 2013	December 02, 2013	December 02, 2013
Sampling	1st	December 08-09, 2013	December 12, 2013	December 12, 2013
	2nd	-	-	-
Test substance	1st	December 08-09, 2013	December 12, 2013	December 12, 2013
	2nd	-	-	-
Test procedures (Bacteria test)	1st	December 08-09, 2013	December 12, 2013	December 12, 2013
	2nd	-	-	-
Observation and counting (≥50㎛, 10㎛-50㎛)	1st	December 08-09, 2013	December 12, 2013	December 12, 2013
	2nd	-	-	-
Observation and counting (Bacteria test)	1st	December 10, 2013	December 12, 2013	December 12, 2013
	2nd	-	-	-
	3rd	-	-	-

Seo, Hyo-Jin (Sign) 12th. Dec. 2014

Seo, Hyo-Jin / Project director Date

Study Personnel and Participants

The test participants recognized the study plan, manual, procedure, guide of Marine Bio-industry Development Center in performing the test.

	Name	Date
Study Personnel	Joe Woo. Lee (sign)	December 31, 2013
	Seo-Jin, Jung (sign)	December 31, 2013
	Eunpang, Kang (sign)	December, 31, 2013
	Jhang Seok Oh (sign)	December 31, 2013
QA/QC	Byung Hyouk (sign)	31st, Dec, 2013
Efficacy Testing Manager	Eunpang, Kang (sign)	December, 31, 2013

Contents

1.Results 1

1.1 Loading record 1

1.2 Water parameters 1

1.3 Influent water : Uptake water 2

1.4 Elimination efficacy 4

2. Validity 6

3. Conclusion 7

4. Appendix 8

1. Results

1.1 Loading record

Vessel name	SSANG YONG CHANGYAHNG
IMO number	9121027

Water ballast tanks			Sample WGT (Mt)	Loading (Date/Location)	Discharge (Date/Location)
Control	No.3 D/B W.B.T	P, S	1370	2013, Dec, 08~09 TOLO (22°26.61N, 114°14.46E)	-
Treated	No.4 D/B W.B.T No.5 D/B W.B.T	P, S	654	-	-

1.2 Water parameters

Table 1. Water parameters at field

Date	Sample ID	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
Day 0	HL-S01UW-B	8.11±0.00	21.15±0.00	32.17±0.01	10.29±0.03	1.2±0.0	-
	HL-S01UW-M	8.12±0.00	20.98±0.01	32.20±0.00	10.39±0.04	1.0±0.1	-
	HL-S01UW-E	8.12±0.00	20.94±0.01	32.09±0.01	10.35±0.05	1.0±0.1	-

Table 2. Results of DOC, POC, TSS

Date	Sample ID	TOC [a)] (mg/L)	DOC [b)] (mg/L)	POC [c)] (mg/L)	TSS [d)] (mg/L)
Day 0	HL-S01UW-B	3.595±0.090	1.075±0.021	2.521	3.0±0.2
	HL-S01UW-M	3.706±0.038	1.043±0.029	2.662	3.3±0.3
	HL-S01UW-E	3.694±0.029	1.070±0.020	2.625	2.4±0.3

Data were presented as mean±S.D of three repeated measurement.
a) TOC: Total Organic Carbon
b) DOC: Dissolved Organic Carbon
c) POC: Particulate Organic Carbon (POC=TOC-DOC)
d) TSS: Total Suspended Solids

1.3 Influent water : Uptake water

1) ≥ 50 µm organism

Table 3. Survival number of the organism larger than 50 µm

Sample ID	Phyla/Divisions	Species	individuals/m^3	Minimum Dimension (µm)
HL-S01UW-B	Arthropoda	*Acartia erythraea*	3,833 ± 1,258	130 ~ 150
		Oithona similis	13,833 ± 2,255	190 ~ 100
		Paracalanus parvus s.l	12,167 ± 1,893	130 ~ 150
		Temora turbinata	500 ± 0	140 ~ 170
		Corycaeus affinis	167 ± 289	90 ~ 100
		Harpacticoida spp.	1,833 ± 289	90 ~ 100
		Cirripedia larvae	1,333 ± 289	90 ~ 100
HL-S01UW-M	Arthropoda	*Acartia erythraea*	4,333 ± 289	130 ~ 150
		Oithona similis	27,333 ± 4,856	190 ~ 100
		Paracalanus parvus s.l	24,000 ± 3,905	130 ~ 150
		Temora turbinata	1,167 ± 289	140 ~ 170
		Corycaeus affinis	333 ± 289	90 ~ 100
		Harpacticoida spp.	2,833 ± 1,041	90 ~ 100
		Cirripedia larvae	500 ± 500	90 ~ 100
	Annelida	Polychaeta larvae	333 ± 289	120 ~ 140
HL-S01UW-E	Arthropoda	*Acartia erythraea*	1,833 ± 764	130 ~ 150
		Oithona similis	13,333 ± 3,175	190 ~ 100
		Paracalanus parvus s.l	22,500 ± 2,646	130 ~ 150
		Temora turbinata	667 ± 289	140 ~ 170
		Corycaeus affinis	333 ± 289	90 ~ 100
		Harpacticoida spp.	1,833 ± 764	90 ~ 100
		Cirripedia larvae	167 ± 289	90 ~ 100
Total	8 species 2 phyla/divisions		44,750 ± 13,339	-
Acceptability			Influent condition: Acceptable (≥10^2 ind./ m^3)	-

Data were presented as mean±S.D of three repeated measurement.
Some species were rare, the standard deviation was high.

2) 10 µm - 50 µm organism

Table 4. Survival number of the organism between 10 to 50 µm

Sample ID	Phyla/Divisions	Species	individuals/mL	Minimum Dimension (µm)
HL-S01UW-B	Bacillariophyta	*Pleurosigma* sp.	1 ± 1	25
		Thalassiosira sp.	15 ± 6	20 ~ 45
		Hemiaulus sinensis	9 ± 2	20 ~ 25
		Leptocylindus sp.	2 ± 3	15
		Dictyocha sp.	2 ± 2	20 ~ 30
		Navicula sp.	5 ± 6	10 ~ 15
	Dinophyta	*Cochlodinium sp.*	9 ± 5	10 ~ 20
		Amphidinium sp.	3 ± 5	15 ~ 25
		Prorocentrum sp.	1 ± 1	25
		Katodinium sp.	5 ± 6	15 ~ 25
		Ceratium sp.	1 ± 1	30
		Ebria sp.	1 ± 1	25
HL-S01UW-M	Bacillariophyta	*Pinnol sp.*	1 ± 2	15 ~ 25
		Chaetoceros sp.	3 ± 6	20
		Thalassiosira sp.	15 ± 4	20 ~ 45
		Hemiaulus sinensis	4 ± 3	20 ~ 25
		Leptocylindus sp.	1 ± 2	15
		Dictyocha sp.	5 ± 5	20 ~ 30
		Navicula sp.	11 ± 2	10 ~ 15
	Dinophyta	*Amphidinium sp.*	1 ± 1	20
		Cochlodinium sp.	5 ± 3	10 ~ 20
		Katodinium sp.	4 ± 3	15 ~ 25
		Gyrodinium sp.	2 ± 2	25 ~ 40
		Ebrica sp.	1 ± 1	20
HL-S01UW-E	Bacillariophyta	*Pleurosigma sp.*	1 ± 2	20 ~ 35
		Thalassiosira sp.	7 ± 5	20 ~ 45
		Hemiaulus sinensis	3 ± 5	20 ~ 25
		Dictyocha sp.	4 ± 2	20 ~ 30
		Navicula sp.	11 ± 4	10 ~ 15
	Dinophyta	*Cochlodinium sp.*	5 ± 5	10 ~ 20
		Prorocentrum sp.	1 ± 1	20
		Katodinium sp.	2 ± 2	15 ~ 25
		Gyrodinium sp.	1 ± 1	25
Total	15 species 2 phyla/divisions		41 ± 23	-
Acceptability			Influent condition: Unacceptable ($\geq 10^2$ ind./mL)	

Data were presented as mean±S.D of three repeated measurement.
Some species were rare, the standard deviation was high.

1.4 Elimination efficacy

1) ≥ 50 µm organism

Table 5. Survival number of the organism larger than 50 µm

Test substance	Sample ID	individuals/m^3	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S01UW-B [a)]	35,250 ± 1,768	Influent condition: Acceptable (≥10^2 ind./m^3)	-
	HL-S01UW-M [b)]	60,000 ± 4,950		
	HL-S01UW-E [c)]	39,000 ± 4,243		

2) 10 µm - 50 µm organism

Table 6. Survival number of the organism between 10 and 50 µm

Test substance	Sampl ID	individuals/mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S01UW-B [a)]	53 ± 21	Influent condition: Unacceptable (≥10^2 ind./m^3)	-
	HL-S01UW-M [b)]	52 ± 15		
	HL-S01UW-E [c)]	17 ± 11		

a) B: Beginning, b) M: Middle c) E: End
Data were presented as mean±S.D of three repeated measurement.

3) Heterotrophic bacteria

Table 7. Survival number of heterotrophic bacteria

Test substance	Sample ID	CFU / mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S01UW-B [a)]	267 ± 115	-	-
	HL-S01UW-M [b)]	333 ± 115		
	HL-S01UW-E [c)]	533 ± 231		

4) *Escherichia coli*

Table 8. Survival number of *Escherichia coli*

Test substance	Sample ID	CFU / mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S01UW-B	1 ± 1	-	-
	HL-S01UW-M	0 ± 1		
	HL-S01UW-E	5 ± 3		

5) Intestinal enterococci

Table 9. Survival number of intestinal enterococci

Test substance	Sample ID	CFU / mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S01UW-B	N.D [d)]	-	-
	HL-S01UW-M	N.D		
	HL-S01UW-E	1 ± 1		

6) *Vibrio cholera* O1, O139

Table 10. Survival number of *Vibrio cholera* O1, O139

Test substance	Sample ID	CFU / mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S01UW-B	N.D	-	-
	HL-S01UW-M	N.D		
	HL-S01UW-E	N.D		

a) B: Beginning, b) M: Middle c) E: End, d) N.D: Not detected
Data were presented as mean±S.D of three repeated measurement.

2. Validity

2.1 Water parameters measurement

- All measurements were tested more than three times.
- Water parameters were analyzed as soon as possible after sampling.

2.2 Biological efficacy test

- Valid tests are indicated by uptake water, for both the control tank and ballast water to be treated, with viable organism concentration exceeding 10 times the maximum permitted values in Regulation D-2.1
  - Influent condition in all tests was unacceptable for IMO standards (MEPC58/2/4).
  - The organism larger than 50 μm: ≥ 10^2 individuals/m^3 (Acceptable)
  - The organism between 10 μm and 50 μm: ≥ 10^2 individuals/mL (Unacceptable)

Sample ID	≥ 50 μm (individuals/m^3)	10 μm - 50 μm (individuals/mL)
HL-S01UW-B	35,250 ± 1,768	53 ± 21
HL-S01UW-M	60,000 ± 4,950	52 ± 15
HL-S01UW-E	39,000 ± 4,243	17 ± 11

※Regulation D-2 stipulates that ships meeting the requirements of the Convention by meeting the ballast water performance standard must discharge:

1. less than 10 viable organisms per cubic metre greater than or equal to 50 micrometres in minimum dimension;
2. less than 10 viable organisms per milliliter less than 50 micrometres in minimum dimension and greater than or equal to 10 micrometres in minimum dimension

- The samples should be analyzed as soon as possible after sampling.

Date	Sample ID	Sampling time	Test ending time
Day 0	HL-S01UW-B	Dec, 08 23:00	Dec, 09 02:01
	HL-S01UW-M	Dec, 09 00:06	
	HL-S01UW-E	Dec, 09 01:11	

3. Conclusion

3.1 Unacceptable of Influent water condition for IMO standards.

- Uptake water condition of organism between 10 μm and 50 μm was unacceptable for IMO standards.
- Therefore, test was invalid.

4. Appendix

Appendix 1. Water parameters at field

1) Uptake water

Date	Sample ID	R [a)]	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)	TOC [b)] (mg/L)	DOC [c)] (mg/L)	TSS [d)] (mg/L)
Day 0	HL-S01UW-B	R1	8.11	21.15	32.17	10.31	1.2	2.79	1.73	7.2
		R2	8.11	21.15	32.17	10.29	1.2	2.77	1.70	6.6
		R3	8.11	21.15	32.16	10.26	1.2	2.73	1.66	6.4
	HL-S01UW-M	R1	8.12	20.98	32.20	10.43	1.0	2.80	1.71	7.6
		R2	8.12	20.98	32.20	10.39	1.0	2.80	1.68	6.6
		R3	8.12	20.99	32.20	10.36	1.1	2.78	1.69	7.0
	HL-S01UW-E	R1	8.12	20.94	32.10	10.40	1.1	2.80	1.72	6.4
		R2	8.12	20.94	32.09	10.35	1.0	2.78	1.70	7.0
		R3	8.12	20.95	32.09	10.31	1.0	2.77	1.74	6.8

a) R: Replicate
b) TOC: Total Organic Carbon (TOC=DOC+POC)
c) DOC: Dissolved Organic Carbon
d) TSS: Total Suspended Solids

Appendix 2. Survival number of ≥ 50㎛ organism in uptake water(Influent water)

Date	Sample ID	Classification	Counting volume	individuals/m^3			Mean	SD [b)]
				R1[a)]	R2	R3		
Day 0	HL-S01UW-B	*Acartia erythraea*	10 mL	5,000	2,500	4,000	3,833	1,258
		Oithona similis		11,500	14,000	16,000	13,833	2,255
		Paracalanus parvus s.l		10,000	13,500	13,000	12,167	1,893
		Temora turbinata		500	500	500	500	0
		Corycaeus affinis		0	500	0	167	289
		Harpacticoida spp.		2,000	2,000	1,500	1,833	289
		Cirripedia larvae		1,500	1,000	1,500	1,333	289
	HL-S01UW-M	*Acartia erythraea*	10 mL	4,500	4,500	4,000	4,333	289
		Oithona similis		31,500	22,000	28,500	27,333	4,856
		Paracalanus parvus s.l		19,500	26,500	26,000	24,000	3,905
		Temora turbinata		1,000	1,000	1,500	1,167	289
		Corycaeus affinis		500	500	0	333	289
		Harpacticoida spp.		4,000	2,000	2,500	2,833	1,041
		Cirripedia larvae		1,000	0	500	500	500
		Polychaeta larvae		500	0	500	333	289
	HL-S01UW-E	*Acartia erythraea*	10 mL	2,500	2,000	1,000	1,833	764
		Oithona similis		17,000	11,500	11,500	13,333	3,175
		Paracalanus parvus s.l		20,500	25,500	21,500	22,500	2,646
		Temora turbinata		1,000	500	500	667	289
		Corycaeus affinis		0	500	500	333	289
		Harpacticoida spp.		2,500	2,000	1,000	1,833	764
		Cirripedia larvae		500	0	0	167	289

a) R: Replicate
b) S.D: Standard deviation
Some species were rare, the standard deviation was high.

Appendix 3. Survival number of 10㎛ - 50㎛ organism in uptake water(Influent water)

Sample ID	Classification	Counting volume	R1[a)]	R2	R3	individuals/mL	
						Mean	S.D. [b)]
HL-S01UW-B	*Pleurosigma* sp.	0.5 mL	1	0	0	1	1
	Thalassiosira sp.		9	9	4	15	6
	Hemiaulus sinensis		6	4	4	9	2
	Leptocylindus sp.		0	3	0	2	3
	Dictyocha sp.		2	0	1	2	2
	Navicula sp.		6	1	1	5	6
	Cochlodinium sp.		7	4	2	9	5
	Amphidinium sp.		0	0	4	3	5
	Prorocentrum sp.		1	0	0	1	1
	Katodinium sp.		6	2	0	5	6
	Ceratium sp.		0	1	0	1	1
	Ebria sp.		0	0	1	1	1
HL-S01UW-M	*Pinnol sp.*	0.5 mL	2	0	0	1	2
	Chaetoceros sp.		0	0	5	3	6
	Thalassiosira sp.		10	6	7	15	4
	Hemiaulus sinensis		0	3	3	4	3
	Leptocylindus sp.		2	0	0	1	2
	Dictyocha sp.		5	1	1	5	5
	Navicula sp.		7	5	5	11	2
	Amphidinium sp.		1	0	0	1	1
	Cochlodinium sp.		4	2	1	5	3
	Katodinium sp.		4	1	1	4	3
	Gyrodinium sp.		0	1	2	2	2
	Ebria sp.		1	0	0	1	1
HL-S01UW-E	*Pleurosigma sp.*	0.5 mL	2	0	0	1	2
	Thalassiosira sp.		3	6	1	7	5
	Hemiaulus sinensis		4	0	0	3	5
	Dictyocha sp.		2	3	1	4	2
	Navicula sp.		7	6	3	11	4
	Cochlodinium sp.		5	3	0	5	5
	Prorocentrum sp.		1	0	0	1	1
	Katodinium sp.		2	0	1	2	2
	Gyrodinium sp.		1	0	0	1	1

a) R: Replicate
b) S.D: Standard deviation
Some species were rare, the standard deviation was high.

Appendix 4. The number of heterotrophic bacteria in uptake water by treatment of EcoGuardian™ BWMS

Date	Sample ID	Dilution factor	CFU / mL			Mean	SD [b)]
			R1[a)]	R2	R3		
Day 0	HL-S01UW-B	X 200	1	2	1	267	115
	HL-S01UW-M		2	2	1	333.3	115
	HL-S01UW-E		2	2	4	533	231

Appendix 5. The number of *Escherichia coli* in uptake water by treatment of EcoGuardian™ BWMS

Date	Sample ID	CFU / 100 mL			Mean	SD [b)]
		R1[a)]	R2	R3		
Day 0	HL-S01UW-B	2	0	2	1	1
	HL-S01UW-M	0	1	0	0	1
	HL-S01UW-E	3	3	8	5	3

Appendix 6. The number of intestinal enterococci in uptake water by treatment of EcoGuardian™ BWMS

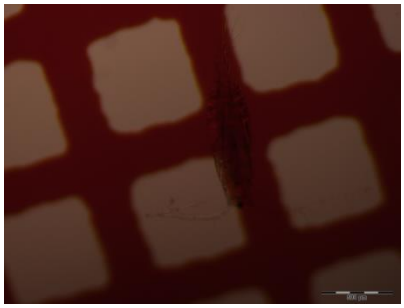
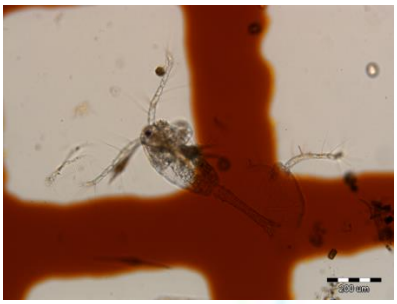
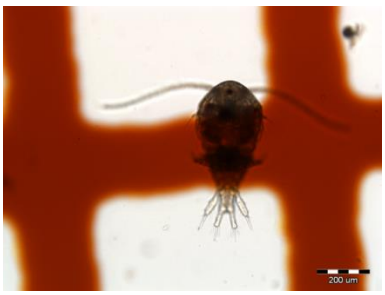
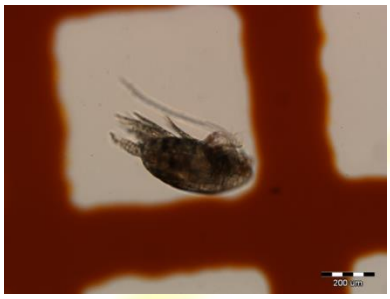
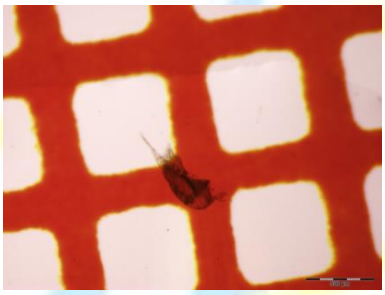
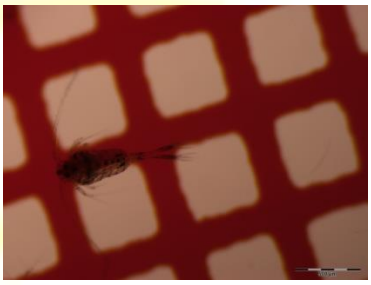
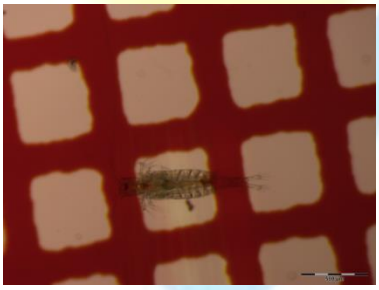
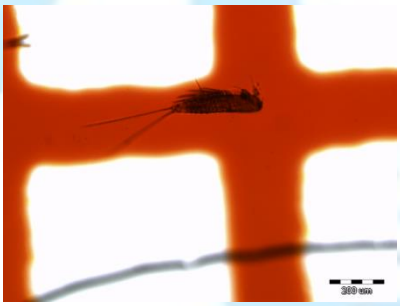
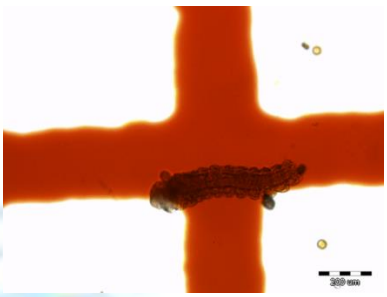
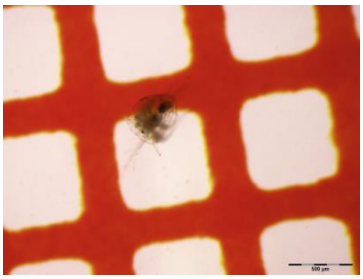
Date	Sample ID	CFU / 100 mL			Mean	SD [b)]
		R1[a)]	R2	R3		
Day 0	HL-S01UW-B	0	0	0	0	0
	HL-S01UW-M	0	0	0	0	0
	HL-S01UW-E	1	1	0	1	1

Appendix 7. The number of *Vibrio cholera* O1, O139 in uptake water by treatment of EcoGuardian™ BWMS

Date	Sample ID	CFU /100 mL			Mean	SD [b)]
		R1[a)]	R2	R3		
Day 0	HL-S01UW-B	0	0	0	0	0
	HL-S01UW-M	0	0	0	0	0
	HL-S01UW-E	0	0	0	0	0

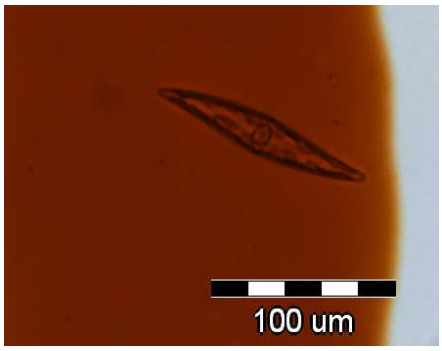
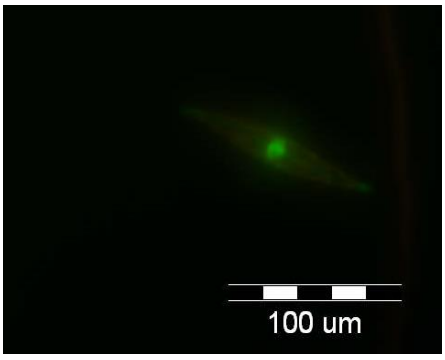
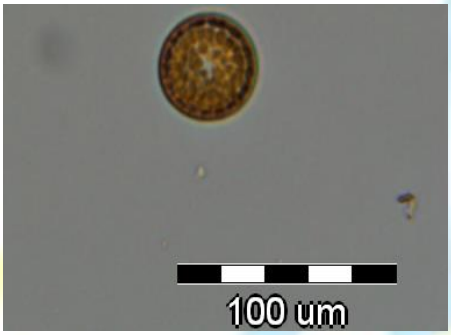
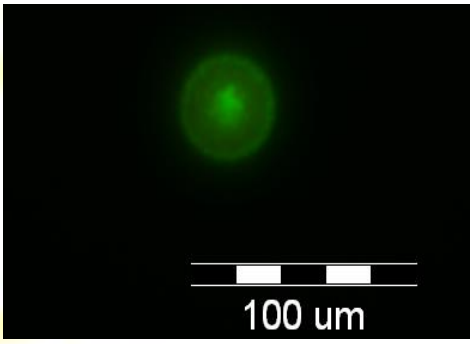
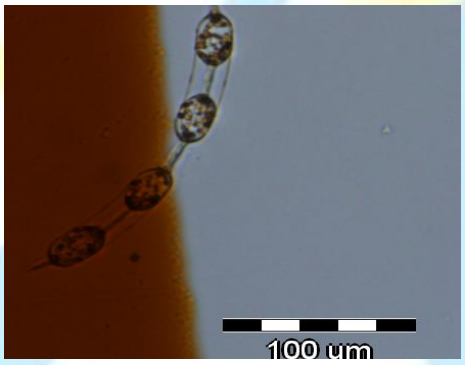
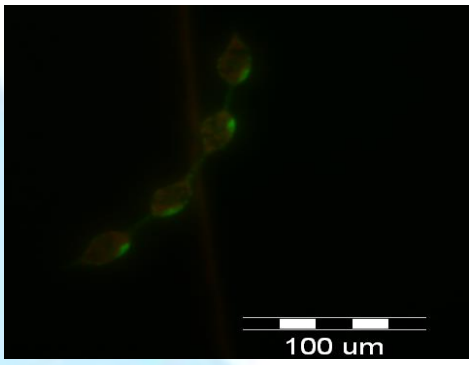
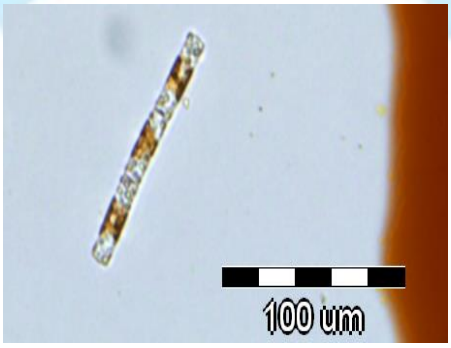
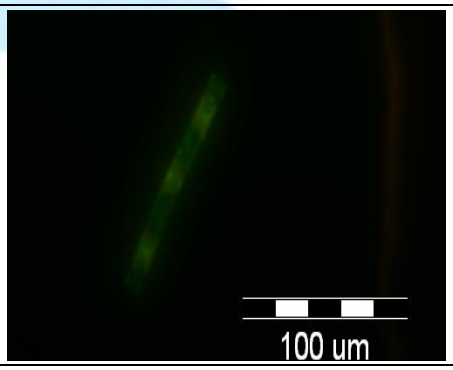
a) R: Replicate
b) S.D: Standard deviation

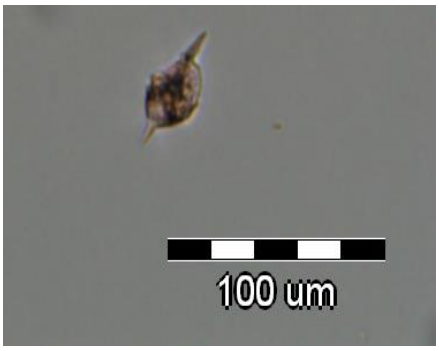
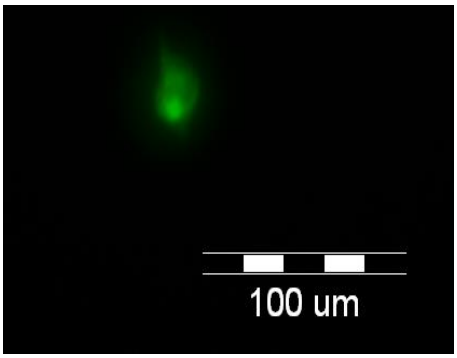
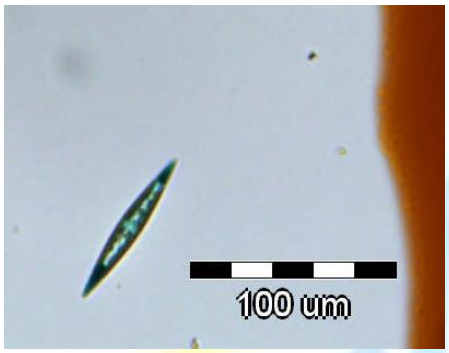
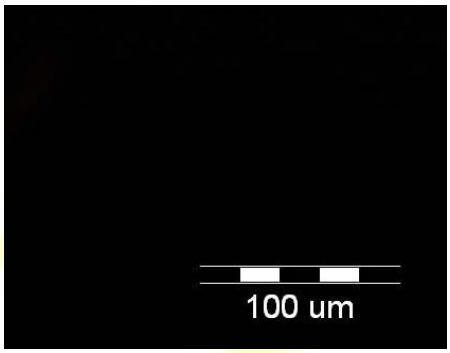
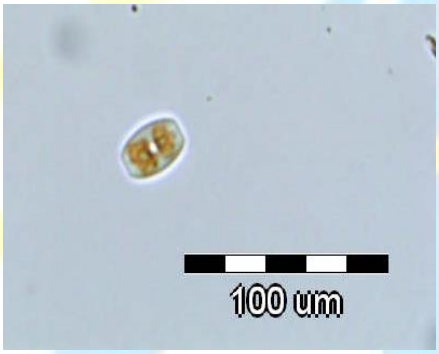
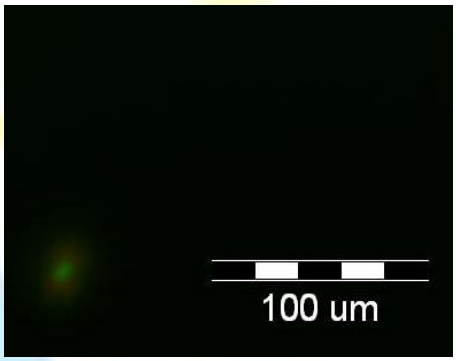
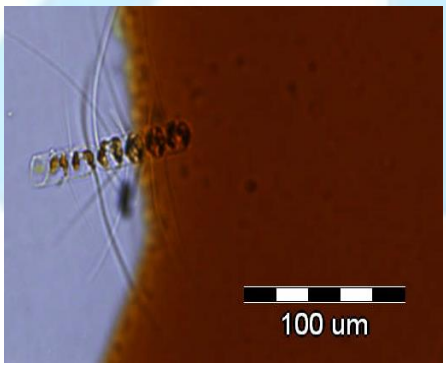
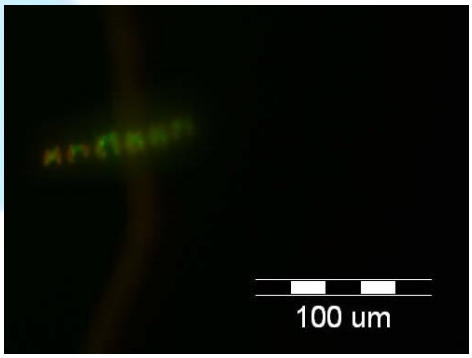
Appendix 8. The microscope image of ≥ 50㎛ in uptake water (Day0)

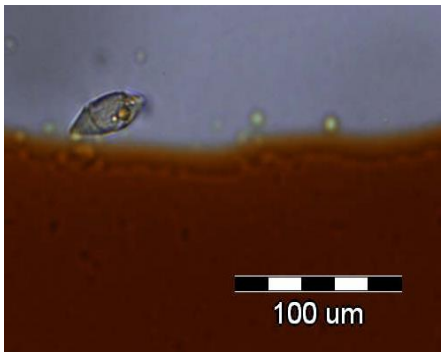
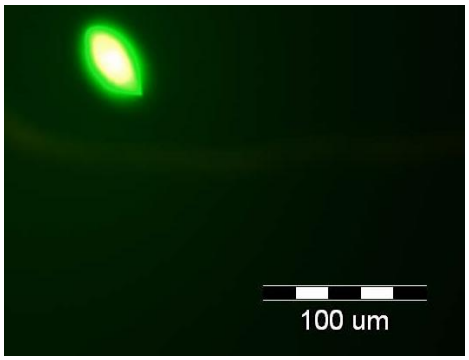
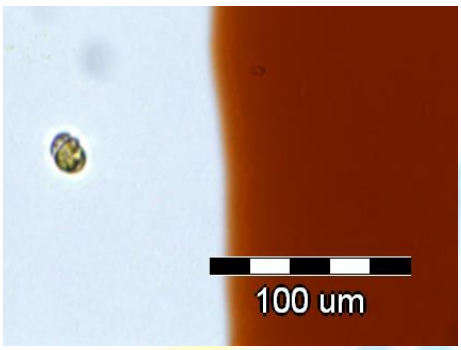
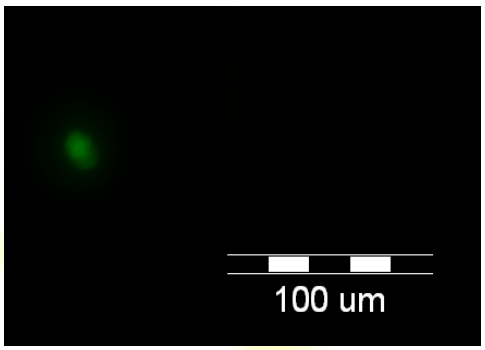
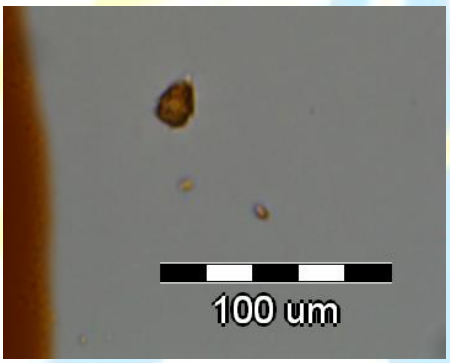
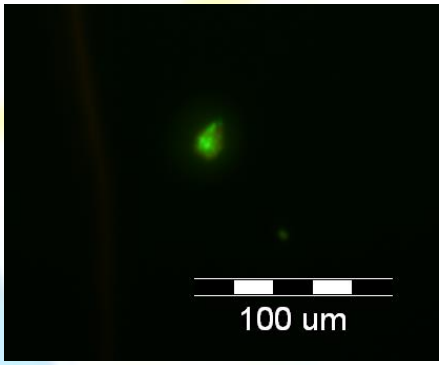
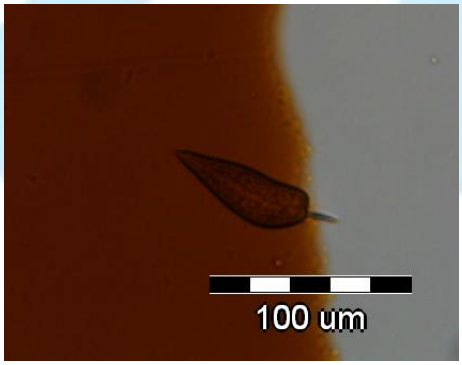
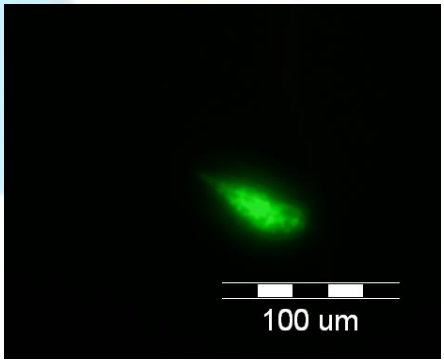
Uptake water (Day 0)		
*Acartia erythraea**	*Oithona similis***	*Temora turbinata***
		
Paracalanus parvus s.l**	*Corycaeus affinis**	*Tortanus forcipatus**
		
*Centropages furcatus**	Harpacticoida spp. **	Polychaeta larvae**
		
Cirripedia larvae*		
		

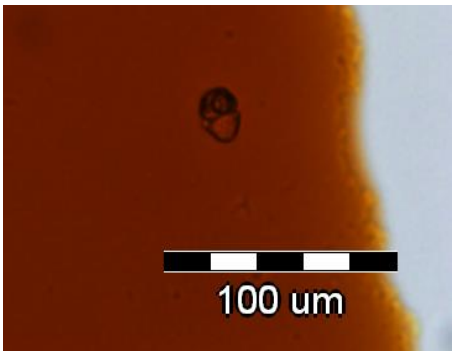
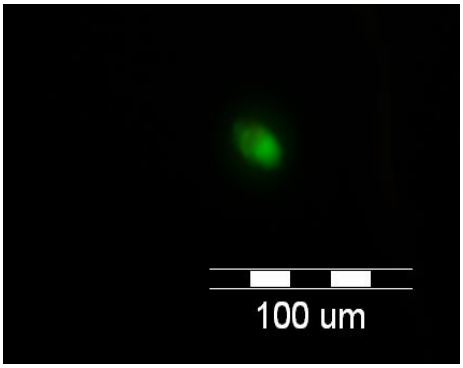
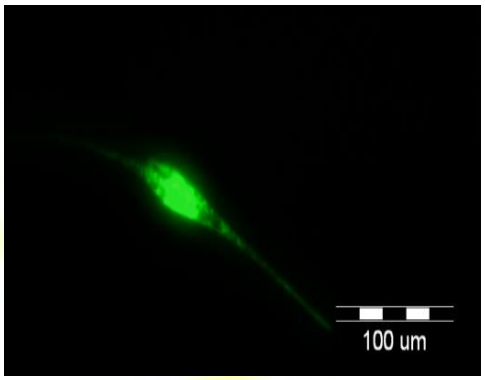
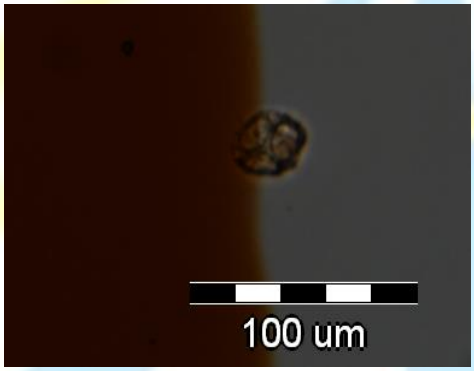
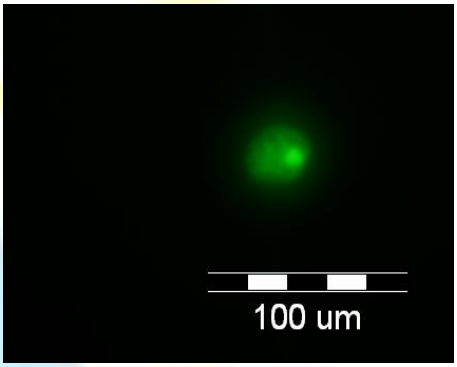
* Magnification : 50
** Magnification : 200

Appendix 9. The microscope image of 10㎛−50㎛ in uptake water (Day0)

Specific name	Original water	
	Optical	Fluorescence
Pleurosigma sp.		
Thalassiosira sp.		
Hemiaulus sinensis		
Leptocylindus sp.		

Dictyocha sp.		
Navicula sp.		
Pinnol sp.		
Chaetoceros sp.		

Gyrodinium sp.		
Cochlodinium sp.		
Amphidinium sp.		
Prorocentrum sp.		

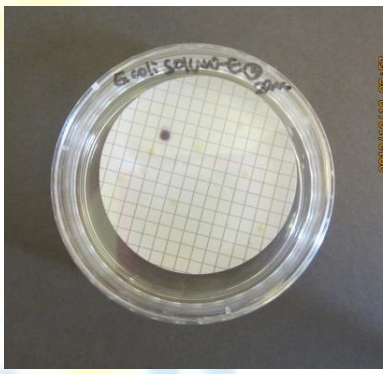
Katodinium sp.		
Ceratium sp.		
Ebria sp.		

Magnification : 200

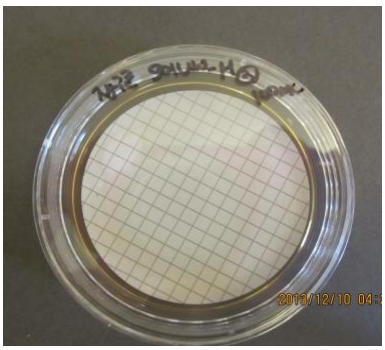
Appendix 10. The image of heterotrophic bacteria

Uptake water (Day 0)		
Beginning	**Middle**	**End**

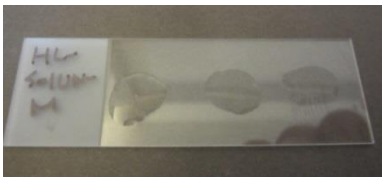
Appendix 11. The image of *Escherichia coli*

Uptake water (Day 0)		
Beginning	**Middle**	**End**
		

Appendix 12. The image of intestinal enterococci

Uptake water (Day 0)		
Beginning	**Middle**	**End**
		

Appendix 13. The image of *Vibrio cholera* O1, O139

Uptake water (Day 0)		
Beginning	**Middle**	**End**
		

5. Attachment

5.1 Sample check & custody Sheet

5.2 Water parameter measurement sheet (I)

5.3 Microbiology test sheet

5.4 Test results sheet with microbiology

5.5 Vibrio cholera O1, O139

5.6 Test results sheet – Classification(II)

Sampling check & custody Sheet

2013

Study number	HAN-Ship (/)	Test number	SET-13-001
Sampling time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Day ( )		

Sample location	☑ Uptake water □ Discharge control water □ Discharge treated water □ Other( )						
Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
TSS		HDPE	2	☑ 1	12.08 23:00	12.09 00:06	12.09 01:11
DOC, POC		HDPE	2	□ 2			
Bacteria (4 item)[b]		HDPE	2				
Organism (10~50 μm)		HDPE	1	□ 3			
Organism (≥50 μm)	1000L→0.5L	HDPE	0.25				

Sample location	□ Treated water □ Treated water (Neutralized)						
Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
Bacteria (4 item)[c]		HDPE		□ 1			
Organism (10~50 μm)		HDPE		□ 2			
Organism (≥50 μm)		HDPE		□ 3			

Concentration

Parameter	Vol. of concentrated before	Equipment	Mesh size
Organism (≥50 μm)	1,000 (L)	net	32 μm
Organism (10-50 μm)	(L)	net	5 μm

Sample storage information

Parameter	Location & condition	Storage time
TSS	Freezer(-20℃)	Beginning 12.08. 23:32
DOC, POC		Middle 12.09 00:34 End 12.09 01:29
Bacteria (4 item)	Refrigerator(4℃)	

Remarks

a), e), f), g) correct 2013. Dec. 08 Joewoo, Lee

* First, fill a ~~20L~~ a) 5L HDPE(high density poly ethylene) ~~bottle~~ beaker e) with water sample,
  f) ~~and split the water sample up into groups (bacteria, organism (10~50 μm), and so forth)~~
  Then measured water parameters(5 item) - pH, Temperature, Salinity, DO, Turbidity
* Separately, organism(≥50 μm, g) ~~10-50 μm~~) sample was concentrated with net.
* Storage time of "bacteria sample" is for "heterotrophic bacteria test"
* TSS and DOC and POC samples are acidified(pH<2) with HCl (in 4 mL HCl of 2 L sample)

Working(pump) start time for Test uptake water(or control water) sample : 22:16
Working(pump and EcoGuadian™) start time for treated(or neutralized) sample : 19:01 (~ 21:19)
21:00 Filter bypass

Working date	Dec. 08 ~ Dec. 09	Personnel	Joewoo. Lee (Sign)
Confirmation date	Dec. 09	Confirmed by	Eunyoung. Kang (Sign)

a) Concentration b) Period
c) Bacteria (4 item) - Heterotrophic bacteria, Coliform, Vibrio cholera, Enterococcus group

Water parameter measurement sheet (I)

20 13

Study Number	HAN-Ship (/)	Test number	SET-13- 001
Sampling time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Day ( )		
Equipment	YSI 6920 - pH, temp., salinity, DO / YSI 6920 - Turbidity		

Sample	Replicate	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)
☑ Uptake water □ Discharge control water □ Discharge treated water □ Discharge treated water(Neutralized water)	R1	8.11	21.15	32.17	10.31	1.2
	R2	8.11	21.15	32.17	10.29	1.2
	R3	8.11	21.15	32.16	10.26	1.2
☑ B( ) □ M( ) □ E( )	Measuring time	23 : 18 ~ 23 : 20 (12/08)				
☑ Uptake water □ Discharge control water □ Discharge treated water □ Discharge treated water(Neutralized water)	R1	8.12	20.98	32.20	10.43	1.0
	R2	8.12	20.98	32.20	10.39	1.0
	R3	8.12	20.99	32.20	10.36	1.1
□ B( ) ☑ M( ) □ E( )	Measuring time	00 : 14 ~ 00 : 16 (12/09)				
☑ Uptake water □ Discharge control water □ Discharge treated water □ Discharge treated water(Neutralized water)	R1	8.12	20.94	32.10	10.40	1.1
	R2	8.12	20.94	32.09	10.35	1.0
	R3	8.12	20.95	32.09	10.31	1.0
□ B( ) □ M( ) ☑ E( )	Measuring time	01 : 10 ~ 01 : 12 (12/09)				
□ Uptake water □ Discharge control water □ Discharge treated water □ Discharge treated water(Neutralized water)	R1					
	R2					
	R3					
□ B( ) □ M( ) □ E( )	Measuring time					
□ Uptake water □ Discharge control water □ Discharge treated water □ Discharge treated water(Neutralized water)	R1					
	R2					
	R3					
□ B( ) □ M( ) □ E( )	Measuring time					
□ Uptake water □ Discharge control water □ Discharge treated water □ Discharge treated water(Neutralized water)	R1					
	R2					
	R3					
□ B( ) □ M( ) □ E( )	Measuring time					

Remarks			
Working Date	Dec. 08 ~ Dec. 09	Study Personnel	Joewoo. Lee (Sign)
Confirming Date	Dec. 09	Confirmed by	Eunyong. Kang (Sign)

Microbiology Test Sheet

2013

Study number	HAN-Ship(1)		Test number	CET-13-001
Sampling Time	☑ Day 0 ☐ Day 1 ☐ Day 2 ☐ Day 3 ☐ Day 4 ☐ Day 5 ☐ Other( )			
Test substance	☑ Uptake water ☐ Discharge control water ☐ Discharge treated water ☐ Other( )			
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122			
Test facility condition	Start : Team 20.5℃, Humidity : 41% P.H. /End : Team 20.4℃, Humidity : 43 % P.H.			

Test condition

Medium name	☐ Marine agar ☑ Aerobic Counter Plate ☐ mTEC ☐ mEI ☐ TCBS	☐ Marine agar ☐ Aerobic Counter Plate ☑ mTEC ☐ mEI ☐ TCBS	☐ Marine agar ☐ Aerobic Counter Plate ☐ mTEC ☑ mEI ☐ TCBS	☐ Marine agar ☐ Aerobic Counter Plate ☐ mTEC ☐ mEI ☑ TCBS
Manufacturing date	a) ~~08th. Dec~~ ~ 09th. Dec	a) ~~08th. Dec~~ 09th. Dec	a) ~~08th~~. 09th. Dec	09th. Dec
Test method	☐ Membrane filter ☐ Spread method ☑ 3M™ Petri film	☑ Membrane filter ☐ Spread method ☐ 3M™ Petri film	☑ Membrane filter ☐ Spread method ☐ 3M™ Petri film	☑ Membrane filter ☐ Spread method ☐ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	☐ 25 ℃ ☑ ~~36.5~~ 35 ℃ ( ) ☐ 41 ℃ ☐ 44.5 ℃ ( )	☐ 25 ℃ ☑ ~~36.5~~ 35 ℃ ( ) ☐ 41 ℃ ☑ 44.5 ℃ ( )	☐ 25 ℃ ☑ ~~36.5~~ 35 ℃ ( ) ☑ 41 ℃ ☐ 44.5 ℃ ( )	☐ 25 ℃ ☑ ~~36.5~~ 35 ℃ ( ) ☐ 41 ℃ ☐ 44.5 ℃ ( )
Culture period	☐ 2 hr ( ) ☐ 22 hr ( ) ☑ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )	☑ 2 hr (1) ☑ 22 hr (2) ☐ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )	☐ 2 hr ( ) ☐ 22 hr ( ) ☑ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )	☐ 2 hr ( ) ☐ 22 hr ( ) ☑ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )
Time (Start/End)	01:38 / 02:01	00:41 / 01:38	00:41 / 01:38	00:41 / 01:38
Volume (mL)	1 / 1	10 / 100	10 / 100	10 / 100
Dilution factor	X200 / X1000	- / -	- / -	- / -
Test substance	UW / UW	UW / UW	UW / UW	UW / UW

Remarks: The test of bacteria can have sample holding time. Incubation : 03:43 start.
(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	09th. Dec	Personnel	Seo-Jin. Jung (sign)
Confirming date	Dec. 09	Confirmed by	Eun-Young. Kang (sign)

Dec. 131209 Seo-Jin. Jung

BSMB-QS-06-04(2)

Test Result Sheet with Microbiology

20/13

Study number	HAM-Ship(1)	Test number	SET-13-001
Sample type	☑1. Uptake water □ 2. Discharge control water □ 3. Discharge treated water □ 4. Other( )		
Sampling time	☑Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □Other ( )		
Medium name	□ A-1. Marine agar(Heterotrophic bacteria) ☑A-2. Aerobic Counter Plate(Heterotrophic bacteria) ☑B. mTEC(*E.coli*) ☑C. mEI(Intestinal Enterococci) □ D. TCBS (Vibrio cholera)		

Test Result

Sample Type	Medium name	Test substance	Test method	Sample vol. (mL)	D[a] factor	CFU/Plate R1	R2	R3
a) ~~1-B~~ 1	C	SOIUIN-B	☑M.F.[b] □ S[c] □P.F.[d]	20	-	0	0	0
		SOIUW-B	☑M.F.[b] □ S[c] □P.F.[d]	100	-	0	0	0
		SOIUW-M	☑M.F.[b] □ S[c] □P.F.[d]	20	-	0	0	0
		SOIUW-M	☑M.F.[b] □ S[c] □P.F.[d]	100	-	0	0	0
		SOIUW-E	☑M.F.[b] □ S[c] □P.F.[d]	20	-	0	0	0
		SOIUW-E	☑M.F.[b] □ S[c] □P.F.[d]	100	-	1	1	0
1	B	SOIUW-B	☑M.F.[b] □ S[c] □P.F.[d]	20	-	0	1	0
		SOIUW-B	☑M.F.[b] □ S[c] □P.F.[d]	100	-	2	0	2
		SOIUW-M	☑M.F.[b] □ S[c] □P.F.[d]	20	-	1	0	0
		SOIUW-M	☑M.F.[b] □ S[c] □P.F.[d]	100	-	0	1	0
		SOIUW-E	☑M.F.[b] □ S[c] □P.F.[d]	20	-	0	0	1
		SOIUW-E	☑M.F.[b] □ S[c] □P.F.[d]	100	-	3	3	8
1	A-2	SOIUW-B	□ M.F.[b] □ S[c] ☑P.F.[d]	1	X200	1	2	1
		SOIUW-B	□ M.F.[b] □ S[c] ☑P.F.[d]	1	X1000	0	0	0
		SOIUW-M	□ M.F.[b] □ S[c] ☑P.F.[d]	1	X200	2	2	1
		SOIUW-M	□ M.F.[b] □ S[c] ☑P.F.[d]	1	X1000	0	0	0
		SOIUW-E	□ M.F.[b] □ S[c] ☑P.F.[d]	1	X200	2	2	4
		SOIUW-E	□ M.F.[b] □ S[c] ☑P.F.[d]	1	X1000	0	0	0

Remaks

Working date	10th. Dec	Personnel	Jeo-Jin. Jung (Sign)
Confirming date	Dec. 10	Confirmed by	Eun-Jung. Kang (Sign)

a) dilution, b) membrane filter, c) spreading, d) petri film a) cont. Jeo-Jin, Jung

Busan Techno-Park
Marine Bio-industry Development Center

Test Result Sheet with Microbiology

2013

Study number	HAN-Ship(1)	Test number	SET-13-001
Sample type	☑1. Uptake water □ 2. Discharge control water □ 3. Discharge treated water □ 4. Other( )		
Sampling time	☑Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □Other ( )		
Medium name	□ A-1. Marine agar(Heterotrophic bacteria) ☑ A-2. Aerobic Counter Plate(Heterotrophic bacteria) ☑B. mTEC(*E.coli*) ☑C. mEI(Intestinal Enterococci) □D. TCBS (Vibrio cholera)		

Test Result

Sample Type	Medium name	Test substance	Test method	Sample vol. (mL)	D[a] factor	CFU/Plate R1	R2	R3
1	C	배지 test	☑M.F.[b] □ S[c] □P.F.[d]	-	-	0	0	
		Filter test	☑M.F.[b] □ S[c] □P.F.[d]	-	-	0		
1	B	배지 test	☑M.F.[b] □ S[c] □P.F.[d]	-	-	0		
		Filter test	☑M.F.[b] □ S[c] □P.F.[d]	-	-	0		
1	A-2	호기성 test	□ M.F.[b] □ S[c] □P.F.[d]	1	-	0		
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					

Remaks

Working date	10th. Dec	Personnel	Jeo-Jin. Jung (sign)
Confirming date	Dec. 10	Confirmed by	Eunyoung. Kang (sign)

a) dilution, b) membrane filter, c) spreading, d) petri film 이상. Teo-Jin, Jung

BSMB-QS-06-05(2)

Vibrio cholerae O1, O139

2013

Study Number	HAN-Ship(1)	Test Number	SET-13-001
Sample type	☑ Uptake water □ Discharge control water □ Discharge treated water □ Other( )		
Sampling time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		

1. Procedures

- ☐ Each yellow sucrose fermenting colonies are placed on Non-salt Alkaline Pepton water.
- ☐ Incubate at 36°C ± 1 °C for 6-18 hours.
- ☐ Presumptive positive colonies are performed using slide agglutination assays by O1 and O139 antiserum for serological identification.

2. Results

Test substance	O1	O139	Sum
SOIUW-B	O	O	O
SOIUW-M	O	O	O
SOIUW-E	O	O	O

3. Remarks

Working date	10th. Dec	Study personnel	Jee-Jun, Jung (sign)
Confirming date	Dec. 10	Confirmed by	Eun-Yang, Kang (sign)

Busan Techno-Park
Marine Bio-industry Development Center

Test Result Sheet - Classification (II)

2013

Study number	HAN-Ship (1)	Test number	SET-13-001
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1000L – 250ml	Testing time	Start : 08th Dec 23:10 / End: 09th Dec 01:36

Sample name	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-Soluw-B	10ml	Acartia Pacifica	10	5	8	130 ~ 150
		Oithona Similis	23	28	32	90 ~ 100
		Paracalanus Parvus S.l	20	29	26	130 ~ 150
		Temora turbinata	1	1	1	140 ~ 170
		Cirripedia larvae	3	2	3	90 ~ 100
		Corycaeus affinis	0	1	0	90 ~ 180
		Harpacticoida sp	4	4	3	90 ~ 100
HL-Soluw-M	10ml	Acartia Pacifica	9	9	8	130 ~ 150
		Paracalanus Parvus S.l	39	53	52	130 ~ 150
		Oithona Similis	63	44	57	90 ~ 100
		Temora turbinata	2	2	3	140 ~ 170
		Corycaeus affinis	1	1	0	90 ~ 180
		Cirripedia larvae	2	0	1	90 ~ 100
		Harpacticoida sp	8	4	5	90 ~ 100
		Polychaeta larvae	1	0	1	120 ~ 140
HL-Soluw-E.	10ml	Acartia Pacifica	5	4	2	130 ~ 150
		Paracalanus Parvus S.l	41	51	43	130 ~ 150
		Oithona Similis	34	23	23	90 ~ 100
		Harpacticoida larvae	5	4	2	90 ~ 100
		Temora turbinata	2	1	1	140 ~ 170
		Corycaeus affinis	0	1	1	90 ~ 180
		Cirripedia larvae	1	0	0	90 ~ 100
						~
						~

Remark	20여 회차 (B) 23:10 ~ 23:50 (M) 00:10 ~ 00:38 (E) 01:21 ~ 01:36		
Working date	08th ~ 09th. Dec. 2013	Study personnel	Jhang Seok oh (sign)
Confirming date	09th. Dec. 2013	Confirmed by	Eunyoung Kang (sign)

* R: Replicate

Worksheet-Plankton–003-2(2)

Test Result Sheet - Classification (II)

2013

Study number	HAN-Ship(1)	Test number	SET-13-001
Organism	☑ ≥ 10 to 50 μm □ ≥ 50 μm	Method	□ Direct ☑ Dye (FDA)
Concentration	—	Testing time	Start : 14:13 / End: 00:55

Sample name	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S01UW-B	0.5ml	Amphidinium sp.	0	0	4	15 ~ 25
		Pleurosigma sp	1	0	0	25
		Thalassiosira sp.	9	9	4	20 ~ 45
		~~Stephanopyxis~~ Hemiaulus sinensis sp.	6	4	4	20 ~ 25
		Leptocylindrus sp.	0	3	0	15
		Dictyocha sp.	2	0	1	20 ~ 30
		Cochlodinium sp.	1	4	2	10 ~ 20
		Navicular sp.	6	1	1	10 ~ 15
		Prorocentrum sp.	1	0	0	25
		Katodinium sp.	6	2	0	15 ~ 25
		Ceratium sp.	0	1	0	30
		Ebria sp.	0	0	1	25
HL-S01UW-M	0.5ml	Amphidinium sp.	1	0	0	20
		Chaetoceros sp.	0	0	5	20
		Thalassiosira sp.	10	6	7	20 ~ 45
		~~Stephanopyxis~~ Hemiaulus sinensis sp.	0	3	3	20 ~ 25
		Leptocylindrus sp.	2	0	0	15
		Dictyocha sp.	5	1	1	20 ~ 30
		Cochlodinium sp	4	2	1	10 ~ 20
		Navicular sp.	7	5	5	10 ~ 15
		Katodinium sp.	4	1	1	15 ~ 25
		Gyrodinium sp.	0	1	2	25 ~ 4
		Pinnol sp.	2	0	0	15
		Ebria sp.	1	0	0	2

Remark	HL-S01UW-B : 00:05 (End time) / ~~14:00:50~~ HL-S01UW-M : Start (00:15)
Working date	09th, Dec, 2013
Study personnel	Eun-Young, Kang
Confirming date	
Confirmed by	

* R: Replicate

Test Result Sheet - Classification (II)

2013

Study number	HAN-Strp(1)	Test number	SET-13-001
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	Method	☐ Direct ☑ Dye (FDA)
Concentration	—	Testing time	Start : 01:23 / End: 01:50

Sample name	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-SOIUW-E	0.5ml	Pleurosigma sp.	2	0	0	20 ~ 35
		Thalassiosira sp.	3	6	1	20 ~ 45
		~~Stephanopyxis sp.~~ Hemiaulus sinensis	4	0	0	20 ~ 25
		Dictyocha sp.	2	3	1	20 ~ 30
		Cochlodinium sp.	5	3	0	10 ~ 20
		Navicula sp.	9	6	3	10 ~ 14
		Prorocentrum sp.	1	0	0	25
		Katodinium sp.	2	0	1	15 ~ 25
		Gyrodinium sp.	1	0	0	25
						~
						~
						~
						~
						~
						~
						~
						~
						~
						~
						~
						~
						~
						~
						~
						~
						~
						~

Remark			
Working date	09th. Dec. 2013	Study personnel	Eunyang Kang (sign)
Confirming date		Confirmed by	(sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

4.2 Test 2 report and raw data

Test Report

Project name	EcoGuardian™
Test number	SET-14-001
Port	Kaohsiung (Taiwan)-Ballasting
Title	Efficacy test of EcoGuardian™ Ballast Water Management System (shipboard scale)

BUSAN TECHNO PARK

Statement of Quality Assurance

Data were reviewed by Quality Assurance Unit of BTP to assure that the study was performed in accordance with protocol and standard operating procedures (SOP) of Busan Techno-Park(BTP). The report was an accurate reflection of the raw data generated at the BTP. Inspection of the routine and repeated procedures that constitute the study was carried out as a continuous major phase at or about the time this study was in progress.

Inspection Phase		Date		
		Inspection	Report to Testing manager	Report to Project director
Test plan		May 19, 2014	May 19, 2014	May 19, 2014
Sampling	1st	May 22, 2014	May 22, 2014	May 22, 2014
	2nd	-	-	-
Test substance	1st	May 22, 2014	May 22, 2014	May 22, 2014
	2nd	-	-	-
Test procedures (Bacteria test)	1st	-	-	-
	2nd	-	-	-
Observation and counting (≥50㎛, 10㎛-50㎛)	1st	May 22, 2014	May 22, 2014	May 22, 2014
	2nd	-	-	-
Observation and counting (Bacteria test)	1st	-	-	-
	2nd	-	-	-

Seo, Hyo-Jin (Sign) 12th. Dec. 2014

Seo, Hyo-Jin / Project director Date

Study Personnel and Participants

The test participants recognized the study plan, manual, procedure, guide of Marine Bio-industry Development Center in performing the test.

	Name	Date
Study Personnel	Kim Hui-Jeong (sign)	12th. Dec. 2014
	Sang-Hyun, Kim (sign)	12th. Dec. 2014
	Lee Ji-sun (sign)	12th. Dec. 2014
	Park Na kyung (sign)	12th. Dec. 2014
	(sign)	
	(sign)	
Project director	Seo, Hyo-Jin (sign)	12th. Dec. 2014

Contents

1.Results 1

1.1 Loading record 1

1.2 Water parameters 1

1.3 Influent water : Uptake water 2

1.4 Elimination efficacy 4

2. Validity 6

3. Conclusion 7

4. Appendix 8

1. Results

1.1 Loading record

Vessel name	SSANG YONG CHANGYAHNG
IMO number	9121027

Water ballast tanks			Sample WGT (Mt)	Loading (Date/Location)	Discharge (Date/Location)
Control	No.3 D/B W.B.T	P, S	1370	May 22nd , 2014 Kaoshiung (22°36.20N, 120°17.1E)	-
Treated	No.4 D/B W.B.T No.5 D/B W.B.T	P, S	650	-	-

1.2 Water parameters

Table 1. Water parameters at field

Date	Sample ID	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
Day 0	HL-S02UW-B	7.88 ± 0.00	28.87 ± 0.02	34.30 ± 0.46	5.55 ± 0.35	10.1 ± 0.0	-
	HL-S02UW-M	7.91 ± 0.01	28.97 ± 0.05	33.93 ± 0.15	5.59 ± 0.04	10.1 ± 0.0	-
	HL-S02UW-E	7.92 ± 0.00	28.98 ± 0.12	33.74 ± 0.03	5.52 ± 0.11	10.1 ± 0.1	-

Data were presented as mean±S.D of three repeated measurement.

1.3 Influent water : Uptake water

1) ≥ 50 µm organism

Table 2. Survival number of the organism larger than 50 µm

Sample ID	Phyla/Divisions	Species	individuals/m^3	Minimum Dimension (µm)
HL-S02UW-B	Arthropoda	*Parvocalanus* sp.	5,383 ± 597	180 ~ 210
		Oithona sp.	5,050 ± 879	100 ~ 120
		Acartia sp.	150 ± 50	170 ~ 220
		Paracalanus sp.	167 ± 58	230 ~ 280
		Harpacticoida sp.	200 ± 50	80 ~ 100
		Nauplius	100 ± 50	60 ~ 80
		Calanus sp.	150 ± 132	180 ~ 220
HL-S02UW-M	Arthropoda	*Parvocalanus* sp.	3,417 ± 153	180 ~ 210
		Oithona sp.	5,167 ± 306	100 ~ 120
		Acartia sp.	300 ± 50	170 ~ 220
		Paracalanus sp.	333 ± 161	230 ~ 280
		Corycaeus sp.	100 ± 87	220 ~ 250
		Harpacticoida sp.	183 ± 189	80 ~ 100
		Evadne sp.	100 ± 132	300 ~ 330
		Nauplius	50 ± 50	60 ~ 80
	Annelida	Polychaeta larvae	67 ± 76	180 ~ 220
	Protozoa	*Tintinnopsis* sp.	567 ±161	70 ~ 90
HL-S02UW-E	Arthropoda	*Parvocalanus* sp.	2,867 ± 153	180 ~ 210
		Oithona sp.	4,317 ± 202	100 ~ 120
		Acartia sp.	50 ± 0	170 ~ 220
		Evadne sp.	67 ± 29	300 ~ 330
		Harpacticoida sp.	83 ± 29	80 ~ 100
		Paracalanus sp.	33 ± 58	230 ~ 280
		Nauplius	17 ± 29	60 ~ 80
	Annelida	Polychaeta larvae	67 ± 76	180 ~ 220
	Protozoa	*Tintinnopsis* sp.	383 ± 189	70 ~ 90
Total	11 species 3 phyla/divisions		9,789 ± 1,713	-
Acceptability			Influent condition: Acceptable (≥10^2 ind./ m^3)	-

Data were presented as mean±S.D of three repeated measurement.
Some species were rare, the standard deviation was high.

2) 10 µm - 50 µm organism

Table 3. Survival number of the organism between 10 to 50 µm

Sample ID	Phyla/Divisions	Species	individuals/mL	Minimum Dimension (µm)
HL-S03UW-B	Chrysophyta	*Thalassiosira* sp.	2±2	15 ~ 25
	Pyrrophyta	*Prorocentrum* sp.	4±1	15 ~ 40
		Ceratium sp.	1±1	16 ~ 30
HL-S03UW-M	Chrysophyta	*Thalassiosira* sp.	1±0	15 ~ 25
		Probosica sp.	0±1	20 ~ 35
		Guinardia sp.	1±1	10 ~ 20
		Melosira sp.	1±2	15 ~ 30
	Pyrrophyta	*Prorocentrum* sp.	5±1	15 ~ 40
HL-S03UW-E	Chrysophyta	*Melosira* sp.	1±1	15 ~ 30
		Thalassiosira sp.	1±1	15 ~ 25
		Eucampia sp.	1±1	15 ~ 30
		Skeletonema sp.	3±1	12 ~ 25
	Pyrrophyta	*Prorocentrum* sp.	4±1	15 ~ 40
Total	8 species 2 phyla/divisions		9±1	-
Acceptability			Influent condition: Unacceptable ($\geq 10^2$ ind./mL)	

Data were presented as mean±S.D of three repeated measurement.
Some species were rare, the standard deviation was high.

1.4 Elimination efficacy

1) ≥ 50 µm organism

Table 4. Survival number of the organism larger than 50 µm

Test substance	Sample ID	individuals/m^3	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S02UW-B [a)]	11,200 ± 589	Influent condition: Acceptable (≥10^2 ind./m^3)	-
	HL-S02UW-M [b)]	10,283 ± 671		
	HL-S02UW-E [c)]	7,883 ± 493		

2) 10 µm - 50 µm organism

Table 5. Survival number of the organism between 10 and 50 µm

Test substance	Sample ID	individuals/mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S02UW-B [a)]	7 ± 3	Influent condition: Unacceptable (≥10^2 ind./m^3)	-
	HL-S02UW-M [b)]	9 ± 2		
	HL-S02UW-E [c)]	9 ± 1		

a) B: Beginning, b) M: Middle c) E: End, d) Calculation = (Uw-T6)/Uw*100
Data were presented as mean±S.D of three repeated measurement.

3) Heterotrophic bacteria

Table 6. Survival number of heterotrophic bacteria

Test substance	Sample ID	CFU / mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S02UW-B [a)]	267 ± 58	-	-
	HL-S02UW-M [b)]	250 ± 87		
	HL-S02UW-E [c)]	200 ± 0		

4) *Escherichia coli*

Table 7. Survival number of *Escherichia coli*

Test substance	Sample ID	CFU / 100 mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S02UW-B [a)]	116 ± 17	-	-
	HL-S02UW-M [b)]	136 ± 18		
	HL-S02UW-E [c)]	67 ± 10		

5) Intestinal Enterococci

Table 8. Survival number of intestinal enterococci

Test substance	Sample ID	CFU / 100 mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S02UW-B [a)]	23 ± 4	-	-
	HL-S02UW-M [b)]	1 ± 1		
	HL-S02UW-E [c)]	3 ± 1		

6) *Vibrio cholera* O1, O139

Table 9. Survival number of *Vibrio cholera* O1, O139

Test substance	Sample ID	CFU / 100 mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S02UW-B [a)]	N.D	-	-
	HL-S02UW-M [b)]	N.D		
	HL-S02UW-E [c)]	N.D		

a) B: Beginning, b) M: Middle c) E: End d) N.D: Not detected
Data were presented as mean±S.D of three repeated measurement.

2. Validity

2.1 Water parameters measurement

- All measurements were tested more than three times.
- Water parameters were analyzed as soon as possible after sampling.

2.2 Biological efficacy test

- Valid tests are indicated by uptake water, for both the control tank and ballast water to be treated, with viable organism concentration exceeding 10 times the maximum permitted values in Regulation D-2.1
  - Influent condition in all tests was unacceptable for IMO standards (MEPC58/2/4).
  - The organism larger than 50 μm: ≥ 10^2 individuals/m^3 (Acceptable)
  - The organism between 10 μm and 50 μm: ≥ 10^2 individuals/mL (Unacceptable)

Sample ID	≥ 50 μm (individuals/m^3)	10 μm - 50 μm (individuals/mL)
HL-S02UW-B	11,200 ± 589	7 ± 3
HL-S02UW-M	10,283 ± 671	9 ± 2
HL-S02UW-E	7,883 ± 493	9 ± 1

※Regulation D-2 stipulates that ships meeting the requirements of the Convention by meeting the ballast water performance standard must discharge:

1. less than 10 viable organisms per cubic metre greater than or equal to 50 micrometres in minimum dimension;
2. less than 10 viable organisms per milliliter less than 50 micrometres in minimum dimension and greater than or equal to 10 micrometres in minimum dimension

- The samples should be analyzed as soon as possible after sampling.

Date	Sample ID	Sampling time	Test ending time
Day 0	HL-S02UW-B, M, E	May, 22 14:00	May, 22 18:00

3. Conclusion

3.1 Unacceptable of Influent water and discharge control water condition for IMO standards.

- Uptake water condition of organism between 10 μm and 50 μm was unacceptable for IMO standards.
- Therefore, test was invalid.

4. Appendix

Appendix 1. Water parameters at field

1) Uptake water

Date	Sample ID	R [a)]	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)
Day 0	HL-S02UW-B	R1	7.88	28.85	34.80	5.28	10.1
		R2	7.88	28.89	34.20	5.43	10.1
		R3	7.88	28.86	33.89	5.95	10.1
	HL-S02UW-M	R1	7.91	29.00	33.76	5.63	10.1
		R2	7.91	29.00	34.01	5.56	10.1
		R3	7.92	28.92	34.02	5.57	10.1
	HL-S02UW-E	R1	7.92	29.12	33.71	5.59	10.2
		R2	7.92	28.92	33.76	5.58	10.1
		R3	7.92	28.90	33.76	5.39	10.1

a) R: Replicate

Appendix 2. Survival number of ≥ 50㎛ organism in uptake water(Influent water)

Date	Sample ID	Classification	Counting volume	individuals/m^3			Mean	SD [b)]
				R1[a)]	R2	R3		
Day 0	HL-S02UW-B	*Parvocalanus* sp.	5 mL	121	98	104	5,383	597
		Oithona sp.		88	121	94	5,050	879
		Acartia sp.		2	3	4	150	50
		Paracalanus sp.		4	4	2	167	58
		Harpacticoida sp.		5	4	3	200	50
		Nauplius		1	2	3	100	50
		Calanus sp.		0	5	4	150	132
	HL-S02UW-M	*Parvocalanus* sp.	5 mL	71	69	65	3,417	153
		Oithona sp.		98	102	110	5,167	306
		Acartia sp.		7	6	5	300	50
		Paracalanus sp.		8	9	3	333	161
		Corycaeus sp.		4	1	1	100	87
		Harpacticoida sp.		8	2	1	183	189
		Evadne sp.		5	1	0	100	132
		Nauplius		2	0	1	50	50
		Polychaeta larvae		3	0	1	67	76
		Tintinnopsis sp.		15	10	9	567	161
	HL-S02UW-E	*Parvocalanus* sp.	5 mL	60	54	58	2,867	153
		Oithona sp.		87	90	82	4,317	202
		Acartia sp.		1	1	1	50	0
		Evadne sp.		2	1	1	67	29
		Harpacticoida sp.		2	2	1	83	29
		Paracalanus sp.		2	0	0	33	58
		Nauplius		0	0	1	17	29
		Polychaeta larvae		3	0	1	67	76
		Tintinnopsis sp.		12	5	6	383	189

a) R: Replicate
b) S.D: Standard deviation
Some species were rare, the standard deviation was high.

Appendix 3. Survival number of 10㎛ - 50㎛ organism in uptake water(Influent water)

Sample ID	Classification	Counting volume	R1[a)]	R2	R3	individuals/mL	
						Mean	S.D. [b)]
HL -S02UW-B	*Prorocentrum* sp.	1 mL	5	4	4	4	1
	Thalassiosira sp.		3	2	0	2	2
	Ceratium sp.		2	1	0	1	1
HL - S02UW-M	*Thalassiosira* sp.	1 mL	1	1	1	1	0
	Prorocentrum sp.		5	5	6	5	1
	Probosica sp.		1	0	0	0	1
	Guinardia sp.		1	1	2	1	1
	Melosira sp.		3	1	0	1	2
HL - S02UW-E	*Melosira* sp.	1 mL	1	0	2	1	1
	Prorocentrum sp.		4	5	4	4	1
	Thalassiosira sp.		1	1	0	1	1
	Eucampia sp.		2	0	0	1	1
	Skeletonema sp.		2	3	3	3	1

a) R: Replicate, b) S.D: Standard deviation
Some species were rare, the standard deviation was high.

Appendix 4. The number of heterotrophic bacteria in uptake water by treatment of EcoGuardian™ BWMS

Date	Sample ID	Dilution factor	CFU /mL			Mean	SD [b)]
			R1[a)]	R2	R3		
Day 0	HL-S02UW-B	x 50	6	6	4	267	58
	HL-S02UW-M		6	6	3	250	87
	HL-S02UW-E		4	4	4	200	0

Appendix 5. The number of *Escherichia coli* in uptake water by treatment of EcoGuardian™ BWMS

Date	Sample ID	CFU /100 mL			Mean	SD [b)]
		R1[a)]	R2	R3		
Day 0	HL-S02UW-B	32	31	24	116	17
	HL-S02UW-M	35	38	29	136	18
	HL-S02UW-E	17	19	14	67	10

Appendix 6. The number of intestinal enterococci in uptake water by treatment of EcoGuardian™ BWMS

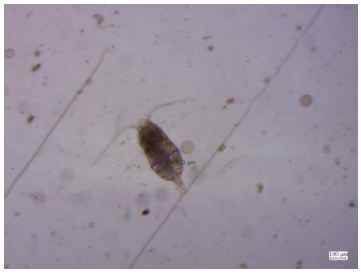
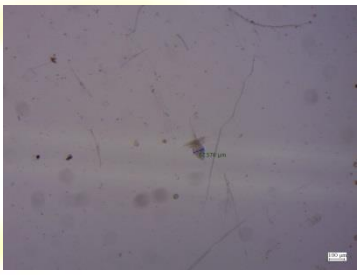
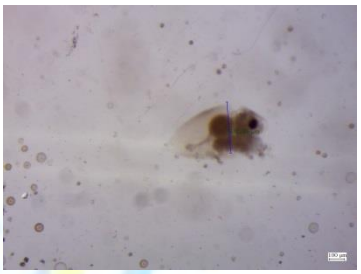
Date	Sample ID	CFU /100 mL			Mean	SD [b)]
		R1[a)]	R2	R3		
Day 0	HL-S02UW-B	22	27	20	23	4
	HL-S02UW-M	2	1	N.D [c)]	1	1
	HL-S02UW-E	4	3	2	3	1

Appendix 7. The number of *Vibrio cholera* O1, O139 in uptake water by treatment of EcoGuardian™ BWMS

Date	Sample ID	CFU /100 mL			Mean	SD [b)]
		R1[a)]	R2	R3		
Day 0	HL-S02UW-B	N.D	N.D	N.D	N.D	-
	HL-S02UW-M	N.D	N.D	N.D	N.D	-
	HL-S02UW-E	N.D	N.D	N.D	N.D	-

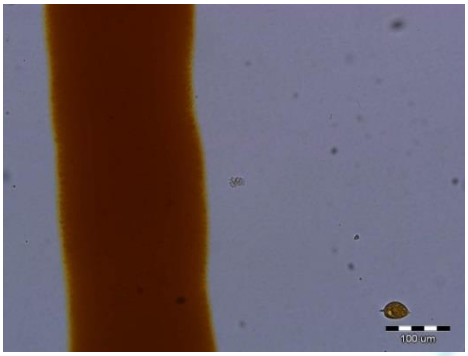
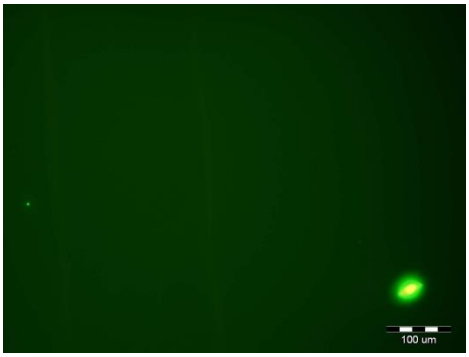
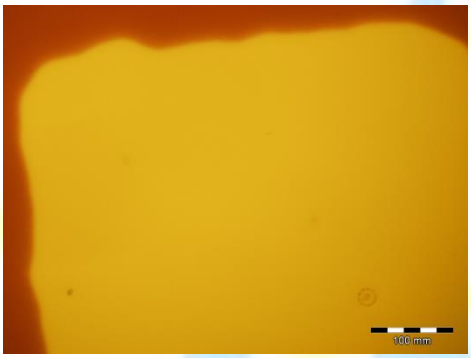
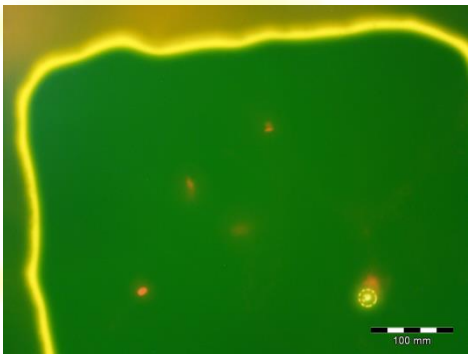
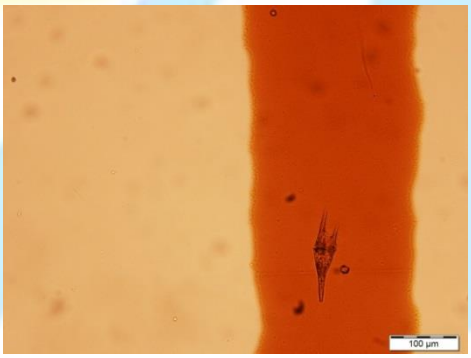
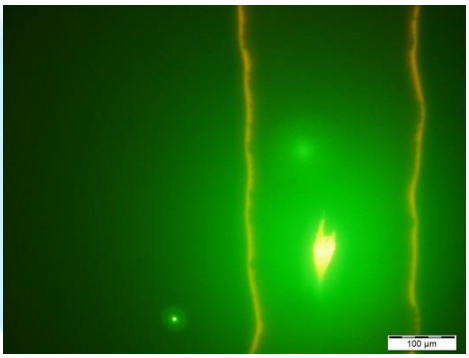
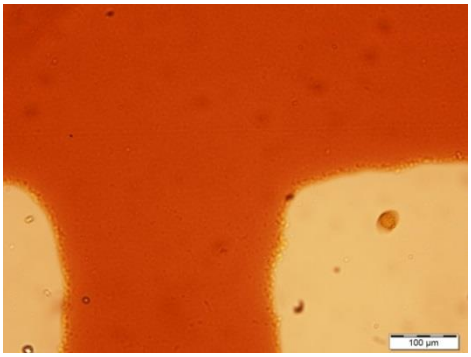
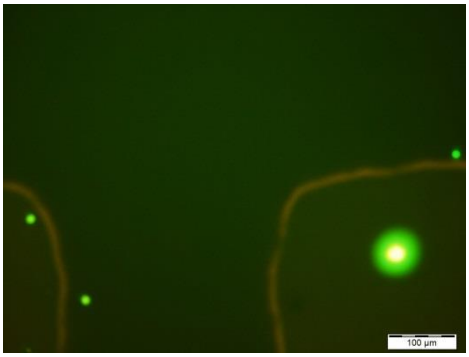
a) R: Replicate
b) S.D: Standard deviation
c) N.D: Not detected

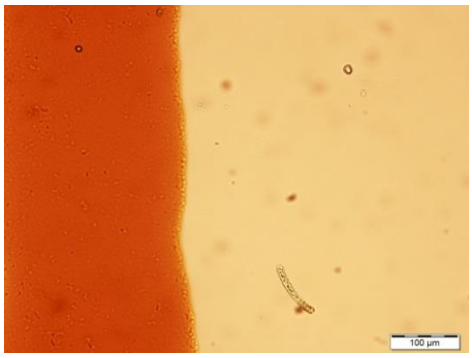
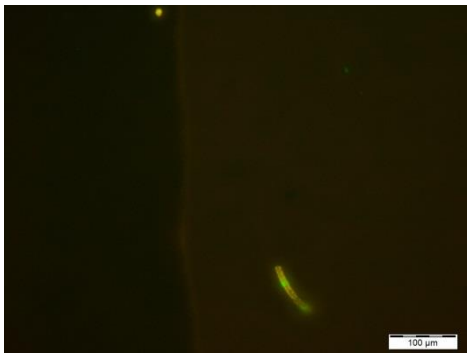
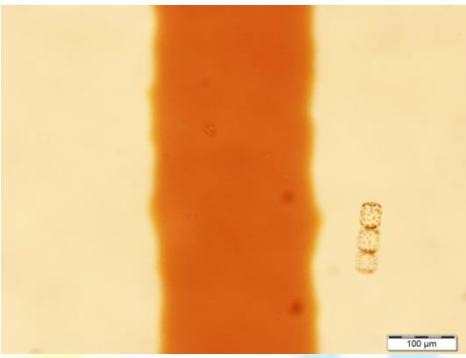
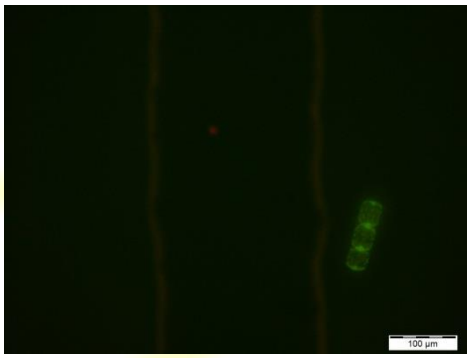
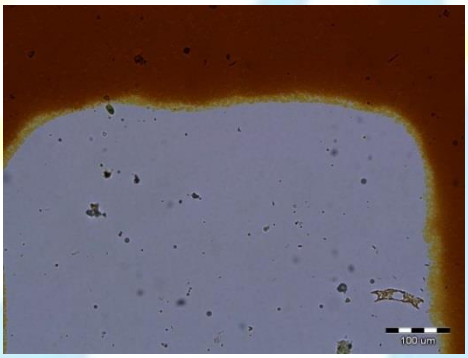
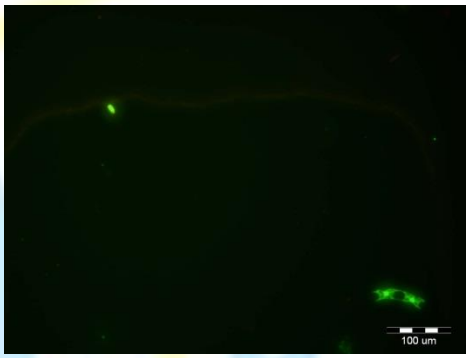
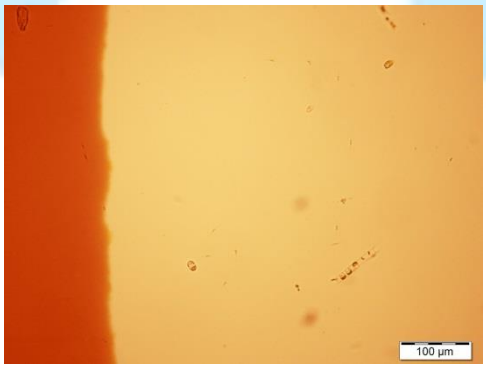
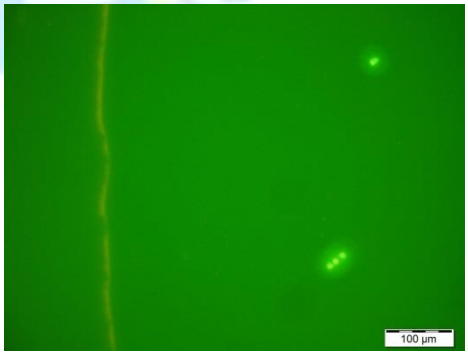
Appendix 8. The microscope image of ≥ 50㎛ in uptake water (Day0)

Uptake water (Day 0)		
Parvocalanus sp.*	*Oithona* sp.*	*Acartia* sp.*
		
Paracalanus sp.*	Harpacticoida sp.*	Nauplius**
		
Calanus sp.*	*Corycaeus* sp.*	*Evadne* sp.*
		
Polychaeta larvae*	*Tintinnopsis* sp.*	
		-

* Magnification : 40

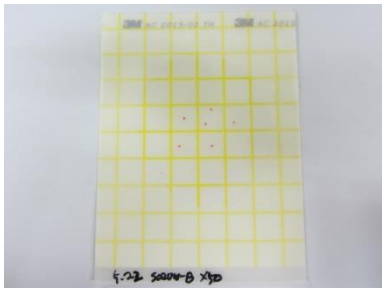
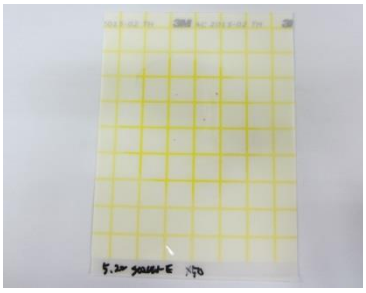
Appendix 9. The microscope image of 10㎛−50㎛ in uptake water (Day0)

Specific Name	Original water	
	Optical	Fluorescence
Prorocentrum sp.		
Thalassiosira sp.		
Ceratium sp.		
Probosica sp.		

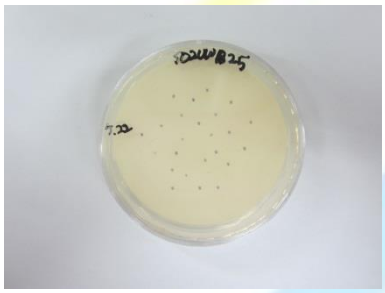
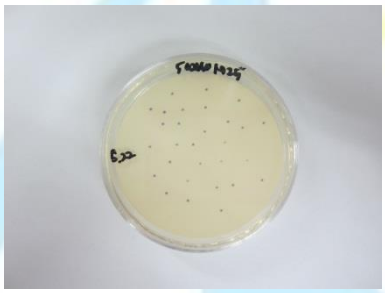
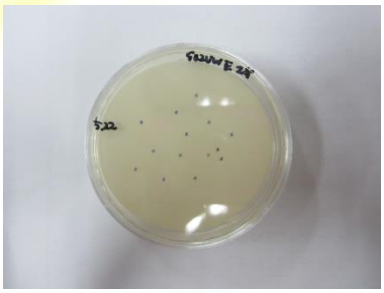
Guinardia sp.		
Melosira sp.		
Eucampia sp.		
Skeletonema sp.		

Magnification : 200

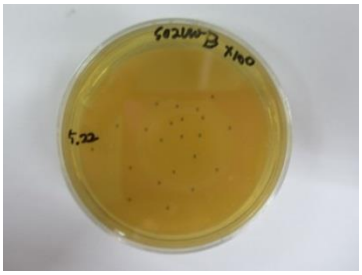
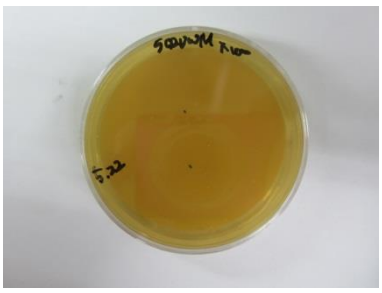
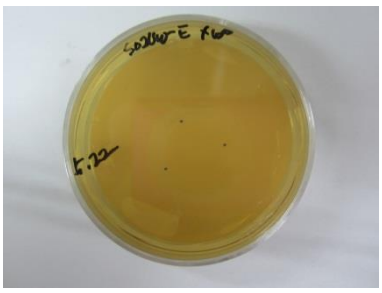
Appendix 10. The image of heterotrophic bacteria

Uptake water (Day 0)		
Beginning	**Middle**	**End**
		

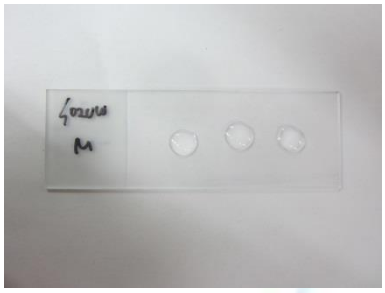
Appendix 11. The image of *Escherichia coli*

Uptake water (Day 0)		
Beginning	**Middle**	**End**
		

Appendix 12. The image of intestinal enterococci

Uptake water (Day 0)		
Beginning	**Middle**	**End**
		

Appendix 13. The image of *Vibrio cholera* O1, O139

Uptake water (Day 0)		
Beginning	**Middle**	**End**
		

5. Attachment

5.1 Sample check & custody Sheet

5.2 Water parameter measurement sheet (I)

5.3 Microbiology test sheet

5.4 Test results sheet with microbiology

5.5 Vibrio cholera O1, O139

5.6 Test results sheet – Classification(II)

Sampling check & custody Sheet

20___

Study number		Test number	SET-14-001
Sampling time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Day ( )		

Sample location	☑ Uptake water □ Discharge control water □ Discharge treated water □ Other( )						
Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
TSS		HDPE	2	□ 1	13:53	14:56	16:03
DOC, POC		HDPE	2	□ 2			
Bacteria (4 item)[b]		HDPE	2				
Organism (10~50 μm)		HDPE	1	□ 3			
Organism (≥50 μm)	1000 → 0.25	HDPE	0.25				

Sample location	□ Treated water □ Treated water (Neutralized)						
Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
Bacteria (4 item)[c]		HDPE		□ 1			
Organism (10~50 μm)		HDPE		□ 2			
Organism (≥50 μm)		HDPE		□ 3			

Concentration			
Parameter	Vol. of concentrated before	Equipment	Mesh size
Organism (≥50 μm)	(L)	net	32 μm
Organism (10-50 μm)	(L)	net	5 μm

Sample storage information		
Parameter	Location & condition	Storage time
TSS	Freezer(-20℃)	
DOC, POC		
Bacteria (4 item)	Refrigerator(4℃)	

Remarks

* First, fill a 1~20L HDPE(high density poly ethylene) bottle with water sample, and split the water sample up into groups (bacteria, organism (10~50 μm), and so forth) Then measured water parameters(5 item) - pH, Temperature, Salinity, DO, Turbidity
* Separately, organism(≥50 μm, 10 ~ 50 μm) sample was concentrated with net.
* Storage time of "bacteria sample" is for "heterotrophic bacteria test"
* TSS and DOC and POC samples are acidified(pH<2) with HCl (in 6 mL HCl of 2 L sample)

Working(pump) start time for Test water(or control water) sample :
Working(pump and EcoGuardian™) start time for treated(or neutralized) sample :

Working date	2014.05.22	Personnel	Lee JT-Sun (sign)
Confirmation date	2014.05.22	Confirmed by	Lee JT-Sun (sign)

a) Concentration b) Period
c) Bacteria (4 item) - Heterotrophic bacteria, Coliform, Vibrio cholera, Enterococcus group

Water parameter measurement sheet (I)

20 14

Study Number	HAN-Ship (1)	Test number	SET-14 - 001
Sampling time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Day ( )		
Equipment	YSI 6920 - pH, temp., salinity, DO / YSI 6920 - Turbidity		

Sample	Replicate	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)
☑ Test water □ Control water □ Treated water □ Neutralized water	R1	7.88	28.85	~~40.0~~ 34.8	5.28	12.1
	R2	7.88	28.89	~~40~~. 34.2	5.43	12.1
	R3	7.88	28.86	33.81	5.45	12.1
☑ B( ) □ M( ) □ E( )	Measuring time	13:56				
☑ Test water □ Control water □ Treated water □ Neutralized water	R1	7.91	29.00	33.76	5.53	12.1
	R2	7.91	29:00	34.01	5.56	12.1
	R3	7.92	28.92	34.02	5.57	12.1
□ B( ) ☑ M( ) □ E( )	Measuring time	15:01				
☑ Test water □ Control water □ Treated water □ Neutralized water	R1	7.92	29.12	33.71	5.59	10.2
	R2	7.92	28.92	33.76	5.58	10.1
	R3	7.92	28.90	33.76	5.79	10.1
□ B( ) □ M( ) ☑ E( )	Measuring time	16:07				
□ Test water □ Control water □ Treated water □ Neutralized water	R1					
	R2					
	R3					
□ B( ) □ M( ) □ E( )	Measuring time					
□ Test water □ Control water □ Treated water □ Neutralized water	R1					
	R2					
	R3					
□ B( ) □ M( ) □ E( )	Measuring time					
□ Test water □ Control water □ Treated water □ Neutralized water	R1					
	R2					
	R3					
□ B( ) □ M( ) □ E( )	Measuring time					
Remarks						

Working Date	May. 22	Study Personnel	Lee Ji-Sun (sign)
Confirming Date	May 22th	Confirmed by	Lee Ji-Sun (sign)

Microbiology Test Sheet

2014

Study number	HAN-Ship(1)	**Test number**	SET-14-001
Sampling Time	☑ Day 0 ☐ Day 1 ☐ Day 2 ☐ Day 3 ☐ Day 4 ☐ Day 5 ☐ Other( )		
Test substance	☑ Uptake water ☐ Discharge control water ☐ Discharge treated water ☐ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team.29 ℃, Humidity : 41 % P.H. /End : Team.29 ℃, Humidity 41 % P.H.		

Test condition

Medium name	☐ Marine agar ☑ Aerobic Counter Plate ☐ mTEC ☐ mEI ☐ TCBS	☐ Marine agar ☐ Aerobic Counter Plate ☑ mTEC ☐ mEI ☐ TCBS	☐ Marine agar ☐ Aerobic Counter Plate ☐ mTEC ☑ mEI ☐ TCBS	☐ Marine agar ☐ Aerobic Counter Plate ☐ mTEC ☐ mEI ☑ TCBS
Manufacturing date	May. 22	May 22	May. 22	May. 27
Test method	☐ Membrane filter ☐ Spread method ☑ 3M™ Petri film	☑ Membrane filter ☐ Spread method ☐ 3M™ Petri film	☑ Membrane filter ☐ Spread method ☐ 3M™ Petri film	☑ Membrane filter ☐ Spread method ☐ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	☐ 25 ℃ ☑ 35.0 ℃ ( ) ☐ 41 ℃ ☐ 44.5 ℃ ( )	☐ 25 ℃ ☐ 35.0 ℃ ( ) ☐ 41 ℃ ☑ 44.5 ℃ ( )	☐ 25 ℃ ☐ 35.0 ℃ ( ) ☑ 41 ℃ ☐ 44.5 ℃ ( )	☐ 25 ℃ ☑ 35.0 ℃ ( ) ☐ 41 ℃ ☐ 44.5 ℃ ( )
Culture period	☐ 2 hr ( ) ☐ 22 hr ( ) ☑ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )	☑ 2 hr (1) ☑ 22 hr (2) ☐ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )	☐ 2 hr ( ) ☐ 22 hr ( ) ☑ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )	☐ 2 hr ( ) ☐ 22 hr ( ) ☑ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )
Time (Start/End)	B 14:20 / 14:25 M 15:11 / 15:20 E 16:22 / 16:25	B 14:20 / 14:45 M 15:20 / 15:35 E 16:25 / 16:38	B 14:20 / 14:45 M 15:20 / 15:35 E 16:25 / 16:38	B 14:20 / 14:45 M 15:20 / 15:35 E 16:25 / 16:38
Volume (mL)	1 1	25 100	25 100	25 100
Dilution factor	X50 X200	· ·	· ·	· ·
Test substance				

Remarks: The test of bacteria can have sample holding time.

(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	May. 22	**Personnel**	Lee JT Sun (sign)
Confirming date	May. 22	**Confirmed by**	Lee JT Sun (sign)

BSMB-QS-06-04(2)

Test Result Sheet with Microbiology

2014

Study number	HAN-SHIP (2)	Test number	SET-14-001
Sample type	☑1. Uptake water □ 2. Discharge control water □ 3. Discharge treated water □ 4. Other( )		
Sampling time	☑Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □Other ( )		
Medium name	□ A-1. Marine agar(Heterotrophic bacteria) ☑ A-2. Aerobic Counter Plate(Heterotrophic bacteria) ☑ B. mTEC(*E.coli*) ☑ C. mEI(Intestinal Enterococci) □ D. TCBS (Vibrio cholera)		

Test Result

Sample Type	Medium name	Test substance	Test method	Sample vol. (mL)	D[a] factor	CFU/Plate R1	R2	R3
1	A-2	SOLW-B	□ M.F.[b] □ S[c] ☑P.F.[d]	1	50	6	6	4
		SOLW-B	□ M.F.[b] □ S[c] ☑P.F.[d]	1	100	0	1	2
		SOLW-M	□ M.F.[b] □ S[c] ☑P.F.[d]	1	50	6	6	3
		SOLW-M	□ M.F.[b] □ S[c] ☑P.F.[d]	1	100	0	1	1
		SOLW-E	□ M.F.[b] □ S[c] ☑P.F.[d]	1	50	4	4	4
		SOLW-E	□ M.F.[b] □ S[c] ☑P.F.[d]	1	100	0	0	0
1	B	SOLW-B	☑M.F.[b] □ S[c] □P.F.[d]	25		32	31	24
		SOLW-B	☑M.F.[b] □ S[c] □P.F.[d]	100		89	94	102
		SOLW-M	☑M.F.[b] □ S[c] □P.F.[d]	25		35	38	29
		SOLW-M	☑M.F.[b] □ S[c] □P.F.[d]	100		56	56	51
		SOLW-E	☑M.F.[b] □ S[c] □P.F.[d]	25		17	19	14
		SOLW-E	☑M.F.[b] □ S[c] □P.F.[d]	100		51	50	56
1	C	SOLW-B	☑M.F.[b] □ S[c] □P.F.[d]	25		7	7	10
		SOLW-B	☑M.F.[b] □ S[c] □P.F.[d]	100		22	27	20
		SOLW-M	☑M.F.[b] □ S[c] □P.F.[d]	25		1	3	0
		SOLW-M	☑M.F.[b] □ S[c] □P.F.[d]	100		2	1	0
		SOLW-E	☑M.F.[b] □ S[c] □P.F.[d]	25		0	1	1
		SOLW-E	☑M.F.[b] □ S[c] □P.F.[d]	100		4	3	2

Remaks

Working date	May. 23th	Personnel	Lee JT SUN (sign)
Confirming date	May. 23th	Confirmed by	Lee JT SUN (sign)

a) dilution, b) membrane filter, c) spreading, d) petri film

BSMB-QS-06-05(2)

Vibrio cholerae O1, O139

2014

Study Number	HA -SHIP.(2)	Test Number	SET-14-001
Sample type	☑ Uptake water □ Discharge control water □ Discharge treated water □ Other( )		
Sampling time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		

1. Procedures

- ☑ Each yellow sucrose fermenting colonies are placed on Non-salt Alkaline Pepton water.
- ☑ Incubate at 36°C ± 1 °C for 6-18 hours.
- ☑ Presumptive positive colonies are performed using slide agglutination assays by O1 and O139 antiserum for serological identification.

2. Results

Test substance	O1	O139	Sum
Solvw - B	-	-	-
Solvw - M	-	-	-
Solvw - E	-	-	-

3. Remarks

Working date	May 23th	Study personnel	Lee JI-Sun (sign)
Confirming date	May 23th	Confirmed by	Lee JI Sun (sign)

Worksheet-Microbiology-003-2(2)

Test Result Sheet - Classification (II)

20 14

Study number	–	**Test number**	SET-14-001
Test substance	–	**Lot. No.**	–
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	**Method**	☑ Direct □ Dye ( )
Concentration	1ton → 250 mL	**Receive time of test substance**	–
Test start time	14:00	**Test end time**	14:45

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S02VW-B	10mL	Parvocalanus sp.	220	–	–	
		Orthona spp.	340	–	–	
		Acartia sp.	9	–	–	
		paracalanus sp.	10	–	–	
		nauplius	1	–	–	
	5mL	Parvocalanus sp.	121	98	104	
		Orthona spp.	88	121	94	
		Acartia sp.	2	3	4	
		Paracalanus sp.	4	4	2	
		Harpacticoida sp.	5	4	3	
		nauplius	1	2	3	
		Calanus sp.	–	5	4	

Remark			
Date	May 22th	**Study personnel**	Kim Hui-Jeong (sign)
Certificate date	May 22th	**Study director**	Kim Hui-Jeong (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Test Result Sheet - Classification (II)

20/4

Study number	–	Test number	SET-14-001
Test substance	–	Lot. No.	–
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 250mL	Receive time of test substance	–
Test start time	15:15	Test end time	15:30

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S020W-M	5mL	Parvocalanus sp.	71	69	65	
		Oithona spp.	98	102	110	
		Acartia sp.	1	6	5	
		Paracalanus parvus s.l.	8	9	a) ~~4~~ 3	
		Corycaeus sp.	4	1	1	
		Harpacticoida sp.	8	2	1	
		Euadne sp.	5	1	–	
		nauplius	2	–	1	
		Tintinnina spp.	15	a) ~~18~~ 10	9	
		Polychaetalarvae	3	–	1	

Remark	a) 오기재수정 14.5.22 김희정 김희정		
Date	May 22th	Study personnel	Kim Hui-Jeong (Sign)
Certificate date	May 22th	Study director	Kim Hui-Jeong

* R: Replicate

Worksheet-Plankton–003(1)

Test Result Sheet - Classification (II)

2d4

Study number	–	**Test number**	SET-14-001
Test substance	–	**Lot. No.**	–
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	**Method**	☑ Direct □ Dye ( )
Concentration	1ton → 250mL	**Receive time of test substance**	–
Test start time	16:18	**Test end time**	16:38

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S02W-E	5mL	Parvocalanus sp.	60	54	58	
		Oithona spp.	80	90	82	
		Acartia sp.	1	1	1	
		Euadne sp.	2	1	1	
		Harpacticoida sp.	2	2	1	
		Tintinina spp.	12	5	6	
		Polychaeta larvae	3	–	1	
		paracalanus sp.	2	–	–	
		nauplius	–	–	a) ~~2~~ 1	

Remark	a) 오기재 May 22th Km Hui Jeong
Date	May 22th
Study personnel	Km Hui-Jeong (sign)
Certificate date	May 22th
Study director	Km Hui-Jeong (sign)

* R: Replicate

Worksheet-Plankton–003(1)

Test Result Sheet - Classification (II)

2014

Study number	HAN-ship (2)	Test number	SET-14-001
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 250mL	Testing time	Start : 14:00 / End: 16:38

Sample name	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-502UW-B	70mL	B	580			~
	5mL	B (14:00~14:45)	221	237	214	~
HL-502UW-M	5mL	M (15:15~15:30)	221	200	196	~
HL-502UW-E	5mL	E (16:18~16:38)	169	153	151	~
						~
						~
						~
						~
						~
						~
						~
						~
						~
						~
						~
						~
						~
						~
						~
						~

Remark	26.1℃ 39 RH%		
Working date	May. 22th	Study personnel	Kim Hui-Jeong (sign)
Confirming date	May. 22th	Confirmed by	Kim Hui-Joong (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Worksheet-Plankton–003-2(2)

Test Result Sheet - Classification (II)

2014

Study number	HAN - Ship (2)	Test number	SET-14-001
Organism	☑ ≥ 10 to 50 µm ☐ ≥ 50 µm	Method	☐ Direct ☑ Dye (FDA)
Concentration	—	Testing time	Start : 14:07 / End: 15:50

Sample name	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (µm)
HL-S02UW-B-1	1ml	Corethron sp.				~
#		Thalassiosira sp.				~
		Licmophora sp.				~
		Gymnodinium sp.				~
		total	4	5	4	~
HL-S02UW-B-2		Probosica sp.				~
		Prorocentrum sp.				~
		Navicula sp.				~
		Ceratium sp.				~
		Thalassiosira sp.				~
		Gymnodinium sp.				~
		total	6	4	5	~
HL-S02UW-B-3		Prorocentrum sp.				
		Thalassiosira sp.				
		Licmophora sp.				~
		Ceratium sp.				
		total	10	7	4	
HL-S02UW-M-1		Thalassiosira sp.				~
		Prorocentrum sp.				~
		Probosica sp.				~
		Guinardia sp.				~
		Melosira sp.				~
		total	11	8	9	~
						~

Remark	
Working date	May 22th
Study personnel	Park Na Kyung (sign)
Confirming date	May 22th
Confirmed by	Kim Hui Jeong (sign)

* R: Replicate

Worksheet-Plankton–003-2(2)

Busan Techno-Park
Marine Bio-industry Development Center

Test Result Sheet - Classification (II)

2014

Study number	HAN - ship(2)	Test number	SET-14-001
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	Method	☐ Direct ☑ Dye (FDA)
Concentration	—	Testing time	Start : 15:50 / End: 16:44

Sample name	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S020W-M-2	1 ml	Protoperidinium sp.				~
		Gymnodinium sp.				~
		Ceratium sp.				~
		Navicula sp.				~
		Thalassiosira sp.				~
		Melosira sp.				~
		total	16	10	18	~
HL-S0VW-M3		Gyrodinium sp.				~
		Prorocentrum sp.				~
		Navicula sp.				~
		Licmophora sp.				~
		Eucampia sp.				~
		chaetoceros sp.				
		Skeletonema sp.				
		Guinardia sp.				~
			22	14	16	
HL-S0VW-E-1		Melosira sp.				
		Prorocentrum sp.				~
		Thalassiosira sp.				~
		Eucampia sp.				~
		skeletonema sp.	10	9	9	~
HL-S0VW-E2		prorocetrum sp.				~
		protoperidinium sp.				~
		chaetoceros sp.				~

Remark			
Working date	May 22th	Study personnel	Park Na Kyung (sign)
Confirming date	May 22th	Confirmed by	KIM HUI-JEO ING (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Worksheet-Plankton–003-2(2)

Test Result Sheet - Classification (II)

20 14

Study number	HAN - ship(2)	Test number	SET-14-001
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	Method	☐ Direct ☑ Dye (FDA)
Concentration	—	Testing time	Start: 16:44 / End: 17:35

Sample name	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-SOZUWE-2	1ml	Licmophora sp.				~
		Skeletonema sp.				~
		Navicula sp.				~
		Gymnodinium sp.				~
		total.	16	20	22	~
HL-SOZUWE-3	1ml	Navicula sp.				~
		Prorocentrum sp.				~
		Melosira sp.				~
		Chaetoceros sp.				~
		Thalassiosira sp.				~
		protoperidinium sp.				~
		Pinnulania sp.				~
		total	13	7	20	
						~
						~
						~
						~
						~
						~
						~
						~

Remark			
Working date	May 22th	Study personnel	Park Na Kyung (sign)
Confirming date	May 22th	Confirmed by	Kim Hui Jeong (sign)

* R: Replicate

Test Result Sheet - Classification (II)

2014

Study number	HAN-Ship (2)	Test number	SET-14-001
Test substance	Uptake water	Lot. No.	
Organism	□ ≥ 10 to 50 μm □ ≥ 50 μm	Method	□ Direct ☒ Dye (FDA)
Concentration	—	Receive time of test substance	
Test start time	14:00	Test end time	

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S02UW-B	1mL	Prorocentrum sp.	5	4	4	
		Thalassiosira sp.	3	2	0	
		Ceratium sp.	2	1	0	
HL-S02UW-M	1mL	Thalassiosira sp.	1	1	1	
		Prorocentrum sp.	5	5	6	
		Probosica sp.	1	0	0	
		Guinardia sp.	1	1	2	
		Melosira sp.	3	1	0	
HL-S02UW-E	1mL	Melosira sp.	1	0	2	
		Prorocentrum sp.	4	5	4	
		Thalassiosira sp.	1	1	0	
		Eucampia sp.	2	0	0	
		Skeletonema sp.	2	3	3	

Remark			
Date	May 22th	Study personnel	Park Na kyung (sign)
Certificate date	May 22th	Study director	Kim Hui-Jeong (sign)

* R: Replicate

4.3 Test 3 report and raw data

Test Report

Project name	EcoGuardian™
Test number	SET-14-002
Port	Gamcheon(Korea)-Ballasting / Donghae(Korea)-Deballasting
Title	Efficacy test of EcoGuardian™ Ballast Water Management System (shipboard scale)

BUSAN TECHNO PARK

Statement of Quality Assurance

Data were reviewed by Quality Assurance Unit of BTP to assure that the study was performed in accordance with protocol and standard operating procedures (SOP) of Busan Techno-Park (BTP). The report was an accurate reflection of the raw data generated at the BTP. Inspection of the routine and repeated procedures that constitute the study was carried out as a continuous major phase at or about the time this study was in progress.

Inspection Phase		Date		
		Inspection	Report to Testing manager	Report to Project director
Test plan		21st May, 2014	21st May, 2014	21st May, 2014
Sampling	1st	26th May, 2014	26th May, 2014	26th May, 2014
	2nd	30th May, 2014	30th May, 2014	30th May, 2014
Test substance	1st	26th May, 2014	26th May, 2014	26th May, 2014
	2nd	30th May, 2014	30th May, 2014	30th May, 2014
Test procedures (Bacteria test)	1st	26th May, 2014	26th May, 2014	26th May, 2014
	2nd	30th May, 2014	30th May, 2014	30th May, 2014
Observation and counting (≥50㎛, 10㎛-50㎛)	1st	26th May, 2014	26th May, 2014	26th May, 2014
	2nd	30th May, 2014	30th May, 2014	30th May, 2014
Observation and counting (Bacteria test)	1st	27th~29th May, 2014	27th~29th May, 2014	27th~29th May, 2014
	2nd	31st May~1st June, 2014	31st May~1st June, 2014	31st May~1st June, 2014

Seo, Hyu-Jin (Sign) 12th, Dec. 2014

Seo, Hyu-Jin / Project director Date

Study Personnel and Participants

The test participants recognized the study plan, manual, procedure, guide of Busan Techno Park in performing the test.

	Name		Date
Study personnel	Kim Hui-Jeong	(sign)	12th. Dec. 2014
	Lee Ji-Sun	(sign)	12th. Dec. 2014
	Lee Sun ok	(sign)	12th. Dec. 2014
	Lee Myounghee	(sign)	12 th. Dec. 2014
	Park Na kyung	(sign)	12th. Dec. 2014
	Young In Song	(sign)	12th. Dec. 2014
	Lee Seok Ju	(sign)	12th. Dec. 2014
Project director	Seo, Hyo Jin	(sign)	12th. Dec. 2014

Contents

1.Results 1

1.1 Loading record 1

1.2 Water parameters 2

1.3 Influent water : Uptake water 4

1.4 Elimination efficacy 6

2. Validity 12

3. Conclusion 14

4. Appendix 15

1. Results

1.1 Loading record

Vessel name	SSANG YONG CHANGYAHNG
IMO number	9121027

Water ballast tanks			Sample WGT (Mt)	Loading (Date/Location)	Discharge (Date/Location)
Control	No.3 D/B W.B.T	P, S	1370	May 28st, 2014 GAMCHEON (35°04.48N, 128°59.70E)	May 30th, 2014 DONGHAE (37°29.4N, 129°08.0.E)
Treated	No.4 D/B W.B.T No.5 D/B W.B.T	P, S	650	May 28st, 2014 GAMCHEON (35°04.48N, 128°59.70E)	May 30th, 2014 DONGHAE (37°29.4N, 129°08.0E)

1.2 Water parameters

Table 1. Water parameters at field

Date	Sample ID	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)
Day 0	HL-S03UW-B	8.29±0.01	19.42±0.10	33.25±0.13	4.37±0.13	4.9±0.8
	HL-S03UW-M	8.31±0.01	18.90±0.24	33.01±0.34	3.89±0.01	5.7±0.0
	HL-S03UW-E	8.34±0.01	19.76±0.06	33.32±0.09	5.49±0.58	3.9±0.3
Day 2	HL-S03CD2-B	8.21±0.01	19.19±0.23	33.37±0.02	5.31±0.25	3.3±0.3
	HL-S03CD2-M	8.26±0.01	19.90±0.06	33.44±0.02	4.58±0.03	6.5±2.4
	HL-S03CD2-E	8.29±0.01	20.56±0.04	33.37±0.07	5.98±0.10	3.2±0.2
	HL-S03TD2-B-1	8.36±0.02	18.07±0.06	33.42±0.05	5.84±0.32	2.4±0.2
	HL-S03TD2-B-2	8.34±0.00	18.14±0.07	33.40±0.11	5.61±0.24	2.0±0.1
	HL-S03TD2-B-3	8.29±0.01	18.19±0.03	33.42±0.03	5.00±0.08	2.3±0.3
	HL-S03TD2-M-1	8.26±0.01	18.29±0.05	33.43±0.07	4.59±0.10	2.6±0.6
	HL-S03TD2-M-2	8.27±0.01	18.37±0.04	33.45±0.06	4.38±0.02	2.0±0.3
	HL-S03TD2-M-3	8.26±0.01	18.48±0.09	33.41±0.03	4.20±0.07	3.5±0.2
	HL-S03TD2-E-1	8.26±0.01	18.52±0.07	33.39±0.08	4.12±0.08	3.3±0.1
	HL-S03TD2-E-2	8.27±0.00	18.49±0.10	33.44±0.09	4.09±0.03	2.6±0.1
	HL-S03TD2-E-3	8.27±0.01	18.43±0.06	33.37±0.05	4.11±0.01	11.6±0.2

Data were presented as mean±S.D of three repeated measurement.

Table 2. Results of DOC, POC, TSS

Date	Sample ID	TOC [a)] (mg/L)	DOC [b)] (mg/L)	POC [c)] (mg/L)	TSS [d)] (mg/L)
Day 0	HL-S03UW-B	4.157 ± 0.067	2.171 ± 0.073	1.986	7.6 ± 2.6
	HL-S03UW-M	4.663 ± 0.215	2.119 ± 0.285	2.465	7.5 ± 1.2
	HL-S03UW-E	4.852 ± 0.072	2.486 ± 0.111	2.366	14.0 ± 12.1

Data were presented as mean±S.D of three repeated measurement.
a) TOC: Total Organic Carbon
b) DOC: Dissolved Organic Carbon
c) POC: Particulate Organic Carbon (POC=TOC-DOC)
d) TSS: Total Suspended Solids

1.3 Influent water : Uptake water

1) ≥ 50 µm organism

Table 3. The survival number of the organism larger than 50 µm

Sample ID	Phyla/Divisions	Species	individuals/m^3	Minimum Dimension (µm)
HL-S03UW-B	Arthopoda	*Acartia* sp.	1,167 ± 231	350-480
		Paracalanus parvus s. l.	833 ± 153	400-500
		Evadne tergestina	300 ± 265	600-680
		Podon sp.	433 ± 115	480-560
		Corycaeus sp.	133 ± 153	400-450
		Oithona sp.	400 ± 100	250-320
		Cirriped larvae	467 ±153	150-200
HL-S03UW-M	Arthopoda	*Acartia* sp.	400 ± 100	350-480
		Paracalanus parvus s. l.	367 ± 58	400-500
		Evadne tergestina	33 ± 58	600-680
		Podon sp.	233 ± 58	480-560
		Oithona sp.	333 ± 58	250-320
		Hemicyclops sp.	67 ± 58	350-370
		Pseudodiaptomus marinus	33 ± 58	600-750
		Nauplius	133 ± 58	170-190
		Cirriped larvae	867 ± 289	150-200
	Annenlida	Polychaeta larvae	300 ± 200	350-550
HL-S03UW-E	Arthopoda	*Acartia* sp.	1,500 ± 200	350-480
		Paracalanus parvus s. l.	833 ± 231	400-500
		Podon sp.	533 ± 208	480-560
		Corycaeus sp.	33 ± 58	400-450
		Oithona sp.	233 ± 58	250-320
		Hemicyclops sp.	100 ± 100	350-370
		Nauplius	167 ± 115	170-190
		Cirriped larvae	533 ± 153	150-200
	Annelida	Polychaeta larvae	300 ± 100	350-550
Total	11 species 2 phyla/divisions		3,578 ± 746	-
Acceptability			Influent condition: Acceptable (≥10^2 ind./ m^3)	-

Data were presented as mean±S.D of three repeated measurement.
Some species were rare, the standard deviation was high.

2) 10 µm - 50 µm organism

Table 4. The survival number of the organism between 10 to 50 µm

Sample ID	Phyla/Divisions	Species	individuals / mL	Minimum Dimension (µm)
HL-S03UW-B	Pyrrophyta	*Ceratium* sp.	5 ± 5	15-45
		Prorocentrum sp.	103 ± 22	10-20
		Gymnodinium sp.	3 ± 1	10-40
		Alexandrium sp.	42 ± 7	13-34
		Akashiwo sp.	27 ± 8	15-40
		Oxyrrhis sp.	1 ± 2	10-30
	Chrysophyta	*Chaetoceros* sp.	2 ± 2	13-40
		Skeletonema sp.	3 ± 6	10-16
		Thalassiosira sp.	4 ± 3	10-45
HL-S03UW-M	Pyrrophyta	*Ceratium* sp.	3 ± 1	15-45
		Alexandrium sp.	26 ± 12	13-34
		Akashiwo sp.	27 ± 5	15-40
		Prorocentrum sp.	143 ± 24	10-20
	Chrysophyta	*Thalassiosira* sp.	3 ± 5	10-45
HL-S03UW-E	Pyrrophyta	*Ceratium* sp.	3 ± 1	15-45
		Alexandrium sp.	12 ± 5	13-34
		Gymnodinium sp.	1 ± 1	10-40
		Akashiwo sp.	27 ± 14	15-40
		Prorocentrum sp.	127 ± 12	10-20
		Oxyrrhis sp.	1 ± 1	10-30
	Chrysophyta	*Thalassiosira* sp	4 ± 5	10-45
		Skeletonema sp.	7 ± 6	10-16
Total	9 species 2 phyla/divisions		191 ± 10	-
Acceptability			Influent condition: Acceptable ($\geq 10^2$ ind./mL)	

Data were presented as mean±S.D of three repeated measurement.
Some species were rare, the standard deviation was high.

1.4 Elimination efficacy

1) ≥ 50 µm organism

Table 5. The survival number of the organism larger than 50 µm

Test substance	Sample ID	individuals / m^3	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S03UW-B [a)]	3,733 ± 451	Influent condition: Acceptable ($\geq 10^2$ ind./m^3)	-
	HL-S03UW-M [b)]	2,767 ± 115		
	HL-S03UW-E [c)]	4,233 ± 231		
Discharged control water (Day 2, C2)	HL-S03CD2-B	1,242 ± 63	Effluent condition: Acceptable ($\geq$10 ind./m^3)	-
	HL-S03CD2-M	1,375 ± 150		
	HL-S03CD2-E	2,133 ± 38		
Discharged treated water (Day 2, T2)	HL-S03TD2-B-1	3	Effluent condition: Acceptable (<10 ind./m^3)	99.9 [d)]
	HL-S03TD2-B-2	N.D [e)]		
	HL-S03TD2-B-3	N.D		
	HL-S03TD2-M-1	N.D		
	HL-S03TD2-M-2	N.D		
	HL-S03TD2-M-3	N.D		
	HL-S03TD2-E-1	N.D		
	HL-S03TD2-E-2	N.D		
	HL-S03TD2-E-3	N.D		

a) B: beginning, b) M: Middle c) E: End, d) Calculation = (Uw-T2)/Uw*100, e) N.D : Not Detected

Data were presented as mean±S.D of three repeated measurement.

2) 10 µm - 50 µm organism

Table 6. The survival number of the organism between 10 and 50 µm

Test substance	Sample ID	individuals / mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S03UW-B [a)]	191 ± 11	Influent condition: Acceptable ($\geq 10^2$ ind./mL)	-
	HL-S03UW-M [b)]	201 ± 27		
	HL-S03UW-E [c)]	181 ± 17		
Discharged control water (Day 2, C2)	HL-S03CD2-B	62 ± 6	Effluent condition: Acceptable (≥10 ind./mL)	-
	HL-S03CD2-M	61 ± 10		
	HL-S03CD2-E	73 ± 6		
Discharged treated water (Day 2, T2)	HL-S03TD2-B-1	<1	Effluent condition: Acceptable (<10 ind./mL)	99.9 [d)]
	HL-S03TD2-B-2	<1		
	HL-S03TD2-B-3	<1		
	HL-S03TD2-M-1	<1		
	HL-S03TD2-M-2	<1		
	HL-S03TD2-M-3	<1		
	HL-S03TD2-E-1	<1		
	HL-S03TD2-E-2	<1		
	HL-S03TD2-E-3	<1		

a) B: Beginning, b) M: Middle c) E: End, d) Calculation = (Uw-T2)/Uw*100
Data were presented as mean±S.D of three repeated measurement.

3) Heterotrophic bacteria

Table 7. The survival number of heterotrophic bacteria

Test substance	Sample ID	CFU / mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S03UW-B [a)]	83 ± 29	-	-
	HL-S03UW-M [b)]	67 ± 58		
	HL-S03UW-E [c)]	33 ± 29		
Discharged control water (Day 2, C2)	HL-S03CD2-B	73 ± 21	-	-
	HL-S03CD2-M	63 ± 6		
	HL-S03CD2-E	87 ± 21		
Discharged treated water (Day 2, T2)	HL-S03TD2-B-1	70 ± 20	-	39.4 [d)]
	HL-S03TD2-B-2	40 ± 10		
	HL-S03TD2-B-3	13 ± 12		
	HL-S03TD2-M-1	57 ± 6		
	HL-S03TD2-M-2	40 ± 17		
	HL-S03TD2-M-3	20 ± 10		
	HL-S03TD2-E-1	33 ± 29		
	HL-S03TD2-E-2	50 ± 0		
	HL-S03TD2-E-3	10 ± 10		

a) B: Beginning, b) M: Middle, c) E: End, d) Calculation = (Uw-T2)/Uw*100
Data were presented as mean±S.D of three repeated measurement.

4) *Escherichia coli*

Table 8. The survival number of *Escherichia coli*

Test substance	Sample ID	CFU / 100mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S03UW-B [a)]	52 ± 9	-	-
	HL-S03UW-M [b)]	68 ± 4		
	HL-S03UW-E [c)]	33 ± 9		
Discharged control water (Day 2, C2)	HL-S03CD2-B	16 ± 4	-	-
	HL-S03CD2-M	15 ± 6		
	HL-S03CD2-E	14 ± 3		
Discharged treated water (Day 2, T2)	HL-S03TD2-B-1	N.D [e)]	Effluent condition: Acceptable (<250 CFU/ 100 mL)	100.0 [d)]
	HL-S03TD2-B-2	N.D		
	HL-S03TD2-B-3	N.D		
	HL-S03TD2-M-1	N.D		
	HL-S03TD2-M-2	N.D		
	HL-S03TD2-M-3	N.D		
	HL-S03TD2-E-1	N.D		
	HL-S03TD2-E-2	N.D		
	HL-S03TD2-E-3	N.D		

a) B: Beginning, b) M: Middle, c) E: End, d) Calculation = (Uw-T2)/Uw*100, e) N.D : Not Detected
Data were presented as mean±S.D of three repeated measurement.

5) Intestinal enterococci

Table 9. The survival number of intestinal enterococci

Test substance	Sample ID	CFU / 100mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S03UW-B [a)]	39 ± 2	-	-
	HL-S03UW-M [b)]	37 ± 5		
	HL-S03UW-E [c)]	8 ± 1		
Discharged control water (Day 2, C2)	HL-S03CD2-B	18 ± 5	-	-
	HL-S03CD2-M	20 ± 4		
	HL-S03CD2-E	17 ± 5		
Discharged treated water (Day 2, T2)	HL-S03TD2-B-1	N.D [e)]	Effluent condition: Acceptable (<100 CFU/ 100 mL)	100.0 [d)]
	HL-S03TD2-B-2	N.D		
	HL-S03TD2-B-3	N.D		
	HL-S03TD2-M-1	N.D		
	HL-S03TD2-M-2	N.D		
	HL-S03TD2-M-3	N.D		
	HL-S03TD2-E-1	N.D		
	HL-S03TD2-E-2	N.D		
	HL-S03TD2-E-3	N.D		

a) B: Beginning, b) M: Middle, c) E: End, d) Calculation = (Uw-T2)/Uw*100, e) N.D : Not Detected
Data were presented as mean±S.D of three repeated measurement.

6) *Vibrio cholera* O1, O139

Table 10. The survival number of *Vibrio cholera* O1, O139

Test substance	Sample ID	CFU / 100mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S03UW-B [a)]	N. D	-	-
	HL-S03UW-M [b)]	N. D		
	HL-S03UW-E [c)]	N. D		
Discharged control water (Day 2, C2)	HL-S03CD2-B	N. D	-	-
	HL-S03CD2-M	N. D		
	HL-S03CD2-E	N. D		
Discharged treated water (Day 2, T2)	HL-S03TD2-B-1	N. D	Effluent condition: Acceptable (<1 CFU/ 100 mL)	N. D [d)]
	HL-S03TD2-B-2	N. D		
	HL-S03TD2-B-3	N. D		
	HL-S03TD2-M-1	N. D		
	HL-S03TD2-M-2	N. D		
	HL-S03TD2-M-3	N. D		
	HL-S03TD2-E-1	N. D		
	HL-S03TD2-E-2	N. D		
	HL-S03TD2-E-3	N. D		

a) B: Beginning, b) M: Middle c) E: End, d) N.D: Not detected
Data were presented as mean±S.D of three repeated measurement.

2. Validity

2.1 Water parameters measurement

- All measurements were tested more than three times.
- Water parameters were analyzed as soon as possible after sampling.

2.2 Biological efficacy test

- Valid tests are indicated by uptake water, for both the control tank and ballast water to be treated, with viable organism concentration exceeding 10 times the maximum permitted values in Regulation D-2.1

Sample ID	≥ 50 µm (individuals/m^3)	10 µm - 50 µm (individuals/mL)
HL-S03UW-B	3,733 ± 451	191 ± 11
HL-S03UW-M	2,767 ± 115	201 ± 27
HL-S03UW-E	4,233 ± 231	181 ± 17

- Valid test is indicated by control tank viable organism concentration exceeding the values of Regulation D-2.1 on discharge.

Sample ID	≥ 50 µm (individuals/m^3)	10 µm - 50 µm (individuals/mL)
HL-S03CD2-B	1,242 ± 63	62 ± 6
HL-S03CD2-M	1,375 ± 150	61 ± 10
HL-S03CD2-E	2,133 ± 481	73 ± 6

※Regulation D-2 stipulates that ships meeting the requirements of the Convention by meeting the ballast water performance standard must discharge:

1. less than 10 viable organisms per cubic metre greater than or equal to 50 micrometres in minimum dimension;
2. less than 10 viable organisms per milliliter less than 50 micrometres in minimum dimension and greater than or equal to 10 micrometres in minimum dimension

• The samples should be analyzed as soon as possible after sampling.

Date	Sample ID	Sampling time	Test ending time
Day 0	HL-S03UW-B	May, 28th 17:50	19:30
	HL-S03UW-M	May, 28th 19:45	20:30
	HL-S03UW-E	May, 28th 20:50	21:25
Day 2	HL-S03CD2-B	May, 30th 14:41	15:30
	HL-S03CD2-M	May, 30th 15:50	16:40
	HL-S03CD2-E	May, 30th 16:40	17:10
	HL-S03TD2-B-1, 2, 3	May, 30th 17:10	18:00
	HL-S03TD2-M-1, 2, 3	May, 30th 18:00	18:50
	HL-S03TD2-E-1, 2, 3	May, 30th 18:50	20:00

3. Conclusion

3.1 Biological efficacy in treated ballast seawater by EcoGuardian™ BWMS

- Treated ballast seawater by EcoGuardian™ system was capable of eliminating organism larger than 50 μm with an efficiency of 99.9%.
- Treated ballast seawater water by EcoGuardian™ BWMS was capable of eliminating organism between 10 and 50 μm with an efficiency of 99.9 %.
- Treated ballast seawater by EcoGuardian™ system was capable of eliminating heterotrophic bacteria with an efficiency of 39.4%.
- Treated ballast seawater by EcoGuardian™ system was capable of eliminating *Escherichia coli* with an efficiency of 100 %.
- Treated ballast seawater by EcoGuardian™ system was capable of eliminating intestinal enterococci with an efficiency of 100 %.
- *Vibrio cholera* O1, O139 were not detected.

4. Appendix

Appendix 1. Water parameters at field

1) Uptake water

Date	Sample ID	R [a)]	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)	TOC [b)] (mg/L)	DOC [c)] (mg/L)	TSS [d)] (mg/L)
Day 0	HL-S03UW-B	R1	8.28	19.47	33.33	4.45	5.8	4.125	2.253	10.0
		R2	8.30	19.49	33.31	4.43	4.2	4.235	2.145	4.8
		R3	8.30	19.31	33.10	4.22	4.6	4.111	2.114	8.0
	HL-S03UW-M	R1	8.30	18.76	32.81	3.89	5.7	4.534	2.420	6.4
		R2	8.30	18.76	32.82	3.89	5.7	4.544	1.877	7.2
		R3	8.32	19.17	33.40	3.90	5.7	4.912	2.298	8.8
	HL-S03UW-E	R1	8.33	19.69	33.31	5.95	3.6	4.772	2.420	27.6
		R2	8.34	19.77	33.41	4.84	3.8	4.871	2.614	10.0
		R3	8.34	19.81	33.24	5.68	4.2	4.912	2.423	4.4

a) R: Replicate
b) TOC: Total Organic Carbon (TOC=DOC+POC)
c) DOC: Dissolved Organic Carbon
d) TSS: Total Suspended Solids

2) Discharged control water and discharged treated water

Date	Sample ID	R [a)]	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)
Day 2	HL-S03CD2-B	R1	8.20	19.21	33.39	5.26	3.2
		R2	8.20	19.40	33.35	5.09	3.6
		R3	8.22	18.95	33.37	5.58	3.0
	HL-S03CD2-M	R1	8.25	19.97	33.42	4.55	6.7
		R2	8.26	19.87	33.45	4.61	8.7
		R3	8.27	19.87	33.44	4.57	4.0
	HL-S03CD2-E	R1	8.29	20.60	33.29	6.08	3.3
		R2	8.29	20.54	33.43	5.97	3.0
		R3	8.28	20.53	33.39	5.89	3.4
	HL-S03TD2-B-1	R1	8.34	18.14	33.47	5.81	2.6
		R2	8.37	18.06	33.39	5.53	2.4
		R3	8.36	18.02	33.39	6.17	2.2
	HL-S03TD2-B-2	R1	8.34	18.19	33.51	5.79	2.1
		R2	8.34	18.16	33.30	5.34	2.1
		R3	8.34	18.06	33.40	5.71	1.9
	HL-S03TD2-B-3	R1	8.29	18.23	33.44	4.95	2.1
		R2	8.28	18.18	33.44	5.09	2.3
		R3	8.30	18.17	33.39	4.97	2.6
	HL-S03TD2-M-1	R1	8.27	18.35	33.51	4.55	2.3
		R2	8.26	18.27	33.39	4.70	3.3
		R3	8.26	18.25	33.38	4.52	2.2
	HL-S03TD2-M-2	R1	8.28	18.41	33.52	4.40	2.1
		R2	8.27	18.37	33.41	4.37	2.3
		R3	8.26	18.33	33.41	4.38	1.7
	HL-S03TD2-M-3	R1	8.27	18.58	33.44	4.18	3.7
		R2	8.26	18.45	33.39	4.15	3.6
		R3	8.25	18.42	33.39	4.28	3.3
	HL-S03TD2-E-1	R1	8.26	18.59	33.46	4.10	3.2
		R2	8.25	18.52	33.31	4.20	3.3
		R3	8.26	18.45	33.39	4.05	3.3
	HL-S03TD2-E-2	R1	8.27	18.59	33.54	4.06	2.5
		R2	8.27	18.48	33.37	4.10	2.6
		R3	8.27	18.40	33.41	4.11	2.7
	HL-S03TD2-E-3	R1	8.28	18.50	33.43	4.10	11.5
		R2	8.27	18.40	33.35	4.10	11.8
		R3	8.26	18.38	33.34	4.12	11.6

Appendix 2. The survival number of ≥ 50㎛ organism in uptake water(Influent water)

Sample ID	Classification	Counting volume	R1[a)]	R2	R3	individuals/m^3	
						Mean	S.D[b)]
HL-S03UW-B	*Acartia* sp.	10 mL	13	9	13	1,167	231
	Paracalanus parvus s. l.		8	7	10	833	153
	Evadne tergestina		0	4	5	300	265
	Podon sp.		5	3	5	433	115
	Corycaeus sp.		1	0	3	133	153
	Oithona sp.		5	4	3	400	100
	Cirriped larvae		5	6	3	467	153
HL-S03UW-M	*Acartia* sp.	10 mL	4	3	5	400	100
	Paracalanus parvus s. l.		3	4	4	367	58
	Evadne tergestina		1	0	0	33	58
	Podon sp.		3	2	2	233	58
	Oithona sp.		4	3	3	333	58
	Hemicyclops sp.		0	1	1	67	58
	Pseudodiaptomus marinus		0	1	0	33	58
	Nauplius		1	1	2	133	58
	Cirriped larvae		12	7	7	867	289
	Polychaeta larvae		1	5	3	300	200
HL-S03UW-E	*Acartia* sp.	10 mL	13	15	17	1,500	200
	Paracalanus parvus s. l.		7	11	7	833	231
	Podon sp.		6	7	3	533	208
	Corycaeus sp.		0	0	1	33	58
	Oithona sp.		3	2	2	233	58
	Hemicyclops sp.		2	0	1	100	100
	Nauplius		3	1	1	167	115
	Cirriped larvae		4	5	7	533	153
	Polychaeta larvae		3	4	2	300	100

a) R: Replicate
b) S.D: Standard deviation
Some species were rare, the standard deviation was high.

Appendix 3. The survival number of ≥ 50㎛ organism in discharged control water

Sample ID	Classification	Counting volume	R1[a)]	R2	R3	individuals/m^3	
						Mean	S.D[b)]
HL-S03CD2-B	*Acartia erythraea*	10 mL	5	0	0	42	83
	Acartia sp.		0	16	19	292	255
	Paracalanus parvus s. l.		12	11	12	292	14
	Podon polyphemoides		3	0	0	25	43
	Corycaeus sp.		3	0	2	42	38
	Oithona similis		7	0	0	58	101
	Oithona sp.		0	3	4	58	52
	Totanus forcipatus		3	0	0	25	43
	Harpacticoida sp.		0	3	0	25	43
	Nauplius		8	2	2	100	87
	Cirriped larvae		5	7	5	142	29
	Polychaeta larvae		6	8	3	142	63
HL-S03CD2-M	*Acartia* sp.	10 mL	10	11	9	250	25
	Paracalanus parvus s. l.		4	10	3	142	95
	Podon polyphemoides		3	1	1	42	29
	Corycaeus sp.		4	1	3	67	38
	Oithona sp.		7	7	3	142	58
	Hemicyclops sp.		2	2	4	67	29
	Pseudodiaptomus marinus		0	1	0	8	14
	Sagitta crassa		1	0	0	8	14
	Nauplius		1	1	0	17	14
	Cirriped larvae		20	24	23	558	52
	Polychaeta larvae		3	3	3	75	0
HL-S03CD2-E	*Acartia* sp.	10 mL	12	15	6	275	115
	Paracalanus parvus s. l.		11	7	4	183	88
	Podon polyphemoides		3	3	6	100	43
	Corycaeus sp.		1	4	2	58	38
	Oithona sp.		6	1	2	75	66
	Hemicyclops sp.		0	4	2	50	50
	Centropages sp.		1	0	3	33	38
	Nauplius		0	2	2	33	29
	Cirriped larvae		49	45	55	1,242	126
	Polychaeta larvae		4	3	3	83	14

a) R: Replicate
b) S.D: Standard deviation Some species were rare, the standard deviation was high.

Appendix 4. The survival number of ≥ 50㎛ organism in discharged treated ballast seawater by treatment of EcoGuardian™ system

Sample ID	Classification	Counting volume	individuals/m^3
HL-S03TD2-B-1	Cirriped larvae	250 mL	3
HL-S03TD2-B-2	-		-
HL-S03TD2-B-3	-		-
HL-S03TD2-M-1	-	250 mL	-
HL-S03TD2-M-2	-		-
HL-S03TD2-M-3	-		-
HL-S03TD2-E-1	-	250 mL	-
HL-S03TD2-E-2	-		-
HL-S03TD2-E-3	-		-

a) R: Replicate
b) S.D: Standard deviation

Appendix 5. The survival number of 10㎛ - 50㎛ organism in uptake water(Influent water)

Sample ID	Classification	Counting volume	R1[a)]	R2	R3	individuals/mL	
						Mean	S.D[b)]
HL-S03UW-B	*Ceratium* sp.	0.5mL	5	2	0	5	5
	Chaetoceros sp.		1	0	2	2	2
	Alexandrium sp.		20	25	18	42	7
	Akashiwo sp.		10	12	18	27	8
	Skeletonema sp.		0	0	5	3	6
	Gymnodinium sp.		1	2	2	3	1
	Thalassiosira sp.		1	1	4	4	3
	Prorocentrum sp.		62	53	40	103	22
	Oxyrrhis sp.		0	2	0	1	2
HL-S03UW-M	*Thalassiosira* sp.	0.5mL	4	0	0	3	5
	Ceratium sp.		2	1	1	3	1
	Alexandrium sp.		10	20	9	26	12
	Akashiwo sp.		13	11	16	27	5
	Prorocentrum sp.		84	70	60	143	24
HL-S03UW-E	*Ceratium* sp.	0.5mL	1	2	1	3	1
	Alexandrium sp.		4	5	9	12	5
	Thalassiosira sp.		5	0	1	4	5
	Akashiwo sp.		6	15	20	27	14
	Gymnodinium sp.		1	0	1	1	1
	Skeletonema sp.		4	6	0	7	6
	Oxyrrhis sp.		0	0	1	1	1
	Prorocentrum sp.		60	70	60	127	12

a) R: Replicate
b) S.D: Standard deviation
Some species were rare, the standard deviation was high.

Appendix 6. The survival number of 10㎛ - 50㎛ organism in discharged control water

Sample ID	Classification	Counting volume	R1[a)]	R2	R3	individuals/mL	
						Mean	S.D[b)]
HL-S03CD2-B	*Prorocentrum* sp.	0.5mL	15	22	26	42	11
	Leptocylindrus sp.		3	3	0	4	3
	Alexandrium sp.		1	0	1	1	1
	Chaetoceros sp.		4	0	0	3	5
	Thalassiosira sp.		3	3	5	7	2
	Skeletonema sp.		2	0	2	3	2
	Eucampia sp.		0	1	0	1	1
	Ceratium sp.		0	1	0	1	1
	Oxyphysis sp.		0	1	0	1	1
HL-S03CD2-M	*Alexandrium* sp.	0.5mL	6	2	4	8	4
	Leptocylindrus sp.		2	2	1	3	1
	Eucampia sp.		1	0	0	1	1
	Gyrodinium sp.		1	0	0	1	1
	Prorocentrum sp.		15	18	20	35	5
	Ceratium sp.		0	2	5	5	5
	Thalassiosira sp.		0	2	3	3	3
	Gymnodinium sp.		0	1	1	1	1
	Skeletonema sp.		0	5	0	3	6
	Protoperidinium sp.		0	0	1	1	1
HL-S03CD2-E	*Prorocentrum* sp.	0.5mL	20	24	18	41	6
	Alexandrium sp.		6	2	4	8	4
	Ceratium sp.		3	5	7	10	4
	Akashiwo sp.		1	3	2	4	2
	Protoperidinium sp.		1	0	0	1	1
	Leptocylindrus sp.		1	3	0	3	3
	Thalassiosira sp.		2	3	4	6	2
	Gymnodinium sp.		0	0	1	1	1

a) R: Replicate
b) S.D: Standard deviation
Some species were rare, the standard deviation was high.

Appendix 7. The survival number of 10㎛ - 50㎛ organism in discharged treated ballast seawater by treatment of EcoGuardian™ system

Sample ID	Classification	Concentration factor[c]	Counting volume	R1[a]	R2	R3	individuals/mL	
							Mean	S.D[b]
HL-S03TD2-B-1	*Akashiwo* sp.	X 20	0.5 mL	1	0	1	0.1	0.1
	Ceratium sp.			1	0	0	0.0	0.1
	Prorocentrum sp.			0	1	2	0.1	0.1
HL-S03TD2-B-2	*Thalassiosira* sp.			1	0	0	0.0	0.1
	Akashiwo sp.			0	1	0	0.0	0.1
	Ceratium sp.			0	0	1	0.0	0.1
HL-S03TD2-B-3	*Alexandrium* sp.			1	0	1	0.1	0.1
	Thalassiosira sp.			0	1	0	0.0	0.1
	Prorocentrum sp.			0	0	1	0.0	0.1
HL-S03TD2-M-1	*Thalassiosira* sp.	X 20	0.5 mL	1	0	2	0.1	0.1
	Akashiwo sp.			0	2	1	0.1	0.1
	Alexandrium sp.			0	1	1	0.1	0.1
HL-S03TD2-M-2	*Prorocentrum* sp.			3	0	1	0.1	0.2
	Akashiwo sp.			0	1	0	0.0	0.1
	Thalassiosira sp.			0	1	1	0.1	0.1
HL-S03TD2-M-3	*Prorocentrum* sp.			1	1	1	0.1	0.0
	Thalassiosira sp.			0	0	1	0.0	0.1
HL-S03TD2-E-1	*Ceratium* sp.	X 20	0.5 mL	1	0	0	0.0	0.1
	Prorocentrum sp.			2	2	1	0.2	0.1
HL-S03TD2-E-2	*Prorocentrum* sp.			1	0	0	0.0	0.1
	Akashiwo sp.			0	0	1	0.0	0.1
HL-S03TD2-E-3	-			0	0	0	0.0	0.0

a) R: Replicate

b) S.D: Standard deviation

c) Concentration factor: Treated water was concentration 10 L to 500 mL by 5 μm net.

Appendix 8. The number of heterotrophic bacteria in uptake water, discharged control water and discharged treated water by treatment of EcoGuardian™ BWMS

Date	Sample ID	Dilution factor	R1[a)]	R2	R3	CFU /mL	
						Mean	S.D[b)]
Day 0	HL-S03UW-B	x 50	2	1	2	83	29
	HL-S03UW-M		2	2	0	67	58
	HL-S03UW-E		1	0	1	33	29
Day 2	HL-S03CD2-B	x 10	5	8	9	73	21
	HL-S03CD2-M		7	6	6	63	6
	HL-S03CD2-E		8	7	11	87	21
	HL-S03TD2-B-1	x 10	7	5	9	70	20
	HL-S03TD2-B-2	x 10	4	5	3	40	10
	HL-S03TD2-B-3	x 10	2	0	2	13	12
	HL-S03TD2-M-1	x 10	5	6	6	57	6
	HL-S03TD2-M-2	x 10	6	3	3	40	17
	HL-S03TD2-M-3	x 10	1	3	2	20	10
	HL-S03TD2-E-1	x 50	0	1	1	33	29
	HL-S03TD2-E-2	x 50	1	1	1	50	0
	HL-S03TD2-E-3	x 10	0	1	2	10	10

a) R: Replicate
b) S.D: Standard deviation

Appendix 9. The number of *Escherichia coli* in uptake water, discharged control water and discharged treated water by treatment of EcoGuardian™ BWMS

Date	Sample ID	Testing volume	R1[a)]	R2	R3	CFU /100 mL	
						Mean	S.D[b)]
Day 0	HL-S03UW-B	100mL	43	53	61	52	9
	HL-S03UW-M		67	72	64	68	4
	HL-S03UW-E		30	27	43	33	9
Day 2	HL-S03CD2-B	100mL	18	11	19	16	4
	HL-S03CD2-M		20	9	17	15	6
	HL-S03CD2-E		12	13	17	14	3
	HL-S03TD2-B-1	100mL	0	0	0	0	0
	HL-S03TD2-B-2		0	0	0	0	0
	HL-S03TD2-B-3		0	0	0	0	0
	HL-S03TD2-M-1		0	0	0	0	0
	HL-S03TD2-M-2		0	0	0	0	0
	HL-S03TD2-M-3		0	0	0	0	0
	HL-S03TD2-E-1		0	0	0	0	0
	HL-S03TD2-E-2		0	0	0	0	0
	HL-S03TD2-E-3		0	0	0	0	0

a) R: Replicate
b) S.D: Standard deviation

Appendix 10. The number of intestinal enterococci in uptake water, discharged control water and discharged treated water by treatment of EcoGuardian™ BWMS

Date	Sample ID	Testing volume	R1[a)]	R2	R3	CFU /100 mL	
						Mean	S.D[b)]
Day 0	HL-S03UW-B	100mL	40	37	40	39	2
	HL-S03UW-M		42	35	33	37	5
	HL-S03UW-E		9	7	9	8	1
Day 2	HL-S03CD2-B	100mL	14	18	23	18	5
	HL-S03CD2-M		22	23	15	20	4
	HL-S03CD2-E		21	12	19	17	5
	HL-S03TD2-B-1	100mL	0	0	0	0	0
	HL-S03TD2-B-2		0	0	0	0	0
	HL-S03TD2-B-3		0	0	0	0	0
	HL-S03TD2-M-1		0	0	0	0	0
	HL-S03TD2-M-2		0	0	0	0	0
	HL-S03TD2-M-3		0	0	0	0	0
	HL-S03TD2-E-1		0	0	0	0	0
	HL-S03TD2-E-2		0	0	0	0	0
	HL-S03TD2-E-3		0	0	0	0	0

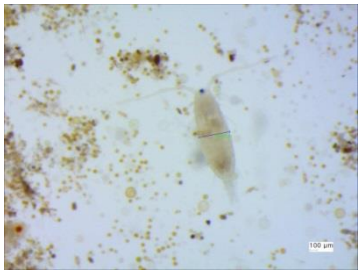
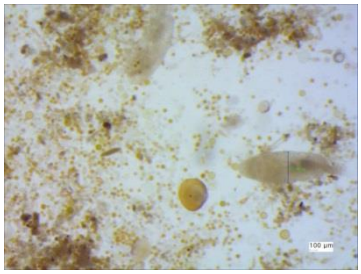
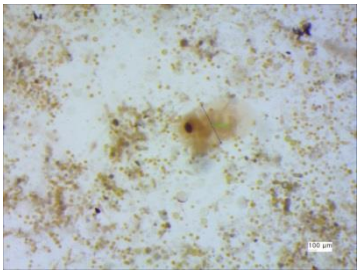
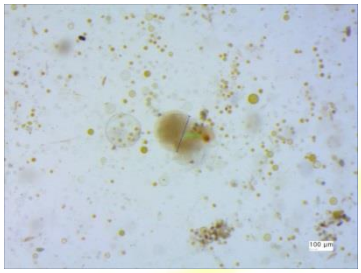
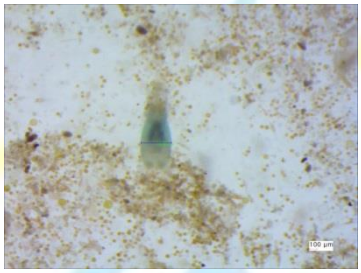
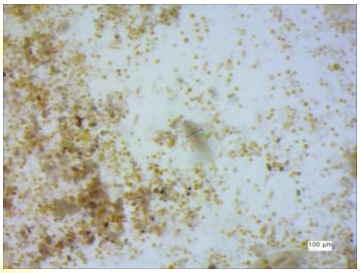
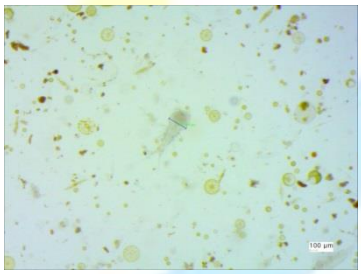
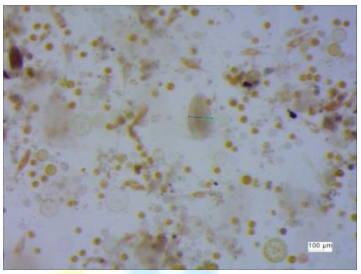
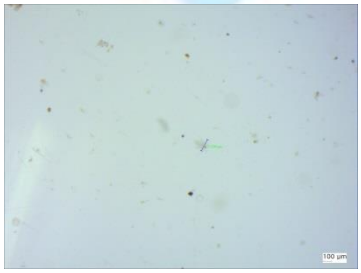
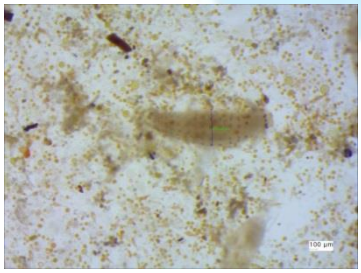
a) R: Replicate
b) S.D: Standard deviation

Appendix 11. The number of *Vibrio cholera* O1, O139 in uptake water, discharged control water and discharged treated water by treatment of EcoGuardian™ BWMS

Date	Sample ID	Testing volume	R1[a)]	R2	R3	CFU /100 mL	
						Mean	S.D[b)]
Day 0	HL-S03UW-B	100mL	0	0	0	0	-
	HL-S03UW-M		0	0	0	0	-
	HL-S03UW-E		0	0	0	0	-
Day 2	HL-S03CD2-B	100mL	0	0	0	0	-
	HL-S03CD2-M		0	0	0	0	-
	HL-S03CD2-E		0	0	0	0	-
	HL-S03TD2-B-1	100mL	0	0	0	0	-
	HL-S03TD2-B-2		0	0	0	0	-
	HL-S03TD2-B-3		0	0	0	0	-
	HL-S03TD2-M-1		0	0	0	0	-
	HL-S03TD2-M-2		0	0	0	0	-
	HL-S03TD2-M-3		0	0	0	0	-
	HL-S03TD2-E-1		0	0	0	0	-
	HL-S03TD2-E-2		0	0	0	0	-
	HL-S03TD2-E-3		0	0	0	0	-

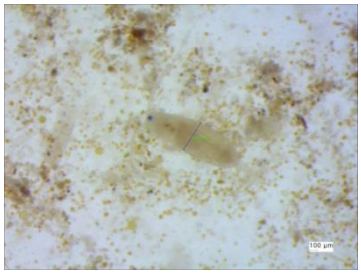
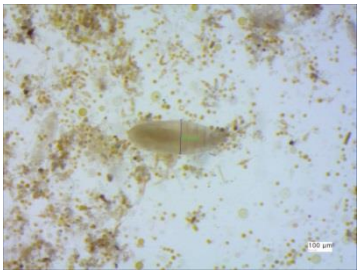
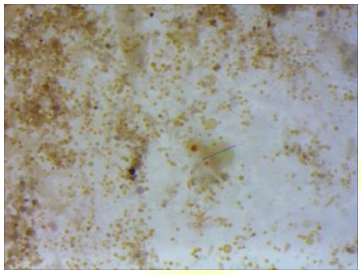
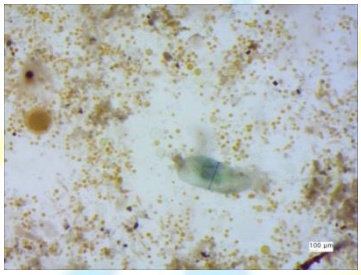
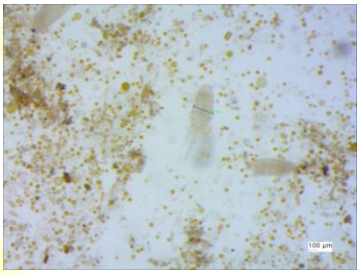
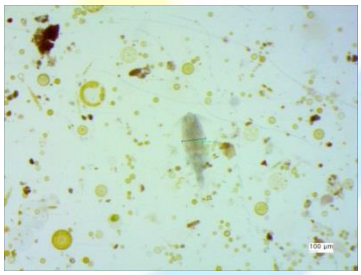
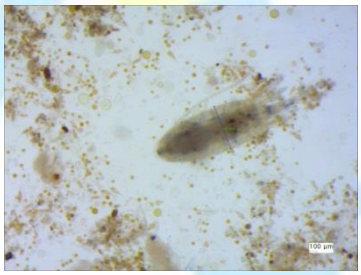
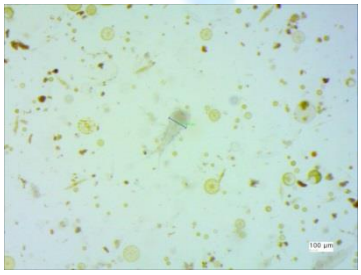
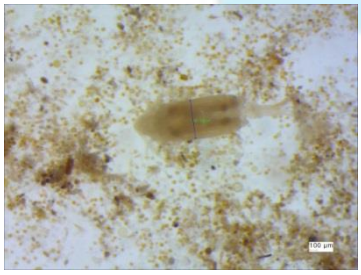
a) R: Replicate
b) S.D: Standard deviation

Appendix 12. The microscopic image of ≥ 50㎛ in uptake water (Day0)

Uptake water (Day 0)		
Acartia sp.*	*Paracalanus parvus* s. l.*	*Evadne* sp.*
		
Podon sp.*	*Corycaeus* sp.*	*Oithona* sp.*
		
Hemicyclops sp.*	*Pseudodiaptomus marinus**	Nauplius*
		
Cirriped larvae*	Polychaeta larvae*	
		

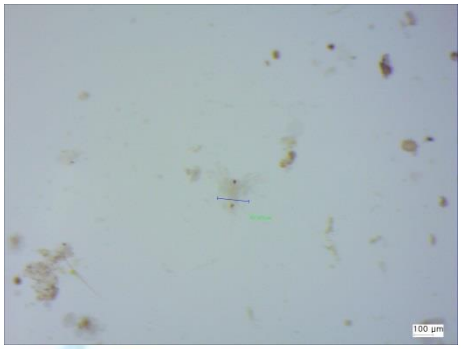
* Magnification : 20

Appendix 13. The microscopic image of ≥ 50㎛ in discharged control water (Day2)

Discharged control water (Day 2)		
Acartia sp.*	*Acartia erythraea**	*Paracalanus parvus* s. l.*
		
*Podon polyphemoides**	*Corycaeus* sp.*	*Oithona* sp.*
		
Hemicyclops sp.*	*Pseudodiaptomus marinus**	*Tortanus forcipatus**
		
Harpacticoida sp.*	*Centropages* sp.*	*Sagitta crassa**
		

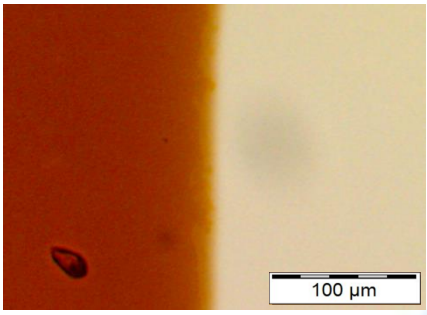
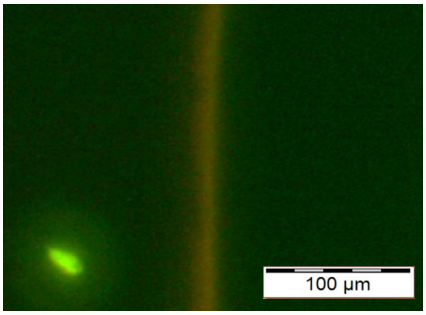
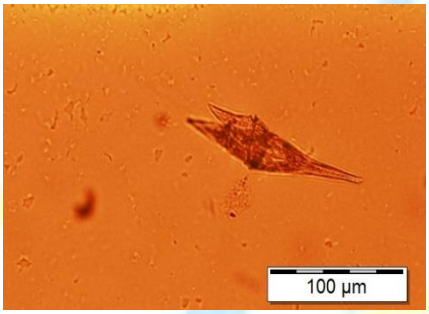
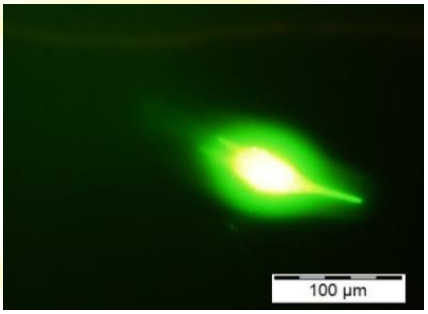
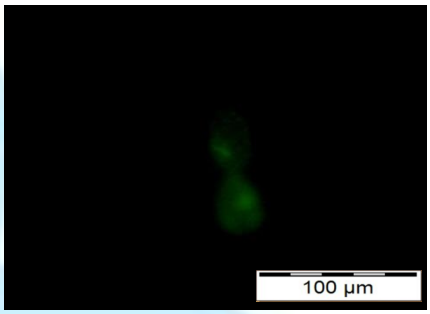
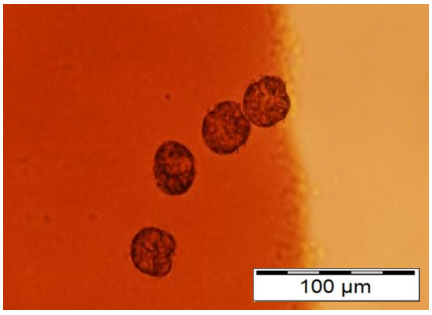
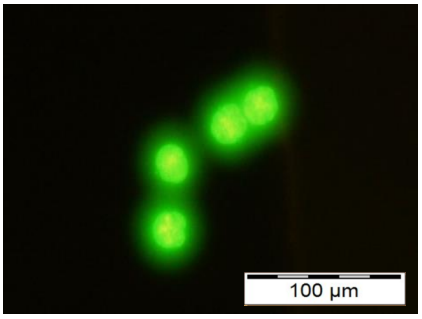
* Magnification : 20

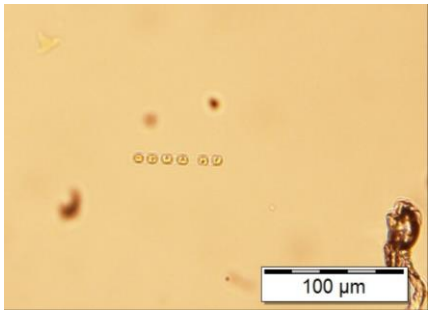
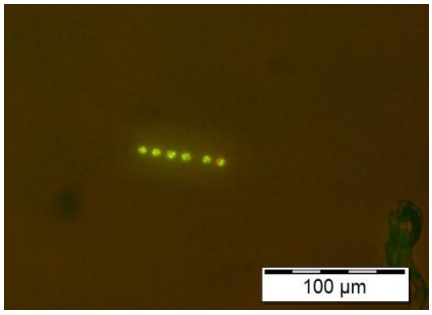
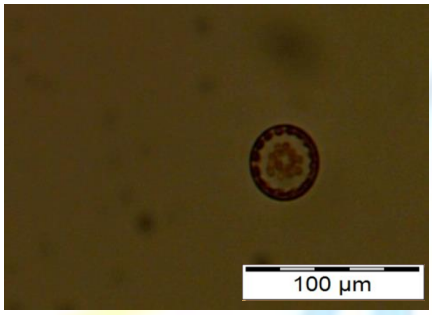
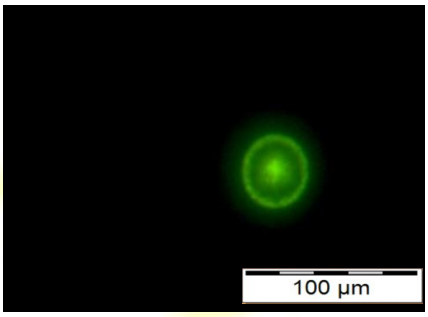
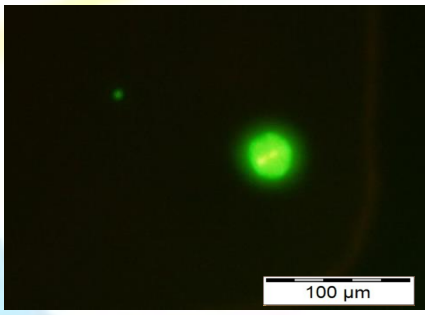
Appendix 14. The microscopic image of ≥ 50㎛ in discharged treated water by treatment of EcoGuardian™ BWMS (Day2)

Specific Name	Discharged treated water
Cirriped larvae*	

* Magnification : 40

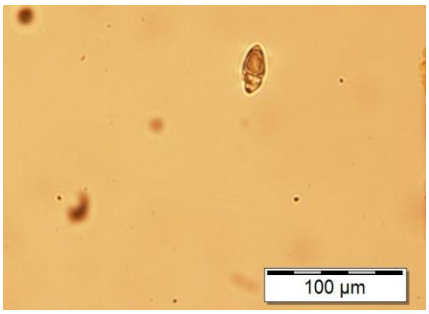
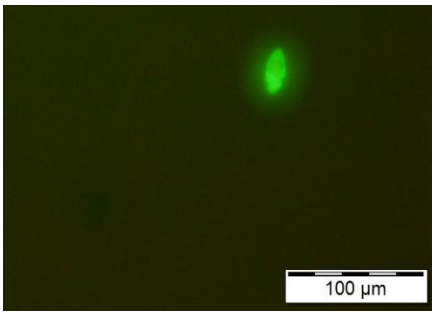
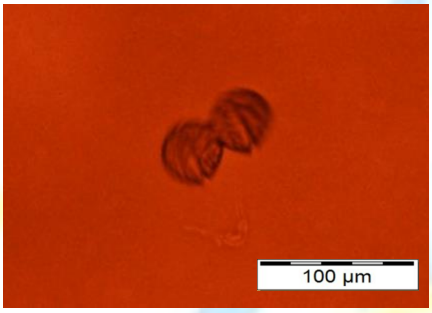
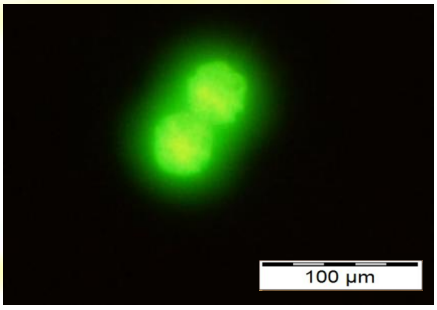
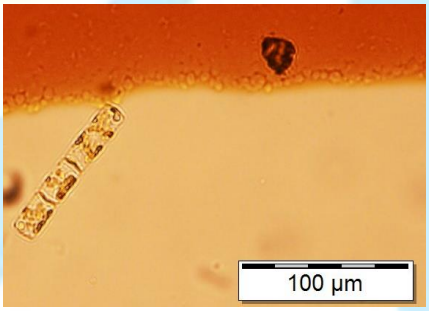
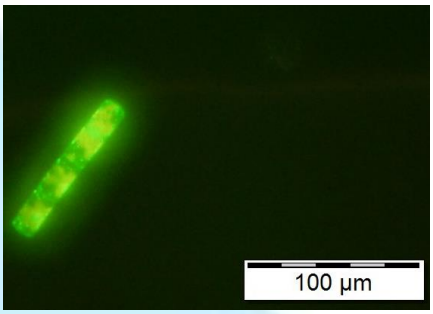
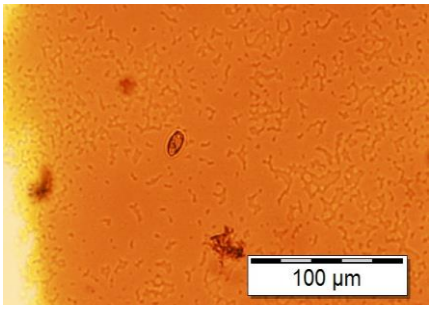
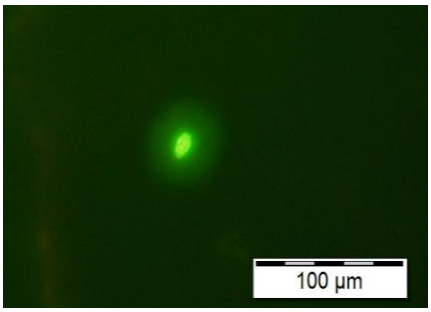
Appendix 15. The microscopic image of 10㎛−50㎛ in uptake water (Day0)

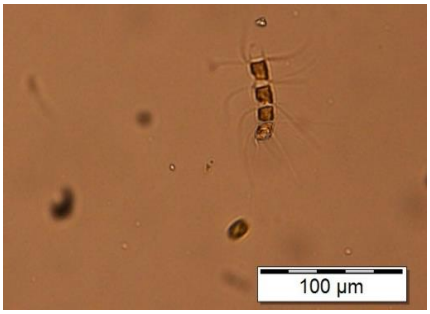
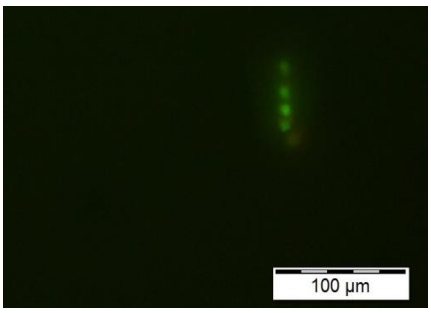
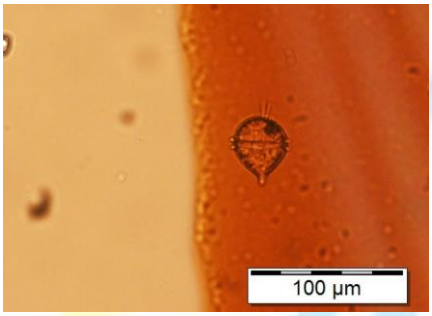
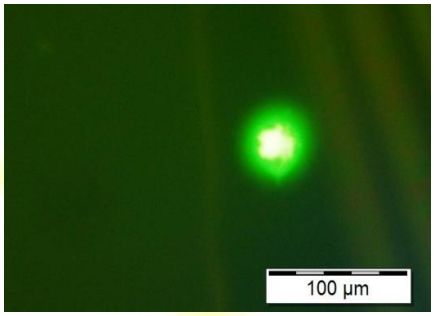
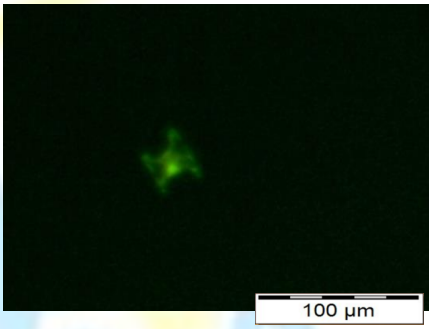
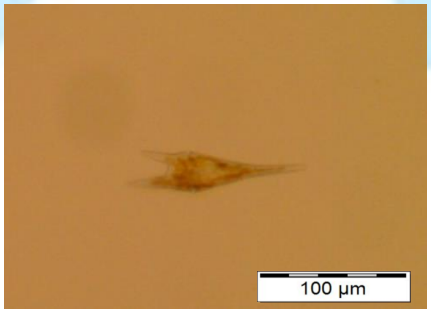
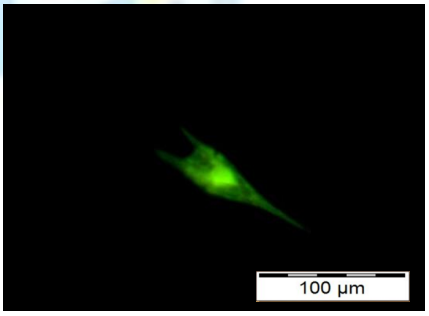
Specific Name	Uptake water	
	Optical	Fluorescence
Prorocentrum sp.		
Ceratium sp.		
Chaetoceros sp.		
Alexandrium sp.		

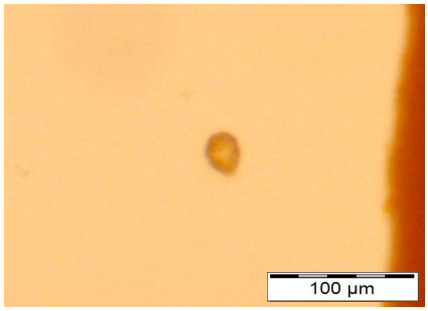
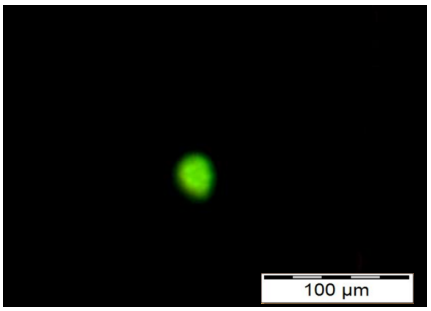
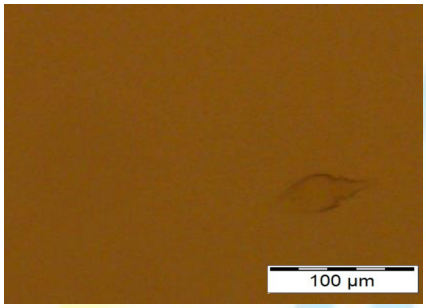
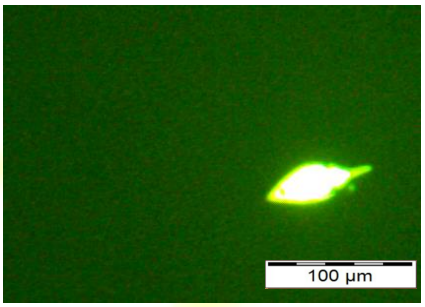
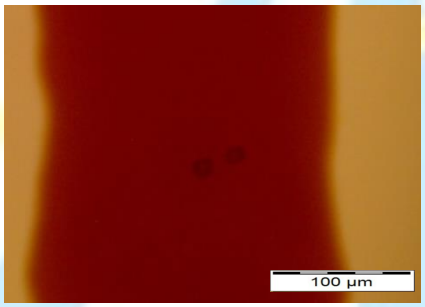
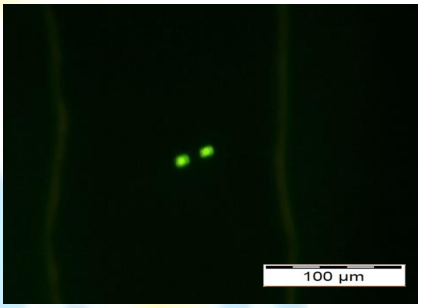
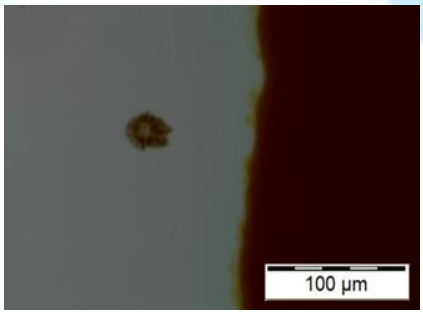
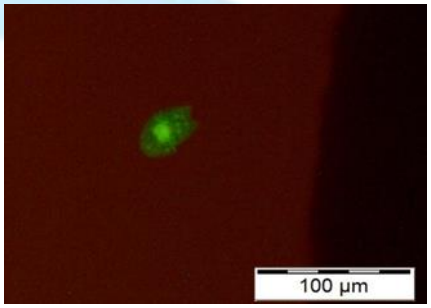
Skeletonema sp.		
Thalassiosira sp.		
Gymnodinium sp.		

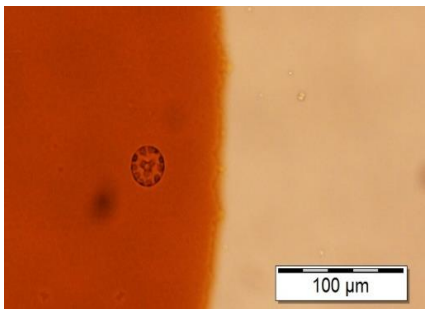
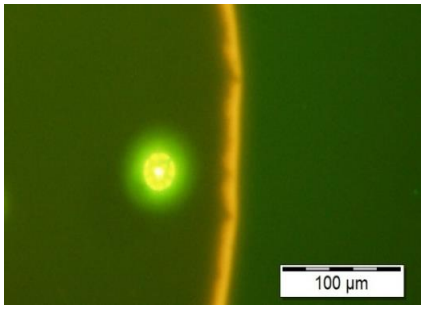
Magnification : 200

Appendix 16. The microscopic image of 10㎛−50㎛ in discharged control water (Day2)

Specific Name	Discharged control water	
	Optical	Fluorescence
Gyrodinium sp.		
Alexandrium sp.		
Leptocylindrus sp.		
Prorocentrum sp.		

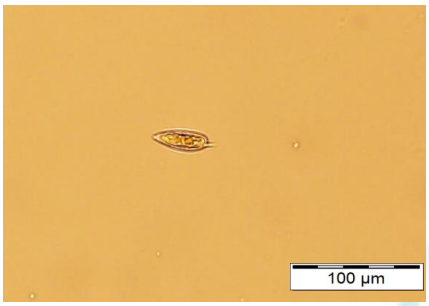
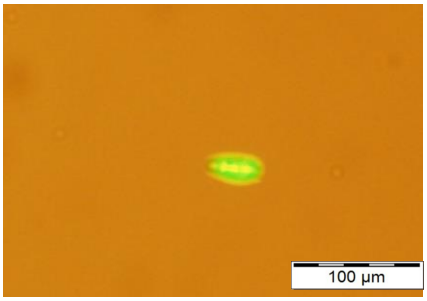
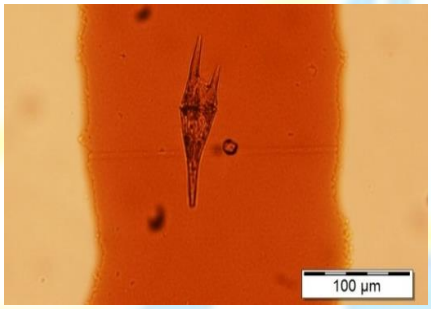
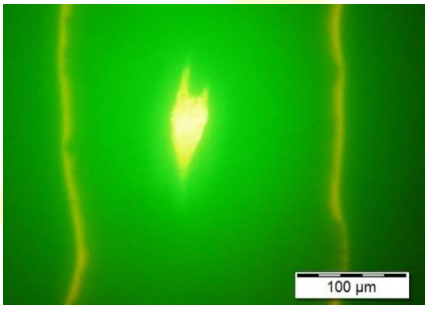
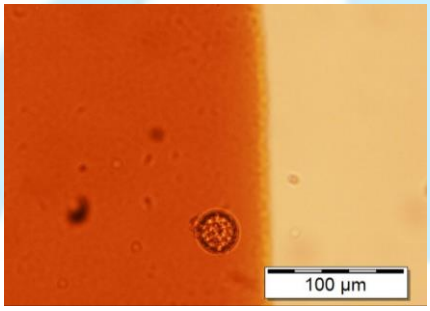
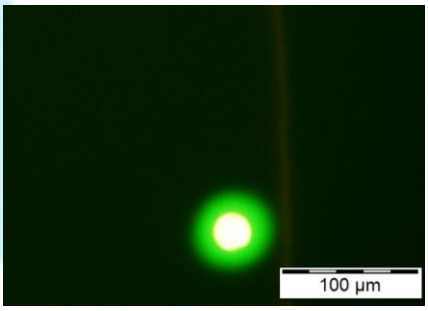
Chaetoceros sp.		
Protoperidinium sp.		
Eucampia sp.		
Ceratium sp.		

Gymnodinium sp.		
Oxyphysis sp.		
Skeletonema sp.		
Akashiwo sp.		

Talassiosira sp.		

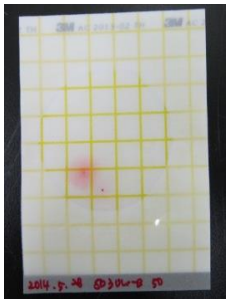
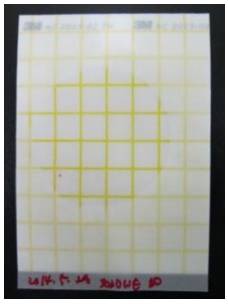
Magnification : 200

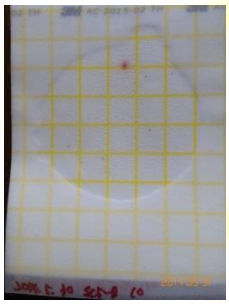
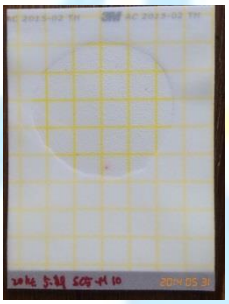
Appendix 17. The microscopic image of 10㎛−50㎛ in discharged treated water by treatment of EcoGuardian™ BWMS (Day2)

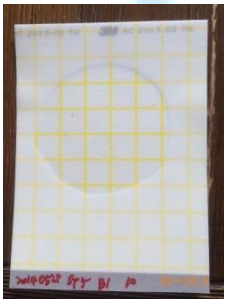
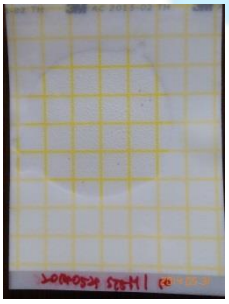
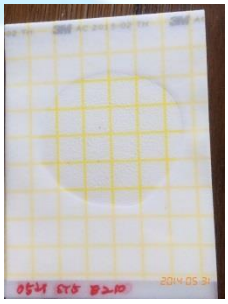
Specific Name	Discharged treated water	
	Optical	Fluorescence
Prorocentrum sp.		
Ceratium sp.		
Thalassiosira sp		

Magnification : 200

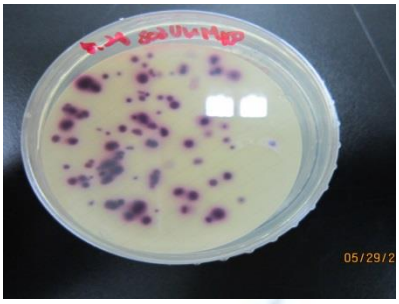
Appendix 18. The image of heterotrophic bacteria

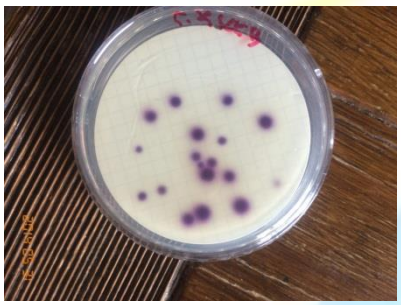
Uptake water (Day 0)		
Beginning	**Middle**	**End**
		

Discharged control water (Day 2)		
Beginning	**Middle**	**End**
		

Discharged treated water (Day 2)		
Beginning	**Middle**	**End**
		

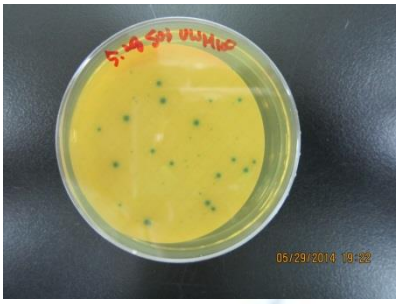
Appendix 19. The image of *Escherichia coli*

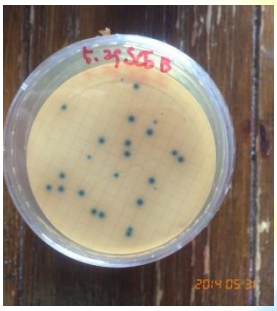
Uptake water (Day 0)		
Beginning	**Middle**	**End**
		

Discharged control water (Day 2)		
Beginning	**Middle**	**End**
		

Discharged treated water (Day 2)		
Beginning	**Middle**	**End**

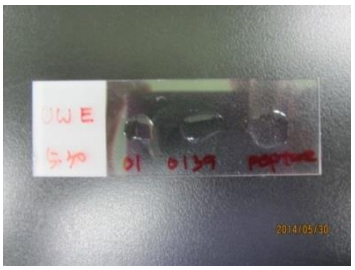
Appendix 20. The image of intestinal enterococci

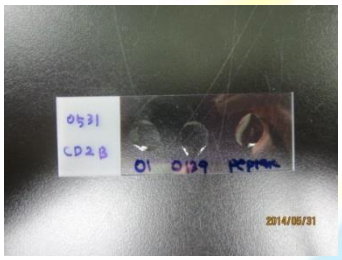
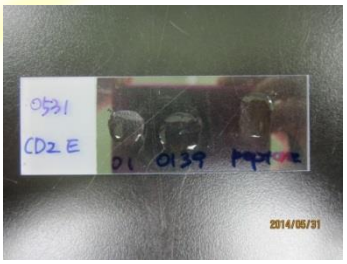
Uptake water (Day 0)		
Beginning	**Middle**	**End**
		

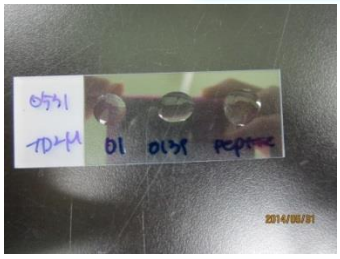
Discharged control water (Day 2)		
Beginning	**Middle**	**End**
		

Discharged treated water (Day 2)		
Beginning	**Middle**	**End**

Appendix 21. The image of *Vibrio cholera* O1, O139

Uptake water (Day 0)		
Beginning	**Middle**	**End**
		

Discharged control water (Day 2)		
Beginning	**Middle**	**End**
		

Discharged treated water (Day 2)		
Beginning	**Middle**	**End**
		

5. Attachment

5.1 Sampling check & custody Sheet

5.2 Freezing keeping sheet

5.3 Water parameter measurement sheet (I)

5.4 TOC measurement sheet

5.5 TSS(Total suspended solid) measurement sheet

5.6 Microbiology Test Sheet

5.7 Test Result sheet with Microbiology

5.8 Vibrio cholera O1, O139

5.9 Test Result Sheet – Classification (II)

Sampling check & custody Sheet

2014

Study number		Test number	SET-14-002
Sampling time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Day ( )		

Sample location	☑ Uptake water □ Discharge control water □ Discharge treated water □ Other( )						
Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
TSS		HDPE	2	□ 1	17:46	18:53	19:57
DOC, POC		HDPE	2		~18:40	~19:25	~20:25
Bacteria (4 item)[b]		HDPE	2	□ 2			
Organism (10~50 μm)		HDPE	1	□ 3			
Organism (≥50 μm)	1000L → 0.5L	HDPE	0.5				

Sample location	□ Treated water □ Treated water (Neutralized)						
Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
Bacteria (4 item)[c]		HDPE		□ 1			
Organism (10~50 μm)		HDPE		□ 2			
Organism (≥50 μm)		HDPE		□ 3			

Concentration

Parameter	Vol. of concentrated before	Equipment	Mesh size
Organism (≥50 μm)	1000 (L)	net	32 μm
Organism (10-50 μm)	— (L)	net	5 μm

Sample storage information

Parameter	Location & condition	Storage time
TSS	Freezer(-20℃)	May. 28th 20:00 ~ May 31st 05:00
DOC, POC		
Bacteria (4 item)	Refrigerator(4℃)	

Remarks

* First, fill a 20L HDPE(high density poly ethylene) bottle with water sample, and split the water sample up into groups (bacteria, organism (10~50 μm), and so forth) Then measured water parameters(5 item) - pH, Temperature, Salinity, DO, Turbidity
* Separately, organism(≥50 μm, 10-50 μm) sample was concentrated with net.
* Storage time of "bacteria sample" is for "heterotrophic bacteria test"
* TSS and DOC and POC samples are acidified(pH<2) with HCl (in 4 mL HCl of 2 L sample)

Working(pump) start time for Test water(or control water) sample :
Working(pump and EcoGuadian™) start time for treated(or neutralized) sample :

Working date	May. 28th	Personnel	Sun ok Lee. (sign)
Confirmation date	May. 28th	Confirmed by	Sun ok Lee (sign)

a) Concentration b) Period
c) Bacteria (4 item) - Heterotrophic bacteria, Coliform, Vibrio cholera, Enterococcus group

Sampling check & custody Sheet

20 14

Study number		Test number	SET-14-002
Sampling time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Day ( )		

Sample location	□ Uptake water ☑ Discharge control water ☑ Discharge treated water □ Other( )						
Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
TSS		HDPE		□ 1	00:41	01:46	02:48
DOC, POC		HDPE					
Bacteria (4 item)[b]	/	HDPE	2	□ 2			
Organism (10~50 μm)	/	HDPE	1	□ 3			
Organism (≥50 μm)	1000L→0.25L	HDPE	0.25				

Sample location	☑ Treated water □ Treated water (Neutralized)						
Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
Bacteria (4 item)[c]	/	HDPE	2	□ 1	03:47	04:14	04:41
Organism (10~50 μm)	10L→0.5L	HDPE	0.5	□ 2			
Organism (≥50 μm)	1000L→0.25L	HDPE	0.25	□ 3			

Concentration			
Parameter	Vol. of concentrated before	Equipment	Mesh size
Organism (≥50 μm)	1000 (L)	net	32 μm
Organism (10-50 μm)	10 (L)	net	5 μm

Sample storage information		
Parameter	Location & condition	Storage time
TSS	Freezer(-20℃)	
DOC, POC		
Bacteria (4 item)	Refrigerator(4℃)	

Remarks

* First, fill a 1~20L HDPE(high density poly ethylene) bottle with water sample, and split the water sample up into groups (bacteria, organism (10~50 μm), and so forth) Then measured water parameters(5 item) - pH, Temperature, Salinity, DO, Turbidity
* Separately, organism(≥50 μm, 10 ~ 50 μm) sample was concentrated with net.
* Storage time of "bacteria sample" is for "heterotrophic bacteria test"
* TSS and DOC and POC samples are acidified(pH<2) with HCl (in 6 mL HCl of 2 L sample)

Working(pump) start time for Test water(or control water) sample :
Working(pump and EcoGuadian™) start time for treated(or neutralized) sample :

Working date	May 30th	Personnel	Sun ok Lee (sign)
Confirmation date	May 30th	Confirmed by	Sun ok Lee (sign)

a) Concentration b) Period
c) Bacteria (4 item) - Heterotrophic bacteria, Coliform, Vibrio cholera, Enterococcus group

Freezing keeping sheet

(Of sample for measurement of water parameter)

2014

Sample	Test water	Sampling time	Day 0
Storage place	Freezing room	Storage Condition	-20 ℃
Study number		Test number	SET-14-002

No.	Sample ID	Labeling	Storage Date & time	Personnel
1	HL-S03UW-B	A / B /( )	5.28 / 18:00	Sun ok Lee (sign)
2	HL-S03UW-M	A / B /( )	5.28 / 20:00	
3	HL-S03UW-E	A / B /( )	5.28 / 21:00	
4		A / B /( )	~~5.28~~ a) /	
5		A / B /( )	/	
6		A / B /( )	/	
7		A / B /( )	/	(sign)
8		A / B /( )	/	
9		A / B /( )	/	
10		A / B /( )	/	
11		A / B /( )	/	
12		A / B /( )	/	
13		A / B /( )	/	(sign)
14		A / B /( )	/	
15		A / B /( )	/	
16		A / B /( )	/	
17		A / B /( )	/	
18		A / B /( )	/	

Remarks

* a) deleted Sun ok Lee 05.28

Confirming date	5.28	Confirmed by	Sun ok Lee (sign)

Water parameter measurement sheet (I)

20 14

Study Number	HAN-Ship ( )	Test number	SET-14 -002
Sampling time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Day ( )		
Equipment	YSI 6920- pH, temp., salinity, DO / YSI 6920 Turbidity		

Sample	Replicate	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)
☑ Test water	R1	8.28	19.47	33.33	4.45	5.8
□ Control water	R2	8.30	19.47	33.31	4.43	4.2
□ Treated water	R3	8.30	19.31	33.10	4.22	4.6
□ Neutralized water						
☑ B( ) □ M( ) □ E( )	Measuring time	17:46				
☑ Test water	R1	8.30	18.96	32.81	3.89	5.7
□ Control water	R2	8.30	18.96	32.82	3.89	5.7
□ Treated water	R3	8.32	19.11	33.40	3.90	5.7
□ Neutralized water						
□ B( ) ☑ M( ) □ E( )	Measuring time	18:53				
☑ Test water	R1	8.33	19.69	33.31	5.95	3.6
□ Control water	R2	8.34	19.77	33.41	4.84	3.8
□ Treated water	R3	8.34	19.81	33.24	5.68	4.2
□ Neutralized water 19:55						
□ B( ) □ M( ) ☑ E( )	Measuring time	19:57				
□ Test water	R1					
□ Control water	R2					
□ Treated water	R3					
□ Neutralized water						
□ B( ) □ M( ) □ E( )	Measuring time					
□ Test water	R1					
□ Control water	R2					
□ Treated water	R3					
□ Neutralized water						
□ B( ) □ M( ) □ E( )	Measuring time					
□ Test water	R1					
□ Control water	R2					
□ Treated water	R3					
□ Neutralized water						
□ B( ) □ M( ) □ E( )	Measuring time					
Remarks						

Working Date	May. 28th	Study Personnel	Lee JT Sun (sign)
Confirming Date	May. 28th	Confirmed by	Lee JT Sun (sign)

Water parameter measurement sheet (I)

20 14

Study Number	HAN-Ship ( )	Test number	SET-14 – 002
Sampling time	☑ Day 0 ☐ Day 1 ☐ Day 2 ☐ Day 3 ☐ Day 4 ☐ Day 5 ☐ Day ( )		
Equipment	YSI 6920 - pH, temp., salinity, DO / YSI 6920 Turbidity		

Sample	Replicate	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)
☐ Test water ☑ Control water ☐ Treated water ☐ Neutralized water	R1	8.20	19.21	33.39	5.26	3.2
	R2	8.20	19.40	33.35	5.09	3.6
	R3	8.22	18.95	33.37	5.58	3.0
☑ B( ) ☐ M( ) ☐ E( )	Measuring time	00:41 / 00:42				
☐ Test water ☑ Control water ☐ Treated water ☐ Neutralized water	R1	8.25	19.97	33.42	4.55	6.7
	R2	8.26	19.87	33.45	4.61	8.7
	R3	8.27	19.87	33.44	4.57	4.0
☐ B( ) ☑ M( ) ☐ E( )	Measuring time	01:46 / 01:48				
☐ Test water ☑ Control water ☐ Treated water ☐ Neutralized water	R1	8.29	20.60	33.29	6.08	3.3
	R2	8.29	20.54	33.43	5.97	3.0
	R3	8.28	20.53	33.42	5.89	3.4
☐ B( ) ☐ M( ) ☑ E( )	Measuring time	02:48 / 02:49				
☐ Test water ☐ Control water ☑ Treated water ☐ Neutralized water	R1	8.34	18.14	33.47	5.81	2.6
	R2	8.37	18.06	33.37	5.53	2.4
	R3	8.36	18.02	33.39	6.17	2.2
☑ B( ) ☐ M( ) ☐ E( )	Measuring time	03:47 / 03:49				
☐ Test water ☐ Control water ☑ Treated water ☐ Neutralized water	R1	8.34	18.19	33.51	5.03	2.1
	R2	8.34	18.16	33.30	5.34	2.1
	R3	8.34	18.03	33.40	5.71	1.9
☑ B( ) ☐ M( ) ☐ E( )	Measuring time	03:56 / 03:57				
☐ Test water ☐ Control water ☑ Treated water ☐ Neutralized water	R1	8.29	18.23	33.44	4.95	2.1
	R2	8.28	18.18	33.44	5.09	2.3
	R3	8.30	18.17	33.39	4.97	2.6
☑ B( ) ☐ M( ) ☐ E( )	Measuring time	04:05 / 04:06				
Remarks						

Working Date	May 30th	Study Personnel	Young In Song (sign)
Confirming Date	May 30th	Confirmed by	Lee Ji Suh (sign)

Water parameter measurement sheet (I)

20 14

Study Number	HAN-Ship ( )				Test number	SET-14 -002
Sampling time	□ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Day ( )					
Equipment	YSI 6920 - pH, temp., salinity, DO / YSI 6920 - Turbidity					
Sample	Replicate	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)
□ Test water □ Control water ☑ Treated water □ Neutralized water	R1	8.27	18.35	33.51	4.55	2.3
	R2	8.26	18.27	33.39	4.10	3.3
	R3	8.26	18.25	33.38	4.52	2.2
□ B( ) ☑ M(1) □ E( )	Measuring time	04:14 / 04:15				
□ Test water □ Control water ☑ Treated water □ Neutralized water	R1	8.28	18.41	33.52	4.40	2.1
	R2	8.27	18.37	33.41	4.37	2.3
	R3	8.26	18.33	33.41	4.38	1.7
□ B( ) ☑ M(2) □ E( )	Measuring time	04:23 / 04:24				
□ Test water □ Control water ☑ Treated water □ Neutralized water	R1	8.27	18.53	33.44	4.17	2.1
	R2	8.26	18.45	33.39	4.18	2.6
	R3	8.25	18.42	33.39	4.28	2.2
□ B( ) ☑ M(3) □ E( )	Measuring time	04:33 / 04:34				
□ Test water □ Control water ☑ Treated water □ Neutralized water	R1	8.26	18.59	33.46	4.10	1.7
	R2	8.25	18.52	33.31	4.20	2.1
	R3	8.26	18.45	33.39	4.05	1.7
□ B( ) □ M( ) ☑ E(1)	Measuring time	04:41 / 04:42				
□ Test water □ Control water ☑ Treated water □ Neutralized water	R1	8.27	18.59	33.54	4.06	2.3
	R2	8.27	18.48	33.37	4.10	2.0
	R3	8.27	18.40	33.41	4.11	1.8
□ B( ) □ M( ) ☑ E(2)	Measuring time	04:50 / 04:51				
□ Test water □ Control water ☑ Treated water □ Neutralized water	R1	8.28	18.50	33.43	4.10	13.8
	R2	8.27	18.40	33.35	4.10	11.0
	R3	8.26	18.38	33.34	4.12	6.7
□ B( ) □ M( ) ☑ E(3)	Measuring time	04:59 / 05:00				
Remarks						
Working Date	May 30th			Study Personnel	Young In Song (sign)	
Confirming Date	May 30th			Confirmed by	Lee JT Sun (sign)	

TOC measurement sheet

2014

Study number		**Test number**	SET-14-002
Method	High Temperature Combustion	**Equipment**	Vario TOC cube
Sampling day	Day 0	**Reception time of test substances**	
Measuring start time	May 30 11:00	**Measuring end time**	May 30 23:00

Parameter / Sample ID & lot No.	TOC (mg/L)	DOC (mg/L)	POC (mg/L)	Remarks
HL-S03UW-B	4.125 4.235 4.111 Aver. : 4.157	2.253 2.145 2.114 Aver. : 2.171	1.986	
HL-S03UW-M	4.534 4.544 4.912 Aver. : 4.663	2.420 1.877 2.298 Aver. : 2.199	2.465	
HL-S03UW-E	4.702 4.871 4.912 Aver. : 4.852	2.420 2.614 2.423 Aver. : 2.486	2.366	
	Aver. :	Aver. :		
	Aver. :	Aver. :		
	Aver. :	Aver. :		
Remarks	* POC = TOC - DOC			

Working date	May 30th	**Study personnel**	Lee JT-Sun (sign)
Confirmation date		**Confirmed by**	(sign)
Certificate date	May 30th	**Study director**	Lee JT-Sun (sign)

TSS(Total suspended solid) measurement sheet

20 14 5.28

Study number	HAN - Ship (1)	Test number	SET-14-002
Test period	5.28 - 6.29	Equipments	Dry oven, Balance, Desiccator
Reception time of test substances	23 : 10	Sample pretreatment time	23 : 00

Sample ID (Lot No.)	R[1]	Sample Volume (mL)	Filter paper Weight - ① (g)	① + SS Weight (g)	SS Weight (g)	Result (mg/L)	Average (mg/L)
SO2UW-B	R1	250	26.1610	26.1635	0.025	10.0	11.6
	R2	250	26.2991	26.3003	0.0012	4.8	
	R3	250	25.3506	25.3526	0.0020	8.0	
SO2UW-M	R1	250	26.5338	26.5354	0.0016	6.4	11.5
	R2	250	25.0562	25.0580	0.0018	7.2	
	R3	250	24.3122	24.3144	0.0022	8.8	
SO2UW-B	R1	250	26.4920	26.4989	0.0069	27.6	14.0
	R2	250	26.3076	26.3101	0.0025	10.0	
	R3	250	25.4116	25.4127	0.0011	4.4	
	R1						
	R2						
	R3						
	R1						
	R2						
	R3						
	R1						
	R2						
	R3						

Remarks

Working Date	May . 29	Study Personnel	Lee JT Sun (sign)
Certificate Date	May . 29	Study Director	Lee JT Sun (sign)

[1] Replicate

Microbiology Test Sheet

2014

Study number	HAN – Ship(1)	Test number	SET-14-002
Sampling Time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		
Test substance	☑ Uptake water E □ Discharge control water □ Discharge treated water □ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team. 25.0 ±0.5 °C, Humidity : 40 ±2 % P.H. /End : Team. 24.0 ±0.5 °C, Humidity : 40 % P.H.		

Test condition

Medium name	□ Marine agar ☑ Aerobic Counter Plate □ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate ☑ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC ☑ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC □ mEI ☑ TCBS
Manufacturing date		2014. 5. 19	2014. 5. 19	2014. 5. 19
Test method	□ Membrane filter □ Spread method ☑ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	☑ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ ☑ 44.5 ℃ ( )	□ 25 ℃ □ 35.0 ℃ ( ) ☑ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )
Culture period	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	☑ 2 hr ( ) ☑ 22 hr ( ) □ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )
Time (Start/End)	20:18 / 20:25	20:25 / 20:41	20:25 / 20:41	20:25 / 20:41
Volume (mL)	1 / 1	25 / 100	25 / 100	25 / 100
Dilution factor	50 / 200			
Test substance	E / E	E / E	E / E	E / E

Remarks: The test of bacteria can have sample holding time.
(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	2014. 05. 20	Personnel	이여은 (sign)
Confirming date	2014. 05. 20	Confirmed by	김은 (sign)

Busan Techno-Park
Marine Bio-industry Development Center

Microbiology Test Sheet

2014

Study number	HAN - Sh7p	Test number	SET -14-002
Sampling Time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		
Test substance	☑ Uptake water ☑ M □ Discharge control water □ Discharge treated water □ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team. 25.9℃ ±0.5, Humidity : 49 ±2 % P.H. /End : Team. 25.8℃ ±0.5, Humidity : 49 ±2 % P.H.		

Test condition

Medium name	□ Marine agar ☑ Aerobic Counter Plate □ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate ☑ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC ☑ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC □ mEI ☑ TCBS
Manufacturing date		2014.5.19	2014.5.19	2014.5.19
Test method	□ Membrane filter □ Spread method ☑ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	☑ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) ☑ 41 ℃ ☑ 44.5 ℃ ( )	□ 25 ℃ □ 35.0 ℃ ( ) ☑ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )
Culture period	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	☑ 2 hr ( ) ☑ 22 hr ( ) □ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )
Time (Start/End)	18:58 / 19:01	19:03 / 19:23	19:03 / 19:23	1903 / 19:23
Volume (mL)	1 / 1	25 / 100	25 / 100	25 / 100
Dilution factor	60 / 200			
Test substance	M / M	M / M	M / M	M / M

Remarks: The test of bacteria can have sample holding time.

(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	2014. 05. 28	Personnel	이 [illegible] (sign)
Confirming date	2014. 05. 28	Confirmed by	[illegible] (sign)

Busan Techno-Park
Marine Bio-industry Development Center

Microbiology Test Sheet

2014

Study number	HAN-Ship ( )	**Test number**	SET-14-002
Sampling Time	☑ Day 0 ☐ Day 1 ☐ Day 2 ☐ Day 3 ☐ Day 4 ☐ Day 5 ☐ Other( )		
Test substance	☑ Uptake water B ☐ Discharge control water ☐ Discharge treated water ☐ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team. 26.1℃ Lot, Humidity : 49 % Lot P.H. /End : Team. 25.9℃ Lot, Humidity : 49 % Lot P.H.		

Test condition

Medium name	☐ Marine agar ☑ Aerobic Counter Plate ☐ mTEC ☐ mEI ☐ TCBS	☐ Marine agar ☐ Aerobic Counter Plate ☑ mTEC ☐ mEI ☐ TCBS	☐ Marine agar ☐ Aerobic Counter Plate ☐ mTEC ☑ mEI ☐ TCBS	☐ Marine agar ☐ Aerobic Counter Plate ☐ mTEC ☐ mEI ☑ TCBS
Manufacturing date		2014.5.19	2014.5.19	2014.5.19
Test method	☐ Membrane filter ☐ Spread method ☑ 3M™ Petri film	☑ Membrane filter ☐ Spread method ☐ 3M™ Petri film	☑ Membrane filter ☐ Spread method ☐ 3M™ Petri film	☑ Membrane filter ☐ Spread method ☐ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	☑ 25 ℃ ☑ 35.0 ℃ ( ) ☐ 41 ℃ ☐ 44.5 ℃ ( )	☐ 25 ℃ ☑ 35.0 ℃ ( ) ☐ 41 ℃ ☑ 44.5 ℃ ( )	☐ 25 ℃ ☐ 35.0 ℃ ( ) ☑ 41 ℃ ☐ 44.5 ℃ ( )	☐ 25 ℃ ☑ 35.0 ℃ ( ) ☐ 41 ℃ ☐ 44.5 ℃ ( )
Culture period	☐ 2 hr ( ) ☐ 22 hr ( ) ☑ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )	☑ 2 hr ( ) ☑ 22 hr ( ) ☐ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )	☐ 2 hr ( ) ☐ 22 hr ( ) ☑ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )	☐ 2 hr ( ) ☐ 22 hr ( ) ☑ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )
Time (Start/End)	17:50 / 18:00	18:01 / 18:31	18:01 / 18:31	18:01 / 18:31
Volume (mL)	1 / 1	25 / 100	25 / 100	25 / 100
Dilution factor	50 / 200			
Test substance	B / B	B / B	B / B	B / B

Remarks: The test of bacteria can have sample holding time.
(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	2014. 05. 29	**Personnel**	이여희 (sign)
Confirming date	2014. 05. 28	**Confirmed by**	이지연 (sign)

Microbiology Test Sheet

2014

Study number	HAN - ship	Test number	SET -14 -002
Sampling Time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		
Test substance	□ Uptake water ☑ Discharge control water ☑ B □ Discharge treated water □ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team. 24.3℃, Humidity : 41% P.H. /End : Team. 24.4℃, Humidity 42 % P.H.		

Test condition

Medium name	□ Marine agar ☑ Aerobic Counter Plate □ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate ☑ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC ☑ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC □ mEI ☑ TCBS
Manufacturing date		5.29	5.29	5.29
Test method	□ Membrane filter □ Spread method ☑ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ ☑ 44.5 ℃ ( )	□ 25 ℃ □ 35.0 ℃ ( ) ☑ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )
Culture period	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	☑ 2 hr ( ) ☑ 22 hr ( ) □ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )
Time (Start/End)	2:36 / 2:46	2:53 / 3:09	2:53 / 3:09	2:53 / 3:09
Volume (mL)	1 / 1	~~25~~ / 100	~~25~~ / 100	~~25~~ / 100
Dilution factor	X10 / X50	' / '	' / '	' / '
Test substance	C-B / C-B	~~C-B~~ / C-B	~~C-B~~ / C-B	~~C-B~~ / C-B

Remarks: The test of bacteria can have sample holding time.

(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	May 30	Personnel	Lee Myung Ha (sign)
Confirming date	May 30	Confirmed by	Lee JT Sun (sign)

BSMB-QS-06-04(2)

Busan Techno-Park
Marine Bio-industry Development Center

Microbiology Test Sheet

2014

Study number	HAN - Ship	**Test number**	SET - 14 - 002
Sampling Time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		
Test substance	□ Uptake water ☑ Discharge control water □ Discharge treated water □ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team. 24.4 ℃, Humidity : 42 % P.H. /End : Team. 25.1 ℃, Humidity : 43 % P.H.		

Test condition

Medium name	□ Marine agar ☑ Aerobic Counter Plate □ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate ☑ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC ☑ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC □ mEI ☑ TCBS
Manufacturing date		5.27	5.27	5.29
Test method	□ Membrane filter □ Spread method ☑ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ (1) □ 41 ℃ ☑ 44.5 ℃ (2)	□ 25 ℃ □ 35.0 ℃ ( ) ☑ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )
Culture period	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	☑ 2 hr (1) ☑ 22 hr (2) □ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )
Time (Start/End)	2:36 / 2:52	3:10 / 3:17	3:10 / 3:17	3:10 / 3:17
Volume (mL)	1 / 1	~~25~~ / 100	~~25~~ / 100	~~25~~ / 100
Dilution factor	x10 / x50			
Test substance	C-M / C-M	~~C-M~~ / C-M	~~C-M~~ / C-M	~~C-M~~ / C-M

Remarks: The test of bacteria can have sample holding time.
(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	May 30	**Personnel**	Lee Myung Lee (sign)
Confirming date	May 30	**Confirmed by**	Lee Ot-Sun (sign)

Microbiology Test Sheet

2014

Study number	HAN - Ship	Test number	SET-14-002
Sampling Time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		
Test substance	□ Uptake water ☑ Discharge control water ☑ Discharge treated water □ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team. 25℃, Humidity : 43 % P.H. /End : Team. 26.2℃, Humidity : 41 % P.H.		

Test condition

Medium name	□ Marine agar ☑ Aerobic Counter Plate □ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate ☑ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC ☑ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC □ mEI ☑ TCBS
Manufacturing date		5.27	5.27	5.29
Test method	□ Membrane filter □ Spread method ☑ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ ☑ 44.5 ℃ ( )	□ 25 ℃ □ 35.0 ℃ ( ) ☑ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )
Culture period	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	☑ 2 hr ( ) ☑ 22 hr ( ) □ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )
Time (Start/End)	3:27 / 3:31	3:17 / 3:27	3:17 / 3:27	3:17 / 3:27

Volume (mL)	1	1			~~25~~	100			~~25~~	100			~~25~~	100		
Dilution factor	x10	x50														
Test substance	C-E	C-E			~~C-E~~	C-E			~~C-E~~	C-E			~~C-E~~	C-E		

Remarks: The test of bacteria can have sample holding time.

(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	May 30	Personnel	Lee Hyunshee (sign)
Confirming date	MAY 30	Confirmed by	Lee Ji Sun (sign)

BSMB-QS-06-04(2)

Microbiology Test Sheet

2014

Study number	HAN - ship	**Test number**	SET-14-002
Sampling Time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		
Test substance	□ Uptake water □ Discharge control water ☑ Discharge treated water □ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team. 26.0 ℃, Humidity : 36 % P.H. /End : Team. 26.0 ℃, Humidity : 32 % P.H.		

Test condition

Medium name	□ Marine agar ☑ Aerobic Counter Plate □ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate ☑ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC ☑ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC □ mEI ☑ TCBS
Manufacturing date		5.27	5.27	5.29
Test method	□ Membrane filter □ Spread method ☑ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	□ Membrane filter □ Spread method □ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ ☑ 44.5 ℃ ( )	□ 25 ℃ □ 35.0 ℃ ( ) ☑ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )
Culture period	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	☑ 2 hr ( ) ☑ 22 hr ( ) □ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )

Time (Start/End)	~~B13 / 4:20 / 4:24~~				~~4:13 / 4:20~~		4:00	~~4:13 / 4:20~~		4:00	~~4:13 / 4:20~~		4:00	
	~~B23 4:24~~		4:27		4:27		4:35	4:27		4:35	4:27		4:35	
Volume (mL)	1	1	1	1	100	100	100	100	100	100	100	100	100	
Dilution factor	X10	X50	X10/X50	X10/X50										
Test substance	T-B1	T-B1	T-B2	T-B3	T-B1	T-B2	T-B2	T-B1	T-B2	T-B3	T-B1	T-B2	T-B3	

Remarks: The test of bacteria can have sample holding time.

(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	May 30	**Personnel**	Lee Myoung Lee (sign)
Confirming date	May 30	**Confirmed by**	Lee JT Son (sign)

BSMB-QS-06-04(2)

Microbiology Test Sheet

2014

Study number	HAH - SHIP	Test number	SET -14 -002
Sampling Time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		
Test substance	□ Uptake water □ Discharge control water ☑ Discharge treated water B2 □ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team. 26.1℃, Humidity : 37 % P.H. /End : Team. 26.5℃, Humidity : 38 % P.H.		

Test condition

Medium name	□ Marine agar ☑ Aerobic Counter Plate □ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate ☑ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC ☑ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC □ mEI □ TCBS
Manufacturing date		5.27	5.27	5.29
Test method	□ Membrane filter □ Spread method ☑ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ ☑ 44.5 ℃ ( )	□ 25 ℃ □ 35.0 ℃ ( ) ☑ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )
Culture period	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	☑ 2 hr ( ) ☑ 22 hr ( ) □ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )

Time (Start/End)	4:40 / 4:52		4:43 / 4:57	5:05	4:44 / 4:50	5:05	4:51 / 5:04	5:11	4:44 / 4:57	5:05	4:51 / 5:04	5:11	4:44 / 4:57	5:05	4:51 / 5:04	5:11
Volume (mL)	1	1	1	1	100	100	100		100	100	100		100	100	100	
Dilution factor	X10	X50	X10/X50	X10/X50	/	/	/		/	/	/		/	/	/	
Test substance	T-M1	T-M1	T-M2	T-M2	T-M1	T-M2	T-M3		T-M1	T-M2	T-M3		T-M1	T-M2	T-M3	

Remarks: The test of bacteria can have sample holding time.

(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	May 30	Personnel	Lee Myounghee (sign)
Confirming date	May 30	Confirmed by	Lee JT Sup (sign)

BSMB-QS-06-04(2)

Microbiology Test Sheet

2014

Study number	HAM-SHIP	**Test number**	SET-14-002
Sampling Time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		
Test substance	□ Uptake water □ Discharge control water ☑ Discharge treated water □ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team: 26.5℃, Humidity : 78 % P.H. /End : Team: 26.5℃, Humidity : 78 % P.H.		

Test condition

Medium name	□ Marine agar ☑ Aerobic Counter Plate □ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate ☑ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC ☑ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC □ mEI ☑ TCBS
Manufacturing date		5.27	5.27	5.29
Test method	□ Membrane filter ☑ Spread method ☑ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ ☑ 44.5 ℃ ( )	□ 25 ℃ □ 35.0 ℃ ( ) ☑ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )
Culture period	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	☑ 2 hr ( ) ☑ 22 hr ( ) □ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )
Time (Start/End)	5:17 5:27 5:34 / 5:28 5:44 6:01	5:29 5:44 6:01 / 5:37 5:53 6:09	5:29 5:44 6:01 / 5:37 5:53 6:09	5:29 5:44 6:01 / 5:39 5:53 6:09
Volume (mL)	1 1 1	100 100 100	100 100 100	100 100 100
Dilution factor	x10/x50 x10/x50 x10/x50	/ / /	/ / /	/ / /
Test substance	T-E1 T-E2 T-E3	T-E1 T-E2 T-E3	T-E1 T-E2 T-E3	T-E1 T-E2 T-E3

Remarks: The test of bacteria can have sample holding time.

(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	May 20	**Personnel**	Myounghee Lee (sign)
Confirming date	May 20	**Confirmed by**	Lee JT Suh (sign)

BSMB-QS-06-04(2)

Test Result Sheet with Microbiology

204

Study number	HAN - SHIP	Test number	SET - 14 - 002
Sample type	☑1. Uptake water □ 2. Discharge control water □ 3. Discharge treated water □ 4. Other( )		
Sampling time	☑Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □Other ( )		
Medium name	□ A-1. Marine agar(Heterotrophic bacteria) ☑ A-2. Aerobic Counter Plate(Heterotrophic bacteria) ☑B. mTEC(*E.coli*) ☑C. mEI(Intestinal Enterococci) □ D. TCBS (Vibrio cholera)		

Test Result

Sample Type	Medium name	Test substance	Test method	Sample vol. (mL)	D[a] factor	CFU/Plate R1	R2	R3
5.29 1. Uptake water.	A-2.	S03UWB	□ M.F.[b] □ S[c] ☑P.F.[d]	1	50	2	1	2
		S03UWB	□ M.F.[b] □ S[c] ☑P.F.[d]	1	200	0	0	0
		S03UWM	□ M.F.[b] □ S[c] ☑P.F.[d]	1	50	2	2	0
		S03UWM	□ M.F.[b] □ S[c] ☑P.F.[d]	1	200	0	0	0
		S03UWE	□ M.F.[b] □ S[c] ☑P.F.[d]	1	50	1	0	1
		S03UWE	□ M.F.[b] □ S[c] ☑P.F.[d]	1	200	0	0	0
	B.	S03UWB	☑ M.F.[b] □ S[c] □P.F.[d]	25		13	11	10
		S03UWB	☑ M.F.[b] □ S[c] □P.F.[d]	100		43	53	61
		S03UWM	☑ M.F.[b] □ S[c] □P.F.[d]	25		19	23	26
		S03UWM	☑ M.F.[b] □ S[c] □P.F.[d]	100		67	72	64
		S03UWE	☑ M.F.[b] □ S[c] □P.F.[d]	25		3	9	8
		S03UWE	☑ M.F.[b] □ S[c] □P.F.[d]	100		30	29	43
	C	S03UWB	☑ M.F.[b] □ S[c] □P.F.[d]	25		12	17	11
		S03UWB	☑ M.F.[b] □ S[c] □P.F.[d]	100		40	37	40
		S03UWM	☑ M.F.[b] □ S[c] □P.F.[d]	25		8	6	9
		S03UWM	☑ M.F.[b] □ S[c] □P.F.[d]	100		42	35	33
		S03UWE	☑ M.F.[b] □ S[c] □P.F.[d]	25		3	2	0
		S03UWE	☑ M.F.[b] □ S[c] □P.F.[d]	100		9	7	9

Remaks

Working date	29 th May	Personnel	Lee · Myung hee (sign)
Confirming date	29th May	Confirmed by	Kim Hui-Jeong (sign)

a) dilution, b) membrane filter, c) spreading, d) petri film

BSMB-QS-06-05(2)

Test Result Sheet with Microbiology

2014

Study number	HAM-Ship	Test number	SET-14-002
Sample type	□ 1. Uptake water ☑ 2. Discharge control water □ 3. Discharge treated water □ 4. Other( )		
Sampling time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □Other ( )		
Medium name	□ A-1. Marine agar(Heterotrophic bacteria) ☑ A-2. Aerobic Counter Plate(Heterotrophic bacteria) ☑ B. mTEC(*E.coli*) ☑ C. mEI(Intestinal Enterococci) □ D. TCBS (Vibrio cholera)		

Test Result

Sample Type	Medium name	Test substance	Test method	Sample vol. (mL)	D[a] factor	CFU/Plate R1	R2	R3
5.31 2. Discharge Control water	A-2.	SCD2-B	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	X10	5	20	9
		SCD2-B	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	X50	1	1	0
		SCD2-M	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	X10	7	6	6
		SCD2-M	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	X50	0	1	0
		SCD2-E	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	X10	8	7	11
		SCD2-E	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	X50	2	1	0
	B m-mTEC	SCD2-B	☑ M.F.[b] □ S[c] □ P.F.[d]	100		16	11	19
		SCD2-M	☑ M.F.[b] □ S[c] □ P.F.[d]	100		20	9	10
		SCD2-E	☑ M.F.[b] □ S[c] □ P.F.[d]	100		12	13	17
	E. mEI	SCD2-B	☑ M.F.[b] □ S[c] □ P.F.[d]	100		14	16	23
		SCD2-M	☑ M.F.[b] □ S[c] □ P.F.[d]	100		22	23	15
		SCD2-E.	☑ M.F.[b] □ S[c] □ P.F.[d]	100		21	12	17
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					

Remaks

Working date	May 31.	Personnel	Lee Myoung hee (sign)
Confirming date	May 31	Confirmed by	Kim Hui-Jeong (sign)

a) dilution, b) membrane filter, c) spreading, d) petri film

BSMB-QS-06-05(2)

Test Result Sheet with Microbiology

2014

Study number	HAN-Ship	Test number	SET-14-002
Sample type	□ 1. Uptake water □ 2. Discharge control water ☑ 3. Discharge treated water □ 4. Other( )		
Sampling time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other ( )		
Medium name	□ A-1. Marine agar(Heterotrophic bacteria) ☑ A-2. Aerobic Counter Plate(Heterotrophic bacteria) □ B. mTEC(*E.coli*) □ C. mEI(Intestinal Enterococci) □ D. TCBS (Vibrio cholera)		

Test Result

Sample Type	Medium name	Test substance	Test method	Sample vol. (mL)	D[a] factor	CFU/Plate R1	R2	R3
3. Discharge treated water	A-2. Aerobic counter plate	STD2-B1	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	x10	7	5	9
		STD2-B1	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	x50	3	3	1
		STD2-B2	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	x10	4	5	3
		STD2-B2	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	x50	0	2	2
		STD2-B3	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	x10	2	0	2
		STD2-B3	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	x50	0	0	1
		STD2-M1	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	x10	5	6	6
		STD2-M1	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	x50	1	3	3
		STD2-M2	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	x10	6	3	3
		STD2-M2	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	x50	1	1	0
		STD2-M3	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	x10	1	3	2
		STD2-M3	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	x50	1	2	1
		STD2-E1	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	x10	0	3	1
		STD2-E1	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	x50	0	1	1
		STD2-E2	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	x10	3	3	6
		STD2-E2	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	x50	1	1	1
		STD2-E3	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	x10	0	1	2
		STD2-E3	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	x50	0	0	0

Remaks

Working date	May 31	Personnel	Lee, Myoung hee (sign)
Confirming date	May 31	Confirmed by	Kim Hui-Jeong (sign)

a) dilution, b) membrane filter, c) spreading, d) petri film

BSMB-QS-06-05(2)

Test Result Sheet with Microbiology

2014

Study number	HAN-SHIP	Test number	STE-14-002
Sample type	□ 1. Uptake water □ 2. Discharge control water ☑ 3. Discharge treated water □ 4. Other( )		
Sampling time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other ( )		
Medium name	□ A-1. Marine agar(Heterotrophic bacteria) □ A-2. Aerobic Counter Plate(Heterotrophic bacteria) ☑ B. mTEC(*E.coli*) ☑ C. mEI(Intestinal Enterococci) □ D. TCBS (Vibrio cholera)		

Test Result

Sample Type	Medium name	Test substance	Test method	Sample vol. (mL)	D[a] factor	CFU/Plate R1	R2	R3
3 Discharge treated water	B m-mTEC	STD2-B1	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		STD2-B2	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		STD2-B3	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		STD2-M1	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		STD2-M2	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		STD2-M3	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		STD2-E1	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		STD2-E2	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		STD2-E3	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
	C. mEI.	STD2-B1	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		STD2-B2	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		STD2-B3	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		STD2-M1	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		STD2-M2	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		STD2-M3	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		STD2-E1	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		STD2-E2	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		STD2-E3	□ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0

Remaks

Working date	May 31.	Personnel	Lee Myounghee (sign)
Confirming date	May 31	Confirmed by	Kim Mui-Jeong (sign)

a) dilution, b) membrane filter, c) spreading, d) petri film

BSMB-QS-06-05(2)

Test Result Sheet with Microbiology

2014

Study number	HAN - Ship	Test number	SET - 14 - 002
Sample type	☑1. Uptake water □ 2. Discharge control water □ 3. Discharge treated water □ 4. Other( )		
Sampling time	☑Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □Other ( )		
Medium name	□ A-1. Marine agar(Heterotrophic bacteria) ☑A-2. Aerobic Counter Plate(Heterotrophic bacteria) ☑B. mTEC(*E.coli*) ☑C. mEI(Intestinal Enterococci) ☑D. TCBS (Vibrio cholera)		

Test Result

Sample Type	Medium name	Test substance	Test method	Sample vol. (mL)	D[a)] factor	CFU/Plate R1	R2	R3
	A-2	증류수	□ M.F.[b)] □ S[c)] □P.F.[d)]	1	-	0		
	B	배지	□ M.F.[b)] □ S[c)] □P.F.[d)]	-	-	0		
		증류수	□ M.F.[b)] □ S[c)] □P.F.[d)]	-	-	0		
	C	배지	□ M.F.[b)] □ S[c)] □P.F.[d)]	-	-	0		
		증류수	□ M.F.[b)] □ S[c)] □P.F.[d)]	-	-	0		
	D	배지	□ M.F.[b)] □ S[c)] □P.F.[d)]	-	-	0		
		증류수	□ M.F.[b)] □ S[c)] □P.F.[d)]			0		
			□ M.F.[b)] □ S[c)] □P.F.[d)]					
			□ M.F.[b)] □ S[c)] □P.F.[d)]					
			□ M.F.[b)] □ S[c)] □P.F.[d)]					
			□ M.F.[b)] □ S[c)] □P.F.[d)]					
			□ M.F.[b)] □ S[c)] □P.F.[d)]					
			□ M.F.[b)] □ S[c)] □P.F.[d)]					
			□ M.F.[b)] □ S[c)] □P.F.[d)]					
			□ M.F.[b)] □ S[c)] □P.F.[d)]					
			□ M.F.[b)] □ S[c)] □P.F.[d)]					
			□ M.F.[b)] □ S[c)] □P.F.[d)]					
			□ M.F.[b)] □ S[c)] □P.F.[d)]					

Remaks

Working date	31th May	Personnel	Myunghee, Lee (sign)
Confirming date	31th May	Confirmed by	Kim Hui-Jeong (sign)

a) dilution, b) membrane filter, c) spreading, d) petri film

BSMB-QS-06-05(2)

Vibrio cholerae O1, O139

2014

Study Number	Han - Ship	Test Number	SET-14-002
Sample type	☑ Uptake water □ Discharge control water □ Discharge treated water □ Other( )		
Sampling time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		

1. Procedures

- ☑ Each yellow sucrose fermenting colonies are placed on Non-salt Alkaline Pepton water.
- ☑ Incubate at 36°C ± 1 °C for 6-18 hours.
- ☑ Presumptive positive colonies are performed using slide agglutination assays by O1 and O139 antiserum for serological identification.

2. Results

Test substance	O1	O139	Sum
S03 UW B	0	0	0
S03 UW M	0	0	0
S03 UW E	0	0	0

3. Remarks

Working date	30 th May	Study personnel	Myounghee, Lee (sign)
Confirming date	30th May	Confirmed by	Kim Hui-Jeong (sign)

Worksheet-Microbiology-003-2(2)

Vibrio cholerae O1, O139

2014

Study Number	HAN Ship	Test Number	SET-14-002.
Sample type	□ Uptake water ☑ Discharge control water ☑ Discharge treated water □ Other( )		
Sampling time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		

1. Procedures

☑ Each yellow sucrose fermenting colonies are placed on Non-salt Alkaline Pepton water.

☑ Incubate at 36°C ± 1 °C for 6-18 hours.

☑ Presumptive positive colonies are performed using slide agglutination assays by O1 and O139 antiserum for serological identification.

2. Results

Test substance	O1	O139	Sum
HL-S03 TD2-B	O	O	O
HL-S03 CD2-M	O	O	O
HL-S03 CD2-E	O	O	O
HL-S03 TD2-B1	O	O	O
HL-S03 TD2-B2	O	O	O
HL-S03 TD2-B3	O	O	O
HL-S03 TD2-M1	O	O	O
HL-S03 TD2-M2	O	O	O
HL-S03 TD2-M3	O	O	O
HL-S03 TD2-E1	O	O	O
HL-S03 TD2-E2	O	O	O
HL-S03 TD2-E3	O	O	O

3. Remarks

Working date	21th May	Study personnel	Lee, Myounghee (sign)
Confirming date	21th May	Confirmed by	Kim Hui-Jeong (sign)

Test Result Sheet - Classification (II)

2014

Study number	HAN - ship	**Test number**	SET-14-002
Test substance	Uptake water	**Lot. No.**	—
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	**Method**	☐ Direct ☑ Dye (FDA)
Concentration	—	**Receive time of test substance**	—
Test start time	17 : 50	**Test end time**	19 : 30.

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S0300-B	50 ml.	Ceratium sp.	5	2	0	
		Chaetoceros sp.	1	0	2	
		Alexandrium sp.	20	25	18	
		Akashiwo sp.	10	12	18	
		Skeletonema sp.	0	0	5	
		Gymnodinium sp.	1	2	2	
		Thalassiosira sp.	1	1	4	
		prorocentrum sp.	62	53	40	
		Oxyrrhis sp.	0	2	0	
	100 ml.	Alexandrium sp.	6	3	5	
		Akashiwo sp.	1	0	0	
		prorocentrum sp.	8	10	9	

Remark			
Date	May 28th	**Study personnel**	박수경 (sign)
Certificate date	May 28th	**Study director**	Kim Hui Jeong (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Test Result Sheet - Classification (II)

20 14

Study number	HAN-Ship	**Test number**	SET-14-002
Test substance	Uptake water	**Lot. No.**	—
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	**Method**	☐ Direct ☑ Dye (FDA)
Concentration	—	**Receive time of test substance**	—
Test start time	19:45	**Test end time**	20:30

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S03UW-M	500ml.	Thalassiosira sp.	4	0	0	
		Ceratium sp.	2	1	1	
		Alexandrium sp.	10	20	9	
		Akashiwo sp.	13	11	16	
		prorocentrum sp.	84	70	60	
		~~Ceratium~~				
		~~prorocen~~				
	100ml.	Alexandrium sp.	1	4	0	
		prorocentrum sp.	15	14	10	
		Akashiwo sp.	0	0	4	
		Ceratium sp.	0	0	3	

Remark			
Date	May 28th	**Study personnel**	박나라 (sign)
Certificate date	May 28th	**Study director**	Kim Mi-Jeong (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Test Result Sheet - Classification (II)

2014

Study number	HAN-ship	**Test number**	SET-14-002
Test substance	Uptake water	**Lot. No.**	—
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	**Method**	☐ Direct ☑ Dye (FDA)
Concentration	—	**Receive time of test substance**	—
Test start time	20 : 50	**Test end time**	21 : 25

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S030W-E	500 μl.	Ceratium sp.	1	2	1	
		Alexandrium sp.	4	5	9	
		Thalassiosira sp.	5	0	1	
		Akashiwo sp.	6	15	20	
		Gymnodinium sp.	1	0	1	
		Skeletonema sp.	4	6	0	
		Oxyrrhis sp.	~~60~~ 0	0	1	
	~~100 μl.~~	~~Al~~ Prorocentrum sp.	60	70	60	
	100 μl.	Akashiwo sp.	4	3	0	
		Alexandrium sp.	3	4	4	
		Prorocentrum sp.	10	7	6	

Remark			
Date	May 28th	**Study personnel**	Park Hy 4-Pb (sign)
Certificate date	May 28th	**Study director**	KMu Mi Jeong (sign)

* R: Replicate

Test Result Sheet - Classification (II)

2014

Study number		Test number	SET-14-002
Test substance	HL-S03CD2-B.M	Lot. No.	
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	Method	☐ Direct ☑ Dye (FDA)
Concentration	—	Receive time of test substance	—
Test start time	2:41	Test end time	4:40

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S03CD2-B (2:41~3:30)	500μl.	prorocentrum sp.	15	22	26	
		Lectocylindrus sp.	3	3		
		Alexandrium sp.	~~1~~	0	1	
		chaetoceros sp.	4	0	0	
		Thalassiosira sp.	3	3	5	
		Skeletonema sp.	2	0	2	
		Eucampia sp.	0	1	0	
		Ceratium sp.	0	1	0	
		Oxyphysis sp.	0	1	0	
HL-S03CD2-M (3:50~4:40)	500μl	Alexandrium sp.	6	2	4	
		Lectocylindrus sp.	2	2	1	
		Eucampia sp.	1	0	0	
		Gyrodinium sp.	1	0	0	
		prorocentrum sp.	15	18	20	
		Ceratium sp.	0	2	5	
		Thalassiosira sp.	0	2	3	
		Gymnodinium sp.	0	1	1	
		Skeletonema sp.	0	5	0	
		protoperidinium sp.	0	0	1	

Remark			
Date	May 30th	Study personnel	Park Na kyung (sign)
Certificate date	May 30th	Study director	Sun ok Lee (sign)

* R: Replicate

Test Result Sheet - Classification (II)

20 14

Study number		Test number	SET-14-002
Test substance	HL-S03C02-E	Lot. No.	
Organism	☑ 10 to 50 μm ☐ ≥ 50 μm	Method	☐ Direct ☑ Dye (FDA)
Concentration	—	Receive time of test substance	—
Test start time	4:40	Test end time	5:10

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S03C02-E (4:40 ~ 5:10)	500 ml.	prorocentrum sp.	20	24	18	
		Alexandrium sp.	6	2	4	
		Ceratium sp.	3	5	7	
		Akashiwo sp.	1	3	2	
		protoperidinium sp	1	0	0	
		Lectocylindrus sp.	1	3	6	
		Thalassiosira sp.	2	3	4	
		Gymnodinium sp.	0	0	1	

Remark			
Date	May 30th	Study personnel	Pork Na Kyung (sign)
Certificate date	May 30th	Study director	Sun ok Lee (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Test Result Sheet - Classification (II)

20 14

Study number		**Test number**	SET-14-002
Test substance	HL-S03TD2-B	**Lot. No.**	
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	**Method**	☐ Direct ☑ Dye (FDA)
Concentration	10ℓ → 500mL	**Receive time of test substance**	—
Test start time	5:10	**Test end time**	6:00

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S03TD2-B1	500ℓ	Akashiwo sp.	1	0	1	
		Ceratium sp.	1	0	0	
		prorocentrum sp.	0	1	2	
HL-S03TD2-B2	500ℓ	Thalassiosira sp.	1	0	0	
		Akashiwo sp.	0	1	0	
		Ceratium sp.	0	0	1	
HL-S03TD2-B3	500ℓ	Alexandrium sp.	1	0	1	
		Thalassiosira sp.	0	1	0	
		prorocentrum sp.	0	0	1	

Remark			
Date	May 30th	**Study personnel**	Park Na Kyung (sign)
Certificate date	May 30th	**Study director**	Sun ok Lee (sign)

* R: Replicate

Test Result Sheet - Classification (II)

20 14

Study number		Test number	SET-14-002
Test substance	HL-S03TD2-M	Lot. No.	~~SET-14-002~~ a)
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	Method	☐ Direct ☑ Dye (FDA)
Concentration	10l → 500mL	Receive time of test substance	—
Test start time	6:00	Test end time	6:50

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S03TD2-M1	500μl	Thalassiosira sp.	~~1~~	0	2	
		Akashiwo sp.	0	2	1	
		Alexandrium sp.	0	1	1	
HL-S03TD2-M2	500μl	prorocentrum sp.	3	0	1	
		Akashiwo sp.	0	1	0	
		Thalassiosira sp.	0	1	1	
HL-S03TD2-M3	500μl	prorocentrum sp.	1	1	1	
		Thalassiosira sp.	0	0	1	

Remark	a) corrected Sun ok Lee MK 05.30		
Date	May 30th	Study personnel	Park Na kyung (sign)
Certificate date	May 30th	Study director	Sun ok Lee (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Test Result Sheet - Classification (II)

2014

Study number		Test number	SET-14-002
Test substance	HL-S03TD2-E	Lot. No.	
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	Method	☐ Direct ☑ Dye (FDA)
Concentration	10 l → 500 mL	Receive time of test substance	—
Test start time	6:50	Test end time	8:00

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S03TD2-E1	500 μl	ceratium sp.	1	0	0	
		prorocentrum sp.	2	2	1	
HL-S03TD2-E2	500 μl	prorocentrum sp	1	0	0	
		Akashiwo sp.	0	0	1	
HL-S03TD2-E3	500 μl	—	0	0	0.	

Remark			
Date	May 30th	Study personnel	Park Na Kyung (sign)
Certificate date	May 30th	Study director	Sun ok Lee (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Worksheet-Plankton–003(1)

Test Result Sheet - Classification (II)

2014

Study number	HAN-Ship	Test number	SET-14-002
Test substance	Uptake water	Lot. No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 1000ml	Receive time of test substance	
Test start time	19:14	Test end time	20:59

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S03UW-B	10ml	Acartia sp.	13	9	13	
		Paracalanus parvus s.l.	8	7	10	
		Evadne tergestina		4	5	
		Podon sp. (polyphemoides)	5	3	5	
		Corycaeus sp.	1		3	
		Oithona sp.	5	4	3	
		Cirriped larvae	5	6	3	
HL-S03UW-M	10ml	Cirriped larvae	11	7	7	
		Acartia sp.	4	3	5	
		Paracalanus parvus s.l.	3	4	4	
		Oithona sp.	4	3	3	
		Polychaeta larvae	1	5	3	
		nauplius	1	1	2	
		Podon sp. (polyphemoides)	3	2	2	
		Evadne tergestina	1			
		Pseudodiaptomus marinus		1		
		Hemycyclops sp.		1	1	

Remark	24°C 46%		
Date	May 28	Study personnel	Seok Ju Lee (sign)
Certificate date	May 28	Study director	Kim Hui-Jeong (sign)

* R: Replicate

Test Result Sheet - Classification (II)

2014

Study number	HAN-Ship	Test number	SET-14-002
Test substance	Uptake water	Lot No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 1000ml	Receive time of test substance	
Test start time	18:14	Test end time	20:59

Test site	Counting volume	Classification	Number of organism R1	R2	R3	Minimum dimension (μm)
HL-03000-E	10ml	Acartia sp.	13	15	17	
		Paracalanus parvus s.l.	7	11	7	
		Podon sp.	6	7	3	
		Cirriped larvae	4	5	7	
		Polychaeta larvae	3	4	2	
		Hemicyclops sp.	2		1	
		Oithona sp.	3	2	2	
		nauplius	3	1		
		Corycaeus sp.				

Remark			
Date	May 28	Study personnel	Seok Ju Lee (sign)
Certificate date	May 28	Study director	Kim Hui Jeong (sign)

* R: Replicate

Test Result Sheet - Classification (II)

2014

Study number	—	Test number	SET-14-002
Test substance	HL-503CD2-B	Lot No.	—
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 250ml	Receive time of test substance	00:42
Test start time	00:40	Test end time	01:22

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
~~HL-503CD2-B+~~ HL-503CD2-B	10mL	~~B-1a)~~				
		Polychaeta larvae	6	8	3	
		Oithona similis	1			
		Paracalanus parvus s.l.	12	11	12	
		Acartia erythraea	5			
		nauplius	8	2	2	
		Podon polyphemoides	3			
		Tortanus forcipatus	3			
		Cirripedi larvae	5	1	5	
		Corycaeus sp.	3		2	
		Acartia sp.		16	19	
		Oithona sp.		3	4	
		Harpacticoida sp.		3		

Remark	a) 27마리에 14:30 / 16:20 / 17:20	24.2°C 40RH% : Start 24.3°C 40RH% : END	
Date	May. 30th	Study personnel	Kim Hui-Jeong (sign)
Certificate date	May. 30th	Study director	Sun ok Lee (sign)

* R: Replicate

Test Result Sheet - Classification (II)

2014

Study number	—	Test number	SET-14-002
Test substance	HL-503CD2-M	Lot. No.	—
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 250ml	Receive time of test substance	02:15
Test start time	2:34	Test end time	3:11

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
~~HL-SCS-10~~ a) HL-503CD2-M	10ml	Cirriped larvae	20	24	23	
		Acartia sp.	10	11	9	
		Corycaeus sp.	4	1	3	
		Polychaeta larvae	3	3	3	
		Paracalanus parvus s.l.	4	10	3	
		Oithona sp.	7	7	3	
		Hemycyclops sp.	2	2	4	
		Sagitta crassa	1			
		nauplius	1	1		
		Podon polyphemoides	3	1	1	
	3:11	Pseudodiaptomus marinus		1		

Remark	a) 인기정지 14.5.30 이후	26.3°C 39RH% : Start 26.5°C 39RH% : End	
Date	May, 30th	Study personnel	Lee Seok Ju (sign)
Certificate date	May, 30th	Study director	Sun ok Lee (sign)

* R: Replicate

Test Result Sheet - Classification (II)

20/4

Study number	–	Test number	SET-14-002
Test substance	HL-503CD2-E	Lot No.	–
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 250mL	Receive time of test substance	02:49
Test start time	3:12	Test end time	3:42

Test site	Counting volume	Classification	Number of organism R1	R2	R3	Minimum dimension (μm)
a) ~~HL-503-E~~ HL-503CD2-E	10ml	Cirriped larvae	49	45	55	
		Acartia sp.	14	15	6	
		Polychaeta larvae	4	3	3	
	3:42	Podon sp.	3	3	6	
		Oithona sp.	6	1	2	
		Paracalanus parvus s.l.	11	7	4	
		Corycaeus sp.	1	4	2	
		nauplius		2	2	
		Hemiaycloops sp		4	2	
		Centropages sp.	1		3	

Remark	a) 일기정정 14.5.30 이석주	21.0℃ 39RH% : Start 21.4℃ 39RH% : End	
Date	May, 30th.	Study personnel	Lee Seok Ju (sign)
Certificate date	May, 30th	Study director	Sun-K Lee (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Worksheet-Plankton-003(1)

Test Result Sheet - Classification (II)

2014

Study number	—	Test number	SET-14-002
Test substance	HL-503TD-B.M.E	Lot. No.	—
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1 ton → 250ml	Receive time of test substance	03:48
Test start time	3:49	Test end time	6:23

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-ST5-B1	250ml	Cirriped larvae	3			
		—				
B2	250ml	—	0			
		—				
B3	250ml	—	0			
M1	250ml	—	0			
M2	250ml	—	0			
M3	250ml	—	0			
E1	250ml	—	0			
5:55 E2	250mL	—	0			
~06:01 E3	250mL	—	0			
~06:23						

Remark	27.5°C 38RH% : start 28.2°C 36RH% : end		
Date	May 30th	Study personnel	Lee Seok Ju (sign)
Certificate date	May 30th	Study director	Kim Hui Jeong (sign)

* R: Replicate

4.4 Test 4 report and raw data

Test Report

Project name	EcoGuardian™
Test number	SET-14-003
Port	Gunsan(Korea)-Ballasting
Title	Efficacy test of EcoGuardian™ Ballast Water Management System (shipboard scale)

BUSAN TECHNO PARK

Statement of Quality Assurance

Data were reviewed by Quality Assurance Unit of BTP to assure that the study was performed in accordance with protocol and standard operating procedures (SOP) of Busan Techno-Park(BTP). The report was an accurate reflection of the raw data generated at the BTP. Inspection of the routine and repeated procedures that constitute the study was carried out as a continuous major phase at or about the time this study was in progress.

Inspection Phase		Date		
		Inspection	Report to Testing manager	Report to Project director
Test plan		June 19, 2014	June 19, 2014	June 19, 2014
Sampling	1st	June 22, 2014	June 22, 2014	June 22, 2014
	2nd	-	-	-
Test substance	1st	June 22, 2014	June 22, 2014	June 22, 2014
	2nd	-	-	-
Test procedures (Bacteria test)	1st	-	-	-
	2nd	-	-	-
Observation and counting (≥50㎛, 10㎛-50㎛)	1st	June 22, 2014	June 22, 2014	June 22, 2014
	2nd	-	-	-
Observation and counting (Bacteria test)	1st	-	-	-
	2nd	-	-	-

Seo, Hyo-Jin (Sign) 12th, Dec. 2014

Seo, Hyo-Jin / Project director Date

Study Personnel and Participants

The test participants recognized the study plan, manual, procedure, guide of Busan Techno Park in performing the test.

	Name	Date
Study Personnel	Kim Hui-Jeong (sign)	12th. Dec. 2014
	Lee JT-Sun (sign)	12th, Dec, 2014
	Lee Sun ok (sign)	12th, Dec. 2014.
	Lee Myounghee (sign)	12th Dec, 2014
	(sign)	
	(sign)	
Project director	Seo, Hyo-Jin (sign)	12th. Dec. 2014

Contents

1.Results.....1

1.1 Loading record 1

1.2 Water parameters 1

1.3 Influent water : Uptake water 2

1.4 Elimination efficacy 4

2. Validity 5

3. Conclusion 6

4. Appendix 7

1. Results

1.1 Loading record

Vessel name	SSANG YONG CHANGYAHNG
IMO number	9121027

Water ballast tanks			Sample WGT (Mt)	Loading (Date/Location)	Discharge (Date/Location)
Control	No.3 D/B W.B.T	P, S	1370	June 22nd , 2014 Gunsan (35°58.61N, 126°37.10E)	-
Treated	No.4 D/B W.B.T No.5 D/B W.B.T	P, S	650	-	-

1.2 Water parameters

Table 1. Water parameters at field

Date	Sample ID	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
Day 0	HL-S04UW-B	8.07 ± 0.00	21.95 ± 0.05	33.03 ± 0.01	8.01 ± 0.17	4.9 ± 0.1	-
	HL-S04UW-M	8.13 ± 0.05	22.12 ± 0.01	33.15 ± 0.06	5.34 ± 0.00	5.9 ± 0.6	-
	HL-S04UW-E	8.19 ± 0.01	21.63 ± 0.01	33.22 ± 0.01	5.48 ± 0.01	4.6 ± 0.1	-

Data were presented as mean±S.D of three repeated measurement.

1.3 Influent water : Uptake water

1) ≥ 50 µm organism

Table 2. The survival number of the organism larger than 50 µm

Sample ID	Phyla/Divisions	Species	individuals/m^3	Minimum Dimension (µm)
HL-S04UW-B	Arthropoda	Cirriped larvae	800 ± 265	250 ~ 280
		Acartia sp.	1,233 ± 416	300~325
		Nauplius	700 ± 265	70 ~ 90
		Oithona sp.	1,267 ± 115	80 ~ 150
		Paracalanus parvus s. l.	1,333 ± 153	220 ~ 240
		Decapoda larvae	1,100 ± 361	200 ~ 230
		Centropages sp.	267 ± 306	180 ~ 250
		Acartia hongi	300 ± 520	170 ~ 210
		Oithona similis	133 ± 231	145 ~ 160
	Annelida	Polychaeta larvae	1,033 ± 153	120 ~ 150
HL-S04UW-M	Arthropoda	*Oithona similis*	667 ± 208	145 ~ 160
		Acartia hongi	400 ± 173	170 ~ 210
		Cirriped larvae	400 ± 200	250 ~ 280
		Acartia sp.	967 ± 208	300~325
		Nauplius	200 ± 200	70 ~ 90
		Oithona sp.	1,033 ± 306	80 ~ 150
		Paracalanus parvus s. l.	1,267 ± 306	220 ~ 240
		Parvocalanus crassirostris	367 ± 153	200 ~ 220
		Decapoda larvae	1,167 ± 208	200 ~ 230
		Acartia sinjiensis	233 ± 208	150 ~ 220
	Annelida	Polychaeta larvae	633 ± 306	120 ~ 150
HL-S04UW-E	Arthropoda	*Paracalanus parvus* s. l.	1,067 ± 153	220 ~ 240
		Decapoda larvae	733 ± 153	200 ~ 230
		Acartia hongi	367 ± 321	170 ~ 210
		Oithona similis	1,133 ± 252	145 ~ 160
		Centropages sp.	800 ± 265	180 ~ 250
		Acartia sp.	933 ± 569	150 ~ 220
		Nauplius	100 ± 100	70 ~ 90
		Oithona sp.	233 ± 153	80 ~ 150
		Parvocalanus crassirostris	133 ± 153	200 ~ 220
	Annelida	Polychaeta larvae	733 ± 153	120 ~ 150
Total	12 species 2 phyla/divisions		7,244 ± 970	-
Acceptability			Influent condition: Acceptable (≥10^2 ind./ m^3)	-

Data were presented as mean±S.D of three repeated measurement.
Some species were rare, the standard deviation was high.

2) 10 µm - 50 µm organism

Table 3. The survival number of the organism between 10 to 50 µm

Sample ID	Phyla/Divisions	Species	individuals/mL	Minimum Dimension (µm)
HL-S04UW-B	Chrysophyta	*Thalassiosira* sp.	2 ± 3	10~30
		Navicula sp.	3 ± 1	10~25
		Actinoptychus sp.	3 ± 1	40~45
		Skeletonema sp.	6 ± 4	10~12
		Eucampia sp.	0 ± 1	10~30
		Chaetoceros sp.	2 ± 3	10~15
	Pyrrophyta	*Gyrodinium* sp.	6 ± 1	10~20
		Prorocentrum sp.	2 ± 1	10~25
		Paralia sp.	3 ± 6	20~22
HL-S04UW-M	Chrysophyta	*Eucampia* sp.	0 ± 1	15~25
		Skeletonema sp.	4 ± 5	10~12
		Thalassiosira sp.	6 ± 1	10~30
		Actinoptychus sp.	3 ± 2	40~45
		Navicula sp.	0 ± 1	10~25
	Pyrrophyta	*Prorocentrum* sp.	1 ± 1	10~25
		Gyrodinium sp.	5 ± 3	10~20
		Unknwon	1 ± 1	20~25
HL-S04UW-E	Chrysophyta	*Skeletonema* sp.	9 ± 3	10~12
		Thalassiosira sp.	3 ± 2	10~30
		Navicula sp.	1 ± 1	10~25
		Pleurosigma sp.	1 ± 1	13~20
		Chaetoceros sp.	0 ± 1	10~15
		Actinoptychus sp.	0 ± 1	40~45
	Pyrrophyta	*Gyrodinium* sp.	3 ± 1	10~20
		Prorocentrum sp.	2 ± 2	10~25
	Protozoa	Protozoa	1 ± 1	20~30
Total	12 species 3 phyla/divisions		24 ± 3	-
Acceptability			Influent condition: Unacceptable ($\geq 10^2$ ind./mL)	

Data were presented as mean±S.D of three repeated measurement.
Some species were rare, the standard deviation was high.

1.4 Elimination efficacy

1) ≥ 50 µm organism

Table 4. The survival number of the organism larger than 50 µm

Test substance	Sample ID	individuals/m^3	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S04UW-B [a)]	8,167 ± 252	Influent condition: Acceptable (≥10^2 ind./m^3)	-
	HL-S04UW-M [b)]	7,333 ± 586		
	HL-S04UW-E [c)]	6,233 ± 306		

2) 10 µm - 50 µm organism

Table 5. The survival number of the organism between 10 and 50 µm

Test substance	Sample ID	individuals/mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S04UW-B [a)]	28 ± 12	Influent condition: Unacceptable (≥10^2 ind./m^3)	-
	HL-S04UW-M [b)]	24 ± 11		
	HL-S04UW-E [c)]	21 ± 8		

a) B: Beginning, b) M: Middle c) E: End
Data were presented as mean±S.D of three repeated measurement.

2. Validity

2.1 Water parameters measurement

- All measurements were tested more than three times.
- Water parameters were analyzed as soon as possible after sampling.

2.2 Biological efficacy test

- Valid tests are indicated by uptake water, for both the control tank and ballast water to be treated, with viable organism concentration exceeding 10 times the maximum permitted values in Regulation D-2.1

Sample ID	≥ 50 µm (individuals/m^3)	10 µm - 50 µm (individuals/mL)
HL-S04UW-B	8,167 ± 252	28 ± 12
HL-S04UW-M	7,333 ± 568	24 ± 11
HL-S04UW-E	6,233 ± 306	21 ± 8

※Regulation D-2 stipulates that ships meeting the requirements of the Convention by meeting the ballast water performance standard must discharge:

1. less than 10 viable organisms per cubic metre greater than or equal to 50 micrometres in minimum dimension;
2. less than 10 viable organisms per milliliter less than 50 micrometres in minimum dimension and greater than or equal to 10 micrometres in minimum dimension

- The samples should be analyzed as soon as possible after sampling.

Date	Sample ID	Sampling time	Test ending time
Day 0	HL-S04UW-B, M, E	June, 22 13:00	June, 22 18:00

3. Conclusion

3.1 Unacceptable of Influent water and discharge control water condition for IMO standards.

- Uptake water condition of organism between 10 μm and 50 μm was unacceptable for IMO standards.
- Therefore, the test was invalid.

4. Appendix

Appendix 1. Water parameters at field

1) Uptake water

Date	Sample ID	R [a)]	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)
Day 0	HL-S04UW-B	R1	8.07	21.90	33.02	8.21	5.0
		R2	8.07	21.98	33.04	7.91	4.9
		R3	8.07	21.98	33.04	7.92	4.9
	HL-S04UW-M	R1	8.07	22.11	33.12	5.34	6.3
		R2	8.16	22.12	33.22	5.34	6.3
		R3	8.16	22.12	33.12	5.34	5.2
	HL-S04UW-E	R1	8.18	21.62	33.22	5.48	4.7
		R2	8.19	21.63	33.21	5.48	4.6
		R3	8.19	21.63	33.22	5.49	4.6

a) R: Replicate
b) TOC: Total Organic Carbon (TOC=DOC+POC)
c) DOC: Dissolved Organic Carbon
d) TSS: Total Suspended Solids

Appendix 2. The survival number of ≥ 50㎛ organism in uptake water(Influent water)

Date	Sample ID	Classification	Counting volume	individuals/m^3			Mean	SD [b)]
				R1[a)]	R2	R3		
Day 0	HL-S04UW-B	Cirriped larvae	5 mL	11	6	7	800	265
		Acartia sp.		17	11	9	1,233	416
		Nauplius		6	10	5	700	265
		Oithona sp.		12	12	14	1,267	115
		Paracalanus parvus s. l.		13	12	15	1,333	153
		Decapoda larvae		8	15	10	1,100	361
		Centropages sp.		0	6	2	267	306
		Acartia hongi		0	0	9	300	520
		Oithona similis		0	0	4	133	231
		Polychaeta larvae		12	10	9	1,033	153
	HL-S04UW-M	*Oithona similis*	5 mL	9	6	5	667	208
		Acartia hongi		5	5	2	400	173
		Cirriped larvae		6	4	2	400	200
		Acartia sp.		12	9	8	967	208
		Nauplius		4	2	0	200	200
		Oithona sp.		7	11	13	1,033	306
		Paracalanus parvus s. l.		16	10	12	1,267	306
		Parvocalanus crassirostris		2	4	5	367	153
		Decapoda larvae		10	14	11	1,167	208
		Acartia sinjiensis		0	3	4	233	208
		Polychaeta larvae		9	3	7	633	306
	HL-S04UW-E	*Paracalanus parvus* s. l.	5 mL	11	9	12	1,067	153
		Decapoda larvae		6	7	9	733	153
		Acartia hongi		5	0	6	367	321
		Oihona similis		14	9	11	1,133	252
		Centropages sp.		9	5	10	800	265
		Acartia sp.		11	14	3	933	569
		Nauplius		0	2	1	100	100
		Oithona sp.		1	4	2	233	153
		Parvocalanus crassirostris		1	3	0	133	153
		Polychaeta larvae		7	6	9	733	153

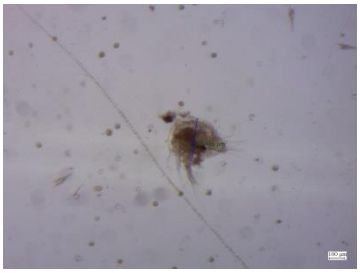
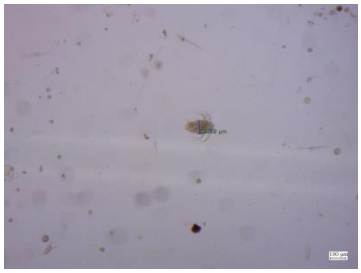
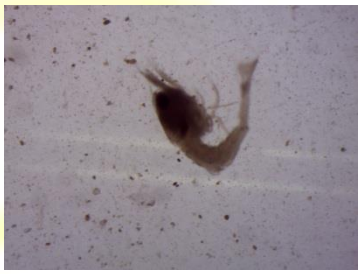
a) R: Replicate, b) S.D: Standard deviation, Some species were rare, the standard deviation was high.

Appendix 3. The survival number of 10㎛ - 50㎛ organism in uptake water (Influent water)

Sample ID	Classification	Counting volume	R1[a)]	R2	R3	individuals/mL	
						Mean	S.D.[b)]
HL-S04UW-B	*Gyrodinium* sp.	1.0 mL	7	5	6	6	1
	Thalassiosira sp.		5	2	0	2	3
	Navicula sp.		4	4	2	3	1
	Actinoptychus sp.		3	4	2	3	1
	Skeletonema sp.		10	3	5	6	4
	Eucampia sp.		1	0	0	0	1
	Prorocentrum sp.		2	1	2	2	1
	Paralia sp.		10	0	0	3	6
	Chaetoceros sp.		0	0	6	2	3
HL-S04UW-M	*Eucampia* sp.	1.0 mL	1	0	0	0	1
	Skeletonema sp.		10	3	0	4	5
	Prorocentrum sp.		5	1	2	3	2
	Gyrodinium sp.		8	3	6	6	3
	Thalassiosira sp.		5	7	7	6	1
	Unknown		2	1	1	1	1
	Actinoptychus sp.		5	2	1	3	2
	Navicula sp.		0	0	1	0	1
HL-S04UW-E	*Gyrodinium* sp.	1.0 mL	4	3	3	3	1
	Prorocentrum sp.		4	0	2	2	2
	Skeletonema sp.		12	7	8	9	3
	Thalassiosira sp.		5	2	1	3	2
	Navicula sp.		2	1	1	1	1
	Pleurosigma sp.		2	2	0	1	1
	Protozoa		1	0	2	1	1
	Chaetoceros sp.		0	0	1	0	1
	Actinoptychus sp.		0	0	1	0	1

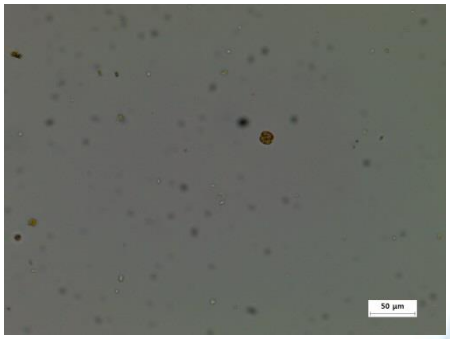
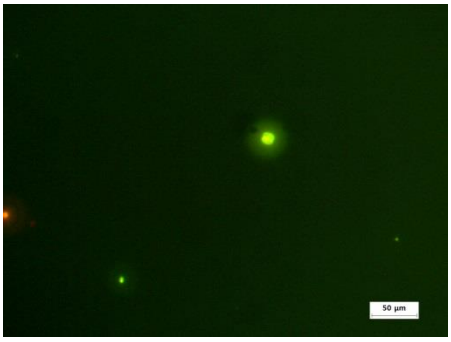
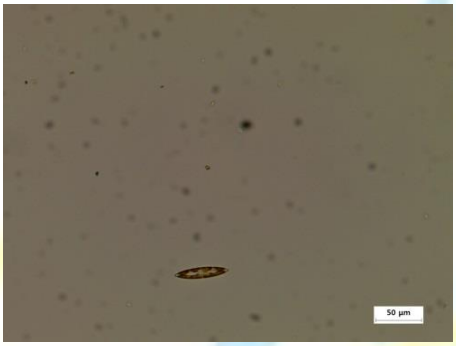
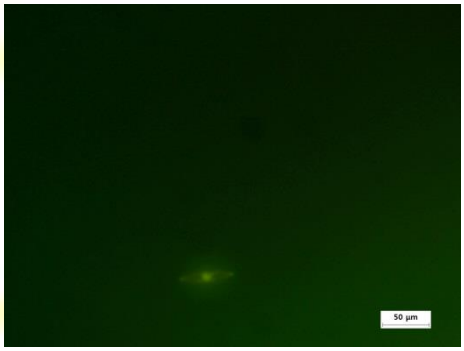
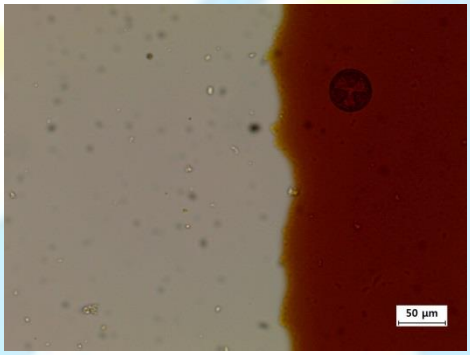
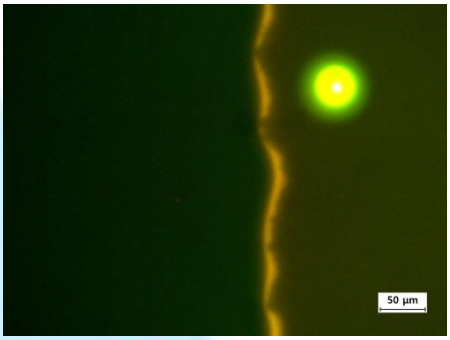
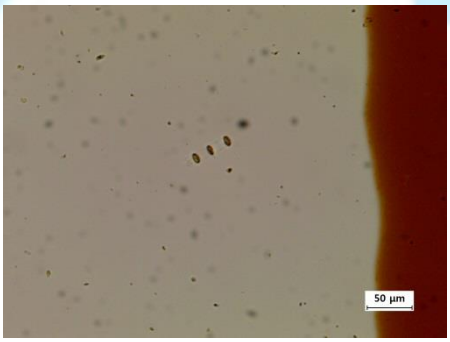
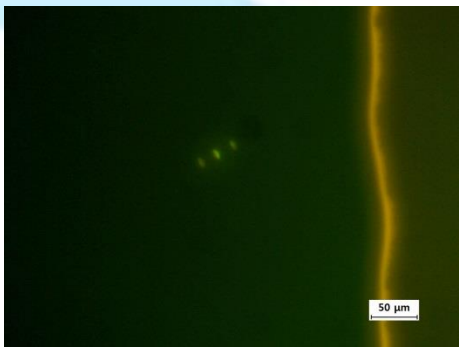
a) R: Replicate
b) S.D: Standard deviation
Some species were rare, the standard deviation was high.

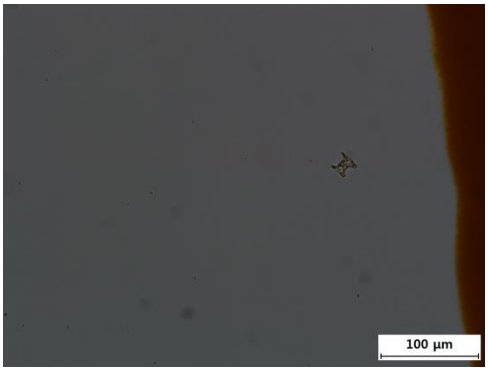
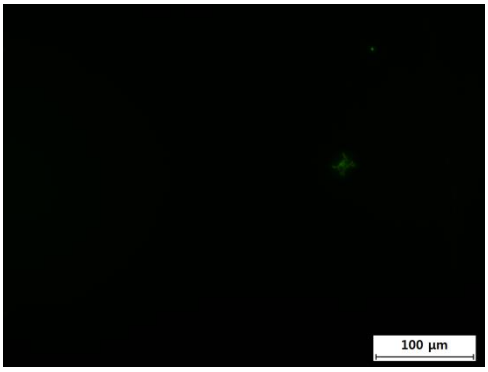
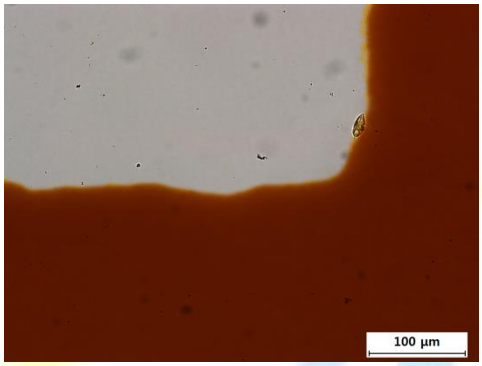
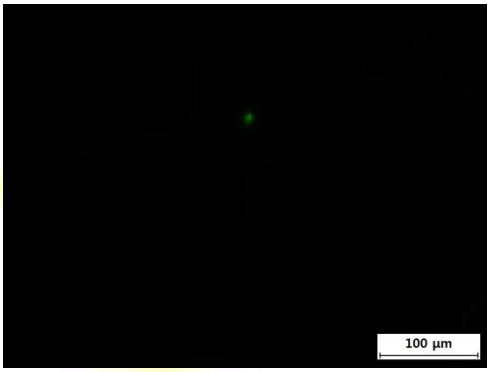
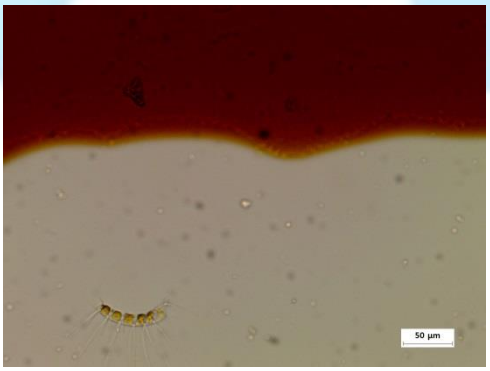
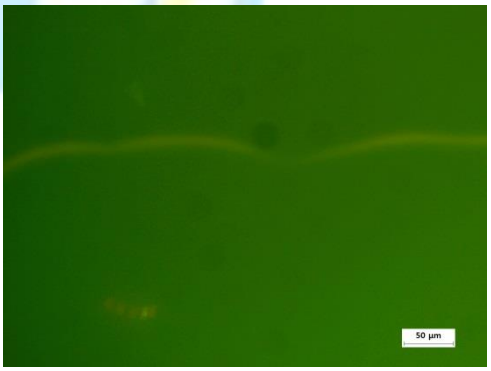
Appendix 4. The microscope image of ≥ 50㎛ in uptake water (Day0)

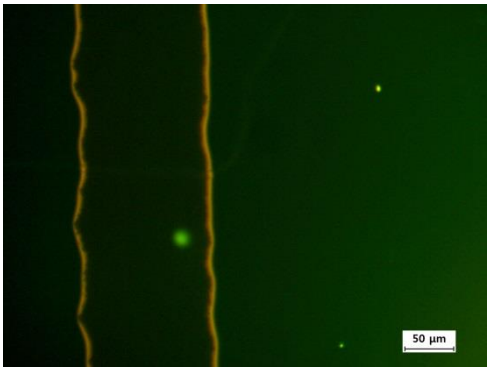
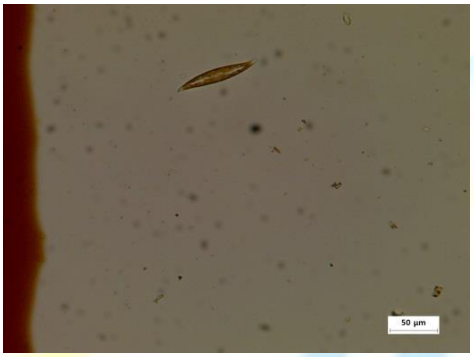
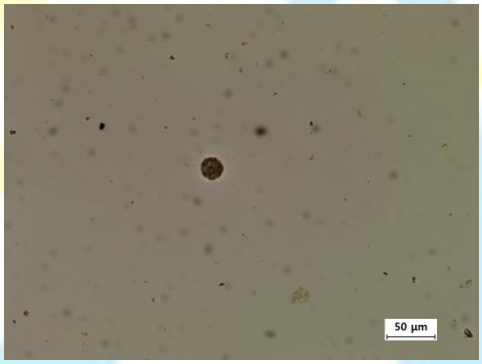
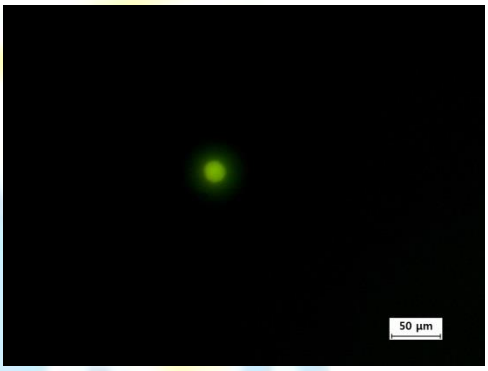
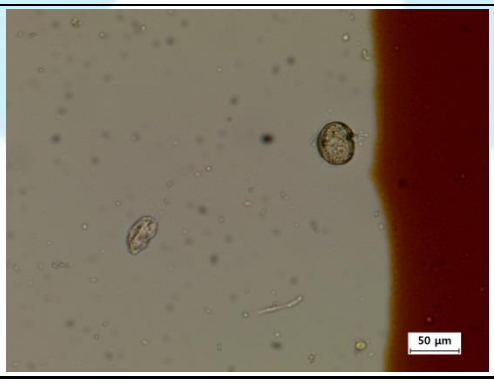
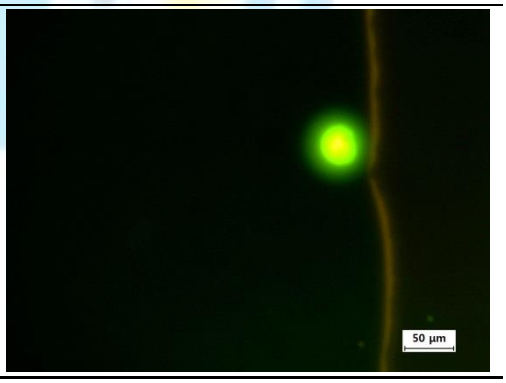
Uptake water (Day 0)		
Cirriped larvae**	*Acartia* sp. **	Nauplius**
		
Oithona sp. **	*Paraclanus parvus* s. l. **	Dcapoda larvae*
		
Centropages sp. **	*Acartia hongi***	*Oithona similis***
Polychaeta larvae**	*Acartia sinjiensis***	*Parvocalanus crassirostri***

* Magnification : 50
** Magnification : 200

Appendix 5. The microscope image of 10 ㎛−50 ㎛ in uptake water (Day0)

Specific Name	Uptake water	
	Optical	Fluorescence
Thalassiosira sp.		
Navicula sp.		
Actinoptychus sp.		
Skeletonema sp.		

Eucampia sp.		
Prorocentrum sp.		
Pralia sp.		
Chaetoceros sp.		

Gyrodinium sp.		
Pleurosigma sp.		
Unknown		
Protozoa		

Magnification : 200

5. Attachment

5.1 Sampling check & custody Sheet

5.2 Water parameter measurement sheet (I)

5.3 Test results sheet – Classification (II)

Sampling check & custody Sheet

20 14

Study number		Test number	SET-14-003
Sampling time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Day ( )		

Sample location	☑ Uptake water □ Discharge control water □ Discharge treated water □ Other( )						
Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
TSS		HDPE	2	□ 1	12:56	14:00	15:05
DOC, POC		HDPE	2				
Bacteria (4 item)[b]		HDPE	2	□ 2			
Organism (10~50 μm)		HDPE	1	□ 3			
Organism (≥50 μm)	1000-0.5	HDPE	0.5				

Sample location	□ Treated water □ Treated water (Neutralized)						
Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
Bacteria (4 item)[c]		HDPE		□ 1			
Organism (10~50 μm)		HDPE		□ 2			
Organism (≥50 μm)		HDPE		□ 3			

Concentration			
Parameter	Vol. of concentrated before	Equipment	Mesh size
Organism (≥50 μm)	(L)	net	32 μm
Organism (10-50 μm)	(L)	net	5 μm

Sample storage information		
Parameter	Location & condition	Storage time
TSS	Freezer(-20℃)	
DOC, POC		
Bacteria (4 item)	Refrigerator(4℃)	

Remarks

* First, fill a 20L HDPE(high density poly ethylene) bottle with water sample, and split the water sample up into groups (bacteria, organism (10~50 μm), and so forth) Then measured water parameters(5 item) - pH, Temperature, Salinity, DO, Turbidity
* Separately, organism(≥50 μm, 10-50 μm) sample was concentrated with net.
* Storage time of "bacteria sample" is for "heterotrophic bacteria test"
* TSS and DOC and POC samples are acidified(pH<2) with HCl (in 4 mL HCl of 2 L sample)

Working(pump) start time for Test water(or control water) sample :
Working(pump and EcoGuadian™) start time for treated(or neutralized) sample :

Working date	6.22	Personnel	Lee JT-Sun (sign)
Confirmation date	6.22	Confirmed by	Lee JT-Sun (sign)

a) Concentration b) Period
c) Bacteria (4 item) - Heterotrophic bacteria, Coliform, Vibrio cholera, Enterococcus group

Water parameter measurement sheet (I)

2014

Study Number		Test number	SET-14-003
Sampling time	☑ Day 0 ☐ Day 1 ☐ Day 2 ☐ Day 3 ☐ Day 4 ☐ Day 5 ☐ Day ( )		
Equipment	YSI 6920 - pH, temp., salinity, DO, Turbidity - TRO		

Sample	Replicate	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
☑ Uptake water ☐ Discharge control water ☐ Discharge treated water ☐ Discharge treated water(Neutralized water)	R1	8.07	21.90	33.02	8.21	5.0	
	R2	8.07	21.98	33.04	7.91	4.9	
	R3	8.07	21.98	33.04	7.92	4.9	
☑ B( ) ☐ M( ) ☐ E( )	Measuring time	13:01					
☑ Uptake water ☐ Discharge control water ☐ Discharge treated water ☐ Discharge treated water(Neutralized water)	R1	8.07	22.11	33.12	5.34	6.3	
	R2	8.16	22.12	33.22	5.34	6.3	
	R3	8.16	22.12	33.12	5.34	5.2	
☐ B( ) ☑ M( ) ☐ E( )	Measuring time	14:04					
☑ Uptake water ☐ Discharge control water ☐ Discharge treated water ☐ Discharge treated water(Neutralized water)	R1	8.18	21.62	33.22	5.48	4.7	
	R2	8.19	21.63	33.21	5.48	4.6	
	R3	8.19	21.63	33.22	5.49	4.6	
☐ B( ) ☐ M( ) ☑ E( )	Measuring time	15:10					
☐ Uptake water ☐ Discharge control water ☐ Discharge treated water ☐ Discharge treated water(Neutralized water)	R1						
	R2						
	R3						
☐ B( ) ☐ M( ) ☐ E( )	Measuring time						
☐ Uptake water ☐ Discharge control water ☐ Discharge treated water ☐ Discharge treated water(Neutralized water)	R1						
	R2						
	R3						
☐ B( ) ☐ M( ) ☐ E( )	Measuring time						
☐ Uptake water ☐ Discharge control water ☐ Discharge treated water ☐ Discharge treated water(Neutralized water)	R1						
	R2						
	R3						
☐ B( ) ☐ M( ) ☐ E( )	Measuring time						
Remarks							

Working Date	6.22	Study Personnel	Lee JI-Sun (sign)
Confirming Date	6.22	Confirmed by	Lee JI-Sun (sign)

Test Result Sheet - Classification (II)

2014

Study number		Test number	SET - 14 - 003
Test substance	control water	Lot. No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 500mL	Receive time of test substance	
Test start time	13:15	Test end time	13:55

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S04UW-B	5mL	Cirripedia larvae	11	6	7	
		Acartia sp.	17	11	9	
		nauplius	6	10	5	
		oithona sp.	12	12	14	
		polychaeta larvae	12	10	9	✓
		Paracalanus parvus s.l.	13	12	15	✓
		DECAPODA	6	15	10	✓
		centropages sp.		6	2	✓
		Acartia hongi			9	✓
		oithona similis			4	✓

Remark			
Date	06.22	Study personnel	Kim Hui-Jeong (sign)
Certificate date	6.22	Study director	Kim Hui-Jeong (sign)

* R: Replicate

Worksheet-Plankton-003(1)

Test Result Sheet - Classification (II)

20 14

Study number		Test number	SET-14-003
Test substance	control water	Lot. No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1 Con → 500mL.	Receive time of test substance	
Test start time	14: 15	Test end time	14: 35

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-5040W-M	5mL	Oithona similis	9	6	5	
		Acartia hongi	5	5	2	
		Cirripedia larvae	6	4	2	
		Acartia sp.	12	9	8	
		Nauplius	4	2		
		Oithona sp.	7	11	13	
		polychaeta larvae	9	3	1	V
		paracalanus parvus s.l.	16	10	12	V
		parvocalanus crassirostris	2	4	5	V
		DECAPODA	10	14	11	V
		Acartia similis		3	4	V

Remark			
Date	06.22	Study personnel	Kim Hui-Jeong (Sign)
Certificate date	6.22	Study director	Kim Hui-Jeong (Sign)

* R: Replicate

Test Result Sheet - Classification (II)

2014

Study number		Test number	SET-14-003
Test substance	control water	Lot. No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 500mL	Receive time of test substance	
Test start time	15:21	Test end time	16:00

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-504DW-E	5mL	polychaeta larvae.	7	6	9	
		Paracalanus parvus s.l.	11	9	12	
		DECAPODA	6	7	9	
		Acartia hongi	5		6	
		oithona similis.	14	9	11	
		Centropages sp.	9	5	10	
		Acartia sp.	11	14	3	
		nauplius		2	1	
		oithona sp.	1	4	2	
		paracalanus crassirostris	1	3		

Remark			
Date	06.22	Study personnel	Kim Hui-Jeong (Sign)
Certificate date	06.22	Study director	Kim Hui-Jeong (Sign)

* R: Replicate

Invalid

Test Result Sheet - Classification (II)

2014

Study number		**Test number**	SET-14-003
Test substance	Control water	**Lot. No.**	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	**Method**	☑ Direct □ Dye ( )
Concentration	1 ton → 500mL	**Receive time of test substance**	
Test start time	13:15	**Test end time**	16:00

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-2040W-B	5mL	B	79	82	85	
		M	80	71	69	
		E	65	59	63	

Remark	21.8°C / 43 RH% → END 26.5 / 45% → start.

Date	06.22	**Study personnel**	Kim Hui-Jeong (sign)
Certificate date	06.22	**Study director**	Kim Hui-Jeong (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Worksheet-Plankton–003(1)

Test Result Sheet - Classification (II)

20 14

Study number		Test number	SET-14-003
Test substance	control water	Lot. No.	
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	Method	☐ Direct ☑ Dye (FDA)
Concentration	—	Receive time of test substance	13:00
Test start time	13:05	Test end time	

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S04UW-B	1 mL	Gyrodinium sp.	7	5	6	
		Thalasiossira sp.	5	2		
		Navicula sp.	4	4	2	
		Actinoptychus sp.	3	4	2	
		Skeletonema sp.	10	3	5	
		Eucampia sp.	1			
		Prorocentrum sp.	2	1	2	
		Paralia sp.	10			
		Chaetoceros sp.			6	
HL-S04UW-M	1 mL	Eucampia sp.	1			
		Skeletonema sp.	10	3		
		Prorocentrum sp.	5	1	2	
		Gyrodinium sp.	8	3	6	
		Thalasiossira sp.	5	7	7	
		Unknown	2	1	1	
		Actinoptychus sp.	5	2	1	
		Navicula sp.			1	

Remark			
Date	06. 22	Study personnel	Sun ok Lee (sign)
Certificate date	06. 22	Study director	Sun ok Lee (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Worksheet-Plankton-003(1)

Test Result Sheet - Classification (II)

2014

Study number		Test number	SET-14-003
Test substance	Control water	Lot. No.	
Organism	□ ≥ 10 to 50 μm □ ≥ 50 μm	Method	□ Direct ☑ Dye (FDA)
Concentration	—	Receive time of test substance	13:00
Test start time	13:05	Test end time	—

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S04UW-E	1mL	Gyrodinium sp.	4	3	3	
		Prorocentrum sp.	4		2	
		Skeletonema sp.	12	7	8	
		Thalasiossira sp.	5	2	1	
		Navicula sp	2	1	1	
		Pleurosigma sp.	2	2		
		Protoza	1		2	
		Chaetoceros sp.			1	
		Actinoptychus sp.			1	

Remark			
Date	06.22	Study personnel	Sun ok Lee (sign)
Certificate date	06.22.	Study director	Sun ok Lee (sign)

* R: Replicate

Worksheet-Plankton–003(1)

Busan Techno-Park
Marine Bio-industry Development Center

4.5 Test 5 report and raw data

Test Report

Project name	EcoGuardian™
Test number	SET-14-003
Port	Gunsan(Korea)-Ballasting
Title	Efficacy test of EcoGuardian™ Ballast Water Management System (shipboard scale)

BUSAN TECHNO PARK

Statement of Quality Assurance

Data were reviewed by Quality Assurance Unit of BTP to assure that the study was performed in accordance with protocol and standard operating procedures (SOP) of Busan Techno-Park(BTP). The report was an accurate reflection of the raw data generated at the BTP. Inspection of the routine and repeated procedures that constitute the study was carried out as a continuous major phase at or about the time this study was in progress.

Inspection Phase		Date		
		Inspection	Report to Testing manager	Report to Project director
Test plan		June 19, 2014	June 19, 2014	June 19, 2014
Sampling	1st	June 22, 2014	June 22, 2014	June 22, 2014
	2nd	-	-	-
Test substance	1st	June 22, 2014	June 22, 2014	June 22, 2014
	2nd	-	-	-
Test procedures (Bacteria test)	1st	-	-	-
	2nd	-	-	-
Observation and counting (≥50㎛, 10㎛-50㎛)	1st	June 22, 2014	June 22, 2014	June 22, 2014
	2nd	-	-	-
Observation and counting (Bacteria test)	1st	-	-	-
	2nd	-	-	-

Seo, Hyo-Jin (Sign) 12th, Dec. 2014

Seo, Hyo-Jin / Project director Date

Study Personnel and Participants

The test participants recognized the study plan, manual, procedure, guide of Busan Techno Park in performing the test.

	Name	Date
Study Personnel	Kim Hui-Jeong (sign)	12th. Dec. 2014
	Lee JT-Sun (sign)	12th, Dec, 2014
	Lee Sun ok (sign)	12th, Dec. 2014.
	Lee Myounghee (sign)	12th Dec, 2014
	(sign)	
	(sign)	
Project director	Seo, Hyo-Jin (sign)	12th. Dec. 2014

Contents

1.Results.....1

1.1 Loading record 1

1.2 Water parameters 1

1.3 Influent water : Uptake water 2

1.4 Elimination efficacy 4

2. Validity 5

3. Conclusion 6

4. Appendix 7

1. Results

1.1 Loading record

Vessel name	SSANG YONG CHANGYAHNG
IMO number	9121027

Water ballast tanks			Sample WGT (Mt)	Loading (Date/Location)	Discharge (Date/Location)
Control	No.3 D/B W.B.T	P, S	1370	June 22nd , 2014 Gunsan (35°58.61N, 126°37.10E)	-
Treated	No.4 D/B W.B.T No.5 D/B W.B.T	P, S	650	-	-

1.2 Water parameters

Table 1. Water parameters at field

Date	Sample ID	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
Day 0	HL-S04UW-B	8.07 ± 0.00	21.95 ± 0.05	33.03 ± 0.01	8.01 ± 0.17	4.9 ± 0.1	-
	HL-S04UW-M	8.13 ± 0.05	22.12 ± 0.01	33.15 ± 0.06	5.34 ± 0.00	5.9 ± 0.6	-
	HL-S04UW-E	8.19 ± 0.01	21.63 ± 0.01	33.22 ± 0.01	5.48 ± 0.01	4.6 ± 0.1	-

Data were presented as mean±S.D of three repeated measurement.

1.3 Influent water : Uptake water

1) ≥ 50 µm organism

Table 2. The survival number of the organism larger than 50 µm

Sample ID	Phyla/Divisions	Species	individuals/m^3	Minimum Dimension (µm)
HL-S04UW-B	Arthropoda	Cirriped larvae	800 ± 265	250 ~ 280
		Acartia sp.	1,233 ± 416	300~325
		Nauplius	700 ± 265	70 ~ 90
		Oithona sp.	1,267 ± 115	80 ~ 150
		Paracalanus parvus s. l.	1,333 ± 153	220 ~ 240
		Decapoda larvae	1,100 ± 361	200 ~ 230
		Centropages sp.	267 ± 306	180 ~ 250
		Acartia hongi	300 ± 520	170 ~ 210
		Oithona similis	133 ± 231	145 ~ 160
	Annelida	Polychaeta larvae	1,033 ± 153	120 ~ 150
HL-S04UW-M	Arthropoda	*Oithona similis*	667 ± 208	145 ~ 160
		Acartia hongi	400 ± 173	170 ~ 210
		Cirriped larvae	400 ± 200	250 ~ 280
		Acartia sp.	967 ± 208	300~325
		Nauplius	200 ± 200	70 ~ 90
		Oithona sp.	1,033 ± 306	80 ~ 150
		Paracalanus parvus s. l.	1,267 ± 306	220 ~ 240
		Parvocalanus crassirostris	367 ± 153	200 ~ 220
		Decapoda larvae	1,167 ± 208	200 ~ 230
		Acartia sinjiensis	233 ± 208	150 ~ 220
	Annelida	Polychaeta larvae	633 ± 306	120 ~ 150
HL-S04UW-E	Arthropoda	*Paracalanus parvus* s. l.	1,067 ± 153	220 ~ 240
		Decapoda larvae	733 ± 153	200 ~ 230
		Acartia hongi	367 ± 321	170 ~ 210
		Oithona similis	1,133 ± 252	145 ~ 160
		Centropages sp.	800 ± 265	180 ~ 250
		Acartia sp.	933 ± 569	150 ~ 220
		Nauplius	100 ± 100	70 ~ 90
		Oithona sp.	233 ± 153	80 ~ 150
		Parvocalanus crassirostris	133 ± 153	200 ~ 220
	Annelida	Polychaeta larvae	733 ± 153	120 ~ 150
Total	12 species 2 phyla/divisions		7,244 ± 970	-
Acceptability			Influent condition: Acceptable (≥10^2 ind./ m^3)	-

Data were presented as mean±S.D of three repeated measurement.
Some species were rare, the standard deviation was high.

2) 10 µm - 50 µm organism

Table 3. The survival number of the organism between 10 to 50 µm

Sample ID	Phyla/Divisions	Species	individuals/mL	Minimum Dimension (µm)
HL-S04UW-B	Chrysophyta	*Thalassiosira* sp.	2 ± 3	10~30
		Navicula sp.	3 ± 1	10~25
		Actinoptychus sp.	3 ± 1	40~45
		Skeletonema sp.	6 ± 4	10~12
		Eucampia sp.	0 ± 1	10~30
		Chaetoceros sp.	2 ± 3	10~15
	Pyrrophyta	*Gyrodinium* sp.	6 ± 1	10~20
		Prorocentrum sp.	2 ± 1	10~25
		Paralia sp.	3 ± 6	20~22
HL-S04UW-M	Chrysophyta	*Eucampia* sp.	0 ± 1	15~25
		Skeletonema sp.	4 ± 5	10~12
		Thalassiosira sp.	6 ± 1	10~30
		Actinoptychus sp.	3 ± 2	40~45
		Navicula sp.	0 ± 1	10~25
	Pyrrophyta	*Prorocentrum* sp.	1 ± 1	10~25
		Gyrodinium sp.	5 ± 3	10~20
		Unknwon	1 ± 1	20~25
HL-S04UW-E	Chrysophyta	*Skeletonema* sp.	9 ± 3	10~12
		Thalassiosira sp.	3 ± 2	10~30
		Navicula sp.	1 ± 1	10~25
		Pleurosigma sp.	1 ± 1	13~20
		Chaetoceros sp.	0 ± 1	10~15
		Actinoptychus sp.	0 ± 1	40~45
	Pyrrophyta	*Gyrodinium* sp.	3 ± 1	10~20
		Prorocentrum sp.	2 ± 2	10~25
	Protozoa	Protozoa	1 ± 1	20~30
Total	12 species 3 phyla/divisions		24 ± 3	-
Acceptability			Influent condition: Unacceptable ($\geq 10^2$ ind./mL)	

Data were presented as mean±S.D of three repeated measurement.
Some species were rare, the standard deviation was high.

1.4 Elimination efficacy

1) ≥ 50 µm organism

Table 4. The survival number of the organism larger than 50 µm

Test substance	Sample ID	individuals/m^3	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S04UW-B [a)]	8,167 ± 252	Influent condition: Acceptable (≥10^2 ind./m^3)	-
	HL-S04UW-M [b)]	7,333 ± 586		
	HL-S04UW-E [c)]	6,233 ± 306		

2) 10 µm - 50 µm organism

Table 5. The survival number of the organism between 10 and 50 µm

Test substance	Sample ID	individuals/mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S04UW-B [a)]	28 ± 12	Influent condition: Unacceptable (≥10^2 ind./m^3)	-
	HL-S04UW-M [b)]	24 ± 11		
	HL-S04UW-E [c)]	21 ± 8		

a) B: Beginning, b) M: Middle c) E: End
Data were presented as mean±S.D of three repeated measurement.

2. Validity

2.1 Water parameters measurement

- All measurements were tested more than three times.
- Water parameters were analyzed as soon as possible after sampling.

2.2 Biological efficacy test

- Valid tests are indicated by uptake water, for both the control tank and ballast water to be treated, with viable organism concentration exceeding 10 times the maximum permitted values in Regulation D-2.1

Sample ID	≥ 50 µm (individuals/m^3)	10 µm - 50 µm (individuals/mL)
HL-S04UW-B	8,167 ± 252	28 ± 12
HL-S04UW-M	7,333 ± 568	24 ± 11
HL-S04UW-E	6,233 ± 306	21 ± 8

※Regulation D-2 stipulates that ships meeting the requirements of the Convention by meeting the ballast water performance standard must discharge:

1. less than 10 viable organisms per cubic metre greater than or equal to 50 micrometres in minimum dimension;
2. less than 10 viable organisms per milliliter less than 50 micrometres in minimum dimension and greater than or equal to 10 micrometres in minimum dimension

- The samples should be analyzed as soon as possible after sampling.

Date	Sample ID	Sampling time	Test ending time
Day 0	HL-S04UW-B, M, E	June, 22 13:00	June, 22 18:00

3. Conclusion

3.1 Unacceptable of Influent water and discharge control water condition for IMO standards.

- Uptake water condition of organism between 10 μm and 50 μm was unacceptable for IMO standards.
- Therefore, the test was invalid.

4. Appendix

Appendix 1. Water parameters at field

1) Uptake water

Date	Sample ID	R [a)]	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)
Day 0	HL-S04UW-B	R1	8.07	21.90	33.02	8.21	5.0
		R2	8.07	21.98	33.04	7.91	4.9
		R3	8.07	21.98	33.04	7.92	4.9
	HL-S04UW-M	R1	8.07	22.11	33.12	5.34	6.3
		R2	8.16	22.12	33.22	5.34	6.3
		R3	8.16	22.12	33.12	5.34	5.2
	HL-S04UW-E	R1	8.18	21.62	33.22	5.48	4.7
		R2	8.19	21.63	33.21	5.48	4.6
		R3	8.19	21.63	33.22	5.49	4.6

a) R: Replicate
b) TOC: Total Organic Carbon (TOC=DOC+POC)
c) DOC: Dissolved Organic Carbon
d) TSS: Total Suspended Solids

Appendix 2. The survival number of ≥ 50㎛ organism in uptake water(Influent water)

Date	Sample ID	Classification	Counting volume	individuals/m^3			Mean	SD [b)]
				R1[a)]	R2	R3		
Day 0	HL-S04UW-B	Cirriped larvae	5 mL	11	6	7	800	265
		Acartia sp.		17	11	9	1,233	416
		Nauplius		6	10	5	700	265
		Oithona sp.		12	12	14	1,267	115
		Paracalanus parvus s. l.		13	12	15	1,333	153
		Decapoda larvae		8	15	10	1,100	361
		Centropages sp.		0	6	2	267	306
		Acartia hongi		0	0	9	300	520
		Oithona similis		0	0	4	133	231
		Polychaeta larvae		12	10	9	1,033	153
	HL-S04UW-M	*Oithona similis*	5 mL	9	6	5	667	208
		Acartia hongi		5	5	2	400	173
		Cirriped larvae		6	4	2	400	200
		Acartia sp.		12	9	8	967	208
		Nauplius		4	2	0	200	200
		Oithona sp.		7	11	13	1,033	306
		Paracalanus parvus s. l.		16	10	12	1,267	306
		Parvocalanus crassirostris		2	4	5	367	153
		Decapoda larvae		10	14	11	1,167	208
		Acartia sinjiensis		0	3	4	233	208
		Polychaeta larvae		9	3	7	633	306
	HL-S04UW-E	*Paracalanus parvus* s. l.	5 mL	11	9	12	1,067	153
		Decapoda larvae		6	7	9	733	153
		Acartia hongi		5	0	6	367	321
		Oihona similis		14	9	11	1,133	252
		Centropages sp.		9	5	10	800	265
		Acartia sp.		11	14	3	933	569
		Nauplius		0	2	1	100	100
		Oithona sp.		1	4	2	233	153
		Parvocalanus crassirostris		1	3	0	133	153
		Polychaeta larvae		7	6	9	733	153

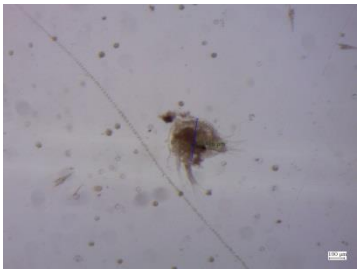
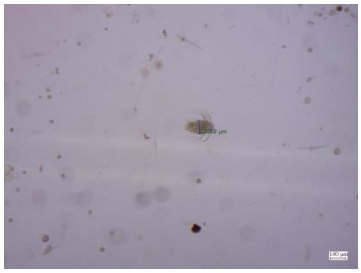
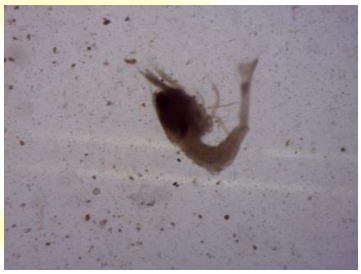
a) R: Replicate, b) S.D: Standard deviation, Some species were rare, the standard deviation was high.

Appendix 3. The survival number of 10㎛ - 50㎛ organism in uptake water (Influent water)

Sample ID	Classification	Counting volume	R1[a)]	R2	R3	individuals/mL	
						Mean	S.D.[b)]
HL-S04UW-B	*Gyrodinium* sp.	1.0 mL	7	5	6	6	1
	Thalassiosira sp.		5	2	0	2	3
	Navicula sp.		4	4	2	3	1
	Actinoptychus sp.		3	4	2	3	1
	Skeletonema sp.		10	3	5	6	4
	Eucampia sp.		1	0	0	0	1
	Prorocentrum sp.		2	1	2	2	1
	Paralia sp.		10	0	0	3	6
	Chaetoceros sp.		0	0	6	2	3
HL-S04UW-M	*Eucampia* sp.	1.0 mL	1	0	0	0	1
	Skeletonema sp.		10	3	0	4	5
	Prorocentrum sp.		5	1	2	3	2
	Gyrodinium sp.		8	3	6	6	3
	Thalassiosira sp.		5	7	7	6	1
	Unknown		2	1	1	1	1
	Actinoptychus sp.		5	2	1	3	2
	Navicula sp.		0	0	1	0	1
HL-S04UW-E	*Gyrodinium* sp.	1.0 mL	4	3	3	3	1
	Prorocentrum sp.		4	0	2	2	2
	Skeletonema sp.		12	7	8	9	3
	Thalassiosira sp.		5	2	1	3	2
	Navicula sp.		2	1	1	1	1
	Pleurosigma sp.		2	2	0	1	1
	Protozoa		1	0	2	1	1
	Chaetoceros sp.		0	0	1	0	1
	Actinoptychus sp.		0	0	1	0	1

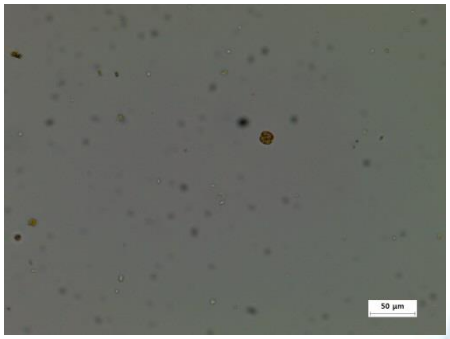
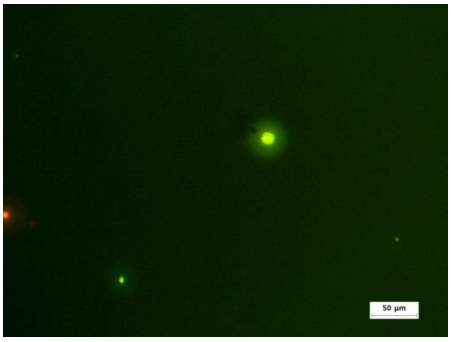
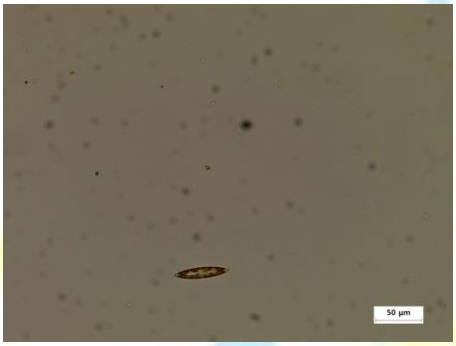
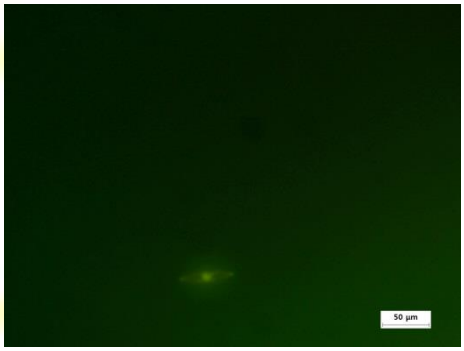
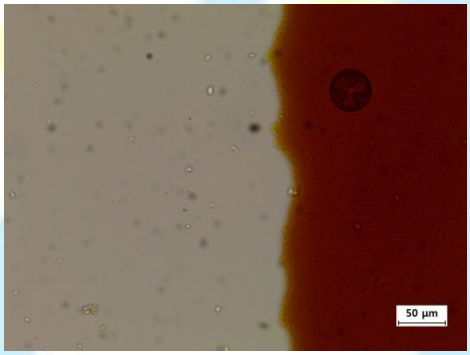
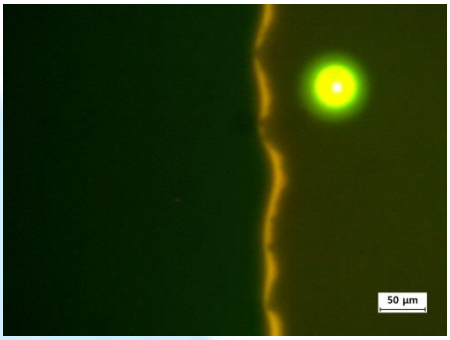
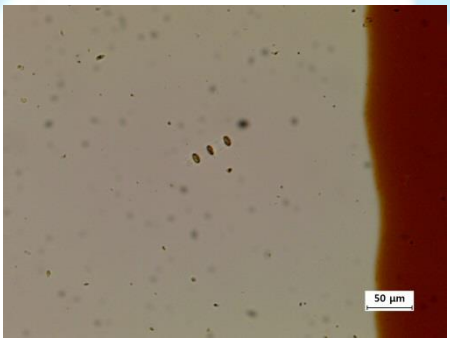
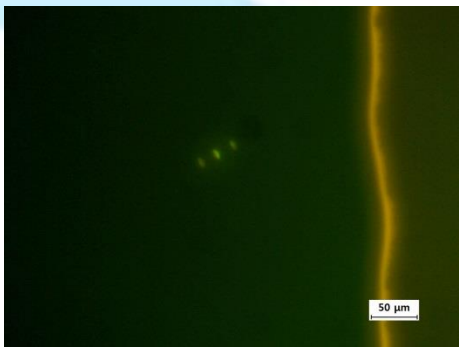
a) R: Replicate
b) S.D: Standard deviation
Some species were rare, the standard deviation was high.

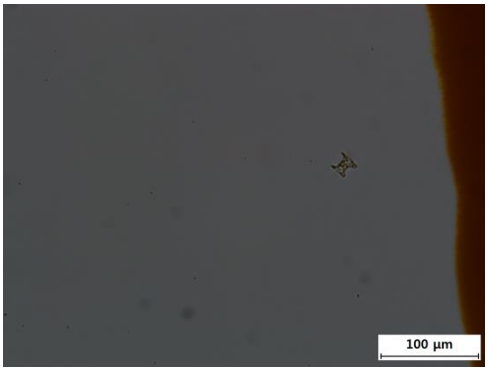
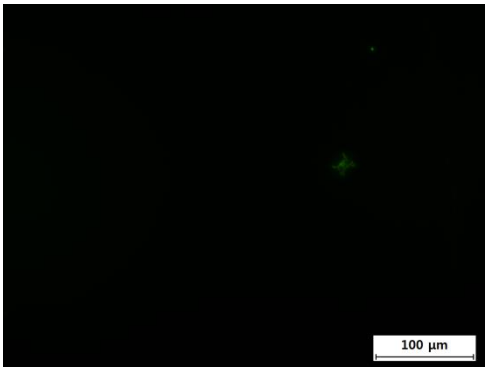
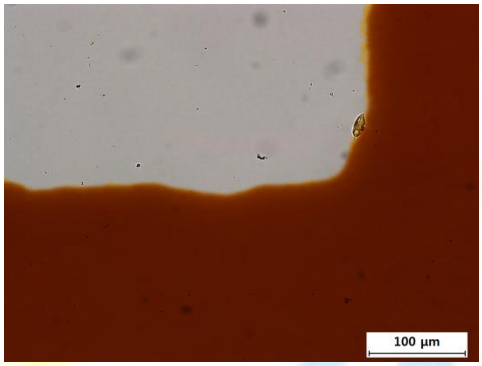
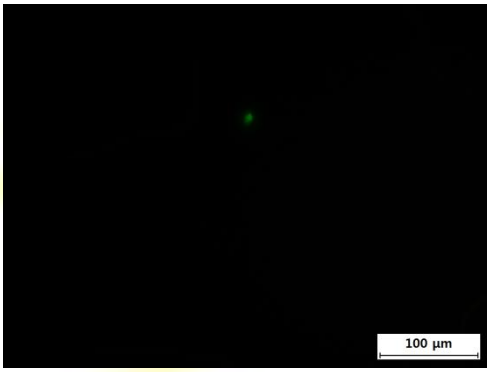
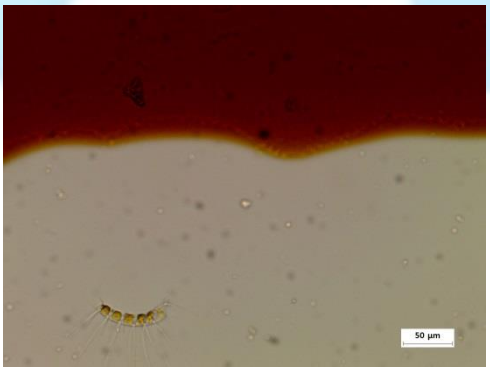
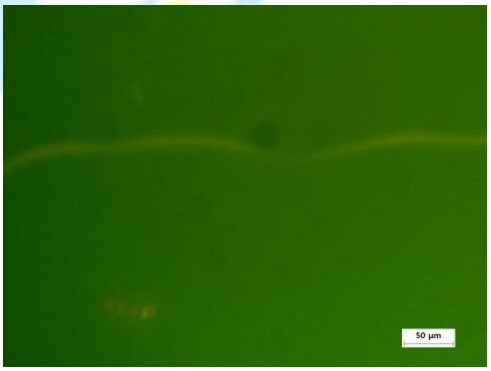
Appendix 4. The microscope image of ≥ 50㎛ in uptake water (Day0)

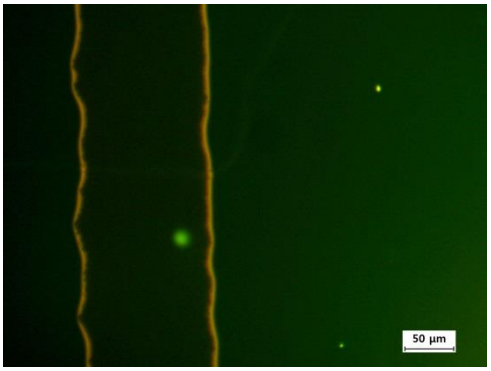
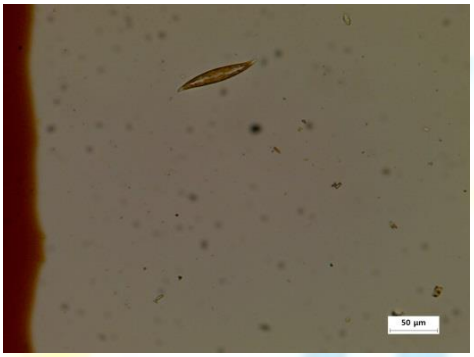
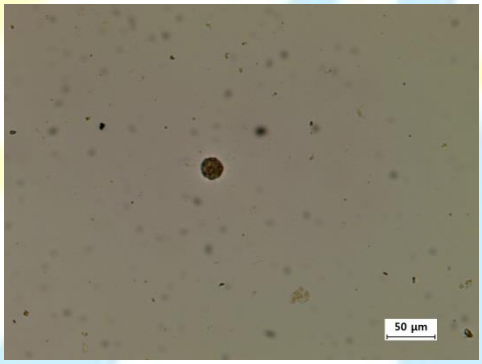
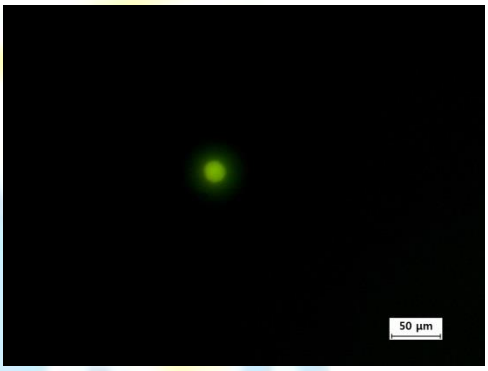
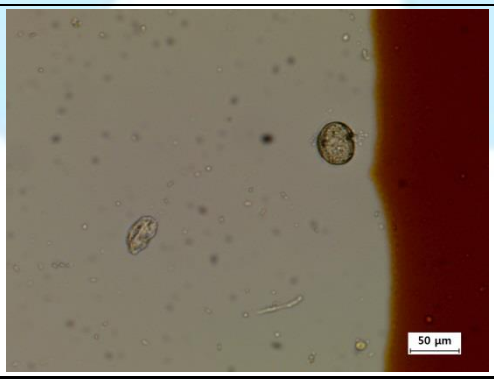
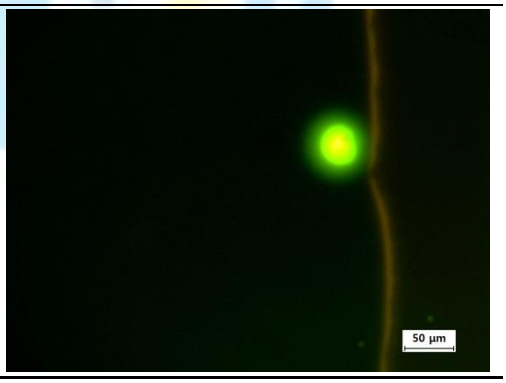
Uptake water (Day 0)		
Cirriped larvae**	*Acartia* sp. **	Nauplius**
		
Oithona sp. **	*Paraclanus parvus* s. l. **	Dcapoda larvae*
		
Centropages sp. **	*Acartia hongi***	*Oithona similis***
Polychaeta larvae**	*Acartia sinjiensis***	*Parvocalanus crassirostri***

* Magnification : 50
** Magnification : 200

Appendix 5. The microscope image of 10 ㎛−50 ㎛ in uptake water (Day0)

Specific Name	Uptake water	
	Optical	Fluorescence
Thalassiosira sp.		
Navicula sp.		
Actinoptychus sp.		
Skeletonema sp.		

Eucampia sp.		
Prorocentrum sp.		
Pralia sp.		
Chaetoceros sp.		

Gyrodinium sp.		
Pleurosigma sp.		
Unknown		
Protozoa		

Magnification : 200

5. Attachment

5.1 Sampling check & custody Sheet

5.2 Water parameter measurement sheet (I)

5.3 Test results sheet – Classification (II)

Sampling check & custody Sheet

20 14

Study number		Test number	SET-14-003
Sampling time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Day ( )		

Sample location	☑ Uptake water □ Discharge control water □ Discharge treated water □ Other( )						
Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
TSS		HDPE	2	□ 1	12:56	14:00	15:05
DOC, POC		HDPE	2				
Bacteria (4 item)[b]		HDPE	2	□ 2			
Organism (10~50 μm)		HDPE	1	□ 3			
Organism (≥50 μm)	1000-0.5	HDPE	0.5				

Sample location	□ Treated water □ Treated water (Neutralized)						
Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
Bacteria (4 item)[c]		HDPE		□ 1			
Organism (10~50 μm)		HDPE		□ 2			
Organism (≥50 μm)		HDPE		□ 3			

Concentration			
Parameter	Vol. of concentrated before	Equipment	Mesh size
Organism (≥50 μm)	(L)	net	32 μm
Organism (10-50 μm)	(L)	net	5 μm

Sample storage information		
Parameter	Location & condition	Storage time
TSS	Freezer(-20℃)	
DOC, POC		
Bacteria (4 item)	Refrigerator(4℃)	

Remarks

* First, fill a 20L HDPE(high density poly ethylene) bottle with water sample, and split the water sample up into groups (bacteria, organism (10~50 μm), and so forth) Then measured water parameters(5 item) - pH, Temperature, Salinity, DO, Turbidity
* Separately, organism(≥50 μm, 10-50 μm) sample was concentrated with net.
* Storage time of "bacteria sample" is for "heterotrophic bacteria test"
* TSS and DOC and POC samples are acidified(pH<2) with HCl (in 4 mL HCl of 2 L sample)

Working(pump) start time for Test water(or control water) sample :
Working(pump and EcoGuadian™) start time for treated(or neutralized) sample :

Working date	6.22	Personnel	Lee JT-Sun (sign)
Confirmation date	6.22	Confirmed by	Lee JT-Sun (sign)

a) Concentration b) Period
c) Bacteria (4 item) - Heterotrophic bacteria, Coliform, Vibrio cholera, Enterococcus group

Water parameter measurement sheet (I)

2014

Study Number		Test number	SET-14-003
Sampling time	☑ Day 0 ☐ Day 1 ☐ Day 2 ☐ Day 3 ☐ Day 4 ☐ Day 5 ☐ Day ( )		
Equipment	YSI 6920 - pH, temp., salinity, DO, Turbidity - TRO		

Sample	Replicate	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
☑ Uptake water ☐ Discharge control water ☐ Discharge treated water ☐ Discharge treated water(Neutralized water)	R1	8.07	21.90	33.02	8.21	5.0	
	R2	8.07	21.98	33.04	7.91	4.9	
	R3	8.07	21.98	33.04	7.92	4.9	
☑ B( ) ☐ M( ) ☐ E( )	Measuring time	13:01					
☑ Uptake water ☐ Discharge control water ☐ Discharge treated water ☐ Discharge treated water(Neutralized water)	R1	8.07	22.11	33.12	5.34	6.3	
	R2	8.16	22.12	33.22	5.34	6.3	
	R3	8.16	22.12	33.12	5.34	5.2	
☐ B( ) ☑ M( ) ☐ E( )	Measuring time	14:04					
☑ Uptake water ☐ Discharge control water ☐ Discharge treated water ☐ Discharge treated water(Neutralized water)	R1	8.18	21.62	33.22	5.48	4.7	
	R2	8.19	21.63	33.21	5.48	4.6	
	R3	8.19	21.63	33.22	5.49	4.6	
☐ B( ) ☐ M( ) ☑ E( )	Measuring time	15:10					
☐ Uptake water ☐ Discharge control water ☐ Discharge treated water ☐ Discharge treated water(Neutralized water)	R1						
	R2						
	R3						
☐ B( ) ☐ M( ) ☐ E( )	Measuring time						
☐ Uptake water ☐ Discharge control water ☐ Discharge treated water ☐ Discharge treated water(Neutralized water)	R1						
	R2						
	R3						
☐ B( ) ☐ M( ) ☐ E( )	Measuring time						
☐ Uptake water ☐ Discharge control water ☐ Discharge treated water ☐ Discharge treated water(Neutralized water)	R1						
	R2						
	R3						
☐ B( ) ☐ M( ) ☐ E( )	Measuring time						
Remarks							

Working Date	6.22	Study Personnel	Lee JI-Sun (sign)
Confirming Date	6.22	Confirmed by	Lee JI-Sun (sign)

Test Result Sheet - Classification (II)

2014

Study number		Test number	SET - 14 - 003
Test substance	control water	Lot. No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 500mL	Receive time of test substance	
Test start time	13:15	Test end time	13:55

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S04UW-B	5mL	Cirripedia larvae	11	6	7	
		Acartia sp.	17	11	9	
		nauplius	6	10	5	
		oithona sp.	12	12	14	
		polychaeta larvae	12	10	9	✓
		Paracalanus parvus s.l.	13	12	15	✓
		DECAPODA	6	15	10	✓
		centropages sp.		6	2	✓
		Acartia hongi			9	✓
		oithona similis			4	✓

Remark			
Date	06.22	Study personnel	Kim Hui-Jeong (sign)
Certificate date	6.22	Study director	Kim Hui-Jeong (sign)

* R: Replicate

Worksheet-Plankton-003(1)

Test Result Sheet - Classification (II)

20 14

Study number		Test number	SET-14-003
Test substance	control water	Lot. No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1 Con → 500mL.	Receive time of test substance	
Test start time	14: 15	Test end time	14: 35

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-5040W-M	5mL	Oithona similis	9	6	5	
		Acartia hongi	5	5	2	
		Cirripedia larvae	6	4	2	
		Acartia sp.	12	9	8	
		Nauplius	4	2		
		Oithona sp.	7	11	13	
		polychaeta larvae	9	3	1	V
		paracalanus parvus s.l.	16	10	12	V
		parvocalanus crassirostris	2	4	5	V
		DECAPODA	10	14	11	V
		Acartia similis		3	4	V

Remark			
Date	06.22	Study personnel	Kim Hui-Jeong (Sign)
Certificate date	6.22	Study director	Kim Hui-Jeong (Sign)

* R: Replicate

Test Result Sheet - Classification (II)

2014

Study number		Test number	SET-14-003
Test substance	control water	Lot. No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 500mL	Receive time of test substance	
Test start time	15:21	Test end time	16:00

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-504DW-E	5mL	polychaeta larvae.	7	6	9	
		Paracalanus parvus s.l.	11	9	12	
		DECAPODA	6	7	9	
		Acartia hongi	5		6	
		oithona similis.	14	9	11	
		Centropages sp.	9	5	10	
		Acartia sp.	11	14	3	
		nauplius		2	1	
		oithona sp.	1	4	2	
		paracalanus crassirostris	1	3		

Remark			
Date	06.22	Study personnel	Kim Hui-Jeong (Sign)
Certificate date	06.22	Study director	Kim Hui-Jeong (Sign)

* R: Replicate

Invalid

Test Result Sheet - Classification (II)

2014

Study number		**Test number**	SET-14-003
Test substance	Control water	**Lot. No.**	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	**Method**	☑ Direct □ Dye ( )
Concentration	1 ton → 500mL	**Receive time of test substance**	
Test start time	13:15	**Test end time**	16:00

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-2040W-B	5mL	B	79	82	85	
		M	80	71	69	
		E	65	59	63	

Remark	21.8°C / 43 RH% → END 26.5 / 45% → start.

Date	06.22	**Study personnel**	Kim Hui-Jeong (sign)
Certificate date	06.22	**Study director**	Kim Hui-Jeong (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Worksheet-Plankton–003(1)

Test Result Sheet - Classification (II)

20 14

Study number		Test number	SET-14-003
Test substance	control water	Lot. No.	
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	Method	☐ Direct ☑ Dye (FDA)
Concentration	—	Receive time of test substance	13:00
Test start time	13:05	Test end time	

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S04UW-B	1 mL	Gyrodinium sp.	7	5	6	
		Thalasiossira sp.	5	2		
		Navicula sp.	4	4	2	
		Actinoptychus sp.	3	4	2	
		Skeletonema sp.	10	3	5	
		Eucampia sp.	1			
		Prorocentrum sp.	2	1	2	
		Paralia sp.	10			
		Chaetoceros sp.			6	
HL-S04UW-M	1 mL	Eucampia sp.	1			
		Skeletonema sp.	10	3		
		Prorocentrum sp.	5	1	2	
		Gyrodinium sp.	8	3	6	
		Thalasiossira sp.	5	7	7	
		Unknown	2	1	1	
		Actinoptychus sp.	5	2	1	
		Navicula sp.			1	

Remark			
Date	06. 22	Study personnel	Sun ok Lee (sign)
Certificate date	06. 22	Study director	Sun ok Lee (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Worksheet-Plankton-003(1)

Test Result Sheet - Classification (II)

2014

Study number		Test number	SET-14-003
Test substance	Control water	Lot. No.	
Organism	□ ≥ 10 to 50 μm □ ≥ 50 μm	Method	□ Direct ☑ Dye (FDA)
Concentration	—	Receive time of test substance	13:00
Test start time	13:05	Test end time	—

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S04UW-E	1mL	Gyrodinium sp.	4	3	3	
		Prorocentrum sp.	4		2	
		Skeletonema sp.	12	7	8	
		Thalasiossira sp.	5	2	1	
		Navicula sp	2	1	1	
		Pleurosigma sp.	2	2		
		Protoza	1		2	
		Chaetoceros sp.			1	
		Actinoptychus sp.			1	

Remark			
Date	06.22	Study personnel	Sun ok Lee (sign)
Certificate date	06.22.	Study director	Sun ok Lee (sign)

* R: Replicate

Worksheet-Plankton–003(1)

Busan Techno-Park
Marine Bio-industry Development Center

4.5 Test 5 report and raw data

Test Report

Project name	EcoGuardian™
Test number	SET-14-004
Port	Tolo (Hong Kong)-Ballasting Tolo (Hong Kong)-Deballasting
Title	Efficacy test of EcoGuardian™ Ballast Water Management System (shipboard scale)

BUSAN TECHNO PARK

Statement of Quality Assurance

Data were reviewed by Quality Assurance Unit of BTP to assure that the study was performed in accordance with protocol and standard operating procedures (SOP) of Busan Techno-Park (BTP). The report was an accurate reflection of the raw data generated at the BTP. Inspection of the routine and repeated procedures that constitute the study was carried out as a continuous major phase at or about the time this study was in progress.

Inspection Phase		Date		
		Inspection	Report to Testing manager	Report to Project director
Test plan		18th July, 2014	18th July, 2014	18th July, 2014
Sampling	1st	21st July, 2014	21st July, 2014	21st July, 2014
	2nd	23rd July, 2014	23rd July, 2014	23rd July, 2014
Test substance	1st	21st July, 2014	21st July, 2014	21st July, 2014
	2nd	23rd July, 2014	23rd July, 2014	23rd July, 2014
Test procedures (Bacteria test)	1st	21st July, 2014	21st July, 2014	21st July, 2014
	2nd	23rd July, 2014	23rd July, 2014	23rd July, 2014
Observation and counting (≥50㎛, 10㎛-50㎛)	1st	21st July, 2014	21st July, 2014	21st July, 2014
	2nd	23rd July, 2014	23rd July, 2014	23rd July, 2014
Observation and counting (Bacteria test)	1st	22nd~24th July, 2014	22nd~24th July, 2014	22nd~24th July, 2014
	2nd	23rd July~25th July, 2014	23rd July~25th July, 2014	23rd July~25th July, 2014

Seo, Hyu-Jin (Sign) 12th, Dec. 2014

Seo, Hyu-Jin / Project director Date

Study Personnel and Participants

The test participants recognized the study plan, manual, procedure, guide of Busan Techno Park in performing the test.

	Name	Date
Study personnel	Kim Hui-Jeong (sign)	12th. Dec. 2014
	Lee Ji-Sun (sign)	12th. Dec, 2014
	Lee Sun ok (sign)	12th. Dec. 2014.
	Lee Myounghee (sign)	12 th. Dec. 2014
	Sang Myun Kim (sign)	12 th. Dec. 2014
	Lee Seok Ju (sign)	12 th. Dec. 2014
	(sign)	
Project director	Seo. Hyo-Jin (sign)	12th. Dec. 2014

Contents

1.Results 1

1.1 Loading record 1

1.2 Water parameters 2

1.3 Influent water : Uptake water 4

1.4 Elimination efficacy 6

2. Validity 12

3. Conclusion 14

4. Appendix 15

1. Results

1.1 Loading record

Vessel name	SSANG YONG CHANGYAHNG
IMO number	9121027

Water ballast tanks			Sample WGT(Mt)	Loading (Date/Location)	Discharge (Date/Location)
Control	No.3 D/B W.B.T	P, S	1370	21st July, 2014 Tolo (22°26.61N, 114°14.51E)	23rd July, 2014 Tolo (22°26.61N, 114°14.51E)
Treated	No.4 D/B W.B.T No.5 D/B W.B.T	P, S	650	21st July, 2014 Tolo (22°26.61N, 114°14.51E)	23rd July, 2014 Tolo (22°26.61N, 114°14.51E)

1.2 Water parameters

Table 1. Water parameters at field

Date	Sample ID	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
Day 0	HL-S05UW-B	8.38±0.16	29.47±0.04	29.73±0.03	5.64±0.19	7.5±0.1	-
	HL-S05UW-M	8.51±0.01	29.47±0.13	29.84±0.06	5.94±0.54	7.7±0.2	-
	HL-S05UW-E	8.52±0.01	29.44±0.04	29.86±0.01	5.61±0.10	7.4±0.3	-
Day 2	HL-S05CD2-B	8.27±0.08	30.43±0.20	30.35±0.81	2.53±1.26	6.6±1.5	-
	HL-S05CD2-M	8.26±0.11	30.22±0.06	29.66±0.07	3.36±0.40	7.7±0.9	-
	HL-S05CD2-E	8.30±0.07	30.30±0.05	29.56±0.22	2.92±1.53	6.9±0.2	-
	HL-S05TD2-B-1	8.27±0.00	30.20±0.0	29.58±0.00	2.27±0.04	7.3±1.5	0.04±0.02
	HL-S05TD2-B-2	8.40±0.00	30.06±0.03	29.69±0.01	3.15±0.00	6.1±0.1	-
	HL-S05TD2-B-3	8.40±0.00	30.02±0.01	29.71±0.01	3.49±0.04	5.0±0.3	-
	HL-S05TD2-M-1	8.43±0.00	30.03±0.01	29.76±0.03	3.64±0.07	6.5±0.1	0.05±0.03
	HL-S05TD2-M-2	8.42±0.00	30.04±0.01	29.66±0.03	3.85±0.49	4.9±0.1	-
	HL-S05TD2-M-3	8.43±0.00	30.08±0.01	29.59±0.00	3.73±0.25	6.7±0.2	-
	HL-S05TD2-E-1	8.43±0.00	30.12±0.01	29.73±0.04	3.41±0.01	4.8±0.0	0.06±0.02
	HL-S05TD2-E-2	8.43±0.00	30.06±0.03	29.69±0.02	3.36±0.01	5.6±0.0	-
	HL-S05TD2-E-3	8.43±0.00	30.12±0.01	29.75±0.04	3.34±0.05	5.7±0.1	-

Data were presented as mean±S.D of three repeated measurement.

Table 2. Results of DOC, POC, TSS

Date	Sample ID	TOC [a)] (mg/L)	DOC [b)] (mg/L)	POC [c)] (mg/L)	TSS [d)] (mg/L)
Day 0	HL-S05UW-B	3.200±0.085	1.793±0.033	1.793	2.4±0.4
	HL-S05UW-M	3.241±0.126	1.726±0.124	1.726	2.4±0.2
	HL-S05UW-E	2.948±0.179	1.759±0.110	1.759	3.0±0.2

Data were presented as mean±S.D of three repeated measurement.
a) TOC: Total Organic Carbon
b) DOC: Dissolved Organic Carbon
c) POC: Particulate Organic Carbon (POC=TOC-DOC)
d) TSS: Total Suspended Solids

1.3 Influent water : Uptake water

1) ≥ 50 µm organism

Table 3. The survival number of the organism larger than 50 µm

Sample ID	Phyla/Divisions	Species	individuals/m^3	Minimum Dimension (µm)
HL-S05UW-B	Arthropoda	*Parvocalanus* sp.	2,167 ± 629	300~350
		Oithona spp.	7,417 ± 764	200~250
		Acartia sp.	1,583 ± 946	350~450
		Paracalanus sp.	83 ± 144	500~550
		Harpacticoida sp.	500 ± 500	125~175
		Evadne tergestina	167 ± 289	550~700
		Nauplius	500 ± 250	175~225
	Annelida	Polychaeta larvae	333 ± 382	300~375
	Mollusca	Bivalve larvae	1,833 ± 878	400~450
HL-S05UW-M	Arthropoda	*Parvocalanus* sp.	8,000 ± 433	300~350
		Oithona spp.	10,000 ± 1,090	200~250
		Acartia sp.	917 ± 382	350~450
		Harpacticoida sp.	250 ± 0	125~175
		Evadne tergestina	83 ± 144	550~700
		Nauplius	167 ± 144	175~225
	Annelida	Polychaeta larvae	333 ± 144	300~375
	Mollusca	Bivalve larvae	1,417 ± 144	400~450
		Gastropod larvae	167 ± 144	500~650
HL-S05UW-E	Arthropoda	*Parvocalanus* sp.	1,167 ± 382	300~350
		Oithona spp.	18,417 ± 289	200~250
		Acartia sp.	1,000 ± 500	350~450
		Harpacticoida sp.	333 ± 289	125~175
		Evadne tergestina	2,417 ± 1,155	550~700
	Annelida	Polychaeta larvae	667 ± 289	300~375
	Mollusca	Bivalve larvae	2,583 ± 722	400~450
		Gastropod larvae	417 ± 144	500~650
Total	10 species 3 phyla/divisions		20,972 ± 6,216	-
Acceptability			Influent condition: Acceptable (≥10^2 ind./ m^3)	-

Data were presented as mean±S.D of three repeated measurement.
Some species were rare, the standard deviation was high.

2) 10 µm - 50 µm organism

Table 4. The survival number of the organism between 10 to 50 µm

Sample ID	Phyla/Divisions	Species	individuals/mL	Minimum Dimension (µm)
HL-S05UW-B	Chrysophyta	*Guinardia* sp.	53 ± 6	11~15
		Leptocylindrus sp.	43 ± 3	10~15
		Chaetoceros sp.	41 ± 8	10~35
		Dictyocha sp.	11 ± 2	15~18
		Skeletonema sp.	2 ± 3	10~20
		Rhizosolenia sp.	1 ± 2	12~20
	Pyrrophyta	*Gyrodinium* sp.	5 ± 3	10~15
		Ceratium sp.	3 ± 2	15~40
		Gymnodinium sp.	3 ± 2	15~40
		Unknown	1 ± 2	20~30
HL-S05UW-M	Chrysophyta	*Chaetoceros* sp.	44 ± 12	10~35
		Guinardia sp.	57 ± 3	11~15
		Dictyocha sp.	7 ± 3	15~18
		Leptocylindrus sp.	33 ± 10	10~15
		Rhizosolenia sp.	1 ± 1	10~20
	Pyrrophyta	*Ceratium* sp.	3 ± 3	15~40
		Gymnodinium sp.	3 ± 3	15~40
		Gyrodinium sp.	2 ± 2	10~13
		Unknown	4 ± 2	20~30
HL-S05UW-E	Chrysophyta	*Leptocylindrus* sp.	31 ± 1	10~15
		Guinardia sp.	54 ± 7	11~15
		Chaetoceros sp.	28 ± 14	10~35
		Rhizosolenia sp.	5 ± 1	10~20
		Dictyocha sp.	5 ± 3	15~18
	Pyrrophyta	*Gymnodinium* sp.	3 ± 3	15~40
		Gyrodinium sp.	2 ± 0	10~15
		Ceratium sp.	3 ± 3	15~40
		Unknown	4 ± 0	20~30
Total	10 species 2 phyla/divisions		152 ± 15	-
Acceptability			Influent condition: Acceptable ($\geq 10^2$ ind./mL)	

Data were presented as mean±S.D of three repeated measurement.
Some species were rare, the standard deviation was high.

1.4 Elimination efficacy

1) ≥ 50 µm organism

Table 5. The survival number of the organism larger than 50 µm

Test substance	Sample ID	individuals/m^3	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S03UW-B [a)]	14,583 ± 1,909	Influent condition: Acceptable (≥10^2 ind./m^3)	-
	HL-S03UW-M [b)]	21,333 ± 1,443		
	HL-S03UW-E [c)]	27,000 ± 500		
Discharged control water (Day 2, C2)	HL-S03CD2-B	11,875 ± 433	Effluent condition: Acceptable (≥10 ind./m^3)	-
	HL-S03CD2-M	10,583 ± 402		
	HL-S03CD2-E	12,792 ± 764		
Discharged treated water (Day 2, T2)	HL-S03TD2-B-1	N.D [e)]	Effluent condition: Acceptable (<10 ind./m^3)	100.0 [d)]
	HL-S03TD2-B-2	N.D		
	HL-S03TD2-B-3	N.D		
	HL-S03TD2-M-1	N.D		
	HL-S03TD2-M-2	N.D		
	HL-S03TD2-M-3	N.D		
	HL-S03TD2-E-1	N.D		
	HL-S03TD2-E-2	N.D		
	HL-S03TD2-E-3	N.D		

a) B: beginning, b) M: Middle c) E: End, d) Calculation = (Uw-T2)/Uw*100, e) N.D : Not Detected
Data were presented as mean±S.D of three repeated measurement.

2) 10 µm - 50 µm organism

Table 6. The survival number of the organism between 10 and 50 µm

Test substance	Sample ID	individuals/mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S05UW-B [a)]	164 ± 13	Influent condition: Acceptable ($\geq 10^2$ ind./mL)	-
	HL-S05UW-M [b)]	155 ± 12		
	HL-S05UW-E [c)]	135 ± 5		
Discharged control water (Day 2, C2)	HL-S05CD2-B	34 ± 4	Effluent condition: Acceptable (≥10 ind./mL)	-
	HL-S05CD2-M	31 ± 2		
	HL-S05CD2-E	29 ± 4		
Discharged treated water (Day 2, T2)	HL-S05TD2-B-1	<1	Effluent condition: Acceptable (<10 ind./mL)	99.9 [d)]
	HL-S05TD2-B-2	<1		
	HL-S05TD2-B-3	<1		
	HL-S05TD2-M-1	N.D [e)]		
	HL-S05TD2-M-2	N.D		
	HL-S05TD2-M-3	N.D		
	HL-S05TD2-E-1	<1		
	HL-S05TD2-E-2	N.D		
	HL-S05TD2-E-3	N.D		

a) B: Beginning, b) M: Middle c) E: End, d) Calculation = (Uw-T2)/Uw*100, e) N.D : Not Detected
Data were presented as mean±S.D of three repeated measurement.

3) Heterotrophic bacteria

Table 7. The survival number of heterotrophic bacteria

Test substance	Sample ID	CFU / mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S05UW-B [a)]	67 ± 14	-	-
	HL-S05UW-M [b)]	25 ± 0		
	HL-S05UW-E [c)]	N.D [e)]		
Discharged control water (Day 2, C2)	HL-S05CD2-B	TNTC [f)]	-	-
	HL-S05CD2-M	TNTC		
	HL-S05CD2-E	TNTC		
Discharged treated water (Day 2, T2)	HL-S05TD2-B-1	78 ± 4	-	0.0 [d)]
	HL-S05TD2-B-2	50 ± 1		
	HL-S05TD2-B-3	69 ±7		
	HL-S05TD2-M-1	40 ± 4		
	HL-S05TD2-M-2	44 ± 3		
	HL-S05TD2-M-3	60 ± 2		
	HL-S05TD2-E-1	37 ± 10		
	HL-S05TD2-E-2	66 ± 5		
	HL-S05TD2-E-3	83 ± 5		

a) B: Beginning, b) M: Middle, c) E: End, d) Calculation = (Uw-T2)/Uw*100, e) N.D : Not Detected
f) TNTC : Too Numerous To Count
Data were presented as mean±S.D of three repeated measurement.

4) *Escherichia coli*

Table 8. The survival number of *Escherichia coli*

Test substance	Sample ID	CFU / 100mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S05UW-B [a)]	128 ± 39	-	-
	HL-S05UW-M [b)]	145 ± 10		
	HL-S05UW-E [c)]	84 ± 24		
Discharged control water (Day 2, C2)	HL-S05CD2-B	4 ± 2	-	-
	HL-S05CD2-M	10 ± 3		
	HL-S05CD2-E	39 ± 3		
Discharged treated water (Day 2, T2)	HL-S05TD2-B-1	5 ± 5	Effluent condition: Acceptable (<250 CFU/ 100 mL)	99.1 [d)]
	HL-S05TD2-B-2	1 ± 1		
	HL-S05TD2-B-3	N.D [e)]		
	HL-S05TD2-M-1	1 ± 1		
	HL-S05TD2-M-2	N.D		
	HL-S05TD2-M-3	N.D		
	HL-S05TD2-E-1	2 ± 1		
	HL-S05TD2-E-2	N.D		
	HL-S05TD2-E-3	N.D		

a) B: Beginning, b) M: Middle, c) E: End, d) Calculation = (Uw-T2)/Uw*100, e) N.D : Not Detected
Data were presented as mean±S.D of three repeated measurement.

5) Intestinal enterococci

Table 9. The survival number of intestinal enterococci

Test substance	Sample ID	CFU / 100mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S05UW-B [a)]	N.D [e)]	-	-
	HL-S05UW-M [b)]	N.D		
	HL-S05UW-E [c)]	N.D		
Discharged control water (Day 2, C2)	HL-S05CD2-B	0 ± 1	-	-
	HL-S05CD2-M	N.D		
	HL-S05CD2-E	N.D		
Discharged treated water (Day 2, T2)	HL-S05TD2-B-1	N.D	Effluent condition: Acceptable (<100 CFU/ 100 mL)	N. D[d)]
	HL-S05TD2-B-2	N.D		
	HL-S05TD2-B-3	N.D		
	HL-S05TD2-M-1	N.D		
	HL-S05TD2-M-2	N.D		
	HL-S05TD2-M-3	N.D		
	HL-S05TD2-E-1	N.D		
	HL-S05TD2-E-2	N.D		
	HL-S05TD2-E-3	N.D		

a) B: Beginning, b) M: Middle, c) E: End, d) N.D: Not detected, e) N.D : Not Detected
Data were presented as mean±S.D of three repeated measurement.

6) *Vibrio cholera* O1, O139

Table 10. The survival number of *Vibrio cholera* O1, O139

Test substance	Sample ID	CFU / 100mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S05UW-B [a)]	N. D	-	-
	HL-S05UW-M [b)]	N. D		
	HL-S05UW-E [c)]	N. D		
Discharged control water (Day 2, C2)	HL-S05CD2-B	N. D	-	-
	HL-S05CD2-M	N. D		
	HL-S05CD2-E	N. D		
Discharged treated water (Day 2, T2)	HL-S05TD2-B-1	N. D	Effluent condition: Acceptable (<1 CFU/ 100 mL)	N. D[d)]
	HL-S05TD2-B-2	N. D		
	HL-S05TD2-B-3	N. D		
	HL-S05TD2-M-1	N. D		
	HL-S05TD2-M-2	N. D		
	HL-S05TD2-M-3	N. D		
	HL-S05TD2-E-1	N. D		
	HL-S05TD2-E-2	N. D		
	HL-S05TD2-E-3	N. D		

a) B: Beginning, b) M: Middle c) E: End, d) N.D: Not detected
Data were presented as mean±S.D of three repeated measurement.

2. Validity

2.1 Water parameters measurement

- All measurements were tested more than three times.
- Water parameters were analyzed as soon as possible after sampling.

2.2 Biological efficacy test

- Valid tests are indicated by uptake water, for both the control tank and ballast water to be treated, with viable organism concentration exceeding 10 times the maximum permitted values in Regulation D-2.1

Sample ID	≥ 50 µm (individuals/m^3)	10 µm - 50 µm (individuals/mL)
HL-S03UW-B	14,583 ± 1,909	164 ± 13
HL-S03UW-M	21,333 ± 1,443	155 ± 12
HL-S03UW-E	27,000 ± 500	135 ± 5

- Valid test is indicated by control tank viable organism concentration exceeding the values of Regulation D-2.1 on discharge.

Sample ID	≥ 50 µm (individuals/m^3)	10 µm - 50 µm (individuals/mL)
HL-S03CD2-B	11,875 ± 433	34 ± 4
HL-S03CD2-M	10,583 ± 402	31 ± 2
HL-S03CD2-E	12,792 ± 764	29 ± 4

※Regulation D-2 stipulates that ships meeting the requirements of the Convention by meeting the ballast water performance standard must discharge:

1. less than 10 viable organisms per cubic metre greater than or equal to 50 micrometres in minimum dimension;
2. less than 10 viable organisms per milliliter less than 50 micrometres in minimum dimension and greater than or equal to 10 micrometres in minimum dimension

• The samples should be analyzed as soon as possible after sampling.

Date	Sample ID	Sampling time	Test ending time
Day 0	HL-S05UW-B	July, 21th 14:54	16:15
	HL-S05UW-M	July, 21th 15:58	17:30
	HL-S05UW-E	July, 21th 17:05	18:40
Day 2	HL-S05CD2-B	July, 23rd 14:18	15:29
	HL-S05CD2-M	July, 23rd 15:25	16:09
	HL-S05CD2-E	July, 23rd 16:29	17:10
	HL-S05TD2-B-1, 2, 3	July, 23rd 17:50	18:55
	HL-S05TD2-M-1, 2, 3	July, 23rd 19:01	20:00
	HL-S05TD2-E-1, 2, 3	July, 23rd 20:01	21:08

3. Conclusion

3.1 Biological efficacy in treated ballast seawater by EcoGuardian™ BWMS

- Treated ballast seawater by EcoGuardian™ system was capable of eliminating organism larger than 50 μm with an efficiency of 100.0%.
- Treated ballast seawater water by EcoGuardian™ BWMS was capable of eliminating organism between 10 and 50 μm with an efficiency of 99.9 %.
- Treated ballast seawater by EcoGuardian™ system was capable of eliminating heterotrophic bacteria with an efficiency of 0.0%.
- Treated ballast seawater by EcoGuardian™ system was capable of eliminating *Escherichia coli* with an efficiency of 99.1 %.
- Intestinal enterococci was not detected.
- *Vibrio cholera* O1, O139 were not detected.

4. Appendix

Appendix 1. Water parameters at field

1) Uptake water

Date	Sample ID	R [a)]	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)	TOC [b)] (mg/L)	DOC [c)] (mg/L)	TSS [d)] (mg/L)
Day 0	HL-S05UW-B	R1	8.19	29.49	29.74	5.70	7.5	3.224	1.788	2.6
		R2	8.48	29.42	29.75	5.79	7.6	3.175	1.762	2.6
		R3	8.46	29.49	29.70	5.42	7.4	3.058	1.827	2.0
	HL-S05UW-M	R1	8.51	29.39	29.93	6.56	7.7	3.125	1.597	2.4
		R2	8.51	29.41	29.83	5.70	7.8	3.224	1.735	2.2
		R3	8.52	29.62	29.84	5.57	7.5	3.375	1.845	2.6
	HL-S05UW-E	R1	8.52	29.41	29.85	5.73	7.3	3.114	1.692	3.2
		R2	8.52	29.48	29.86	5.54	7.7	2.972	1.698	3.0
		R3	8.53	29.43	29.86	5.57	7.2	2.758	1.885	2.8

a) R: Replicate
b) TOC: Total Organic Carbon (TOC=DOC+POC)
c) DOC: Dissolved Organic Carbon
d) TSS: Total Suspended Solids

2) Discharged control water and discharged treated water

Date	Sample ID	R [a)]	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
Day 2	HL-S05CD2-B	R1	8.21	30.59	30.12	3.26	5.7	-
		R2	8.25	30.50	31.25	3.26	5.8	-
		R3	8.36	30.21	29.67	1.08	8.3	-
	HL-S05CD2-M	R1	8.14	30.29	29.58	3.77	8.3	-
		R2	8.30	30.20	29.71	3.34	8.2	-
		R3	8.35	30.18	29.70	2.98	6.7	-
	HL-S05CD2-E	R1	8.22	30.35	29.30	3.79	7.1	-
		R2	8.33	30.27	29.67	3.82	6.8	-
		R3	8.36	30.27	29.70	1.15	6.7	-
	HL-S05TD2-B-1	R1	8.27	30.20	29.58	2.22	9.0	0.05
		R2	8.27	30.20	29.58	2.28	6.3	0.02
		R3	8.27	30.20	29.58	2.30	6.5	0.05
	HL-S05TD2-B-2	R1	8.40	30.02	29.68	3.15	6.2	-
		R2	8.40	30.08	29.69	3.15	6.0	-
		R3	8.40	30.08	29.69	3.15	6.2	-
	HL-S05TD2-B-3	R1	8.40	30.01	29.71	3.45	5.3	-
		R2	8.40	30.01	29.71	3.51	4.9	-
		R3	8.40	30.03	29.72	3.52	4.8	-
	HL-S05TD2-M-1	R1	8.43	30.02	29.73	3.60	6.5	0.07
		R2	8.43	30.03	29.78	3.60	6.5	0.05
		R3	8.43	30.03	29.78	3.72	6.6	0.02
	HL-S05TD2-M-2	R1	8.42	30.05	29.64	4.38	4.8	-
		R2	8.42	30.05	29.65	3.41	4.9	-
		R3	8.42	30.03	29.70	3.75	4.9	-
	HL-S05TD2-M-3	R1	8.43	30.08	29.59	3.44	6.8	-
		R2	8.43	30.08	29.59	3.82	6.7	-
		R3	8.43	30.09	29.59	3.92	6.5	-
	HL-S05TD2-E-1	R1	8.43	30.12	29.71	3.40	4.8	0.04
		R2	8.43	30.12	29.78	3.42	4.8	0.05
		R3	8.43	30.11	29.70	3.41	4.8	0.08
	HL-S05TD2-E-2	R1	8.43	30.09	29.68	3.36	5.6	-
		R2	8.43	30.04	29.68	3.36	5.6	-
		R3	8.43	30.05	29.72	3.37	5.6	-
	HL-S05TD2-E-3	R1	8.43	30.11	29.71	3.33	5.8	-
		R2	8.43	30.13	29.77	3.29	5.7	-
		R3	8.43	30.12	29.78	3.39	5.7	-

Appendix 2. The survival number of ≥ 50㎛ organism in uptake water(Influent water)

Sample ID	Classification	Counting volume	R1[a)]	R2	R3	individuals/m^3	
						Mean	S.D[b)]
HL-S05UW-B	*Parvocalanus* sp.	1 mL	11	9	6	2,167	629
	Oithona spp.		29	33	27	7,417	764
	Acartia sp.		9	2	8	1,583	946
	Paracalanus sp.		1	0	0	83	144
	Harpacticoida sp.		4	2	0	500	500
	Evadne tergestina		2	0	0	167	289
	Nauplius		2	3	1	500	250
	Polychaeta larvae		3	0	1	333	382
	Bivalve larvae		4	11	7	1,833	878
HL-S05UW-M	*Parvocalanus* sp.	1 mL	33	33	30	8,000	433
	Oithona spp.		45	38	37	10,000	1,090
	Acartia sp.		4	2	5	917	382
	Harpacticoida sp.		1	1	1	250	0
	Evadne tergestina		1	0	0	83	144
	Nauplius		1	0	1	167	144
	Polychaeta larvae		1	2	1	333	144
	Bivalve larvae		5	6	6	1,417	144
	Gastropod larvae		1	0	1	167	144
HL-S05UW-E	*Parvocalanus* sp.	1 mL	5	3	6	1,167	382
	Oithona spp.		75	73	73	18,417	289
	Acartia sp.		4	6	2	1,000	500
	Harpacticoida sp.		2	2	0	333	289
	Evadne tergestina		7	15	7	2,417	1,155
	Polychaeta larvae		2	2	4	667	289
	Bivalve larvae		12	7	12	2,583	722
	Gastropod larvae		1	2	2	417	144

a) R: Replicate
b) S.D: Standard deviation
Some species were rare, the standard deviation was high.

Appendix 3. The survival number of ≥ 50㎛ organism in discharged control water

Sample ID	Classification	Counting volume	R1[a)]	R2	R3	individuals/m^3	
						Mean	S.D[b)]
HL-S05CD2-B	*Parvocalanus* sp.	2 mL	56	50	56	6,750	433
	Oithona spp.		29	35	31	3,958	382
	Acartia sp.		1	3	0	167	191
	Paracalanus sp.		1	0	2	125	125
	Cirriped larvae		2	7	3	500	331
	Polychaeta larvae		0	2	0	83	144
	Bivalve larvae		2	0	3	208	191
	Gastropod larvae		0	0	2	83	144
HL-S05CD2-M	*Parvocalanus* sp.	2 mL	57	52	50	6,625	451
	Oithona spp.		21	16	21	2,417	361
	Acartia sp.		4	1	5	417	260
	Paracalanus sp.		1	0	1	83	72
	Cirriped larvae		1	1	3	208	144
	Polychaeta larvae		0	1	1	83	72
	Bivalve larvae		1	7	4	500	375
	Gastropod larvae		1	3	2	250	125
HL-S05CD2-E	*Parvocalanus* sp.	2 mL	55	52	52	6,625	217
	Oithona spp.		22	20	19	2,542	191
	Acartia sp.		20	17	22	2,458	315
	Paracalanus sp.		1	0	0	42	72
	Harpacticoida sp.		0	0	2	83	144
	Cirriped larvae		2	3	1	250	125
	Nauplius		0	2	0	83	144
	Penilia avirostris		0	1	1	83	72
	Polychaeta larvae		1	2	2	208	72
	Bivalve larvae		2	0	0	83	144
	Gastropod larvae		6	0	2	333	382

a) R: Replicate
b) S.D: Standard deviation
Some species were rare, the standard deviation was high.

Appendix 4. The survival number of ≥ 50㎛ organism in discharged treated ballast water by treatment of EcoGuardian™ system

Sample ID	Classification	Counting volume	individuals/m^3
HL-S05TD2-B1	-	250 mL	-
HL-S05TD2-B2	-		-
HL-S05TD2-B3	-		-
HL-S05TD2-M1	-	250 mL	-
HL-S05TD2-M2	-		-
HL-S05TD2-M3	-		-
HL-S05TD2-E1	-	250 mL	-
HL-S05TD2-E2	-		-
HL-S05TD2-E3	-		-

a) R: Replicate
b) S.D: Standard deviation

Appendix 5. The survival number of 10㎛ - 50㎛ organism in uptake water(Influent water)

Sample ID	Classification	Counting volume	R1[a)]	R2	R3	individuals/mL	
						Mean	S.D[b)]
HL-S05UW-B	*Guinardia* sp.	0.5 mL	30	25	24	53	6
	Leptocylindrus sp.		21	23	20	43	3
	Gyrodinium sp.		4	1	3	5	3
	Chaetoceros sp.		19	25	17	41	8
	Dictycha sp.		5	7	5	11	2
	Ceratium sp.		1	1	3	3	2
	Skeletonema sp.		3	0	0	2	3
	Gymnodinium sp.		1	1	3	3	2
	Rhizosolenia sp.		2	0	0	1	2
	Unknown		2	0	0	1	2
HL-S05UW-M	*Chaetoceros* sp.	0.5 mL	25	26	15	44	12
	Guinardia sp.		30	27	29	57	3
	Dictycha sp.		5	3	2	7	3
	Leptocylindrus sp.		11	21	18	33	10
	Ceratium sp.		2	3	0	3	3
	Rhizosolenia sp.		1	0	1	1	1
	Gymnodinium sp.		2	0	3	3	3
	Unknown		3	2	1	4	2
	Gyrodinium sp.		0	1	2	2	2
HL-S05UW-E	*Leptocylindrus* sp.	0.5 mL	16	16	15	31	1
	Guinardia sp.		28	30	23	54	7
	Chaetoceros sp.		9	11	22	28	14
	Gymnodinium sp.		2	3	0	3	3
	Gyrodinium sp.		1	1	1	2	0
	Unknown		2	2	2	4	0
	Ceratium sp.		3	0	1	3	3
	Rhizosolenia sp.		3	2	2	5	1
	Dictycha sp.		1	3	4	5	3

a) R: Replicate
b) S.D: Standard deviation
Some species were rare, the standard deviation was high.

Appendix 6. The survival number of 10㎛ - 50㎛ organism in discharged control water

Sample ID	Classification	Counting volume	R1[a)]	R2	R3	individuals/mL	
						Mean	S.D[b)]
HL-S05CD2-B	*Guinardia* sp.	0.5 mL	12	6	8	17	6
	Gyrodinium sp.		1	1	0	1	1
	Unidentified ciliate		1	2	5	5	4
	Dictyocha sp.		1	3	4	5	3
	Ceratium sp.		0	1	0	1	1
	Chaetoceros sp.		0	6	0	4	7
HL-S05CD2-M	Unidentified ciliate	0.5 mL	4	3	3	7	1
	Guinardia sp.		4	3	6	9	3
	Rhizosolenia sp.		1	0	1	1	1
	Chaetoceros sp.		4	3	5	8	2
	Prorocentrum sp.		1	0	0	1	1
	Dictyocha sp.		2	1	1	3	1
	Leptocylindrus sp.		0	4	0	3	5
HL-S05CD2-E	*Guinardia* sp.	0.5 mL	6	3	5	9	3
	Rhizosolenia sp.		1	0	1	1	1
	Chaetoceros sp.		1	3	2	4	2
	Dictyocha sp.		2	1	1	3	1
	Unidentified ciliate		4	4	3	7	1
	Gyrodinium sp.		2	1	0	2	2
	Leptocylindrus sp.		0	3	0	2	3

a) R: Replicate
b) S.D: Standard deviation
Some species were rare, the standard deviation was high.

Appendix 7. The survival number of 10㎛ - 50㎛ organism in discharged treated ballast seawater by treatment of EcoGuardian™ system

Sample ID	Classification	Concentration factor[c)]	Counting volume	R1[a)]	R2	R3	individuals/mL	
							Mean	S.D[b)]
HL-S05TD2-B-1	Unidentified ciliate	X 20	0.5 mL	3	2	1	0.2	0.1
HL-S05TD2-B-2	Unknown			0	0	1	0.0	0.1
	Unidentified ciliate			1	0	0	0.0	0.1
HL-S05TD2-B-3	Unidentified ciliate			0	0	1	0.0	0.1
HL-S05TD2-M-1	-	X 20	0.5 mL	0	0	0	0.0	0.0
HL-S05TD2-M-2	-			0	0	0	0.0	0.0
HL-S05TD2-M-3	-			0	0	0	0.0	0.0
HL-S05TD2-E-1	Unidentified ciliate	X 20	0.5 mL	1	0	0	0.0	0.1
HL-S05TD2-E-2	Unidentified ciliate			0	0	0	0.0	0.0
HL-S05TD2-E-3	Unidentified ciliate			0	0	1	0.0	0.1

a) R: Replicate
b) S.D: Standard deviation
c) Concentration factor: Treated water was concentration 10 L to 500 mL by 5 μm net.

Appendix 8. The number of heterotrophic bacteria in uptake water, discharged control water and discharged treated water by treatment of EcoGuardian™ BWMS

Date	Sample ID	Dilution factor	R1[a)]	R2	R3	CFU / mL	
						Mean	S.D[b)]
Day 0	HL-S05UW-B	x 25	2	3	3	67	14
	HL-S05UW-M		1	1	1	25	0
	HL-S05UW-E		0	0	0	0	0
Day 2	HL-S05CD2-B	-	TNTC[c)]	TNTC	TNTC	-	-
	HL-S05CD2-M	-	TNTC	TNTC	TNTC	-	-
	HL-S05CD2-E	-	TNTC	TNTC	TNTC	-	-
	HL-S05TD2-B-1	-	82	76	75	78	4
	HL-S05TD2-B-2	-	51	51	49	50	1
	HL-S05TD2-B-3	-	77	66	64	69	7
	HL-S05TD2-M-1	-	39	37	44	40	4
	HL-S05TD2-M-2	-	47	41	43	44	3
	HL-S05TD2-M-3	-	61	58	60	60	2
	HL-S05TD2-E-1	-	48	32	31	37	10
	HL-S05TD2-E-2	-	60	67	70	66	5
	HL-S05TD2-E-3	-	78	85	87	83	5

a) R: Replicate
b) S.D: Standard deviation
c) TNTC : Too Numerous To Count

Appendix 9. The number of *Escherichia coli* in uptake water, discharged control water and discharged treated water by treatment of EcoGuardian™ BWMS

Date	Sample ID	Testing volume	R1[a)]	R2	R3	CFU / 100 mL	
						Mean	S.D[b)]
Day 0	HL-S05UW-B	25 mL	36	39	21	128	39
	HL-S05UW-M		34	36	39	145	10
	HL-S05UW-E		17	18	28	84	24
Day 2	HL-S05CD2-B	100 mL	3	3	6	4	2
	HL-S05CD2-M		7	12	10	10	3
	HL-S05CD2-E		42	38	36	39	3
	HL-S05TD2-B-1	100 mL	2	3	11	5	5
	HL-S05TD2-B-2		2	1	0	1	1
	HL-S05TD2-B-3		0	0	0	0	0
	HL-S05TD2-M-1		2	0	0	1	1
	HL-S05TD2-M-2		0	0	0	0	0
	HL-S05TD2-M-3		0	0	0	0	0
	HL-S05TD2-E-1		2	2	3	2	1
	HL-S05TD2-E-2		0	0	0	0	0
	HL-S05TD2-E-3		0	0	0	0	0

a) R: Replicate
b) S.D: Standard deviation

Appendix 10. The number of intestinal enterococci in uptake water, discharged control water and discharged treated water by treatment of EcoGuardian™ BWMS

Date	Sample ID	Testing volume	R1[a)]	R2	R3	CFU / 100 mL	
						Mean	S.D[b)]
Day 0	HL-S05UW-B	100 mL	0	0	0	0	0
	HL-S05UW-M		0	0	0	0	0
	HL-S05UW-E		0	0	0	0	0
Day 2	HL-S05CD2-B	100 mL	1	0	0	0	1
	HL-S05CD2-M		0	0	0	0	0
	HL-S05CD2-E		0	0	0	0	0
	HL-S05TD2-B-1	100 mL	0	0	0	0	0
	HL-S05TD2-B-2		0	0	0	0	0
	HL-S05TD2-B-3		0	0	0	0	0
	HL-S05TD2-M-1		0	0	0	0	0
	HL-S05TD2-M-2		0	0	0	0	0
	HL-S05TD2-M-3		0	0	0	0	0
	HL-S05TD2-E-1		0	0	0	0	0
	HL-S05TD2-E-2		0	0	0	0	0
	HL-S05TD2-E-3		0	0	0	0	0

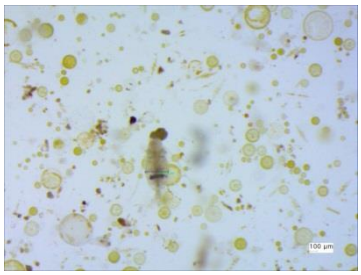
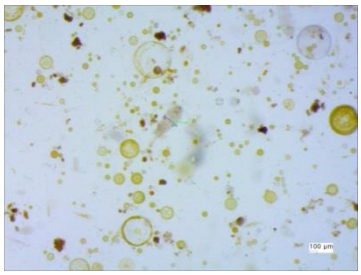
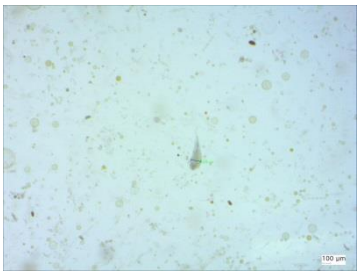
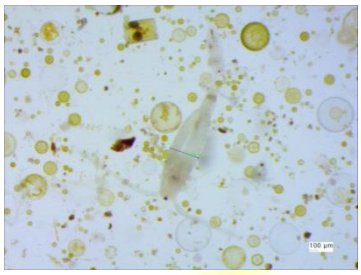
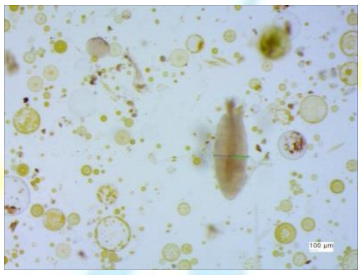
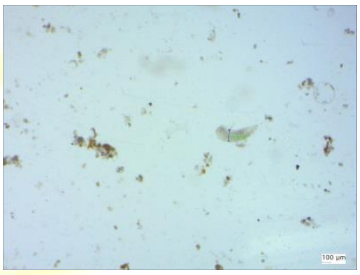
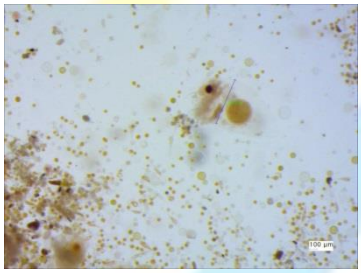
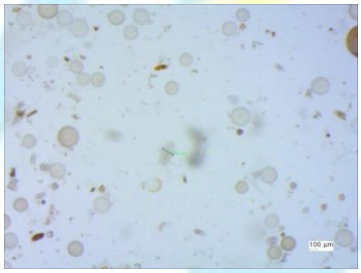
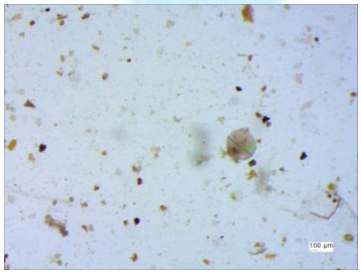
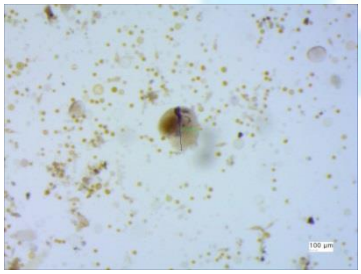
a) R: Replicate
b) S.D: Standard deviation

Appendix 11. The number of *Vibrio cholera* O1, O139 in uptake water, discharged control water and discharged treated water by treatment of EcoGuardian™ BWMS

Date	Sample ID	Testing volume	R1[a)]	R2	R3	CFU / 100 mL	
						Mean	S.D[b)]
Day 0	HL-S05UW-B	100 mL	0	0	0	0	-
	HL-S05UW-M		0	0	0	0	-
	HL-S05UW-E		0	0	0	0	-
Day 2	HL-S05CD2-B	100 mL	0	0	0	0	-
	HL-S05CD2-M		0	0	0	0	-
	HL-S05CD2-E		0	0	0	0	-
	HL-S05TD2-B-1	100 mL	0	0	0	0	-
	HL-S05TD2-B-2		0	0	0	0	-
	HL-S05TD2-B-3		0	0	0	0	-
	HL-S05TD2-M-1		0	0	0	0	-
	HL-S05TD2-M-2		0	0	0	0	-
	HL-S05TD2-M-3		0	0	0	0	-
	HL-S05TD2-E-1		0	0	0	0	-
	HL-S05TD2-E-2		0	0	0	0	-
	HL-S05TD2-E-3		0	0	0	0	-

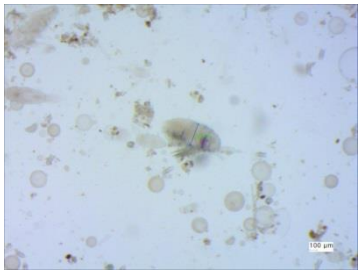
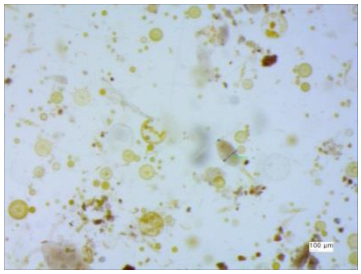
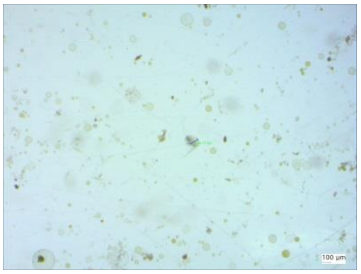
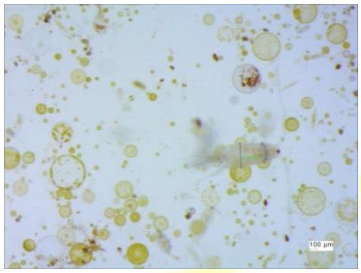
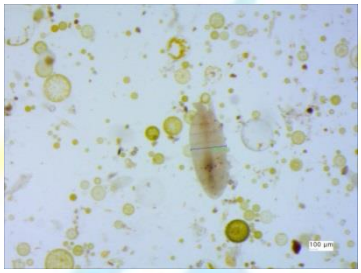
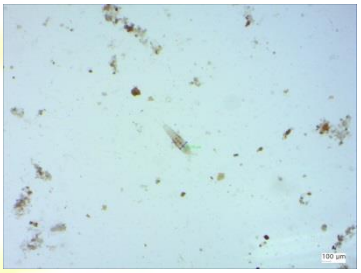
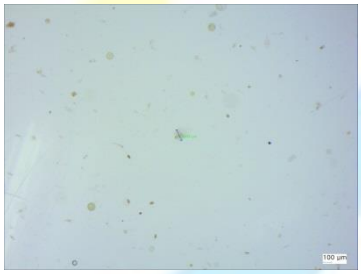
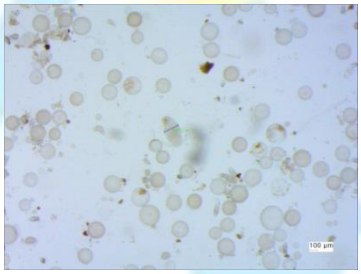
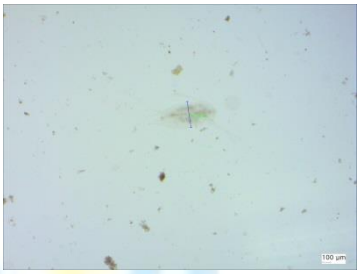
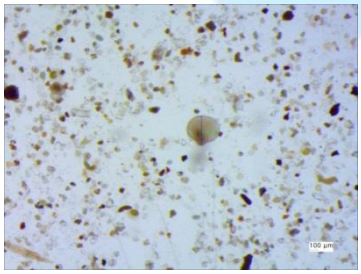
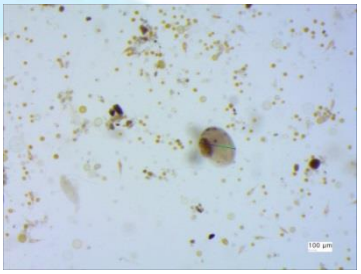
a) R: Replicate
b) S.D: Standard deviation

Appendix 12. The microscopic image of ≥ 50㎛ in uptake water (Day0)

Uptake water (Day 0)		
Parvocalanus sp.*	*Oithona* spp.*	
		
Acartia sp.*	*Paracalanus* sp.*	Harpacticoida sp.*
		
*Evadne tergestina**	Nauplius*	Polychaeta larvae*
		
Bivalve larvae*	Gastropod larvae*	
		

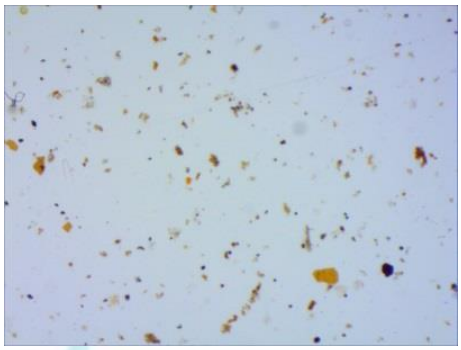
* Magnification : 20

Appendix 13. The microscopic image of ≥ 50㎛ in discharged control water (Day2)

Discharged control water (Day 2)		
Parvocalanus sp.*	*Oithona* spp.*	
		
Acartia sp.*	*Paracalanus* sp.*	Harpacticoida sp.*
		
Cirriped larvae*	Nauplius*	*Penilia avirostris*
		
Polychaeta larvae*	Bivalve larvae*	Gastropod larvae*
		

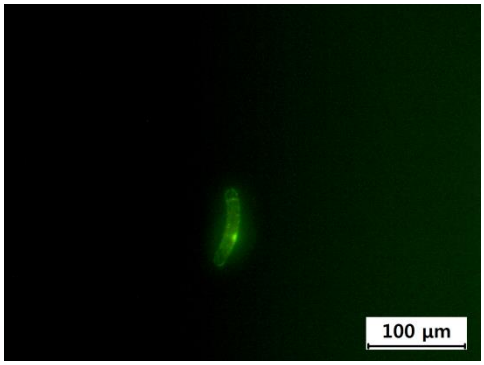
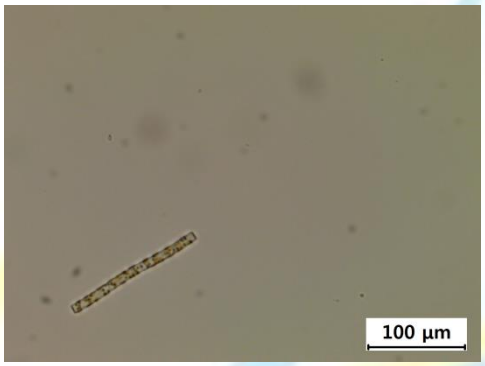
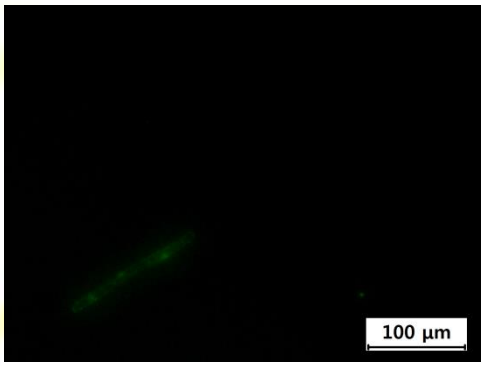
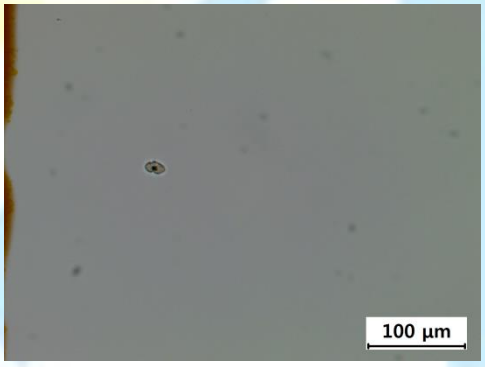
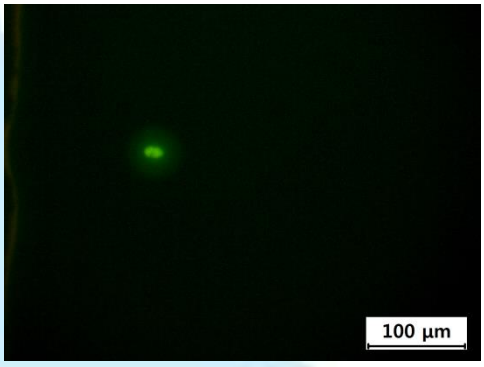
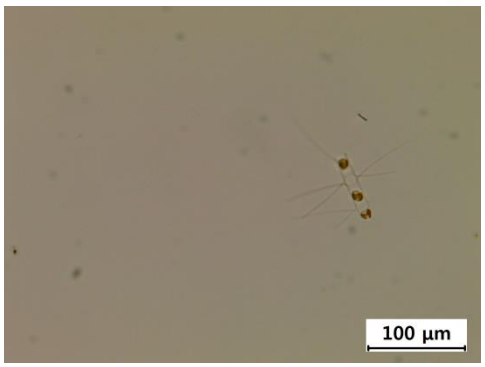
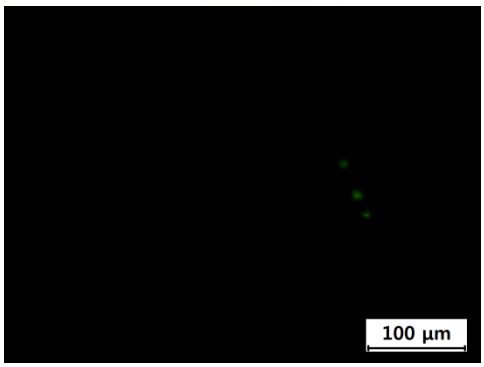
* Magnification : 20

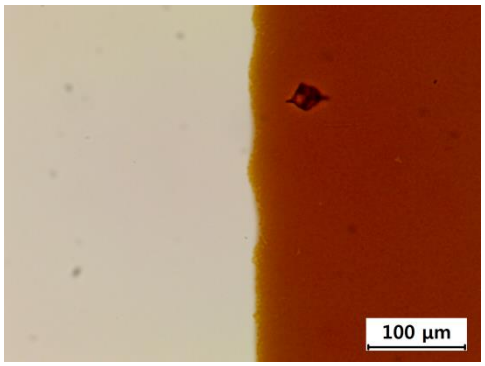
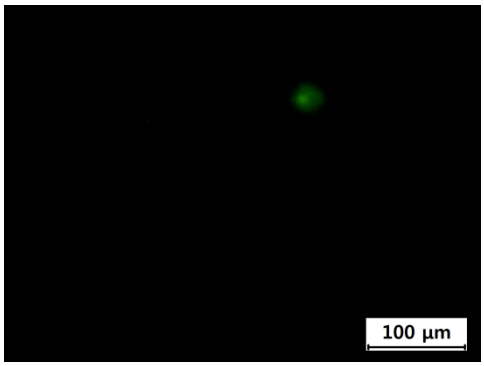
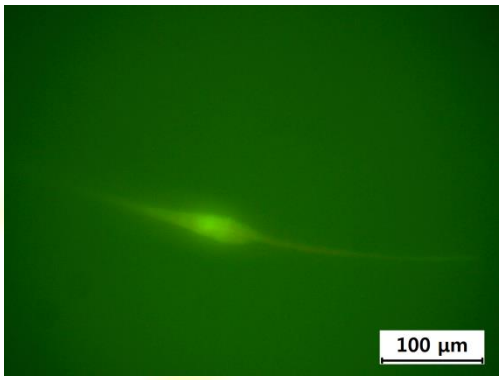
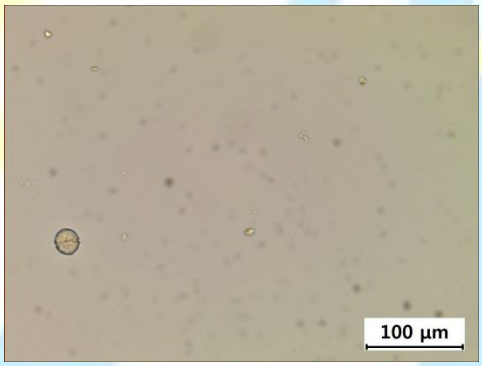
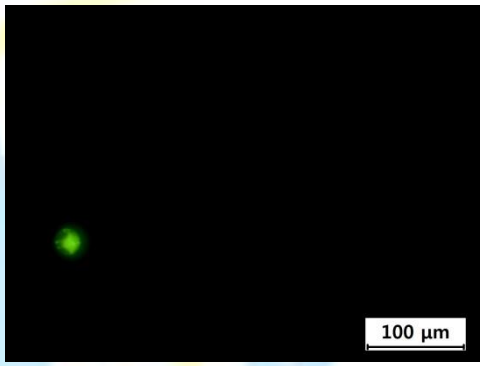
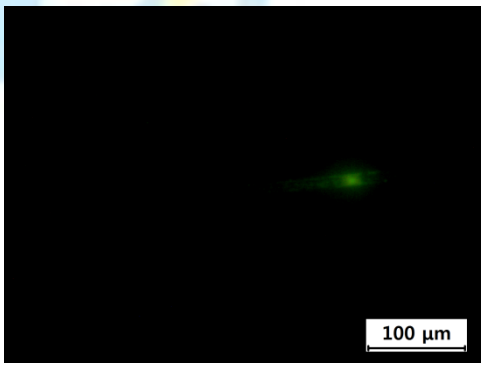
Appendix 14. The microscopic image of ≥ 50㎛ in discharged treated water by treatment of EcoGuardian™ BWMS (Day2)

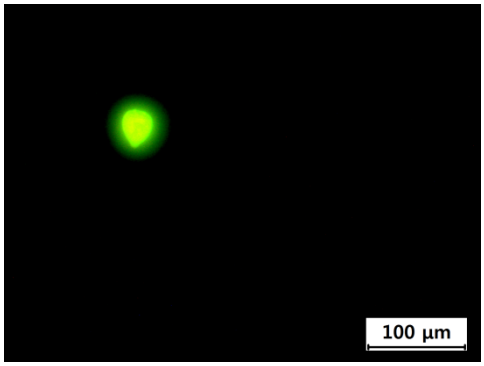
Specific Name	Discharged treated water
-	

* Magnification : 20

Appendix 15. The microscopic image of 10㎛−50㎛ in uptake water (Day0)

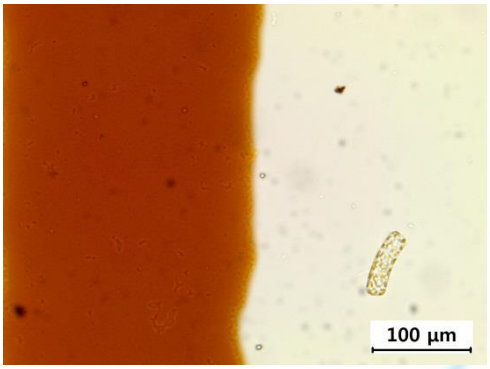
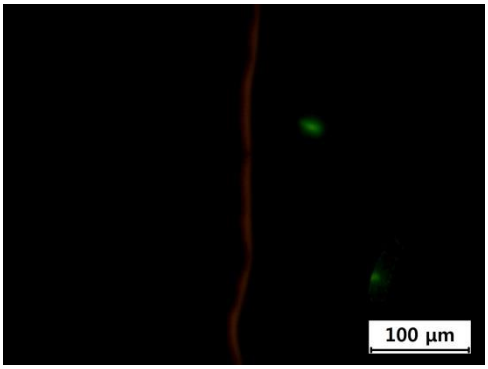
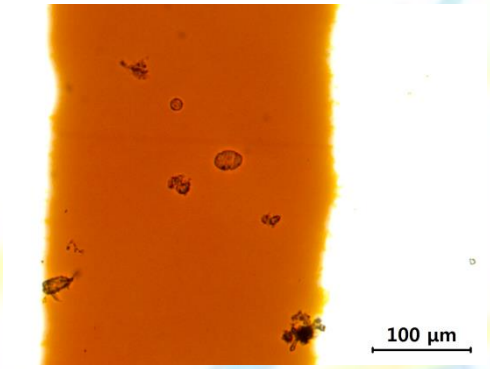
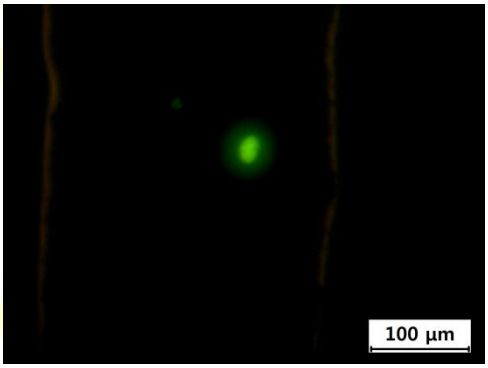
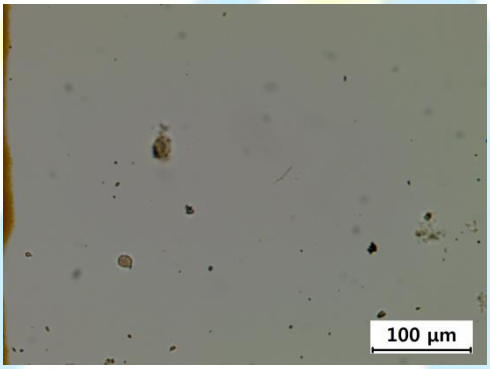
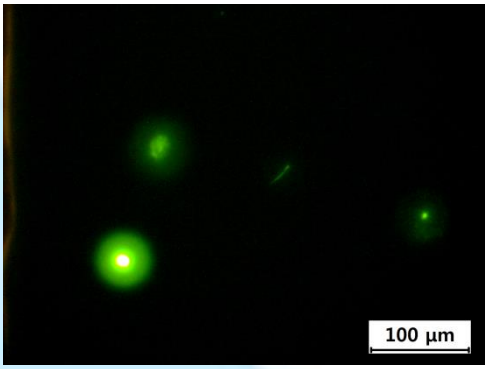
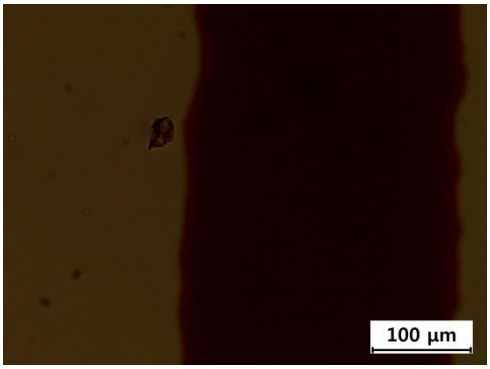
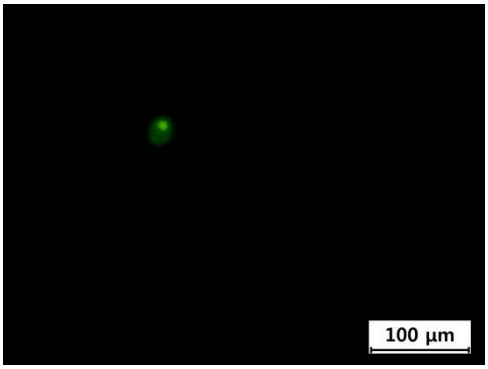
Specific Name	Uptake water	
	Optical	Fluorescence
Guinardia sp.		
Leptocylindrus sp.		
Gyrodinium sp.		
Chaetoceros sp.		

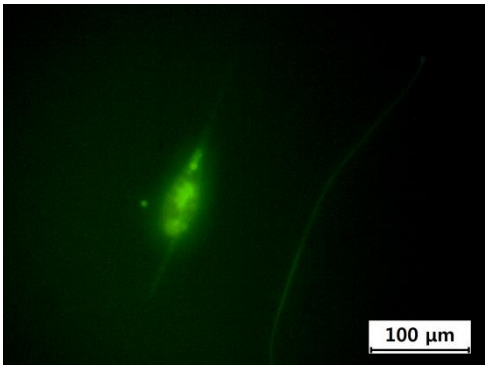
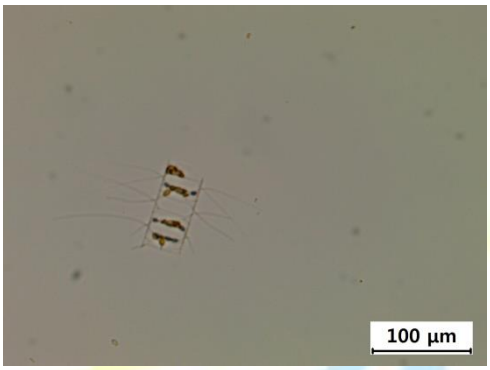
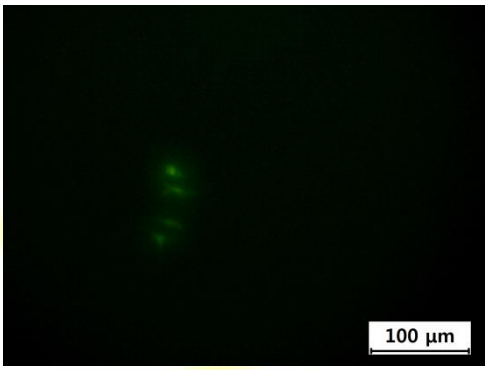
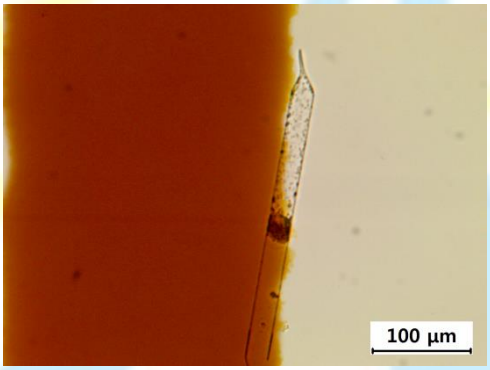
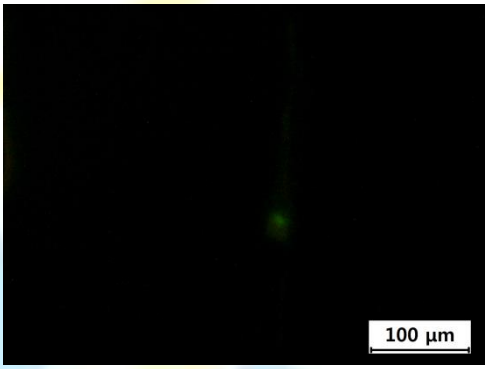
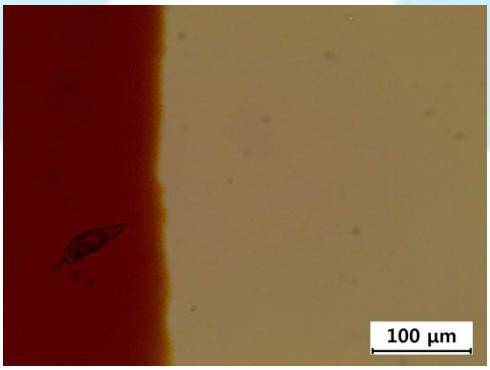
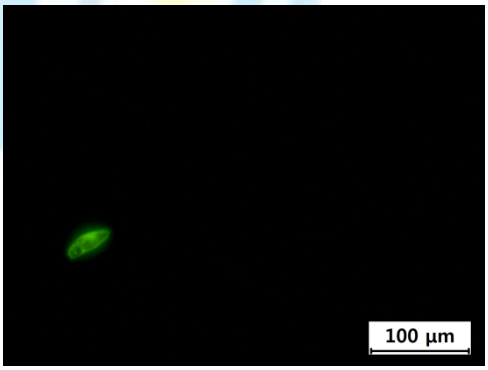
Dictyocha sp.		
Ceratium sp.		
Gymnodinium sp.		
Rhizosolenia sp.		

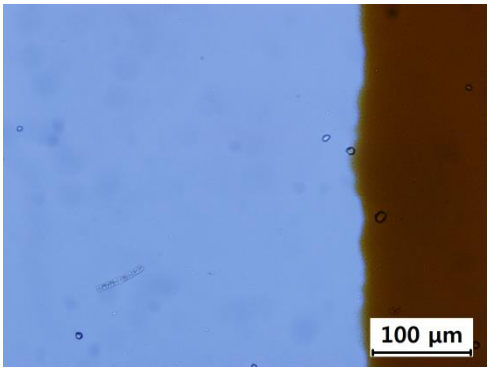
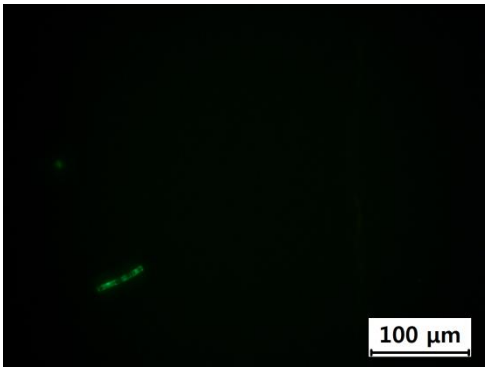
Unknown		

Magnification : 200

Appendix 16. The microscopic image of 10㎛−50㎛ in discharged control water (Day2)

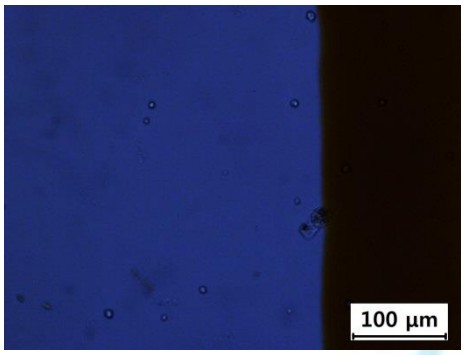
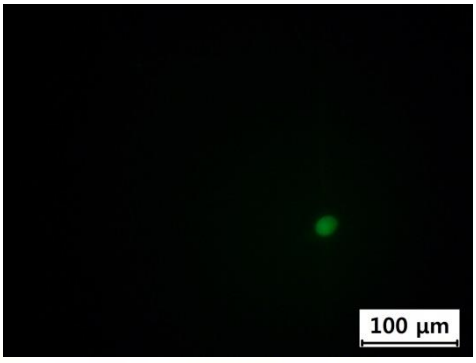
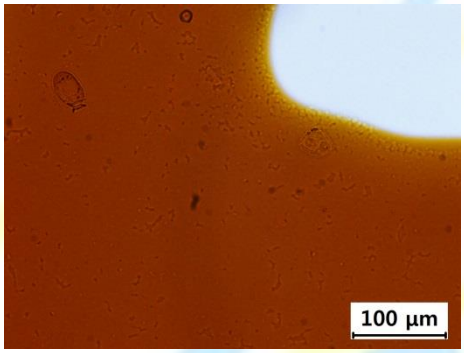
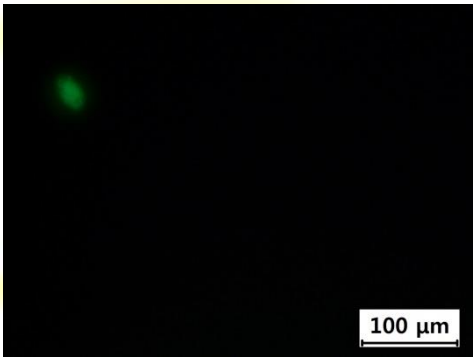
Specific Name	Discharged control water	
	Optical	Fluorescence
Guinardia sp.		
Gyrodinium sp.		
Unidentified ciliate		
Dictyocha sp.		

Ceratium sp.		
Chaetoceros sp.		
Rhizosolenia sp.		
Prorocentrum sp.		

Leptocylindrus sp.		

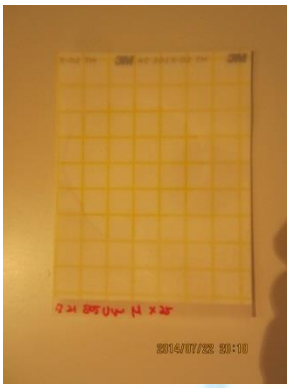
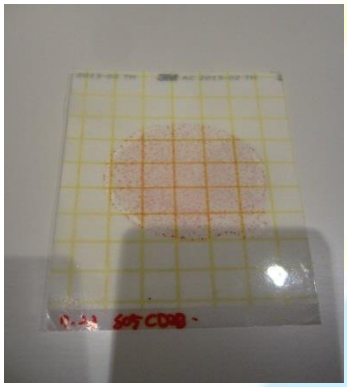
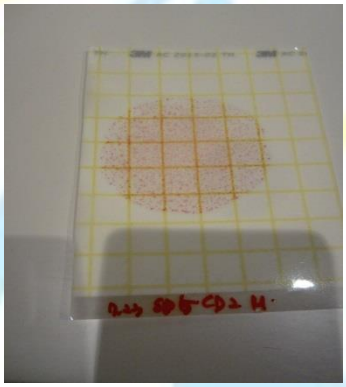
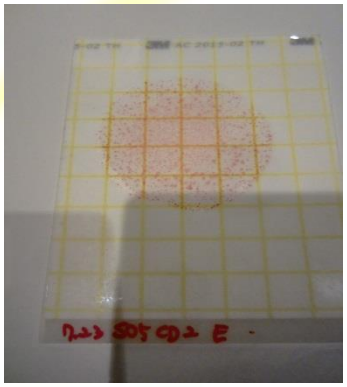
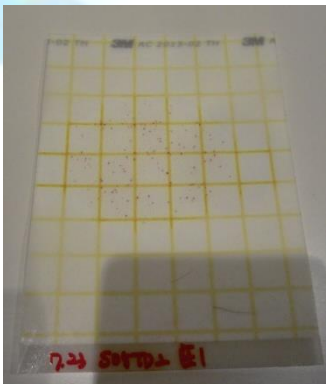
Magnification : 200

Appendix 17. The microscopic image of 10㎛−50㎛ in discharged treated water by treatment of EcoGuardian™ BWMS (Day2)

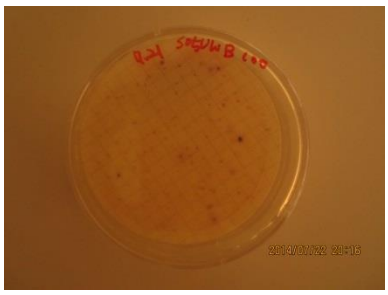
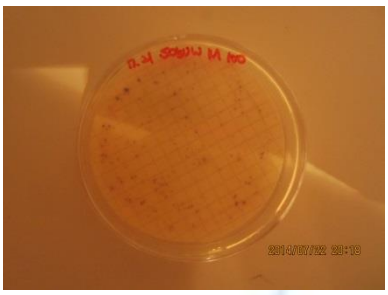
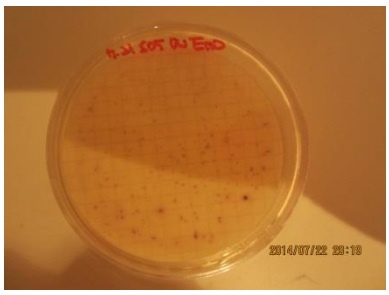
Specific Name	Discharged treated water	
	Optical	Fluorescence
Unidentified ciliate		
Unknown		

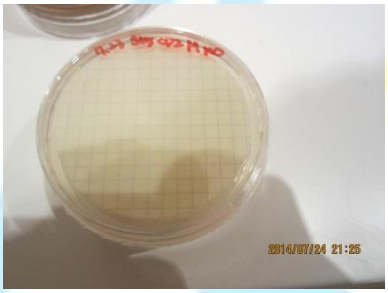
Magnification : 200

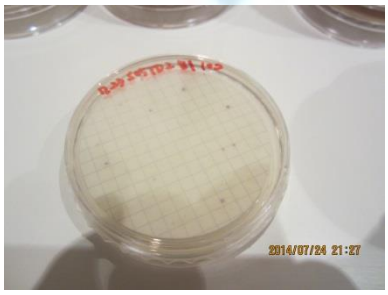
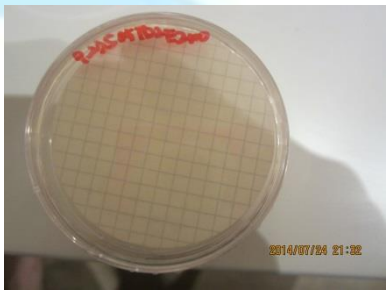
Appendix 18. The image of heterotrophic bacteria

Uptake water (Day 0)		
Beginning	**Middle**	**End**
		
Discharged control water (Day 2)		
Beginning	**Middle**	**End**
		
Discharged treated water (Day 2)		
Beginning	**Middle**	**End**
		

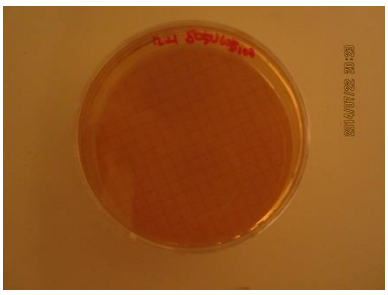
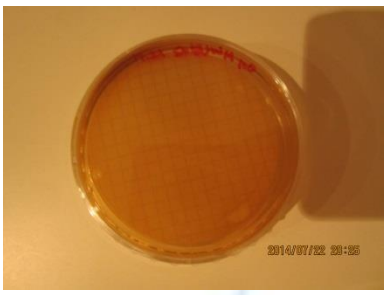
Appendix 19. The image of *Escherichia coli*

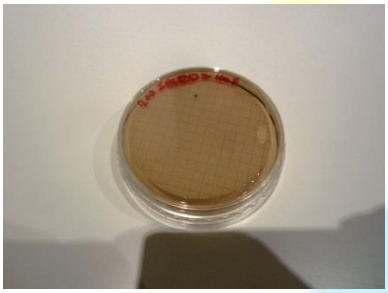
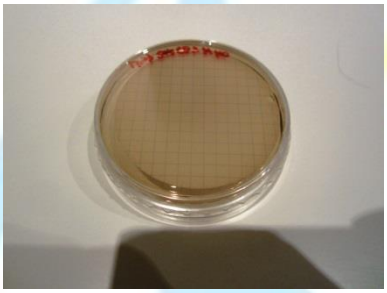
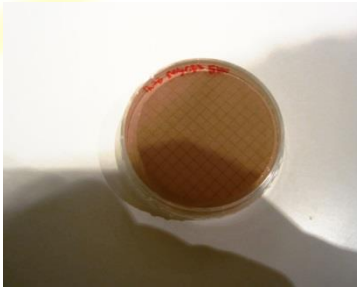
Uptake water (Day 0)		
Beginning	**Middle**	**End**
		

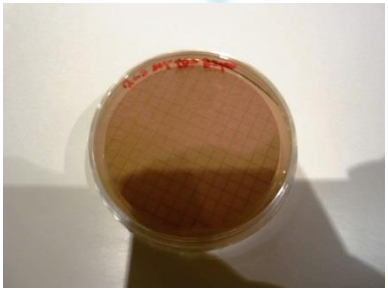
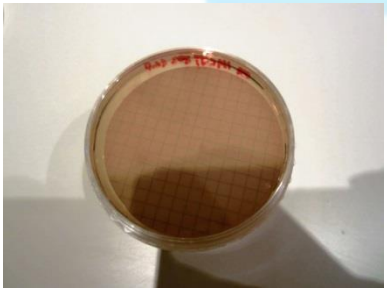
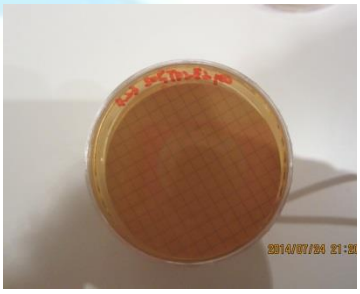
Discharged control water (Day 2)		
Beginning	**Middle**	**End**
		

Discharged treated water (Day 2)		
Beginning	**Middle**	**End**
		

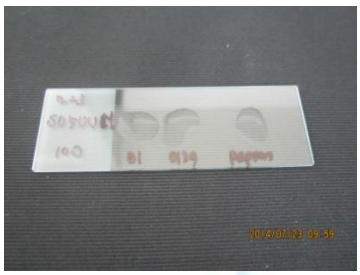
Appendix 20. The image of intestinal enterococci

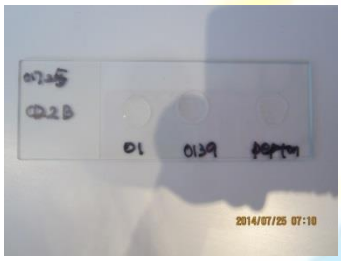
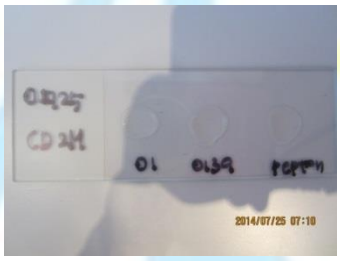
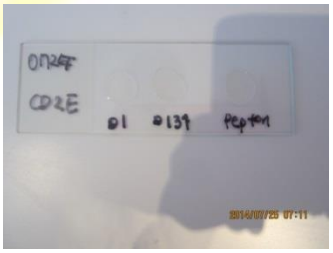
Uptake water (Day 0)		
Beginning	**Middle**	**End**
		

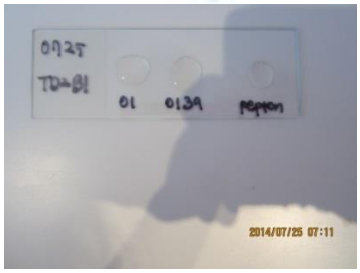
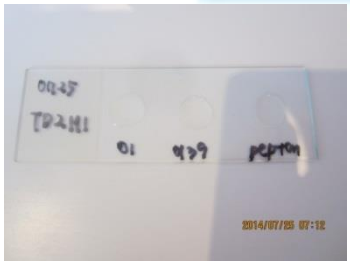
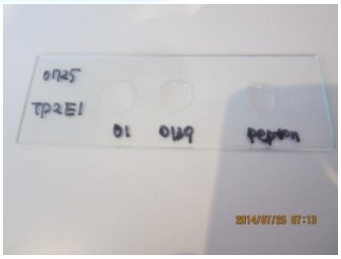
Discharged control water (Day 2)		
Beginning	**Middle**	**End**
		

Discharged treated water (Day 2)		
Beginning	**Middle**	**End**
		

Appendix 21. The image of *Vibrio cholera* O1, O139

Uptake water (Day 0)		
Beginning	**Middle**	**End**
		

Discharged control water (Day 2)		
Beginning	**Middle**	**End**
		

Discharged treated water (Day 2)		
Beginning	**Middle**	**End**
		

5. Attachment

5.1 Sampling check & custody Sheet

5.2 Freezing keeping sheet

5.3 Water parameter measurement sheet (I)

5.4 TOC measurement sheet

5.5 TSS(Total suspended solid) measurement sheet

5.6 Microbiology Test Sheet

5.7 Test Result sheet with Microbiology

5.8 Vibrio cholera O1, O139

5.9 Test Result Sheet – Classification (II)

Sampling check & custody Sheet

20 14

Study number		Test number	SET - 2014 - 004
Sampling time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Day ( )		

Sample location	☑ Uptake water □ Discharge control water □ Discharge treated water □ Other( )						
Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
TSS		HDPE	2	☑ 1	14:45	15:53	16:59
DOC, POC		HDPE	2				
Bacteria (4 item)[b]		HDPE	2	□ 2			
Organism (10~50 μm)		HDPE	1	□ 3			
Organism (≥50 μm)		HDPE					

Sample location	□ Treated water □ Treated water (Neutralized)						
Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
Bacteria (4 item)[c]		HDPE		□ 1			
Organism (10~50 μm)		HDPE		□ 2			
Organism (≥50 μm)		HDPE		□ 3			

Concentration

Parameter	Vol. of concentrated before	Equipment	Mesh size
Organism (≥50 μm)	1,000 (L)	net	32 μm
Organism (10-50 μm)	(L)	net	5 μm

Sample storage information

Parameter	Location & condition	Storage time
TSS	Freezer(-20℃)	B 17:21 M 17:21 ~ July 24th 21:00 E 17:21
DOC, POC		
Bacteria (4 item)	Refrigerator(4℃)	

Remarks

* First, fill a 1~20L HDPE(high density poly ethylene) bottle with water sample, and split the water sample up into groups (bacteria, organism (10~50 μm), and so forth) Then measured water parameters(5 item) - pH, Temperature, Salinity, DO, Turbidity
* Separately, organism(≥50 μm, 10 ~ 50 μm) sample was concentrated with net.
* Storage time of "bacteria sample" is for "heterotrophic bacteria test"
* TSS and DOC and POC samples are acidified(pH<2) with HCl (in 6 mL HCl of 2 L sample)

Working(pump) start time for Test water(or control water) sample :
Working(pump and EcoGuadian™) start time for treated(or neutralized) sample :

Working date	July. 24th	Personnel	Sang-Hyun. Kim (sign)
Confirmation date	July. 21st	Confirmed by	Sun ok Lee (sign)

a) Concentration b) Period
c) Bacteria (4 item) - Heterotrophic bacteria, Coliform, Vibrio cholera, Enterococcus group

Sampling check & custody Sheet

20 14

Study number		Test number	SET-14-004
Sampling time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Day ( )		

Sample location	□ Uptake water ☑ Discharge control water □ Discharge treated water □ Other( )						
Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
TSS		HDPE		□ 1	14:25	15:31	16:38
DOC, POC		HDPE					
Bacteria (4 item)[b]	/	HDPE	2	□ 2			
Organism (10~50 μm)	/	HDPE	/	□ 3			
Organism (≥50 μm)	1000L→0.25L	HDPE	0.25				

Sample location	☑ Treated water □ Treated water (Neutralized)						
Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
Bacteria (4 item)[c]	/	HDPE	2	□ 1	17:50	18:20	18:52
Organism (10~50 μm)	10L→0.5L	HDPE	0.5	□ 2			
Organism (≥50 μm)	1000L→0.25L	HDPE	0.25	□ 3			

Concentration			
Parameter	Vol. of concentrated before	Equipment	Mesh size
Organism (≥50 μm)	1,000 (L)	net	32 μm
Organism (10-50 μm)	10 (L)	net	5 μm

Sample storage information		
Parameter	Location & condition	Storage time
TSS	Freezer(-20℃)	
DOC, POC		
Bacteria (4 item)	Refrigerator(4℃)	

Remarks

* First, fill a 1~20L HDPE(high density poly ethylene) bottle with water sample, and split the water sample up into groups (bacteria, organism (10~50 μm), and so forth) Then measured water parameters(5 item) - pH, Temperature, Salinity, DO, Turbidity
* Separately, organism(≥50 μm, 10 ~ 50 μm) sample was concentrated with net.
* Storage time of "bacteria sample" is for "heterotrophic bacteria test"
* TSS and DOC and POC samples are acidified(pH<2) with HCl (in 6 mL HCl of 2 L sample)

Working(pump) start time for Test water(or control water) sample :
Working(pump and EcoGuadian™) start time for treated(or neutralized) sample :

Working date	July 23rd	Personnel	Sun ok Lee (sign)
Confirmation date	July 23rd	Confirmed by	Sun ok Lee (sign)

a) Concentration b) Period
c) Bacteria (4 item) - Heterotrophic bacteria, Coliform, Vibrio cholera, Enterococcus group

Freezing keeping sheet

(Of sample for measurement of water parameter)

2014

Sample	Test water	Sampling time	Day 0
Storage place	Freezing room	Storage Condition	-20 ℃
Study number		Test number	SET- 2014 - 004

No.	Sample ID	Labeling	Storage Date & time	Personnel
1	HL- S05UW-B	A / B /( )	07.21 / 17:21	Sang-Hyun, Kim (sign)
2	HL- S05UW-M	A / B /( )	07.21 / 17:21	
3	HL- S05UW-E	A / B /( )	07.21 / 17:21	
4		A / B /( )	/	
5		A / B /( )	/	
6		A / B /( )	/	
7		A / B /( )	/	(sign)
8		A / B /( )	/	
9		A / B /( )	/	
10		A / B /( )	/	
11		A / B /( )	/	
12		A / B /( )	/	
13		A / B /( )	/	(sign)
14		A / B /( )	/	
15		A / B /( )	/	
16		A / B /( )	/	
17		A / B /( )	/	
18		A / B /( )	/	

Remarks

*

Confirming date	07.21	Confirmed by	Lee JI Sun (sign)

Water parameter measurement sheet (I)

2014

Study Number		Test number	SET- 2014- 004
Sampling time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Day ( )		
Equipment	YSI 6920 - pH, temp., salinity, DO / YSI 6920 - Turbidity		

Sample	Replicate	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)
☑ Uptake water □ Discharge control water □ Discharge treated water □ Discharge treated water(Neutralized water)	R1	8.19	29.49	29.74	5.70	7.50
	R2	8.48	29.42	29.75	5.79	7.60
	R3	8.46	29.49	29.70	5.42	7.40
☑ B( ) □ M( ) □ E( )	Measuring time	14:45		14:54		
☑ Uptake water □ Discharge control water □ Discharge treated water □ Discharge treated water(Neutralized water)	R1	8.51	29.39	29.93	6.56	7.70
	R2	8.51	29.41	29.83	5.70	7.80
	R3	8.52	29.62	29.84	5.57	7.50
□ B( ) ☑ M( ) □ E( )	Measuring time	15:53		16:01		
☑ Uptake water □ Discharge control water □ Discharge treated water □ Discharge treated water(Neutralized water)	R1	8.52	29.41	29.85	5.73	7.30
	R2	8.52	29.48	29.86	5.54	7.70
	R3	8.53	29.43	29.86	5.57	7.20
□ B( ) □ M( ) ☑ E( )	Measuring time	16:59		17:06		
□ Uptake water □ Discharge control water □ Discharge treated water □ Discharge treated water(Neutralized water)	R1					
	R2					
	R3					
□ B( ) □ M( ) □ E( )	Measuring time					
□ Uptake water □ Discharge control water □ Discharge treated water □ Discharge treated water(Neutralized water)	R1					
	R2					
	R3					
□ B( ) □ M( ) □ E( )	Measuring time					
□ Uptake water □ Discharge control water □ Discharge treated water □ Discharge treated water(Neutralized water)	R1					
	R2					
	R3					
□ B( ) □ M( ) □ E( )	Measuring time					

Remarks			
Working Date	July 21th	Study Personnel	Sang-Hyun, Kim (sign)
Confirming Date	07. 21	Confirmed by	Lee Ji-Sun (sign)

Water parameter measurement sheet (I)

2014

Study Number		Test number	SET-2014-004
Sampling time	□ Day -1 □ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □ ( )		
Equipment	☑ YSI-6920 □ HQ-40D □ Pocket colorimeter II □ 2100AN □ Orion 3STAR □ ( )		

Sample	Replicate	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
□ Feed Tank (1) □ Feed Tank (2) ☑ Control water □ Treated water □ ( ) ☑ B □ M □ E	R1	8.21	30.59	30.12	3.26	5.7	
	R2	8.25	30.50	31.25	3.26	5.8	
	R3	8.36	30.21	29.67	1.08	8.3	
	Measuring time	14:25					
□ Feed Tank (1) □ Feed Tank (2) ☑ Control water □ Treated water □ ( ) □ B ☑ M □ E	R1	8.14	30.29	29.58	3.77	8.3	
	R2	8.30	30.20	29.71	3.34	8.2	
	R3	8.35	30.18	29.70	2.98	6.7	
	Measuring time	15:31					
□ Feed Tank (1) □ Feed Tank (2) ☑ Control water □ Treated water □ ( ) □ B □ M ☑ E	R1	8.22	30.35	29.70	3.79	7.1	
	R2	8.33	30.27	29.67	3.82	6.8	
	R3	8.36	30.27	29.70	1.15	6.7	
	Measuring time	16:38					
□ Feed Tank (1) □ Feed Tank (2) □ Control water ☑ Treated water □ (1) ☑ B □ M □ E	R1	8.27	30.20	29.58	2.27	9.0	0.05
	R2	8.27	30.20	29.58	2.28	6.3	0.02
	R3	8.27	30.20	29.58	2.30	6.5	0.05
	Measuring time	17:50					
□ Feed Tank (1) □ Feed Tank (2) □ Control water ☑ Treated water □ (2) ☑ B □ M □ E	R1	8.40	30.02	29.68	3.15	6.2	
	R2	8.40	30.08	29.69	3.15	6.0	
	R3	8.40	30.08	29.69	3.15	6.2	
	Measuring time	18:03					
□ Feed Tank (1) □ Feed Tank (2) □ Control water ☑ Treated water ☑ (3) ☑ B □ M □ E	R1	8.40	30.01	29.71	3.45	5.3	
	R2	8.40	30.01	29.71	3.51	4.9	
	R3	8.40	30.03	29.72	3.52	4.8	
	Measuring time	18:15					

Remarks			
Working Date	July 23th	Study Personnel	Lee JT-Sun (sign)
Certificate Date	July 23th	Study Director	Lee JT-Sun (sign)

Water parameter measurement sheet (I)

20 14

Study Number		Test number	SET-2014-006
Sampling time	□ Day -1 □ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □ ( )		
Equipment	□ YSI-6920 □ HQ-40D □ Pocket colorimeter II □ 2100AN □ Orion 3STAR □ ( )		

Sample	Replicate	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
□ Feed Tank (1) □ Feed Tank (2) □ Control water ☑ Treated water □ (1) □B ☑M □E	R1	8.43	30.02	29.73	3.60	6.5	0.07
	R2	8.43	30.03	29.78	3.60	6.5	0.05
	R3	8.43	30.03	29.78	3.72	6.6	0.02
	Measuring time	18:20					
□ Feed Tank (1) □ Feed Tank (2) □ Control water □ Treated water □ (2) □B ☑M □E	R1	8.42	30.05	29.64	4.38	4.8	
	R2	8.42	30.05	29.65	3.41	4.9	
	R3	8.42	30.05	27.70	3.15	4.9	
	Measuring time	18:25					
□ Feed Tank (1) □ Feed Tank (2) □ Control water □ Treated water □ (3) □B ☑M □E	R1	8.43	30.08	29.59	3.44	6.8	
	R2	8.43	30.08	29.59	3.82	6.7	
	R3	8.43	30.09	29.59	3.92	6.5	
	Measuring time	18:32					
□ Feed Tank (1) □ Feed Tank (2) □ Control water ☑ Treated water □ (1) □B □M ☑E	R1	8.43	30.12	29.71	3.40	4.8	0.04
	R2	8.43	30.12	29.78	3.42	4.8	0.05
	R3	8.43	30.11	29.70	3.41	4.8	0.03
	Measuring time	18:52					
□ Feed Tank (1) □ Feed Tank (2) □ Control water ☑ Treated water □ (2) □B □M ☑E	R1	8.43	30.09	29.68	3.36	5.6	
	R2	8.43	30.04	29.68	3.36	5.6	
	R3	8.43	30.05	29.72	3.37	5.6	
	Measuring time	19:05					
□ Feed Tank (1) □ Feed Tank (2) □ Control water ☑ Treated water □ (3) □B □M ☑E	R1	8.43	30.11	29.77	3.33	5.8	
	R2	8.43	30.13	29.77	3.29	5.7	
	R3	8.43	30.12	29.78	3.39	5.7	
	Measuring time						

Remarks			
Working Date	July 23th	Study Personnel	Lee Ji-Sun (sign)
Certificate Date	July 23th	Study Director	Lee Ji-Sun (sign)

TOC measurement sheet

2014

Study number		Test number	SET - 14 - 004
Method	High Temperature combustion	Equipment	Vario TOC Cube
Sampling day	Day 0	Reception time of test substances	
Measuring start time	July 24th 10:00	Measuring end time	July 24th 11:00

Parameter / Sample ID & lot No.	TOC (mg/L)	DOC (mg/L)	POC (mg/L)	Remarks
HL-S05UW-B	3.224 3.115 3.058 Aver. : 3.200	1.788 1.762 1.827 Aver. : 1.793	1.407	
HL-S05UW-M	3.125 3.224 3.305 Aver. : 3.241	1.597 1.735 1.845 Aver. : 1.726	1.515	
HL-S05UW-E	3.114 2.972 2.958 Aver. : 2.948	1.692 1.698 1.885 Aver. : 1.759	1.189	
	Aver. :	Aver. :		
	Aver. :	Aver. :		
	Aver. :	Aver. :		
Remarks	* POC = TOC - DOC			

Working date	July 24th	Study personnel	Lee JT - Sun (sign)
Confirmation date		Confirmed by	(sign)
Certificate date	July 24th	Study director	Lee JT - Sun (sign)

TSS(Total suspended solid) measurement sheet

20 14

Study number		**Test number**	SET- 14 - 004
Test period	July. 28th - 29th	**Equipments**	Dry oven, Balance, Desiccator
Reception time of test substances	July. 28th 10:00	**Sample pretreatment time**	11:00

Sample ID (Lot No.)	R[1]	Sample Volume (mL)	Filter paper Weight - ① (g)	① + SS Weight (g)	SS Weight (g)	Result (mg/L)	Average (mg/L)
HL-505UW-B	R1	500	25.3709	25.3722	0.0013	2.6	2.4
	R2	500	26.3055	26.3068	0.0013	2.6	
	R3	500	27.0588	27.0598	0.0010	2.0	
HL-505UW-M	R1	500	25.7207	25.7219	0.0012	2.4	2.4
	R2	500	26.6121	26.6132	0.0011	2.2	
	R3	500	26.2012	26.2025	0.0013	2.6	
HL-505UW-E	R1	500	26.6233	26.6249	0.0016	3.2	3.0
	R2	500	24.0466	24.0481	0.0015	3.0	
	R3	500	27.6851	27.6865	0.0014	2.8	
	R1						
	R2						
	R3						
	R1						
	R2						
	R3						
	R1						
	R2						
	R3						

Remarks

Working Date	July. 29th	**Study Personnel**	Sang-Hyun. Kim (sign)
Certificate Date	July 29th	**Study Director**	Sun ok Lee (sign)

[1] Replicate

Microbiology Test Sheet

2014

Study number	-	Test number	SET - 14 - 004
Sampling Time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		
Test substance	☑ Uptake water □ Discharge control water □ Discharge treated water □ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team. 29 ℃, Humidity : 79 % P.H. /End : Team 29 ℃, Humidity : 78 % P.H.		

Test condition

Medium name	□ Marine agar ☑ Aerobic Counter Plate □ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate ☑ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC ☑ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC □ mEI ☑ TCBS
Manufacturing date		2014. 7. 17	2014. 7. 16	2014. 7. 18
Test method	□ Membrane filter □ Spread method ☑ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ (1) □ 41 ℃ ☑ 44.5 ℃ (2)	□ 25 ℃ □ 35.0 ℃ ( ) ☑ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )
Culture period	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	☑ 2 hr (1) ☑ 22 hr (2) □ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )
Time (Start/End)	14:50 / 15:00	15:09 / 15:31	15:09 / 15:31	15:09 / 15:31
Volume (mL)	1 / 1 / 1	25 / 100	25 / 100	25 / 100
Dilution factor	X25 / X60 / X100			
Test substance	B / B / B	B / B	B / B	B / B

Remarks: The test of bacteria can have sample holding time.
(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	2014. 7. 21	Personnel	Lee Myoung Ae (sign)
Confirming date	2014. 7. 21	Confirmed by	Sun ok Lee (sign)

Busan Techno-Park
Marine Bio-industry Development Center

Microbiology Test Sheet

2014

Study number	-	Test number	SET-14-004
Sampling Time	☑ Day 0 ☐ Day 1 ☐ Day 2 ☐ Day 3 ☐ Day 4 ☐ Day 5 ☐ Other( )		
Test substance	☑ Uptake water ☐ Discharge control water ☐ Discharge treated water ☐ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team. 27 ℃, Humidity : 74 % P.H. /End : Team. 30 ℃, Humidity : 74 % P.H.		

Test condition

Medium name	☐ Marine agar ☑ Aerobic Counter Plate ☐ mTEC ☐ mEI ☐ TCBS	☐ Marine agar ☐ Aerobic Counter Plate ☑ mTEC ☐ mEI ☐ TCBS	☐ Marine agar ☐ Aerobic Counter Plate ☐ mTEC ☑ mEI ☐ TCBS	☐ Marine agar ☐ Aerobic Counter Plate ☐ mTEC ☐ mEI ☑ TCBS
Manufacturing date		2014. 7. 17	2014. 7. 16	2014. 7. 18
Test method	☐ Membrane filter ☐ Spread method ☑ 3M™ Petri film	☑ Membrane filter ☐ Spread method ☐ 3M™ Petri film	☑ Membrane filter ☐ Spread method ☐ 3M™ Petri film	☑ Membrane filter ☐ Spread method ☐ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	☐ 25 ℃ ☑ 35.0 ℃ ( ) ☐ 41 ℃ ☐ 44.5 ℃ ( )	☐ 25 ℃ ☑ 35.0 ℃ (1) ☐ 41 ℃ ☑ 44.5 ℃ (2)	☐ 25 ℃ ☐ 35.0 ℃ ( ) ☑ 41 ℃ ☐ 44.5 ℃ ( )	☐ 25 ℃ ☑ 35.0 ℃ ( ) ☐ 41 ℃ ☐ 44.5 ℃ ( )
Culture period	☐ 2 hr ( ) ☐ 22 hr ( ) ☑ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )	☑ 2 hr (1) ☑ 22 hr (2) ☐ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )	☐ 2 hr ( ) ☐ 22 hr ( ) ☑ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )	☐ 2 hr ( ) ☐ 22 hr ( ) ☑ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )
Time (Start/End)	16:02 / 16:12	16:15 / 16:30	16:15 / 16:30	16:15 / 16:30
Volume (mL)	1 / 1 / 1	25 / 100	25 / 100	25 / 100
Dilution factor	X24 / X80 / X100	/ /	/ /	/ /
Test substance	M / M / M	M / M	M / M	M / M

Remarks: The test of bacteria can have sample holding time.
(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	2014. 7. 21	Personnel	Lee Myunghee (Sign)
Confirming date	2014. 7. 21	Confirmed by	Sun. K. Lee (Sign)

Microbiology Test Sheet

2014

Study number	-	Test number	SET-14-004
Sampling Time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		
Test substance	☑ Uptake water □ Discharge control water □ Discharge treated water □ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team 29 ℃, Humidity : 32 % P.H. /End : Team 30 ℃, Humidity : 33 % P.H.		

Test condition

Medium name	□ Marine agar ☑ Aerobic Counter Plate □ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate ☑ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC ☑ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC □ mEI ☑ TCBS
Manufacturing date		2014.7.17	2014.7.16	2014.7.18
Test method	□ Membrane filter □ Spread method ☑ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ (1) □ 41 ℃ ☑ 44.5 ℃ (2)	□ 25 ℃ □ 35.0 ℃ ( ) ☑ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )
Culture period	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	☑ 2 hr (1) ☑ 22 hr (2) □ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )
Time (Start/End)	17:09 / 17:16	17:18 / 17:32	17:18 / 17:32	17:18 / 17:32

Volume (mL)	1	1	1	/	25	100		/	25	100		/	25	100		/
Dilution factor	x25	x60	x100	/	/	/	/	/	/	/	/	/	/	/	/	/
Test substance	E	E	E	/	E	E	/	/	E	E	/	/	E	E	/	/

Remarks: The test of bacteria can have sample holding time.
(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	2014. 7. 21	Personnel	Lee Myoung hee (sign)
Confirming date	2014. 07. 21	Confirmed by	Sun ok Lee (sign)

Microbiology Test Sheet

2014

Study number		Test number	SET-14-004
Sampling Time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		
Test substance	□ Uptake water ☑ Discharge control water □ Discharge treated water □ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team. B 26 ℃, Humidity : 60 % P.H. /End : Team. 30 ℃, Humidity : 54 % P.H.		

Test condition				
	M 30°C E 31°C 54% 41%	31°C 31°C 47% 42%		
Medium name	□ Marine agar ☑ Aerobic Counter Plate □ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate ☑ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC ☑ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC □ mEI ☑ TCBS
Manufacturing date		7.11	7.16	7.18
Test method	□ Membrane filter □ Spread method ☑ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ ☑ 44.5 ℃ ( )	□ 25 ℃ □ 35.0 ℃ ( ) ☑ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )
Culture period	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( )	☑ 2 hr ( ) ☑ 22 hr ( ) □ 24 hr □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( )
Time (Start/End)	E 14:24 / (16:) 32 M 15:24 / 15:27 B 14:11 / 14:22	□ (16:) hr 32 / (16:) 42 15:28 / 15:38 14:23 / 14:37	□ (16:) hr / (16:) 42 15:28 / 15:38 14:23 / 14:37	□ (16:) hr (16:) 42 15:28 / 15:38 14:23 / 14:37
Volume (mL)	1 / 1 / 1	100 / 100 / 100	100 / 100 / 100	100 / 100 / 100
Dilution factor	~~10~~ / ~~10~~ / ~~10~~	/ / /	/ / /	/ / /
Test substance	B / M / E	B / M / E	B / M / E	B / M / E

Remarks: The test of bacteria can have sample holding time. a) b) c) deleted by Myounghee Lee
(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	2014. 7. 23	Personnel	Myounghee Lee (sign)
Confirming date	2014. 07. 23	Confirmed by	Sun. K Lee (sign)

Microbiology Test Sheet

2014

Study number		Test number	SET - 14-004
Sampling Time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		
Test substance	□ Uptake water □ Discharge control water ☑ Discharge treated water □ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team. 20 ℃, Humidity : 41 % P.H. /End : Team. 21 ℃, Humidity : 4 % P.H.		

Test condition

Medium name	□ Marine agar ☑ Aerobic Counter Plate □ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate ☑ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC ☑ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC □ mEI ☑ TCBS
Manufacturing date		7.17	7.16	7.18
Test method	□ Membrane filter □ Spread method ☑ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ (1) □ 41 ℃ ☑ 44.5 ℃ (2)	□ 25 ℃ □ 35.0 ℃ ( ) ☑ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )
Culture period	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	☑ 2 hr (1) ☑ 22 hr (2) □ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )
Time (Start/End)	B3 18:32 18:36 / 18:34 18:31 B2 18:25 / 18:29	18:50 18:43 / 18:57 18:50 18:25 / 18:42	18:50 18:43 / 18:57 18:50 18:35 / 18:42	18:50 18:43 / 18:57 18:50 18:35 / 18:42
Volume (mL)	1 1 1	100 100 100	100 100 100	100 100 100
Dilution factor	/ / /	100 / /	/ / /	/ / /
Test substance	B1 B2 B3	B1 B2 B3	B1 B2 B3	B1 B2 B3

Remarks: The test of bacteria can have sample holding time.

(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	2014. 7.23	Personnel	Hyunghee Lee (sign)
Confirming date	2014. 07.23	Confirmed by	Sun-k Lee (sign)

Microbiology Test Sheet

2014

Study number		Test number	SET-14-004
Sampling Time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		
Test substance	□ Uptake water ☑ Discharge control water □ Discharge treated water □ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team. 21 ℃, Humidity : 41 % P.H. /End : Team. 21 ℃, Humidity : 40 % P.H.		

Test condition

Medium name	□ Marine agar ☑ Aerobic Counter Plate □ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate ☑ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC ☑ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC □ mEI ☑ TCBS
Manufacturing date		2014.7.17	2014.7.16	2014.7.18
Test method	□ Membrane filter □ Spread method ☑ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ (1) □ 41 ℃ ☑ 44.5 ℃ (2)	□ 25 ℃ □ 35.0 ℃ ( ) ☑ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )
Culture period	□ 2 hr ( ) ☑ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	☑ 2 hr (1) ☑ 22 hr (2) □ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )
Time (Start/End)	M1 18:59 / 19:02 M2 19:02 / 19:06 M3 19:06 / 19:09	19:09 / 19:20 19:21 / 19:23 19:29 / 19:33	19:09 / 19:20 19:21 / 19:29 19:29 / 19:33	19:09 / 19:20 19:21 / 19:29 19:29 / 19:33
Volume (mL)	1 1 1	100 100 100	100 100 100	100 100 100
Dilution factor	1 1 1	1 1 1	1 1 1	1 1 1
Test substance	M1 M2 M3	M1 M2 M3	M1 M2 M3	M1 M2 M3

Remarks: The test of bacteria can have sample holding time.

(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	2014. 7. 23	Personnel	Myounghee Lee (sign)
Confirming date	2014. 7. 23	Confirmed by	Sunok Lee (sign)

Microbiology Test Sheet

2014

Study number		Test number	SET-14-004
Sampling Time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		
Test substance	□ Uptake water □ Discharge control water ☑ Discharge treated water □ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team. 31 ℃, Humidity : 39 % P.H. /End : Team. 31 ℃, Humidity : 39 % P.H.		

Test condition

Medium name	□ Marine agar ☑ Aerobic Counter Plate □ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate ☑ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC ☑ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC □ mEI ☑ TCBS
Manufacturing date		2014.07.17	2014.7.16	2014.7.18
Test method	□ Membrane filter □ Spread method ☑ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ ☑ 44.5 ℃ ( )	□ 25 ℃ □ 35.0 ℃ ( ) ☑ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )
Culture period	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	☑ 2 hr ( ) ☑ 22 hr ( ) □ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )
Time (Start/End)	19:37 / 19:41 19:41 / 19:43 19:43 / 19:46	19:47 / 19:54 19:54 / 20:02 20:02 / 20:10	19:47 / 19:54 19:54 / 20:02 20:02 / 20:10	19:47 / 19:54 19:54 / 20:02 20:02 / 20:10
Volume (mL)	1 1 1	100 100 100	100 100 100	100 100 100
Dilution factor	/ / /	/ / /	/ / /	/ / /
Test substance	E1 E2 E3	E1 E2 E3	E1 E2 E3	E1 E2 E3

Remarks: The test of bacteria can have sample holding time.

(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	2014. 7. 23	Personnel	Hyounghee Lee (sign)
Confirming date	2014.07.23	Confirmed by	Sun ok Lee (sign)

Test Result Sheet with Microbiology

2014

Study number		Test number	SET-14-004
Sample type	☑1. Uptake water □2. Discharge control water □3. Discharge treated water □4. Other( )		
Sampling time	☑Day 0 □Day 1 □Day 2 □Day 3 □Day 4 □Day 5 □Other ( )		
Medium name	□A-1. Marine agar(Heterotrophic bacteria) ☑A-2. Aerobic Counter Plate(Heterotrophic bacteria) ☑B. mTEC(*E.coli*) □C. mEI(Intestinal Enterococci) □D. TCBS (Vibrio cholera)		

Test Result

Sample Type	Medium name	Test substance	Test method	Sample vol. (mL)	D[a)] factor	CFU/Plate R1	R2	R3
uptake water	A-2	SOSUW-B	□M.F.[b)] □S[c)] ☑P.F.[d)]		X25	2	3	3
		SOSUW-B	□M.F.[b)] □S[c)] ☑P.F.[d)]		X50	0	0	2
		SOSUW-B	□M.F.[b)] □S[c)] ☑P.F.[d)]		X100	0	0	0
		SOSUW-M	□M.F.[b)] □S[c)] ☑P.F.[d)]		X25	1	1	1
		SOSUW-M	□M.F.[b)] □S[c)] ☑P.F.[d)]		X50	0	0	0
		SOSUW-M	□M.F.[b)] □S[c)] ☑P.F.[d)]		X100	0	0	0
		SOSUW-E	□M.F.[b)] □S[c)] ☑P.F.[d)]		X25	0	0	0
		SOSUW-E	□M.F.[b)] □S[c)] ☑P.F.[d)]		X50	0	0	0
		SOSUW-E	□M.F.[b)] □S[c)] ☑P.F.[d)]		X100	0	0	0
	B	SOSUW-B	☑M.F.[b)] □S[c)] □P.F.[d)]	25	-	36	39	21
		SOSUW-B	☑M.F.[b)] □S[c)] □P.F.[d)]	100	-	84	77	83
		SOSUW-M	☑M.F.[b)] □S[c)] □P.F.[d)]	25	-	34	36	39
		SOSUW-M	☑M.F.[b)] □S[c)] □P.F.[d)]	100	-	102	104	100
		SOSUW-E	☑M.F.[b)] □S[c)] □P.F.[d)]	25	-	a) ~~102~~ 17	~~104~~ 18	~~100~~ 28
		SOSUW-E	☑M.F.[b)] □S[c)] □P.F.[d)]	100	-	104	104	107
		D.W	☑M.F.[b)] □S[c)] □P.F.[d)]	-	-	0	0	0
			□M.F.[b)] □S[c)] □P.F.[d)]					
			□M.F.[b)] □S[c)] □P.F.[d)]					

Remaks a) Corrected by Myounghee. Lee

Working date	2014. 11. 22	Personnel	Myounghee. Lee (sign)
Confirming date	2014. 01. 22	Confirmed by	Sun ok Lee (sign)

a) dilution, b) membrane filter, c) spreading, d) petri film

BSMB-QS-06-05(2)

Test Result Sheet with Microbiology

20 14

Study number		Test number	SET - 14 - 004
Sample type	☑ 1. Uptake water □ 2. Discharge control water □ 3. Discharge treated water □ 4. Other( )		
Sampling time	□ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □Other ( )		
Medium name	□ A-1. Marine agar(Heterotrophic bacteria) □ A-2. Aerobic Counter Plate(Heterotrophic bacteria) □ B. mTEC(*E.coli*) ☑ C. mEI(Intestinal Enterococci) □ D. TCBS (Vibrio cholera)		

Test Result

Sample Type	Medium name	Test substance	Test method	Sample vol. (mL)	D[a] factor	CFU/Plate R1	R2	R3
Uptake water	C	SOSUW-B	☑ M.F.[b] □ S[c] □P.F.[d]	25		0	0	0
		SOSUW-B	☑ M.F.[b] □ S[c] □P.F.[d]	100		0	0	0
		SOSUW-H	☑ M.F.[b] □ S[c] □P.F.[d]	25		0	0	0
		SOSUW-H	☑ M.F.[b] □ S[c] □P.F.[d]	100		0	0	0
		SOSUW-E	☑ M.F.[b] □ S[c] □P.F.[d]	25		0	0	0
		SOSUW-E	☑ M.F.[b] □ S[c] □P.F.[d]	100		0	0	0
		DW	☑ M.F.[b] □ S[c] □P.F.[d]			0	0	0
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					
			□ M.F.[b] □ S[c] □P.F.[d]					

Remaks

Working date	2014. 7. 22	Personnel	Lee Myoungkee (sign)
Confirming date	2014. 07. 22	Confirmed by	Sun ok Lee (sign)

a) dilution, b) membrane filter, c) spreading, d) petri film

BSMB-QS-06-05(2)

Test Result Sheet with Microbiology

20 14

Study number		Test number	SET-14-004
Sample type	□ 1. Uptake water ☑ 2. Discharge control water ☑ 3. Discharge treated water □ 4. Other( )		
Sampling time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □Other ( )		
Medium name	□ A-1. Marine agar(Heterotrophic bacteria) ☑ A-2. Aerobic Counter Plate(Heterotrophic bacteria) □ B. mTEC(*E.coli*) □ C. mEI(Intestinal Enterococci) □ D. TCBS (Vibrio cholera)		

Test Result

Sample Type	Medium name	Test substance	Test method	Sample vol. (mL)	D[a] factor	CFU/Plate R1	R2	R3
2	A-2	S05CD2-B	□ M.F.[b] □ S[c] ☑ P.F.[d]	1mL	-	TNTC	TNTC	TNTC
		S05CD2-M	□ M.F.[b] □ S[c] ☑ P.F.[d]	1mL	-	TNTC	TNTC	TNTC
		S05CD2-E	□ M.F.[b] □ S[c] ☑ P.F.[d]	1mL	-	TNTC	TNTC	TNTC
3		S05TD2-B1	□ M.F.[b] □ S[c] ☑ P.F.[d]	1mL	-	82	76	75
		S05TD2-B2	□ M.F.[b] □ S[c] ☑ P.F.[d]	1mL	-	51	51	49
		S05TD2-B3	□ M.F.[b] □ S[c] ☑ P.F.[d]	1mL	-	77	66	64
		S05TD2-M1	□ M.F.[b] □ S[c] ☑ P.F.[d]	1mL	-	39	37	44
		S05TD2-M2	□ M.F.[b] □ S[c] ☑ P.F.[d]	1mL	-	47	41	43
		S05TD2-M3	□ M.F.[b] □ S[c] ☑ P.F.[d]	1mL	-	61	58	60
		S05TD2-E1	□ M.F.[b] □ S[c] ☑ P.F.[d]	1mL	-	48	32	31
		S05TD2-E2	□ M.F.[b] □ S[c] ☑ P.F.[d]	1mL	-	60	67	70
		S05TD2-E3	□ M.F.[b] □ S[c] ☑ P.F.[d]	1mL	-	78	85	87
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					

Remaks

Working date	2014. 07. 24	Personnel	Myounghee Lee (sign)
Confirming date	2014. 07. 24	Confirmed by	Kim Hui-Jeong (sign)

a) dilution, b) membrane filter, c) spreading, d) petri film

BSMB-QS-06-05(2)

Test Result Sheet with Microbiology

2014

Study number		Test number	SET-14-004
Sample type	□ 1. Uptake water ☑ 2. Discharge control water ☑ 3. Discharge treated water □ 4. Other( )		
Sampling time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other ( )		
Medium name	□ A-1. Marine agar(Heterotrophic bacteria) □ A-2. Aerobic Counter Plate(Heterotrophic bacteria) □ B. mTEC(*E.coli*) ☑ C. mEI(Intestinal Enterococci) □ D. TCBS (Vibrio cholera)		

Test Result

Sample Type	Medium name	Test substance	Test method	Sample vol. (mL)	D[a] factor	CFU/Plate R1	R2	R3
2	C	S05CD2-B	☑ M.F.[b] □ S[c] □ P.F.[d]	100mL	-	1	0	0
		S05CD2-M	☑ M.F.[b] □ S[c] □ P.F.[d]	100mL	-	0	0	0
		S05CD2-E	☑ M.F.[b] □ S[c] □ P.F.[d]	100mL	-	0	0	0
3		S05TD2-B1	☑ M.F.[b] □ S[c] □ P.F.[d]	100mL	-	0	0	0
		S05TD2-B2	☑ M.F.[b] □ S[c] □ P.F.[d]	100mL	-	0	0	0
		S05TD2-B3	☑ M.F.[b] □ S[c] □ P.F.[d]	100mL	-	0	0	0
		S05TD2-M1	☑ M.F.[b] □ S[c] □ P.F.[d]	100	-	0	0	0
		S05TD2-M2	☑ M.F.[b] □ S[c] □ P.F.[d]	100	-	0	0	0
		S05TD2-M3	☑ M.F.[b] □ S[c] □ P.F.[d]	100	-	0	0	0
		S05TD2-E1	☑ M.F.[b] □ S[c] □ P.F.[d]	100	-	0	0	0
		S05TD2-E2	☑ M.F.[b] □ S[c] □ P.F.[d]	100	-	0	0	0
		S05TD2-E3	☑ M.F.[b] □ S[c] □ P.F.[d]	100	-	0	0	0
		D.W	☑ M.F.[b] □ S[c] □ P.F.[d]	100	-	0	0	0
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					

Remaks

Working date	2014. 07. 24	Personnel	Lee Myang Ae (sign)
Confirming date	2014. 07. 24	Confirmed by	Kim Hui-Jeong (sign)

a) dilution, b) membrane filter, c) spreading, d) petri film

BSMB-QS-06-05(2)

Test Result Sheet with Microbiology

2014

Study number		Test number	SET-14-004
Sample type	□ 1. Uptake water ☑ 2. Discharge control water ☑ 3. Discharge treated water □ 4. Other( )		
Sampling time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □Other ( )		
Medium name	□ A-1. Marine agar(Heterotrophic bacteria) □ A-2. Aerobic Counter Plate(Heterotrophic bacteria) ☑ B. mTEC(*E.coli*) ☑ C. mEI(Intestinal Enterococci) □ D. TCBS (Vibrio cholera)		

Test Result

Sample Type	Medium name	Test substance	Test method	Sample vol. (mL)	D[a] factor	CFU/Plate R1	R2	R3
2	B	S05CD2-B	☑ M.F.[b] □ S[c] □ P.F.[d]	100mL	-	3	3	6
		S05CD2-M	☑ M.F.[b] □ S[c] □ P.F.[d]	100	-	7	12	10
		S05CD2-E	☑ M.F.[b] □ S[c] □ P.F.[d]	100	-	42	38	36
3		S05TD2-B1	☑ M.F.[b] □ S[c] □ P.F.[d]	100	-	2	3	11
		S05TD2-B2	☑ M.F.[b] □ S[c] □ P.F.[d]	100	-	2	1	0
		S05TD2-B3	☑ M.F.[b] □ S[c] □ P.F.[d]	100	-	0	0	0
		S05TD2-M1	☑ M.F.[b] □ S[c] □ P.F.[d]	100	-	2	0	0
		S05TD2-M2	☑ M.F.[b] □ S[c] □ P.F.[d]	100	-	0	0	0
		S05TD2-M3	☑ M.F.[b] □ S[c] □ P.F.[d]	100	-	0	0	0
		S05TD2-E1	☑ M.F.[b] □ S[c] □ P.F.[d]	100	-	2	2	3
		S05TD2-E2	☑ M.F.[b] □ S[c] □ P.F.[d]	100	-	0	0	0
		S05TD2-E3	☑ M.F.[b] □ S[c] □ P.F.[d]	100	-	0	0	0
		D.W	☑ M.F.[b] □ S[c] □ P.F.[d]	100	-	0	0	0
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					

Remaks

Working date	2014. 9. 24	Personnel	Lee Myung hee (sign)
Confirming date	2014. 09. 24	Confirmed by	Kim Hui-Jeong (sign)

a) dilution, b) membrane filter, c) spreading, d) petri film

BSMB-QS-06-05(2)

Vibrio cholerae O1, O139

20 14

Study Number		Test Number	SET-14-004
Sample type	☑ Uptake water ☐ Discharge control water ☐ Discharge treated water ☐ Other( )		
Sampling time	☑ Day 0 ☐ Day 1 ☐ Day 2 ☐ Day 3 ☐ Day 4 ☐ Day 5 ☐ Other( )		

1. Procedures

☑ Each yellow sucrose fermenting colonies are placed on Non-salt Alkaline Pepton water.

☑ Incubate at 36°C ± 1 °C for 6-18 hours.

☑ Presumptive positive colonies are performed using slide agglutination assays by O1 and O139 antiserum for serological identification.

2. Results

Test substance	O1	O139	Sum
HL-SOSUW-B	O	O	O
HL-SOSUW-M	O	O	O
HL-SOSUW-E	O	O	O

3. Remarks

Working date	2014. 7. 23	Study personnel	Myounghee Lee (sign)
Confirming date	2014. 07. 23	Confirmed by	Gyu. k Lee (sign)

Vibrio cholerae O1, O139

2014

Study Number		Test Number	SET-14-004
Sample type	□ Uptake water ☑ Discharge control water ☑ Discharge treated water □ Other( )		
Sampling time	□ Day 0 □ Day 1 ☑ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		

1. Procedures

- ☑ Each yellow sucrose fermenting colonies are placed on Non-salt Alkaline Pepton water.
- ☑ Incubate at 36°C ± 1 °C for 6-18 hours.
- ☑ Presumptive positive colonies are performed using slide agglutination assays by O1 and O139 antiserum for serological identification.

2. Results

Test substance	O1	O139	Sum
HL-505TD2 B	0	0	0
HL-505CD2 M	0	0	0
HL-505CD2 E	0	0	0
HL-505TD2 B1	0	0	0
HL-505TD2 B2	0	0	0
HL-505TD2 B3	0	0	0
HL-505TD2 M1	0	0	0
HL-505TD2 M2	0	0	0
HL-505TD2 M3	0	0	0
HL-505TD2 E1	0	0	0
HL-505TD2 E2	0	0	0
HL-505TD2 E3	0	0	0

3. Remarks

Working date	2014. 07. 25	Study personnel	Myoungkee Lee (sign)
Confirming date	2014. 07. 25	Confirmed by	Sun-K Lee (sign)

Test Result Sheet - Classification (II)

20 14

Study number		Test number	SET-14-004
Test substance	Control water	Lot. No.	
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	Method	☐ Direct ☑ Dye (FDA .)
Concentration	—	Receive time of test substance	14:54
Test start time	15:03	Test end time	16:15.

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S05UW-B	500ML	Guinardia sp.	30	25	24	
		Leptocylindrus sp.	21	23	20	
		Gyrodinium sp.	4	1	3	
		Chaetoceros spp.	19	25	17	
		Dictyocha sp.	5	7	5	
		Ceratium sp.	1	1	3	
		Skeletonema sp.	3			
		Gymnodium sp.	1	1	3	
		Rhizosolenia sp.	2			
		unknown.	2			

Remark	Start : 25.4°C, 43%. a) corrected Sun ok Lee July. 21st
Date	21st a), July
Study personnel	Sun ok Lee (sign)
Certificate date	21st a), July
Study director	Sun ok Lee (sign)

* R: Replicate

Test Result Sheet - Classification (II)

20 14

Study number		**Test number**	SET-14-004
Test substance	Control water	**Lot. No.**	
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	**Method**	☐ Direct ☑ Dye ( )
Concentration	—	**Receive time of test substance**	15:58
Test start time	16:18	**Test end time**	17:30

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-SOSUWM	500ML	Chaetoceros spp.	25	26	15	
		Guinardia sp.	30	27	29	
		Dictyocha sp	5	3	2	
		Leptocylindrus sp.	11	21	18	
		ceratium sp.	2	3		
		Rhizosolenia sp.	1		1	
		Gymnodinium sp.	2		3	
		unknown	3	2	1	
		Gyrodinium sp.		1	2	

Remark	a) corrected sun·k Lee ~~Lee~~ 21th, July		
Date	~~21th a) July Sun·k Lee a)~~ 21st a) July	**Study personnel**	Sun·k Lee (sign)
Certificate date	21st a) July	**Study director**	Sun·k Lee (sign)

* R: Replicate

Test Result Sheet - Classification (II)

2014

Study number		**Test number**	SET-14-004
Test substance	Control water	**Lot. No.**	
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	**Method**	☐ Direct ☑ Dye (FDA)
Concentration	—	**Receive time of test substance**	17 : 05
Test start time	17 : 31	**Test end time**	18 : 40.

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S05W-E	500μL	Leptocylindrus sp.	16	16	15	
		Guinardia sp.	28	30	23	
		Chaetoceros spp.	9	11	22	
		Gymnodinium sp.	2	3		
		Gyrodium sp	1	1	1	
		unknown	2	2	2	
		Ceratium sp.	3		1	
		Rhizosolenia sp.	3	2	2	
		Dictyocha sp.	1	3	4	

Remark	End : 25.4°C , 43 %, a) corrected sun ok Lee 21st July
Date	21st a), July
Study personnel	Sun-k Lee (sign)
Certificate date	21st a), July
Study director	Sun-k Lee (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Worksheet-Plankton–003(1)

Test Result Sheet - Classification (II)

2014

Study number		**Test number**	SET-14-004
Test substance	Control water	**Lot. No.**	
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	**Method**	☐ Direct ☑ Dye (FDA)
Concentration	—	**Receive time of test substance**	B: 14:18 E: 16:29 M: 15:25
Test start time	E: 16:30, B: 14:20, M: 15:30,	**Test end time**	B: 15:29, M: 16:09, E: 17:10

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S05CD2-B ~~(H~~ a)	500μL	Guinardia sp.	12	6	8	
		Gyrodinium sp	1	1		
		ciliate	1	2	5	
		Dictyocha sp.	1	3	4	
		Ceratium sp.		1		
		Chaetoceros spp.		6		
HL-S05CD2-M	500μL	Ciliate	4	3	3	
		Guinardia sp.	4	3	6	
		Rhizosolenia sp.	1		1	
		Chaetoceros spp.	4	3	5	
		phaocentrum sp.	1			
		Dictyocha sp.	2	1	1	
		Leptocylindrus sp.		4		
HL-S05CD2-E	500μL	Guinardia sp.	6	3	5	
		Rhizosolenia sp.	1		1	
		Chaetoceros spp.	1	3	2	
		Dictyocha sp.	2	1	1	
		ciliate	4	4	3	
		Gyrodinium sp	2	1		
		Leptocylindrus sp.		3		

Remark	start : 27.8°C, 42 %, End : 27.6°C, 51 %. a) deleted Sun-ok Lee on 23rd. July.
Date	23rd, July
Study personnel	Sun ok Lee (signed)
Certificate date	23rd, July
Study director	Sun ok Lee (signed)

* R: Replicate

Test Result Sheet - Classification (II)

2014

Study number		Test number	SET-14-004
Test substance	Treated water	Lot. No.	
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	Method	☐ Direct ☑ Dye (FDA)
Concentration	10L → 500mL	Receive time of test substance	B1: 17:50 B2~M1: 18:21 M2~E2: 19:00
Test start time	B: 17:52, M: 18:01, E: 20:01	Test end time	B: 18:55, M: 20:00, E: 21:08

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S05TD2-B1	500μL	unidentifed ciliate	3	2	1	
HL-S05TD2-B2	500μL	unknown			1	
a) ~~HL-S05TD2-B3~~		unidentifed ciliate	1			
HL-S05TD2-B3	500μL	unidentifed ciliate			1	
HL-S05TD2-M1	500μL	–	0	0	0	
HL-S05TD2-M2		–	0	0	0	
HL-S05TD2-M3		–	0	0	0	
HL-S05TD2-E1	500μL	unidentifed ciliate	1			
HL-S05TD2-E2		unidentifed ciliate				
HL-S05TD2-E3		unidentifed ciliate			1	

Remark	a) deleted sun ok Lee 23rd, July. Start: 26.8°C, 46%, End: 26.4°C, 45%.		
Date	23rd. July	Study personnel	Sun ok Lee (sign)
Certificate date	23rd. July	Study director	Sun ok Lee (sign)

* R: Replicate

Test Result Sheet - Classification (II)

Uptake

2014

Study number		Test number	LET-14-004
Test substance	Control water	Lot. No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 250ml	Receive time of test substance	14:51
Test start time	14:56	Test end time	15:51

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S05010-B	1ml	Parvocalanus sp.(crassirostris)	11	9	6	
		Oithona spp.	29	33	21	
		Acartia sp.	9	2	8	
		Paracalanus sp.(parvus s.l.)	1			
		Polychaeta larvae	3		1	
		Bivalve larvae	4	11	1	
		Harpacticoida sp.	4	2		
		Euchaeta sp.(tergestina)	2			
		nauplius	2	3	1	

Remark	start 25°C 48RH%	End 26°C 44RH%	
Date	21th Jul.	Study personnel	Lee Seok Ju (sign)
Certificate date	27th Jul	Study director	Lee Sunok (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Worksheet-Plankton-003(1)

Test Result Sheet - Classification (II)

2014

Study number		Test number	LET-14-004
Test substance	Control water a)	Lot. No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 250ml	Receive time of test substance	15:58
Test start time	16:03	Test end time	16:28

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-505000-M	1ml	Parvocalanus sp. (crassirostris)	33	33	30	
		Oithona spp.	45	38	37	
		Acartia sp.	4	2	5	
		Bivalve larvae	5	6	6	
		Harpacticoida sp.	/	/	/	
		Evadne sp. (tergestina)	/			
		nauplius	/		/	
		Gastropoda larvae	/		/	
		Polychaeta larvae	/	2	/	

Remark	start:- 25.4°C 46RH% End 25.6°C 48RH%	a) 조사지점 이름을 아니라고	
Date	21th Jul.	Study personnel	Lee Seok Ju (Sign)
Certificate date	21th Jul	Study director	Lee Sun-K (Sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Worksheet-Plankton–003(1)

Test Result Sheet - Classification (II)

2014

Study number		Test number	LET-14-006
Test substance	Control water	Lot. No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 250ml	Receive time of test substance	17:05
Test start time	17:10	Test end time	17:48

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-405000-E	1ml	Paracalanus sp.(crassirostris)	5	3	6	
		Oithona spp.	15	13	13	
		Acartia sp.	4	6	2	
		Evadne sp.(tergestina)	7	15	7	
		Bivalve larvae	12	7	12	
		Harpacticoida sp.	2	2		
		Polychaeta larvae	2	2	4	
		Gasstropoda larvae	1	2	2	

Remark	start: 25.1°C 45RH%	End 25.6°C 45RH%	
Date	21th Jul.	Study personnel	Lee Seok Ju (sign)
Certificate date	24th Jul	Study director	Lee Sun ole (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Worksheet-Plankton-003(1)

Test Result Sheet - Classification (II)

Con

2014

Study number		Test number	LET-14-004
Test substance	Control water	Lot. No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 50ml	Receive time of test substance	14:25
Test start time	14:25	Test end time	14:58

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S05CD1-B	2ml	Paracalanus sp.(Chaissiostris)	56	50	56	
		Oithona spp.	29	35	31	
		Acartia sp.	1	3		
		Cirriped larvae	2	1	3	
		Bivalve larvae	2		3	
		Paracalanus sp.(parvus s. l.)	1		2	
		Polychaeta larvae		2		
		Gastropod larvae			2	

Remark	start 27.8°C 42RH% End 27.1°C 45RH%		
Date	23th Jul.	Study personnel	Lee Seok Ju (sign)
Certificate date	23rd Jul	Study director	Lee Sun ok (sign)

* R: Replicate

Test Result Sheet - Classification (II)

2014

Study number		Test number	LET-14-004
Test substance	Control water	Lot. No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 250ml	Receive time of test substance	15:25
Test start time	15:30	Test end time	16:00

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S05(D2)-M	2ml	Paracalanus sp.-(crassirostris)	51	58	50	
		Oithona spp.	21	16	21	
		Acartia sp.	4	1	5	
		Cirriped larvae	1	1	3	
		Bivalve larvae	1	1	4	
		Paracalanus sp.(parvus s.l.)	1		1	
		Polychaeta larvae		1	1	
		Gastropod larvae	1	3	2	

Remark	start 20.5°C 43 RH% End 20.5 48 RH%		
Date	23th Jul.	Study personnel	Lee Seok Ju (sign)
Certificate date	23rd Jul	Study director	Lee Sun-K (sign)

* R: Replicate

Test Result Sheet - Classification (II)

2014

Study number		Test number	LET-14-004
Test substance	Control water	Lot. No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 250ml	Receive time of test substance	16:35
Test start time	16:40	Test end time	17:15

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-505CD1-E	2ml	Paracalanus sp. (crassirostris)	54	52	52	
		Oithona spp.	22	20	19	
		Acartia sp.	20	17	22	
		Cirriped larvae	2	3	1	
		Bivalve larvae	2			
		Paracalanus sp. (parvus s.l.)	1			
		Polychaeta larvae	1	2	2	
		Gasthropod larvae	6		2	
		nauplius		2		
		Penilia avirostris		1	1	
		Harpacticoida sp.			2	

Remark	Start 27.3°C 46RH%	End 27.5°C 52RH%	
Date	23th Jul.	Study personnel	Lee Seok Ju (sign)
Certificate date	23rd Jul	Study director	Sun-K Lee (sign)

* R: Replicate

Test Result Sheet - Classification (II)

2014

Study number		Test number	LET-14-004
Test substance	a) Treated water	Lot. No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 250ml	Receive time of test substance	18:21
Test start time	18:09	Test end time	21:36

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-605TD2-B1	250ml	–	–			
B2		–	–			
B3		–	–			19:5
M1	250ml	–	–			
M2		–	–			
M3		–	–			20:4
E1	250ml	–	–			
E2		–	–			
E3		–	–			

Remark	start 26.5℃ 48RH% End 26.9℃ 54RH% a) 환경정책 이사장 → 14.07.23		
Date	23th Jul	Study personnel	Lee Seok Ju (sign)
Certificate date	23rd Jul	Study director	Sun-k Lee (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

4.6 Test 6 report and raw data

Test Report

Project name	EcoGuardian™
Test number	SET-14-006
Port	Gunsan(Korea)-Ballasting Gamcheon(Korea)-Deballasting
Title	Efficacy test of EcoGuardian™ Ballast Water Management System (shipboard scale)

BUSAN TECHNO PARK

Statement of Quality Assurance

Data were reviewed by Quality Assurance Unit of BTP to assure that the study was performed in accordance with protocol and standard operating procedures (SOP) of Busan Techno-Park (BTP). The report was an accurate reflection of the raw data generated at the BTP. Inspection of the routine and repeated procedures that constitute the study was carried out as a continuous major phase at or about the time this study was in progress.

Inspection Phase		Date		
		Inspection	Report to Testing manager	Report to Project director
Test plan		12nd September, 2014	12nd September, 2014	12nd September, 2014
Sampling	1st	16th September, 2014	16th September, 2014	16th September, 2014
	2nd	18th September, 2014	18th September, 2014	18th September, 2014
Test substance	1st	16th September, 2014	16th September, 2014	16th September, 2014
	2nd	18th September, 2014	18th September, 2014	18th September, 2014
Test procedures (Bacteria test)	1st	16th September, 2014	16th September, 2014	16th September, 2014
	2nd	18th September, 2014	18th September, 2014	18th September, 2014
Observation and counting (≥50㎛, 10㎛-50㎛)	1st	16th September, 2014	16th September, 2014	16th September, 2014
	2nd	18th September, 2014	18th September, 2014	18th September, 2014
Observation and counting (Bacteria test)	1st	17th~19th September, 2014	17th~19th September, 2014	17th~19th September, 2014
	2nd	19th~21st September, 2014	19th~21st September, 2014	19th~21st September, 2014

Seo, Hyo-Jin (Sign) — 12th Dec. 2014

Seo, Hyo-Jin / Project director — Date

Study Personnel and Participants

The test participants recognized the study plan, manual, procedure, guide of Busan Techno Park in performing the test.

	Name	Date
Study personnel	Lee Ui-Sun (sign)	12th. Dec. 2014
	Lee Seok Ju (sign)	12th. Dec. 2014
	Lee Sun ok (sign)	12th. Dec. 2014
	Park Na kyung (sign)	12th. Dec. 2014
	Min-Ji Kim (sign)	12th. Dec. 2014
	Cho Yunkyeong (sign)	12th. Dec. 2014
	Sang-Hyun. Kim (sign)	12th. Dec. 2014
	Young In Song (sign)	12th. Dec. 2014
	(sign)	
Project director	Seo. Hyo-Jin (sign)	12th. Dec. 2014

Contents

1.Results 1

1.1 Loading record 1

1.2 Water parameters 2

1.3 Influent water : Uptake water 4

1.4 Elimination efficacy 6

2. Validity 12

3. Conclusion 14

4. Appendix 15

1. Results

1.1 Loading record

Vessel name	SSANG YONG CHANGYAHNG
IMO number	9121027

Water ballast tanks			Sample WGT(Mt)	Loading (Date/Location)	Discharge (Date/Location)
Control	No.3 D/B W.B.T	P, S	1370	16th September, 2014 GUNSAN (35°58.30N, 126°37.10E)	18th September, 2014 GAMCHEON (35°04.48N, 128°59.70E)
Treated	No.4 D/B W.B.T No.5 D/B W.B.T	P, S	650	16th September, 2014 GUNSAN (35°58.30N, 126°37.10E)	18th September, 2014 GAMCHEON (35°04.48N, 128°59.70E)

1.2 Water parameters

Table 1. Water parameters at field

Date	Sample ID	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
Day 0	HL-S06UW-B	7.91±0.19	24.42±0.01	30.06±0.27	6.19±0.17	7.8±0.2	-
	HL-S06UW-M	8.10±0.04	24.43±0.01	30.15±0.14	6.06±0.08	7.3±0.2	-
	HL-S06UW-E	8.12±0.05	24.43±0.02	29.99±0.23	6.02±0.15	6.6±0.1	-
Day 3	HL-S06CD3-B	7.81±0.30	24.46±0.07	30.33±0.03	5.34±0.10	6.2±0.2	-
	HL-S06CD3-M	7.95±0.16	24.44±0.05	30.25±0.05	5.76±0.17	6.6±0.4	-
	HL-S06CD3-E	8.03±0.11	24.47±0.04	30.25±0.04	5.66±0.12	6.4±0.2	-
	HL-S06TD3-B-1	8.06±0.12	24.67±0.08	30.58±0.09	5.94±0.06	8.0±0.4	0.11±0.02
	HL-S06TD3-B-2	8.19±0.11	24.58±0.03	30.57±0.09	6.03±0.07	6.8±0.2	-
	HL-S06TD3-B-3	8.16±0.16	24.59±0.03	30.59±0.06	5.92±0.08	6.8±0.2	-
	HL-S06TD3-M-1	8.14±0.18	24.60±0.03	30.58±0.09	5.86±0.43	6.8±0.2	0.09±0.01
	HL-S06TD3-M-2	8.26±0.05	24.62±0.09	30.46±0.32	5.68±0.06	6.8±0.3	-
	HL-S06TD3-M-3	8.21±0.05	24.61±0.03	30.59±0.06	5.87±0.08	7.0±0.1	-
	HL-S06TD3-E-1	8.06±0.08	24.59±0.03	30.62±0.01	5.88±0.05	7.4±0.2	0.07±0.02
	HL-S06TD3-E-2	8.03±0.11	24.61±0.04	30.57±0.09	5.92±0.09	9.7±2.2	-
	HL-S06TD3-E-3	8.10±0.10	24.63±0.04	30.61±0.02	6.19±0.13	9.2±1.4	-

Data were presented as mean±S.D of three repeated measurement.

Table 2. Results of DOC, POC, TSS

Date	Sample ID	TOC [a)] (mg/L)	DOC [b)] (mg/L)	POC [c)] (mg/L)	TSS [d)] (mg/L)
Day 0	HL-S06UW-B	2.840 ± 0.16	1.737 ± 0.03	1.103	76.8±1.1
	HL-S06UW-M	2.690 ± 0.13	1.682 ± 0.16	1.008	78.4±1.2
	HL-S06UW-E	2.911 ± 0.04	1.791 ± 0.03	1.120	75.5±1.4

Data were presented as mean±S.D of three repeated measurement.
a) TOC: Total Organic Carbon
b) DOC: Dissolved Organic Carbon
c) POC: Particulate Organic Carbon (POC=TOC-DOC)
d) TSS: Total Suspended Solids

1.3 Influent water : Uptake water

1) ≥ 50 µm organism

Table 3. The survival number of the organism larger than 50 µm

Sample ID	Phyla/Divisions	Species	individuals/m^3	Minimum Dimension (µm)
HL-S06UW-B	Arthropoda	*Parvocalanus crassirostris*	233 ± 104	350~425
		Acartia sp.	333 ± 29	500~575
		Cirriped larvae	233 ± 29	150~200
		Paracalanus parvus s. l.	250 ± 132	500~550
		Oithona sp.	367 ± 76	225~250
		Nauplius	717 ± 58	150~200
		Corycaeus sp.	67 ± 58	350~400
		Labidocera sp.	33 ± 58	700~900
	Annelida	Polychaeta larvae	50 ± 50	250~550
HL-S06UW-M	Arthropoda	*Parvocalanus crassirostris*	100 ± 100	350~425
		Acartia sp.	317 ± 126	500~575
		Cirriped larvae	183 ± 29	150~200
		Paracalanus parvus s. l.	150 ± 100	500~550
		Oithona sp.	717 ± 104	225~250
		Nauplius	717 ± 126	150~200
		Labidocera sp.	17 ± 29	700~900
		Centropages sp.	17 ± 29	450~550
	Annenlida	Polychaeta larvae	117 ± 58	250~550
HL-S06UW-E	Arthropoda	*Parvocalanus crassirostris*	267 ± 115	350~425
		Acartia sp.	333 ± 58	500~575
		Cirriped larvae	83 ± 104	150~200
		Paracalanus parvus s. l.	833 ± 176	500~550
		Oithona sp.	1,067 ± 76	225~250
		Nauplius	133 ± 29	150~200
		Centropages sp. 1	17 ± 29	450~550
		Centropages sp. 2	33 ± 29	600~650
		Labidocera sp.	100 ± 50	700~900
		Corycaeus sp.	100 ± 87	350~400
	Annelida	Polychaeta larvae	150 ± 50	250~550
Total	11 species 2 phyla/divisions		2,578 ± 467	-
Acceptability			Influent condition: Acceptable (≥10^2 ind./m^3)	-

Data were presented as mean±S.D of three repeated measurement.
Some species were rare, the standard deviation was high.

2) 10 µm - 50 µm organism

Table 4. The survival number of the organism between 10 to 50 µm

Sample ID	Phyla/Divisions	Species	individuals/mL	Minimum Dimension (µm)
HL-S06UW-B	Pyrrophyta	*Prorocentrum* sp.	14 ± 7	10~20
		Ceratium sp.	7 ± 4	15~37
	Chrysophyta	*Rhizosolenia* sp.	1 ± 2	13~30
		Stephanopyxis sp.	9 ± 4	15~40
		Thalassiosira sp.	36 ± 6	13~35
		Chaetoceros sp.	32 ± 9	13~30
		Eucampia sp.	11 ± 13	15~30
		Pleurosigma sp.	4 ± 2	15~40
	Protozoa	*Tintinnopsis* sp.	2 ± 1	20~40
		Unknown	1 ± 1	20~43
HL-S06UW-M	Pyrrophyta	*Ceratium* sp.	10 ± 3	15~37
		Prorocentrum sp.	25 ± 2	10~20
	Chrysophyta	*Pleurosigma* sp.	7 ± 2	15~40
		Leptocylindrus sp.	7 ± 2	12~30
		Thalassiosira sp.	34 ± 10	13~35
		Eucampia sp.	5 ± 5	15~30
		Stephanopyxis sp.	9 ± 8	15~40
		Rhizosolenia sp.	1 ± 1	13~30
	Protozoa	*Tintinnopsis* sp.	2 ± 1	20~40
		Unknown	2 ± 1	20~43
HL-S06UW-E	Pyrrophyta	*Prorocentrum* sp.	32 ±5	10~20
		Ceratium sp.	8 ± 1	15~37
	Chrysophyta	*Leptocylindrus* sp.	6 ± 3	12~30
		Diploneis sp.	1 ± 1	10~30
		Thalassiosira sp	36 ± 4	13~35
		Chaetoceros sp.	30 ± 7	13~30
		Eucampia sp.	9 ± 4	15~30
		Pleurosigma sp.	2 ± 3	15~40
	Protozoa	*Tintinnopsis* sp.	2 ± 3	20~40
Total	12 species 3 phyla/divisions		120 ± 5	-
Acceptability			Influent condition: Acceptable ($\geq 10^2$ ind./mL)	

Data were presented as mean±S.D of three repeated measurement.
Some species were rare, the standard deviation was high.

1.4 Elimination efficacy

1) ≥ 50 µm organism

Table 5. The survival number of the organism larger than 50 µm

Test substance	Sample ID	individuals/m^3	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S06UW-B [a)]	2,283 ± 104	Influent condition: Acceptable (≥10^2 ind./m^3)	-
	HL-S06UW-M [b)]	2,333 ± 257		
	HL-S06UW-E [c)]	3,117 ± 325		
Discharged control water (Day 3, C3)	HL-S06CD3-B	2,000 ± 87	Effluent condition: Acceptable (≥10 ind./m^3)	-
	HL-S06CD3-M	2,017 ± 126		
	HL-S06CD3-E	2,667 ± 189		
Discharged treated water (Day 3, T3)	HL-S06TD3-B-1	N.D [e)]	Effluent condition: Acceptable (<10 ind./m^3)	99.9 [d)]
	HL-S06TD3-B-2	N.D		
	HL-S06TD3-B-3	N.D		
	HL-S06TD3-M-1	N.D		
	HL-S06TD3-M-2	N.D		
	HL-S06TD3-M-3	1		
	HL-S06TD3-E-1	N.D		
	HL-S06TD3-E-2	N.D		
	HL-S06TD3-E-3	N.D		

a) B: beginning, b) M: Middle c) E: End, d) Calculation = (Uw-T3)/Uw*100, e) N.D : Not Detected
Data were presented as mean±S.D of three repeated measurement.

2) 10 µm - 50 µm organism

Table 6. The survival number of the organism between 10 and 50 µm

Test substance	Sample ID	individuals/mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S06UW-B [a)]	114 ± 7	Influent condition: Acceptable ($\geq 10^2$ ind./mL)	-
	HL-S06UW-M [b)]	123 ± 9		
	HL-S06UW-E [c)]	123 ± 9		
Discharged control water (Day 3, C3)	HL-S06CD3-B	18 ± 3	Effluent condition: Acceptable (≥10 ind./mL)	-
	HL-S06CD3-M	15 ± 1		
	HL-S06CD3-E	17 ± 2		
Discharged treated water (Day 3, T3)	HL-S06TD3-B-1	<1	Effluent condition: Acceptable (<10 ind./mL)	99.9 [d)]
	HL-S06TD3-B-2	<1		
	HL- S06TD3-B-3	<1		
	HL- S06TD3-M-1	<1		
	HL- S06TD3-M-2	<1		
	HL- S06TD3-M-3	<1		
	HL- S06TD3-E-1	<1		
	HL- S06TD3-E-2	<1		
	HL- S06TD3-E-3	<1		

a) B: Beginning, b) M: Middle c) E: End, d) Calculation = (Uw-T3)/Uw*100
Data were presented as mean±S.D of three repeated measurement.

3) Heterotrophic bacteria

Table 7. The survival number of heterotrophic bacteria

Test substance	Sample ID	CFU / mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S06UW-B [a)]	0 ± 0	-	-
	HL-S06UW-M [b)]	33 ± 29		
	HL-S06UW-E [c)]	100 ± 50		
Discharged control water (Day 3, C3)	HL-S06CD3-B	317 ± 52	-	-
	HL-S06CD3-M	108 ± 14		
	HL-S06CD3-E	150 ± 43		
Discharged treated water (Day 3, T3)	HL-S06TD3-B-1	TNTC [e)]	-	0.0 [d)]
	HL-S06TD3-B-2	TNTC		
	HL-S06TD3-B-3	TNTC		
	HL-S06TD3-M-1	TNTC		
	HL-S06TD3-M-2	199 ± 15		
	HL-S06TD3-M-3	148 ± 6		
	HL-S06TD3-E-1	TNTC		
	HL-S06TD3-E-2	TNTC		
	HL-S06TD3-E-3	TNTC		

a) B: Beginning, b) M: Middle, c) E: End, d) Calculation = (Uw-T3)/Uw*100
e) TNTC : Too Numerous To Count
Data were presented as mean±S.D of three repeated measurement.

4) *Escherichia coli*

Table 8. The survival number of *Escherichia coli*

Test substance	Sample ID	CFU / 100 mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S06UW-B [a)]	18 ± 7	-	-
	HL-S06UW-M [b)]	31 ± 5		
	HL-S06UW-E [c)]	52 ± 10		
Discharged control water (Day 3, C3)	HL-S06CD3-B	3 ± 1	-	-
	HL-S06CD3-M	3 ± 2		
	HL-S06CD3-E	1 ± 1		
Discharged treated water (Day 3, T3)	HL-S06TD3-B-1	N.D [e)]	Effluent condition: Acceptable (<250 CFU/ 100 mL)	100.0 [d)]
	HL-S06TD3-B-2	N.D		
	HL-S06TD3-B-3	N.D		
	HL-S06TD3-M-1	N.D		
	HL-S06TD3-M-2	N.D		
	HL-S06TD3-M-3	N.D		
	HL-S06TD3-E-1	N.D		
	HL-S06TD3-E-2	N.D		
	HL-S06TD3-E-3	N.D		

a) B: Beginning, b) M: Middle, c) E: End, d) Calculation = (Uw-T3)/Uw*100, e) N.D : Not Detected
Data were presented as mean±S.D of three repeated measurement.

5) Intestinal enterococci

Table 9. The survival number of intestinal enterococci

Test substance	Sample ID	CFU / 100 mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S06UW-B [a)]	2 ± 1	-	-
	HL-S06UW-M [b)]	7 ± 3		
	HL-S06UW-E [c)]	22 ± 5		
Discharged control water (Day 3, C3)	HL-S06CD3-B	2 ± 2	-	-
	HL-S06CD3-M	3 ± 2		
	HL-S06CD3-E	1 ± 1		
Discharged treated water (Day 3, T3)	HL-S06TD3-B-1	N.D [e)]	Effluent condition: Acceptable (<100 CFU/ 100 mL)	100.0 [d)]
	HL-S06TD3-B-2	N.D		
	HL-S06TD3-B-3	N.D		
	HL-S06TD3-M-1	N.D		
	HL-S06TD3-M-2	N.D		
	HL-S06TD3-M-3	N.D		
	HL-S06TD3-E-1	N.D		
	HL-S06TD3-E-2	N.D		
	HL-S06TD3-E-3	N.D		

a) B: Beginning, b) M: Middle, c) E: End, d) Calculation = (Uw-T3)/Uw*100, e) N.D : Not Detected
Data were presented as mean±S.D of three repeated measurement.

6) *Vibrio cholera* O1, O139

Table 10. The survival number of *Vibrio cholera* O1, O139

Test substance	Sample ID	CFU / 100 mL	Acceptability	Elimination efficacy (%)
Uptake water (Day 0, Uw)	HL-S06UW-B [a)]	N.D	-	-
	HL-S06UW-M [b)]	N.D		
	HL-S06UW-E [c)]	N.D		
Discharged control water (Day 3, C3)	HL-S06CD3-B	N.D	-	-
	HL-S06CD3-M	N.D		
	HL-S06CD3-E	N.D		
Discharged treated water (Day 3, T3)	HL-S06TD3-B-1	N.D	Effluent condition: Acceptable (<1 CFU/ 100 mL)	N.D[d)]
	HL-S06TD3-B-2	N.D		
	HL-S06TD3-B-3	N.D		
	HL-S06TD3-M-1	N.D		
	HL-S06TD3-M-2	N.D		
	HL-S06TD3-M-3	N.D		
	HL-S06TD3-E-1	N.D		
	HL-S06TD3-E-2	N.D		
	HL-S06TD3-E-3	N.D		

a) B: Beginning, b) M: Middle c) E: End, d) N.D: Not detected
Data were presented as mean±S.D of three repeated measurement.

2. Validity

2.1 Water parameters measurement

- All measurements were tested more than three times.
- Water parameters were analyzed as soon as possible after sampling.

2.2 Biological efficacy test

- Valid tests are indicated by uptake water, for both the control tank and ballast water to be treated, with viable organism concentration exceeding 10 times the maximum permitted values in Regulation D-2.1

Sample ID	≥ 50 µm (individuals/m^3)	10 µm - 50 µm (individuals/mL)
HL-S06UW-B	2,283 ± 104	114 ± 7
HL-S06UW-M	2,333 ± 257	123 ± 9
HL-S06UW-E	3,117 ± 325	123 ± 9

- Valid test is indicated by control tank viable organism concentration exceeding the values of Regulation D-2.1 on discharge.

Sample ID	≥ 50 µm (individuals/m^3)	10 µm - 50 µm (individuals/mL)
HL-S06CD3-B	2,000 ± 87	18 ± 3
HL-S06CD3-M	2,017 ± 126	15 ± 1
HL-S06CD3-E	2,667 ± 189	17 ± 1

※Regulation D-2 stipulates that ships meeting the requirements of the Convention by meeting the ballast water performance standard must discharge:

1. less than 10 viable organisms per cubic metre greater than or equal to 50 micrometres in minimum dimension;
2. less than 10 viable organisms per milliliter less than 50 micrometres in minimum dimension and greater than or equal to 10 micrometres in minimum dimension

• The samples should be analyzed as soon as possible after sampling.

Date	Sample ID	Sampling time	Test ending time
Day 0	HL-S06UW-B	September, 16th 07:08	08:30
	HL-S06UW-M	September, 16th 08:10	09:40
	HL-S06UW-E	September, 16th 09:40	11:20
Day 3	HL-S06CD3-B	September, 18th 09:27	10:12
	HL-S06CD3-M	September, 18th 10:35	11:14
	HL-S06CD3-E	September, 18th 11:37	12:12
	HL-S06TD3-B-1, 2, 3	September, 18th 13:31	14:42
	HL-S06TD3-M-1, 2, 3	September, 18th 14:44	15:36
	HL-S06TD3-E-1, 2, 3	September, 18th 15:36	16:30

3. Conclusion

3.1 Biological efficacy in treated ballast seawater by EcoGuardian™ BWMS

- Treated ballast seawater by EcoGuardian™ system was capable of eliminating organism larger than 50 μm with an efficiency of 99.9 %.
- Treated ballast seawater water by EcoGuardian™ BWMS was capable of eliminating organism between 10 and 50 μm with an efficiency of 99.9 %.
- Treated ballast seawater by EcoGuardian™ system was capable of eliminating heterotrophic bacteria with an efficiency of 0 %.
- Treated ballast seawater by EcoGuardian™ system was capable of eliminating *Escherichia coli* with an efficiency of 100 %.
- Treated ballast seawater by EcoGuardian™ system was capable of eliminating intestinal enterococci with an efficiency of 100 %.
- *Vibrio cholera* O1, O139 were not detected.

4. Appendix

Appendix 1. Water parameters at field

1) Uptake water

Date	Sample ID	R [a)]	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)	TOC [b)] (mg/L)	DOC [c)] (mg/L)	TSS [d)] (mg/L)
Day 0	HL-S06UW-B	R1	7.69	24.42	29.82	6.30	8.0	2.685	1.732	78.0
		R2	8.00	24.42	30.00	6.28	7.8	2.994	1.706	76.0
		R3	8.03	24.41	30.36	5.99	7.6	2.785	1.771	76.4
	HL-S06UW-M	R1	8.06	24.44	29.99	6.14	7.1	2.542	1.671	79.6
		R2	8.10	24.43	30.21	6.07	7.5	2.752	1.529	78.4
		R3	8.13	24.42	30.26	5.98	7.4	2.775	1.845	77.2
	HL-S06UW-E	R1	8.09	24.45	29.73	6.19	6.5	2.911	1.773	76.8
		R2	8.10	24.42	30.08	5.91	6.6	2.998	1.765	74.0
		R3	8.18	24.42	30.15	5.97	6.6	2.945	1.835	75.6

a) R: Replicate
b) TOC: Total Organic Carbon (TOC=DOC+POC)
c) DOC: Dissolved Organic Carbon
d) TSS: Total Suspended Solids

2) Discharged Control water and Discharged Treated water

Date	Sample ID	R [a)]	pH	Temp (°C)	Salinity (PSU)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
Day 3	HL-S06CD3-B	R1	7.46	24.53	30.30	5.26	6.1	-
		R2	7.96	24.45	30.34	5.31	6.1	-
		R3	8.01	24.40	30.35	5.45	6.5	-
	HL-S06CD3-M	R1	7.79	24.50	30.20	5.96	6.9	-
		R2	7.96	24.43	30.27	5.67	6.8	-
		R3	8.10	24.40	30.29	5.66	6.2	-
	HL-S06CD3-E	R1	7.91	24.51	30.21	5.80	6.6	-
		R2	8.05	24.46	30.28	5.59	6.5	-
		R3	8.13	24.44	30.27	5.60	6.2	-
	HL-S06TD3-B-1	R1	7.94	24.76	30.47	5.87	7.6	0.09
		R2	8.07	24.62	30.63	5.99	8.2	0.10
		R3	8.18	24.62	30.63	5.97	8.3	0.13
	HL-S06TD3-B-2	R1	8.07	24.62	30.47	5.95	6.6	-
		R2	8.20	24.57	30.62	6.09	6.9	-
		R3	8.29	24.56	30.62	6.06	6.8	-
	HL-S06TD3-B-3	R1	7.98	24.62	30.52	5.84	6.5	-
		R2	8.22	24.58	30.62	5.94	6.9	-
		R3	8.29	24.57	30.64	5.99	6.9	-
	HL-S06TD3-M-1	R1	7.94	24.64	30.48	5.94	6.7	0.08
		R2	8.21	24.58	30.61	5.40	6.7	0.09
		R3	8.28	24.59	30.64	6.25	7.0	0.09
	HL-S06TD3-M-2	R1	8.30	24.57	30.65	5.72	7.0	-
		R2	8.28	24.57	30.65	5.72	6.9	-
		R3	8.20	24.72	30.09	5.61	6.5	-
	HL-S06TD3-M-3	R1	8.25	24.64	30.53	5.78	7.0	-
		R2	8.16	24.60	30.62	5.89	7.0	-
		R3	8.22	24.58	30.63	5.93	7.1	-
	HL-S06TD3-E-1	R1	7.99	24.62	30.61	5.84	7.2	0.05
		R2	8.06	24.59	30.63	5.86	7.5	0.08
		R3	8.14	24.57	30.63	5.93	7.4	0.09
	HL-S06TD3-E-2	R1	7.92	24.65	30.47	5.81	7.7	-
		R2	8.03	24.59	30.62	5.96	9.3	-
		R3	8.13	24.58	30.63	5.98	12.1	-
	HL-S06TD3-E-3	R1	7.99	24.67	30.58	6.04	8.0	-
		R2	8.15	24.62	30.62	6.27	10.7	-
		R3	8.16	24.60	30.62	6.26	8.9	-

Appendix 2. The survival number of ≥ 50㎛ organism in uptake water(Influent water)

Sample ID	Classification	Counting volume	R1[a)]	R2	R3	individuals/m^3	
						Mean	S.D[b)]
HL-S06UW-B	*Parvocalanus crassirostris*	5 mL	7	3	4	233	104
	Acartia sp.		7	6	7	333	29
	Cirriped larvae		4	5	5	233	29
	Paracalanus parvus s.l.		6	2	7	250	132
	Oithona sp.		6	9	7	367	76
	Nauplius		15	15	13	717	58
	Corycaeus sp.		2	2	0	67	58
	Labidocera sp.		0	0	2	33	58
	Polychaeta larvae		1	2	0	50	50
HL-S06UW-M	*Parvocalanus crassirostris*	5 mL	4	0	2	100	100
	Acartia sp.		4	6	9	317	126
	Cirriped larvae		3	4	4	183	29
	Paracalanus parvus s.l.		3	1	5	150	100
	Oithona sp.		12	15	16	717	104
	Nauplius		14	17	12	717	126
	Labidocera sp.		0	1	0	17	29
	Centropages sp.		0	1	0	17	29
	Polychaeta larvae		1	3	3	117	58
HL-S06UW-E	*Parvocalanus crassirostris*	5 mL	4	8	4	267	115
	Acartia sp.		6	6	8	333	58
	Cirriped larvae		0	1	4	83	104
	Paracalanus parvus s.l.		17	13	20	833	176
	Oithona sp.		21	20	23	1,067	76
	Nauplius		3	3	2	133	29
	Centropages sp.1		0	1	0	17	29
	Centropages sp.2		1	1	0	33	29
	Labidocera sp.		1	2	3	100	50
	Corycaeus sp.		0	3	3	100	87
	Polychaeta larvae		3	4	2	150	50

a) R: Replicate
b) S.D: Standard deviation
Some species were rare, the standard deviation was high.

Appendix 3. The survival number of ≥ 50㎛ organism in discharged control water

Sample ID	Classification	Counting volume	R1[a)]	R2	R3	individuals/m^3	
						Mean	S.D[b)]
HL-S06CD-B	*Paracalanus parvus* s.l.	5 mL	3	6	6	250	87
	Acartia sp.		5	2	3	167	76
	Parvocalanus crassirostris		4	6	2	200	100
	Oithona sp.		21	25	24	1,167	104
	Corycaeus affinis		2	0	2	67	58
	Labidocera sp.		3	0	2	83	76
	Nauplius		0	1	0	17	29
	Centropages sp.		0	0	1	17	29
	Polychaeta larvae		0	1	1	33	29
HL-S06CD-M	*Paracalanus parvus* s.l.	5 mL	7	10	7	400	87
	Acartia sp.		6	2	2	167	115
	Parvocalanus crassirostris		3	3	4	167	29
	Oithona sp.		20	16	15	850	132
	Labidocera sp.		5	5	6	267	29
	Cirriped larvae		1	0	1	33	29
	Corycaeus affinis		0	1	1	33	29
	Centropages sp.		0	1	1	33	29
	Polychaeta larvae		1	0	3	67	76
HL-S06CD-E	*Paracalanus parvus* s.l.	5 mL	18	19	17	900	50
	Acartia sp.		4	6	7	283	76
	Parvocalanus crassirostris		7	8	13	467	161
	Oithona sp.		10	10	9	483	29
	Corycaeus affinis		2	0	2	67	58
	Labidocera sp.		4	3	3	167	29
	Cirriped larvae		3	7	4	233	104
	Centropages sp.		1	1	0	33	29
	Polychaeta larvae		0	1	1	33	29

a) R: Replicate
b) S.D: Standard deviation
Some species were rare, the standard deviation was high.

Appendix 4. The survival number of ≥ 50㎛ organism in discharged treated ballast seawater by treatment of EcoGuardian™ system

Sample ID	Classification	Counting volume	individuals/m^3
HL-S06TD3-B-1	-	250 mL	-
HL-S06TD3-B-2	-		-
HL-S06TD3-B-3	-		-
HL-S06TD3-M-1	-	250 mL	-
HL-S06TD3-M-2	-		-
HL-S06TD3-M-3	Nauplius		1
HL-S06TD3-E-1	-	250 mL	-
HL-S06TD3-E-2	-		-
HL-S06TD3-E-3	-		-

a) R: Replicate
b) S.D: Standard deviation

Appendix 5. The survival number of 10㎛ - 50㎛ organism in uptake water(Influent water)

Sample ID	Classification	Counting volume	R1[a)]	R2	R3	individuals/mL	
						Mean	S.D[b)]
HL-S06UW-B	*Prorocentrum* sp.	1 mL	13	21	7	14	7
	Tintinnopsis sp.		2	1	2	2	1
	Rhizosolenia sp.		3	0	0	1	2
	Stephanopyxis sp.		12	5	8	8	4
	Thalassiosira sp.		42	36	30	36	6
	Ceratium sp.		7	2	10	6	4
	Chaetoceros sp.		22	40	32	31	9
	Eucampia sp.		0	7	26	11	13
	Pleurosigma sp.		5	4	2	4	2
	Unknown		0	1	2	1	1
HL-S06UW-M	*Pleurosigma* sp.	1 mL	6	6	9	7	2
	Leptocylindrus sp.		6	9	5	7	2
	Thalassiosira sp.		37	42	22	34	10
	Eucampia sp.		6	0	9	5	5
	Tintinnopsis sp.		3	1	1	2	1
	Chaetoceros sp.		16	20	36	24	11
	Ceratium sp.		13	10	7	10	3
	Prorocentrum sp.		24	26	23	24	2
	Stephanopyxis sp.		0	14	12	9	8
	Rhizosolenia sp.		0	0	1	0	1
	Unknown		2	2	1	2	1
HL-S06UW-E	*Prorocentrum* sp.	1 mL	32	36	26	31	5
	Leptocylindrus sp.		6	2	8	5	3
	Diploneis sp.		1	0	0	0	1
	Thalassiosira sp.		32	40	36	36	4
	Ceratium sp.		7	8	9	8	1
	Chaetoceros sp.		36	22	32	30	7
	Eucampia sp.		7	6	14	9	4
	Pleurosigma sp.		2	1	1	1	1
	Tintinnopsis sp.		0	0	6	2	3

a) R: Replicate
b) S.D: Standard deviation
Some species were rare, the standard deviation was high.

Appendix 6. The survival number of 10㎛ - 50㎛ organism in discharged control water

Sample ID	Classification	Counting volume	R1[a)]	R2	R3	individuals/mL	
						Mean	S.D[b)]
HL-S06CD3-B	*Thalassiosira* sp.	0.5 mL	6	3	7	11	4
	Melosira sp.		2	0	0	1	2
	Ceratium sp.		1	1	1	2	0
	Unidentified diatom		0	0	1	1	1
	Unidentified dinoflagellates		1	3	1	3	2
HL-S06CD3-M	*Thalassiosira* sp.	0.5 mL	2	4	3	6	2
	Chaetoceros sp.		1	0	0	1	1
	Melosira sp.		0	1	2	2	2
	Unidentified diatom		1	1	1	2	0
	Unidentified dinoflagellates		3	2	1	4	2
HL-S06CD3-E	*Thalassiosira* sp.	0.5 mL	4	3	2	6	2
	Melosira sp.		2	2	0	3	2
	Ceratium sp.		2	1	0	2	2
	Chaetoceros sp.		0	2	0	1	2
	Cochlodinium polykrikoides		0	0	5	3	6
	Unidentified dinoflagellates		1	0	2	2	2

a) R: Replicate

b) S.D: Standard deviation

Some species were rare, the standard deviation was high.

Appendix 7. The survival number of 10㎛ - 50㎛ organism in discharged treated ballast seawater by treatment of EcoGuardian™ system

Sample ID	Classification	Concentration factor[c)]	Counting volume	R1[a)]	R2	R3	individuals/mL	
							Mean	S.D[b)]
HL-S06TD3-B-1	*Cochlodinium polykrikoides*	X 20	0.5 mL	3	0	0	0.1	0.2
	Unidentified dinoflagellate			0	0	1	0.0	0.1
HL-S06TD3-B-2	-			0	0	0	0.0	0.0
HL-S06TD3-B-3	-			0	0	0	0.0	0.0
HL-S06TD3-M-1	Unidentified dinoflagellate	X 20	0.5 mL	0	1	1	0.1	0.1
HL-S06TD3-M-2	-			0	0	0	0.0	0.0
HL-S06TD3-M-3	-			0	0	0	0.0	0.0
HL-S06TD3-E-1	-	X 20	0.5 mL	0	0	0	0.0	0.0
HL-S06TD3-E-2	-			0	0	0	0.0	0.0
HL-S06TD3-E-3	-			0	0	0	0.0	0.0

a) R: Replicate
b) S.D: Standard deviation
c) Concentration factor: Treated water was concentration 10 L to 500 mL by 5 μm net.

Appendix 8. The number of heterotrophic bacteria in uptake water, discharged control water and discharged treated water by treatment of EcoGuardian™ BWMS

Date	Sample ID	Dilution factor	R1[a)]	R2	R3	CFU / mL	
						Mean	S.D[b)]
Day 0	HL-S06UW-B	x 50	0	0	0	0	0
	HL-S06UW-M		1	1	0	33	29
	HL-S06UW-E		1	3	2	100	50
Day 3	HL-S06CD3-B	x 25	12	15	11	317	52
	HL-S06CD3-M		4	4	5	108	14
	HL-S06CD3-E		7	7	4	150	43
	HL-S06TD3-B-1	-	TNTC[c)]	TNTC	TNTC	-	-
	HL-S06TD3-B-2		TNTC	TNTC	TNTC	-	-
	HL-S06TD3-B-3		TNTC	TNTC	TNTC	-	-
	HL-S06TD3-M-1		TNTC	TNTC	TNTC	-	-
	HL-S06TD3-M-2		208	182	207	199	15
	HL-S06TD3-M-3		154	149	142	148	6
	HL-S06TD3-E-1		TNTC	TNTC	TNTC	-	-
	HL-S06TD3-E-2		TNTC	TNTC	TNTC	-	-
	HL-S06TD3-E-3		TNTC	TNTC	TNTC	-	-

a) R: Replicate
b) S.D: Standard deviation
c) TNTC: Too Numerous To Count

Appendix 9. The number of *Escherichia coli* in uptake water, discharged control water and discharged treated water by treatment of EcoGuardian™ BWMS

Date	Sample ID	Testing volume	R1[a)]	R2	R3	CFU / 100 mL	
						Mean	S.D[b)]
Day 0	HL-S06UW-B	100 mL	12	17	26	18	7
	HL-S06UW-M		27	36	31	31	5
	HL-S06UW-E		62	52	43	52	10
Day 3	HL-S06CD3-B	100 mL	4	2	4	3	1
	HL-S06CD3-M		5	3	1	3	2
	HL-S06CD3-E		2	2	0	1	1
	HL-S06TD3-B-1	100 mL	0	0	0	0	0
	HL-S06TD3-B-2		0	0	0	0	0
	HL-S06TD3-B-3		0	0	0	0	0
	HL-S06TD3-M-1		0	0	0	0	0
	HL-S06TD3-M-2		0	0	0	0	0
	HL-S06TD3-M-3		0	0	0	0	0
	HL-S06TD3-E-1		0	0	0	0	0
	HL-S06TD3-E-2		0	0	0	0	0
	HL-S06TD3-E-3		0	0	0	0	0

a) R: Replicate
b) S.D: Standard deviation

Appendix 10. The number of intestinal enterococci in uptake water, discharged control water and discharged treated water by treatment of EcoGuardian™ BWMS

Date	Sample ID	Testing volume	R1[a)]	R2	R3	CFU / 100 mL	
						Mean	S.D[b)]
Day 0	HL-S06UW-B	100 mL	1	2	3	2	1
	HL-S06UW-M		6	10	4	7	3
	HL-S06UW-E		17	24	26	22	5
Day 3	HL-S06CD3-B	100 mL	0	4	2	2	2
	HL-S06CD3-M		3	4	1	3	2
	HL-S06CD3-E		2	2	0	1	1
	HL-S06TD3-B-1	100 mL	0	0	0	0	0
	HL-S06TD3-B-2		1	0	0	0	0
	HL-S06TD3-B-3		0	0	0	0	0
	HL-S06TD3-M-1		0	0	0	0	0
	HL-S06TD3-M-2		0	0	0	0	0
	HL-S06TD3-M-3		0	0	0	0	0
	HL-S06TD3-E-1		0	0	0	0	0
	HL-S06TD3-E-2		0	0	0	0	0
	HL-S06TD3-E-3		0	0	0	0	0

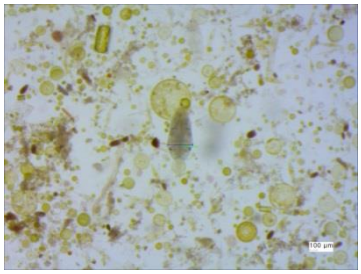
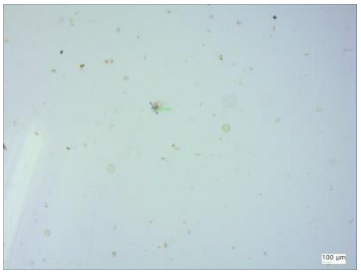
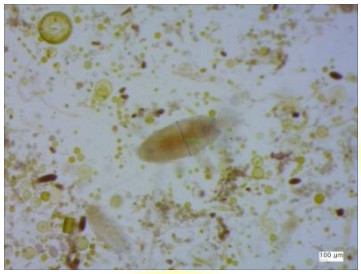
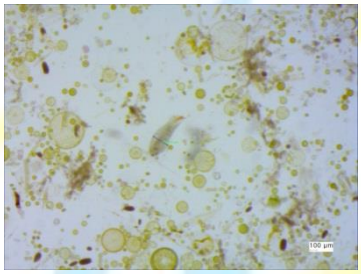
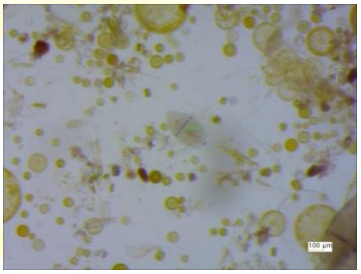
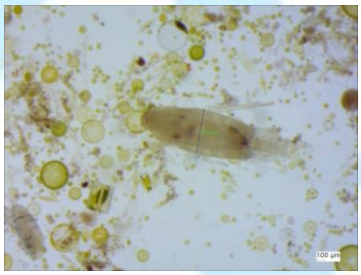
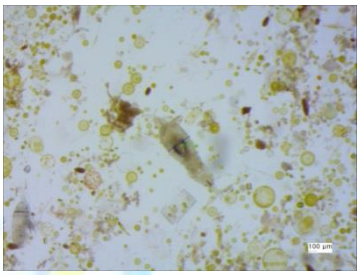
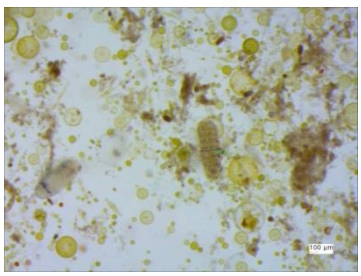
a) R: Replicate
b) S.D: Standard deviation

Appendix 11. The number of *Vibrio cholera* O1, O139 in uptake water, discharged control water and discharged treated water by treatment of EcoGuardian™ BWMS

Date	Sample ID	Testing volume	R1[a)]	R2	R3	CFU / 100 mL	
						Mean	S.D[b)]
Day 0	HL-S06UW-B	100 mL	0	0	0	0	-
	HL-S06UW-M		0	0	0	0	-
	HL-S06UW-E		0	0	0	0	-
Day 3	HL-S06CD3-B	100 mL	0	0	0	0	-
	HL-S06CD3-M		0	0	0	0	-
	HL-S06CD3-E		0	0	0	0	-
	HL-S06TD3-B-1	100 mL	0	0	0	0	-
	HL-S06TD3-B-2		0	0	0	0	-
	HL-S06TD3-B-3		0	0	0	0	-
	HL-S06TD3-M-1		0	0	0	0	-
	HL-S06TD3-M-2		0	0	0	0	-
	HL-S06TD3-M-3		0	0	0	0	-
	HL-S06TD3-E-1		0	0	0	0	-
	HL-S06TD3-E-2		0	0	0	0	-
	HL-S06TD3-E-3		0	0	0	0	-

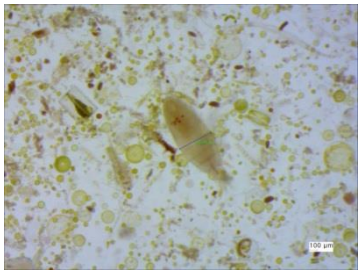
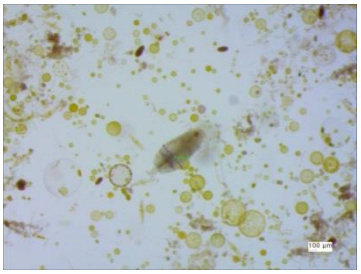
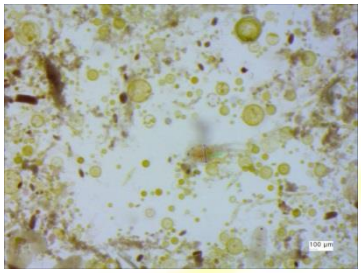
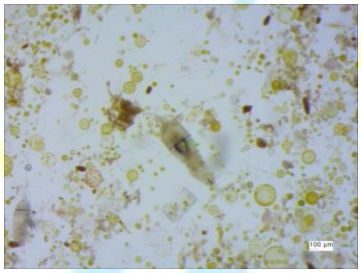
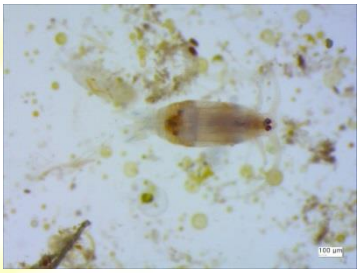
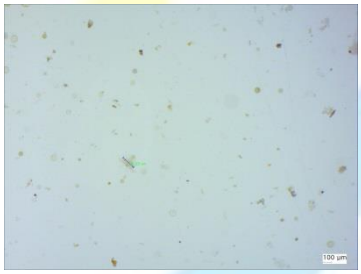
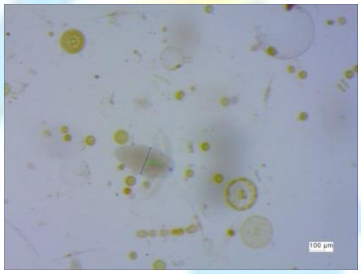
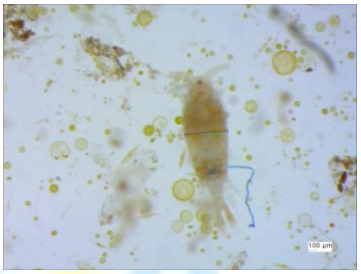
a) R: Replicate
b) S.D: Standard deviation

Appendix 12. The microscopic image of ≥ 50㎛ in uptake water (Day0)

Uptake water (Day 0)		
*Parvocalanus crassirostris**	*Acartia* sp.*	Cirriped larvae*
		
Paracalanus parvus s. l.*	*Oithona* sp.*	Nauplius**
		
Centropages sp. 1*	*Centropages* sp. 2*	*Corycaeus* sp.*
		
Labidocera sp.*	Polychaeta larvae*	
		-

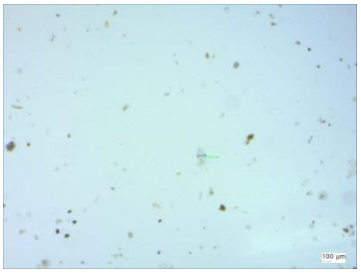
* Magnification : 20
** Magnification : 40

Appendix 13. The microscopic image of ≥ 50㎛ in discharged control water (Day3)

Discharged control water (Day 3)		
Paracalanus parvus s. l.*	*Acartia* sp.*	*Parvocalanus crassirostris**
		
Oithona sp.*	*Corycaeus affinis**	*Labidocera* sp.*
		
Cirriped larvae*	Nauplius**	*Centropages* sp.
		
Polychaeta larvae*		

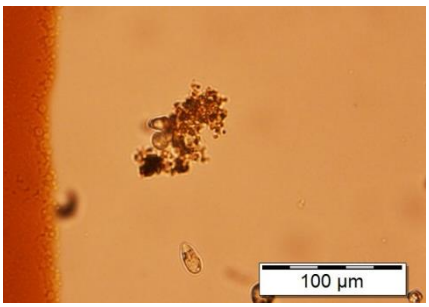
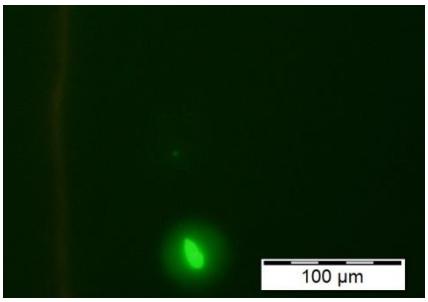
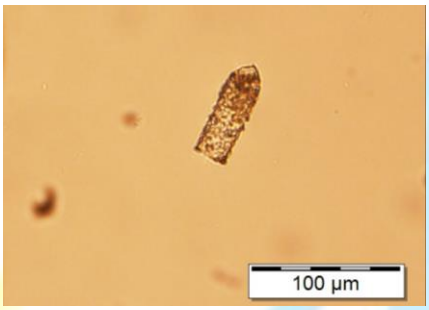
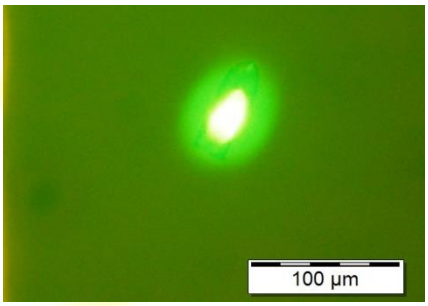
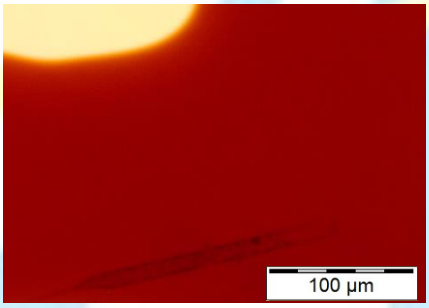
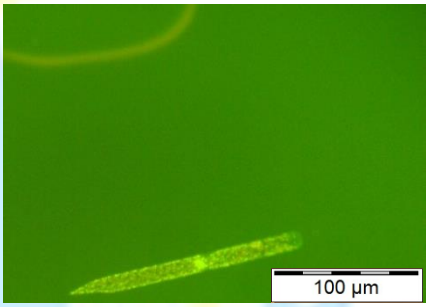
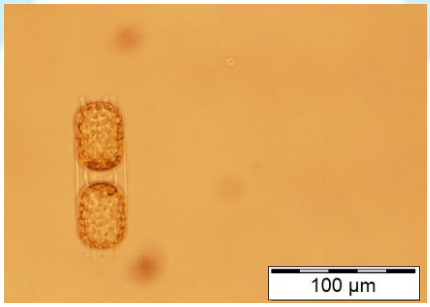
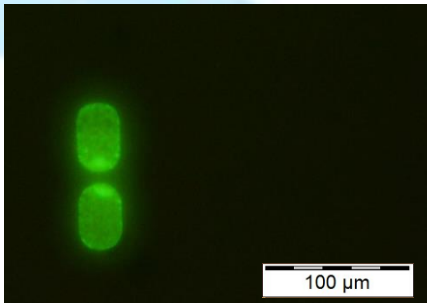
* Magnification : 20
**Magnification : 40

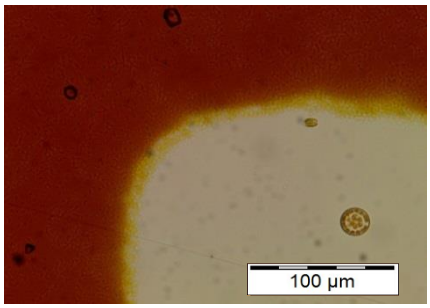
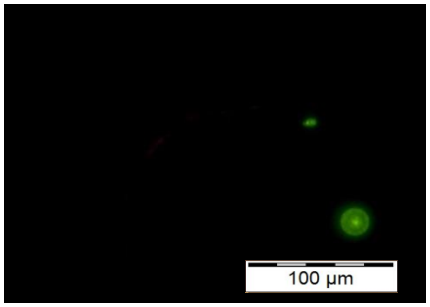
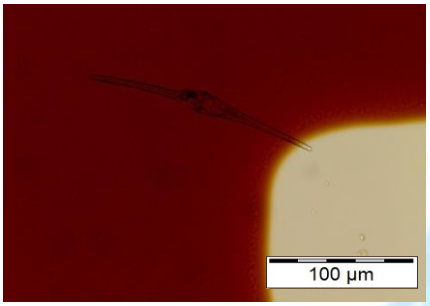
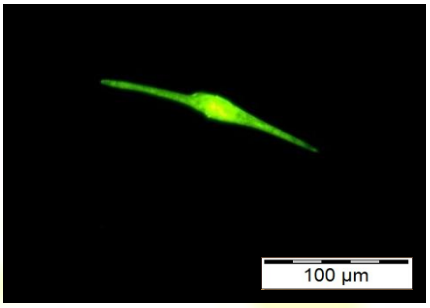
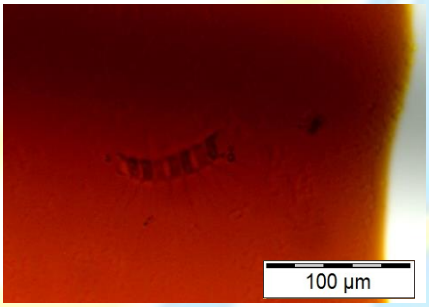
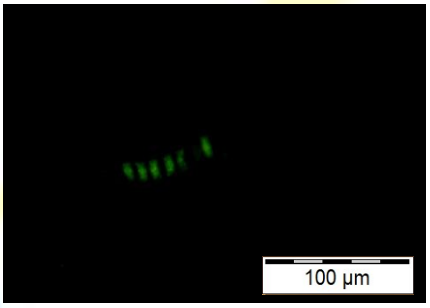
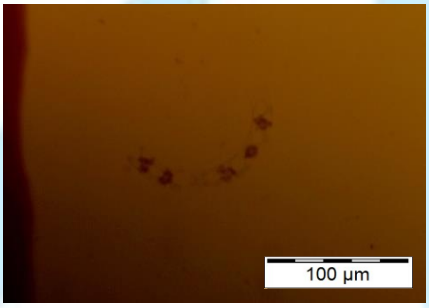
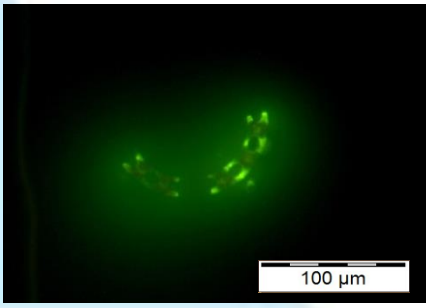
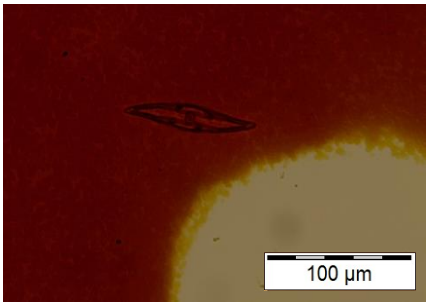
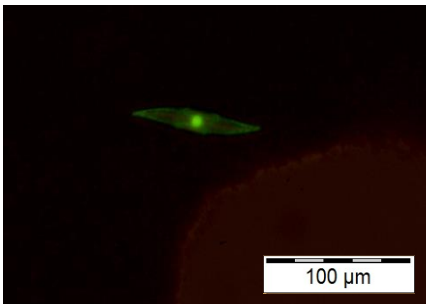
Appendix 14. The microscopic image of ≥ 50 ㎛ in discharged treated water by treatment of EcoGuardian™ BWMS (Day3)

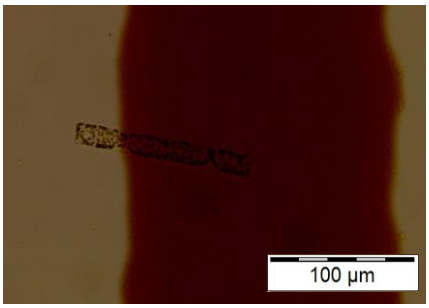
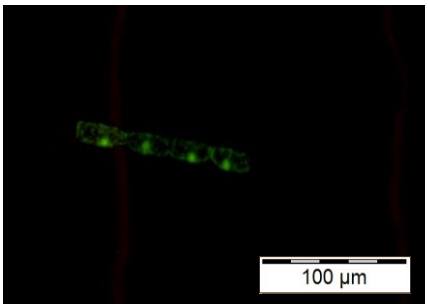
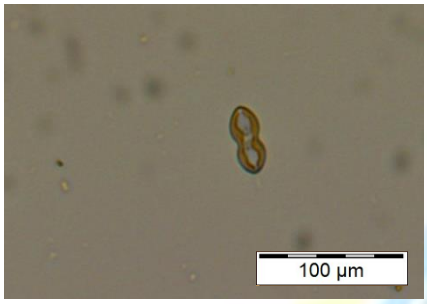
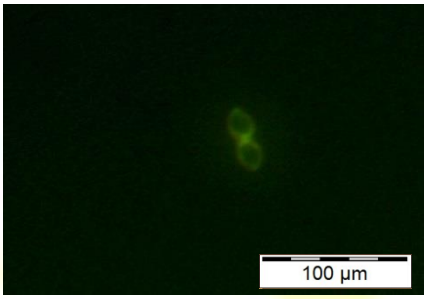
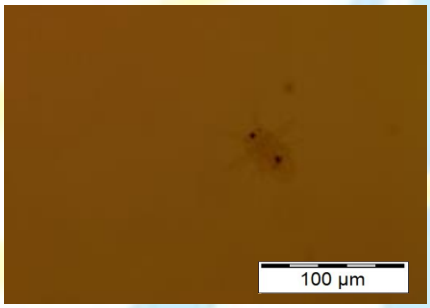
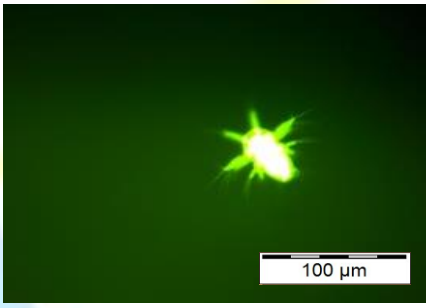
Specific Name	Discharged treated water
Nauplius *	

* Magnification : 20

Appendix 15. The microscopic image of 10㎛−50㎛ in uptake water (Day0)

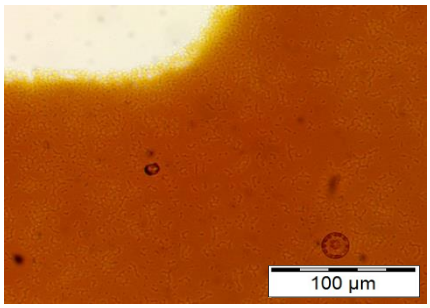
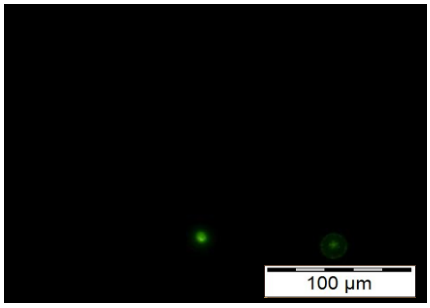
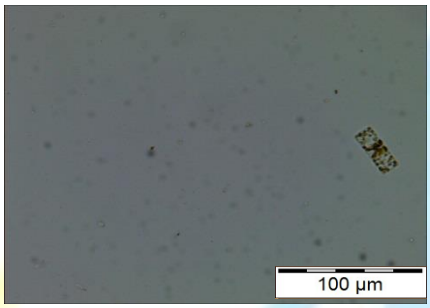
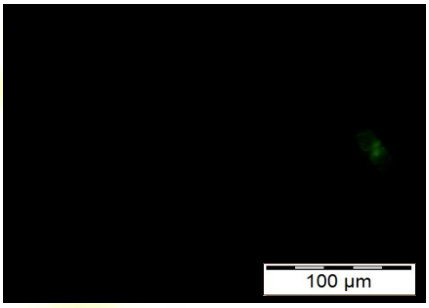
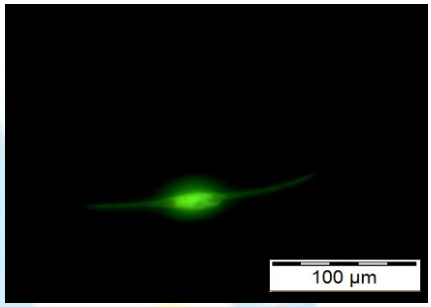
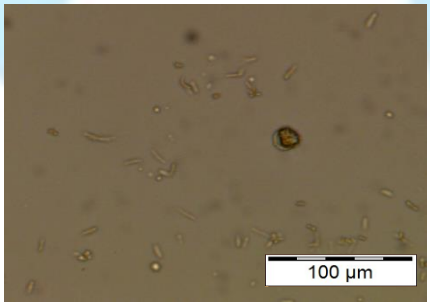
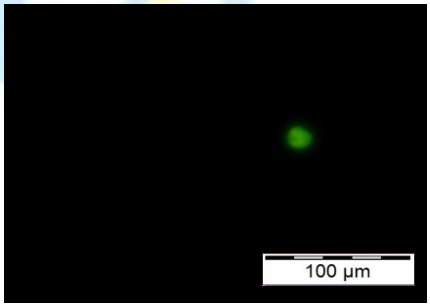
Specific Name	Uptake water	
	Optical	Fluorescence
Prorocentrum sp.		
Tintinnopsis sp.		
Rhizosolenia sp.		
Stephanopyxis sp.		

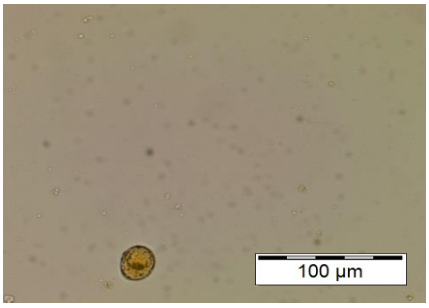
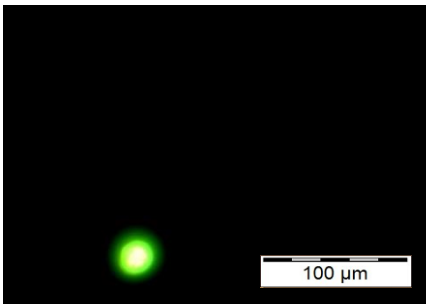
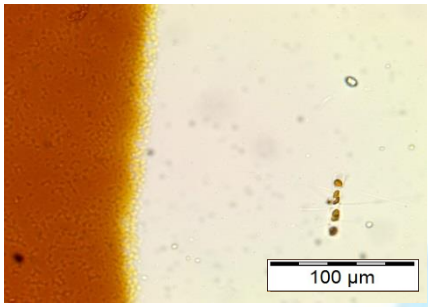
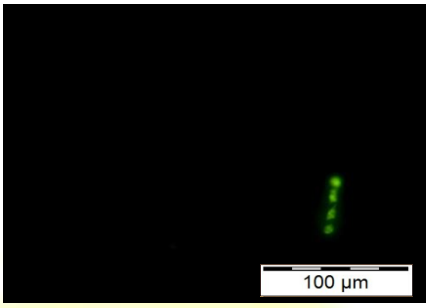
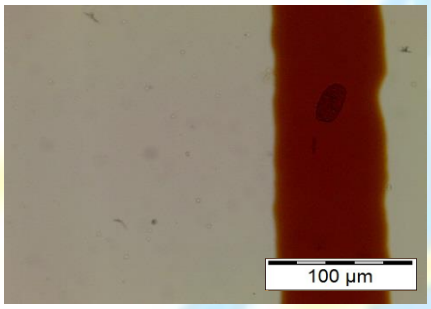
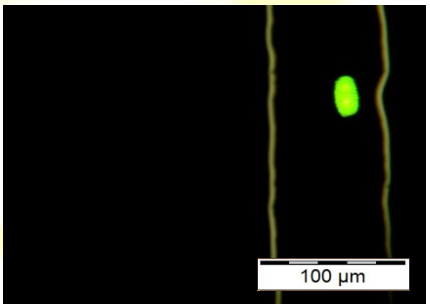
Thalassiosira sp.		
Ceratium sp.		
Chaetoceros sp.		
Eucampia sp.		
Pleurosigma sp.		

Leptocylindrus sp.		
Diploneis sp.		
Unknown		

Magnification : 200

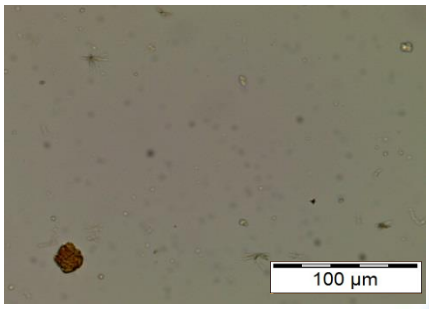
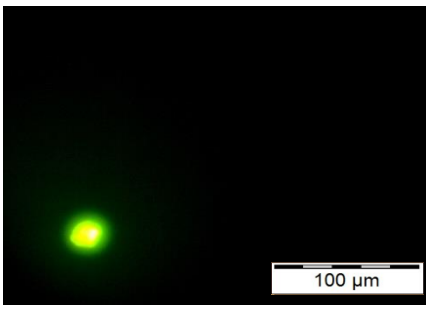
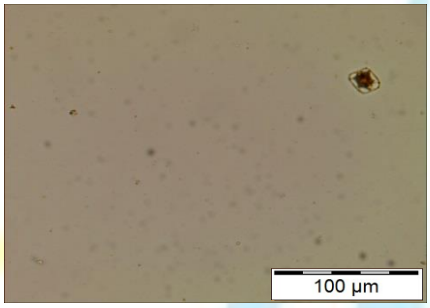
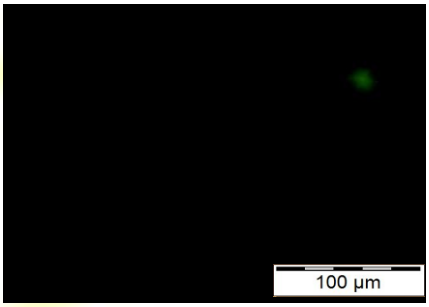
Appendix 16. The microscopic image of 10㎛−50㎛ in discharged control water (Day3)

Specific Name	Discharged control water	
	Optical	Fluorescence
Thalassiosira sp. .		
Melosira sp.		
Ceratium sp.		
Diatom		

Unidentified dinoflagellate		
Chaetoceros sp.		
. *Cochlodinium polykrikoides*		

Magnification : 200

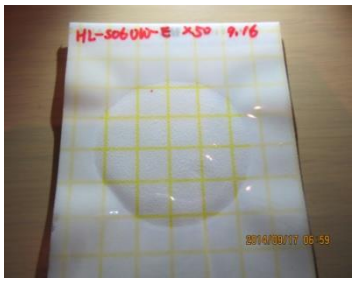
Appendix 17. The microscopic image of 10㎛−50㎛ in discharged treated water by treatment of EcoGuardian™ BWMS (Day3)

Specific Name	Discharged treated seawater	
	Optical	Fluorescence
Cochlodinium polykrikoides		
Unidentified dinoflagellate .		

Magnification : 200

Appendix 18. The image of heterotrophic bacteria

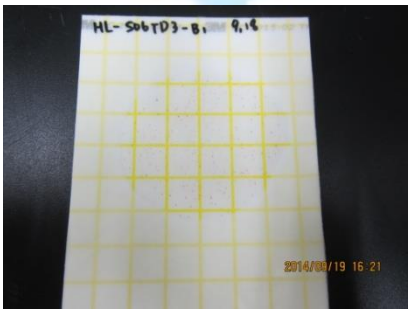
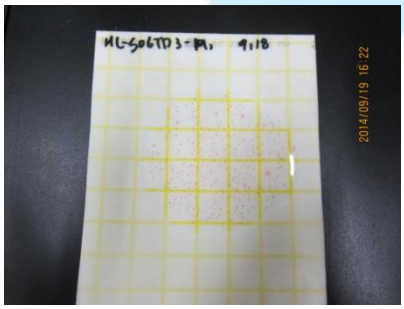
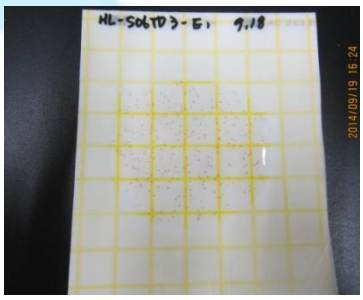
Uptake water (Day 0)

Beginning	Middle	End
		

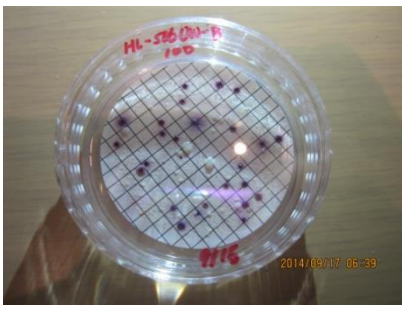
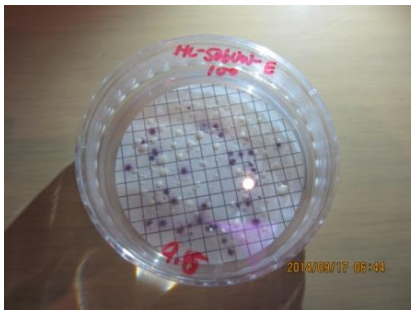
Discharged control water (Day 3)

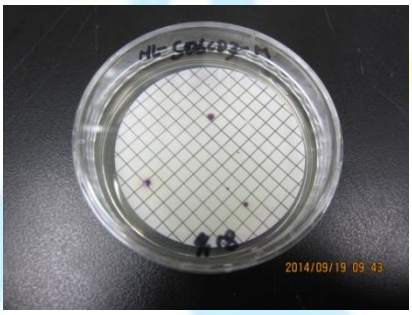
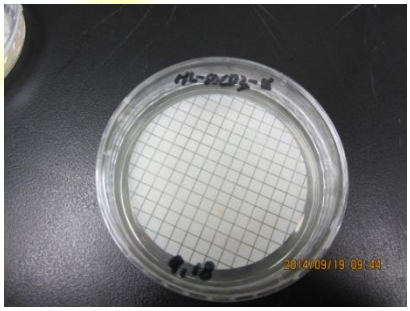
Beginning	Middle	End

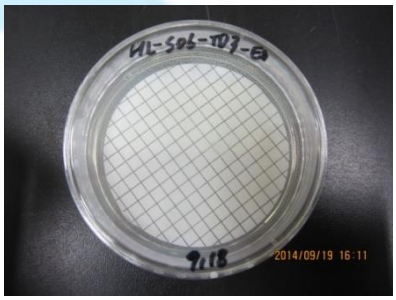
Discharged treated water (Day 3)

Beginning	Middle	End
		

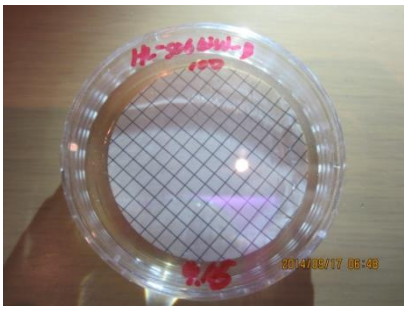
Appendix 19. The image of *Escherichia coli*

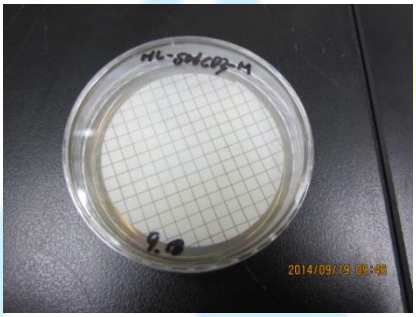
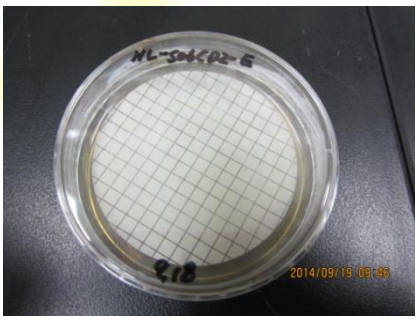
Uptake water (Day 0)		
Beginning	**Middle**	**End**
		

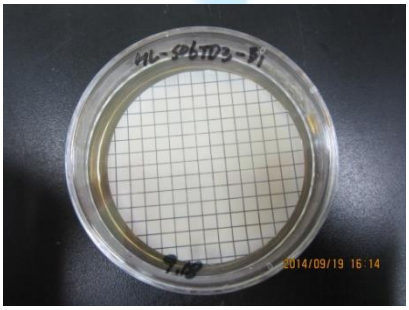
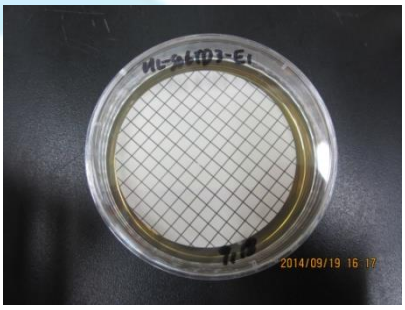
Discharged control water (Day 3)		
Beginning	**Middle**	**End**
		

Discharged treated water (Day 3)		
Beginning	**Middle**	**End**
		

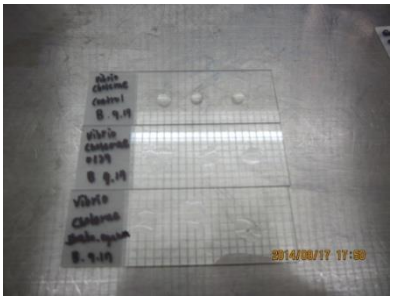
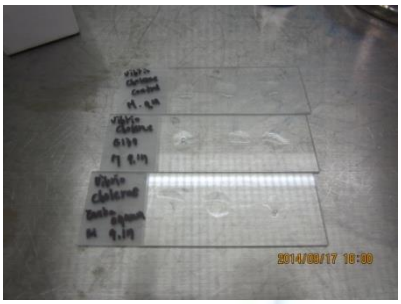
Appendix 20. The image of intestinal enterococci

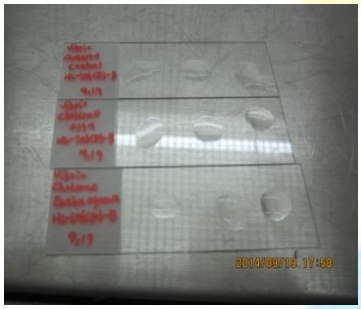
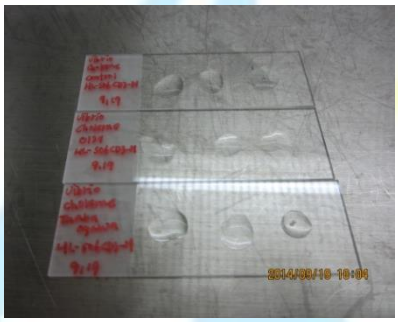
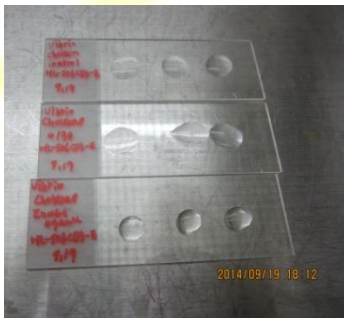
Uptake water (Day 0)		
Beginning	**Middle**	**End**
		

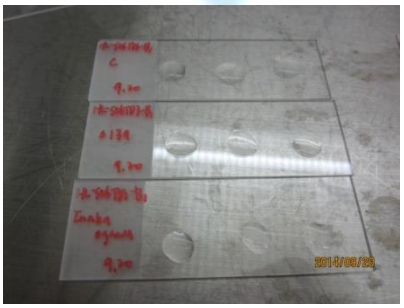
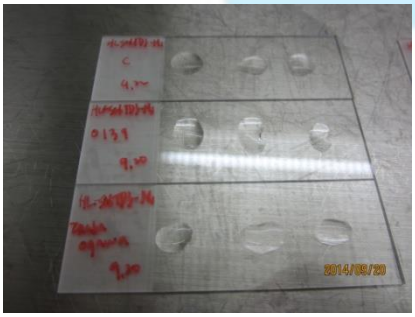
Discharged control water (Day 3)		
Beginning	**Middle**	**End**
		

Discharged treated water (Day 3)		
Beginning	**Middle**	**End**
		

Appendix 21. The image of *Vibrio cholera* O1, O139

Uptake water (Day 0)		
Beginning	**Middle**	**End**
		

Discharged control water (Day 3)		
Beginning	**Middle**	**End**
		

Discharged treated water (Day 3)		
Beginning	**Middle**	**End**
		

5. Attachment

5.1 Sampling check & custody Sheet

5.2 Freezing keeping sheet

5.3 Water parameter measurement sheet (I)

5.4 TOC measurement sheet

5.5 TSS(Total suspended solid) measurement sheet

5.6 Microbiology Test Sheet

5.7 Test Result sheet with Microbiology

5.8 Vibrio cholera O1, O139

5.9 Test Result Sheet – Classification (II)

Sampling check & custody Sheet

2014

Study number		Test number	SET-14-006
Sampling time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Day ( )		

Sample location	☑ Uptake water □ Discharge control water □ Discharge treated water □ Other( )						
Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
TSS		HDPE	2	□ 1	07:00	08:05	09:14
DOC, POC		HDPE	2				
Bacteria (4 item)[b]		HDPE	2	□ 2			
Organism (10~50 μm)		HDPE	1	□ 3			
Organism (≥50 μm)	1000L→0.25L	HDPE	0.125				

Sample location	□ Treated water □ Treated water (Neutralized)						
Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
Bacteria (4 item)[c]		HDPE		□ 1			
Organism (10~50 μm)		HDPE		□ 2			
Organism (≥50 μm)		HDPE		□ 3			

Concentration				
Parameter	Vol. of concentrated before		Equipment	Mesh size
Organism (≥50 μm)	1,000	(L)	net	32 μm
Organism (10-50 μm)	—	(L)	net	5 μm

Sample storage information		
Parameter	Location & condition	Storage time
TSS	Freezer(-20℃)	Sep. 16th 09:30 ~ Sep. 18th 19:00
DOC, POC		
Bacteria (4 item)	Refrigerator(4℃)	

Remarks

* First, fill a 1~20L HDPE(high density poly ethylene) bottle with water sample, and split the water sample up into groups (bacteria, organism (10~50 μm), and so forth) Then measured water parameters(5 item) - pH, Temperature, Salinity, DO, Turbidity
* Separately, organism(≥50 μm, 10 ~ 50 μm) sample was concentrated with net.
* Storage time of "bacteria sample" is for "heterotrophic bacteria test"
* TSS and DOC and POC samples are acidified(pH<2) with HCl (in 6 mL HCl of 2 L sample)

Working(pump) start time for Test water(or control water) sample :
Working(pump and EcoGuadian™) start time for treated(or neutralized) sample :

Working date	09.16	Personnel	Sun ok Lee (sign)
Confirmation date	09.16.	Confirmed by	Sun ok Lee (sign)

a) Concentration b) Period
c) Bacteria (4 item) - Heterotrophic bacteria, Coliform, Vibrio cholera, Enterococcus group

Sampling check & custody Sheet

2014

Study number		Test number	SET-14-006
Sampling time	□ Day 0 □ Day 1 □ Day 2 ☑ Day 3 □ Day 4 □ Day 5 □ Day ( )		

Sample location	□ Uptake water ☑ Discharge control water □ Discharge treated water □ Other( )

Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
TSS		HDPE		□ 1	09:16	10:28	11:33
DOC, POC		HDPE					
Bacteria (4 item)[b]	/	HDPE	2	□ 2			
Organism (10~50 μm)	/	HDPE	/	□ 3			
Organism (≥50 μm)	1000L→0.25L	HDPE	0.25				

Sample location	☑ Treated water □ Treated water (Neutralized)

Parameter	Sample			Sampling time			
	Con.[a]	Bottle	Vol. (L)	P.[b]	Beginning	Middle	End
Bacteria (4 item)[c]	/	HDPE	2	□ 1	13:22	13:46	14:12
Organism (10~50 μm)	10L→0.5L	HDPE	0.5	□ 2			
Organism (≥50 μm)	1000L→0.25L	HDPE	0.25	□ 3			

Concentration				
Parameter	Vol. of concentrated before		Equipment	Mesh size
Organism (≥50 μm)	1000	(L)	net	32 μm
Organism (10-50 μm)	10	(L)	net	5 μm

Sample storage information		
Parameter	Location & condition	Storage time
TSS	Freezer(-20℃)	
DOC, POC		
Bacteria (4 item)	Refrigerator(4℃)	

Remarks

* First, fill a 1~20L HDPE(high density poly ethylene) bottle with water sample, and split the water sample up into groups (bacteria, organism (10~50 μm), and so forth) Then measured water parameters(5 item) - pH, Temperature, Salinity, DO, Turbidity
* Separately, organism(≥50 μm, 10 ~ 50 μm) sample was concentrated with net.
* Storage time of "bacteria sample" is for "heterotrophic bacteria test"
* TSS and DOC and POC samples are acidified(pH<2) with HCl (in 6 mL HCl of 2 L sample)

Working(pump) start time for Test water(or control water) sample :
Working(pump and EcoGuadian™) start time for treated(or neutralized) sample :

Working date	Sep. 18th	Personnel	Sunok Lee (sign)
Confirmation date	Sep. 18th.	Confirmed by	Sunok Lee (sign)

a) Concentration b) Period
c) Bacteria (4 item) - Heterotrophic bacteria, Coliform, Vibrio cholera, Enterococcus group

Freezing keeping sheet

(Of sample for measurement of water parameter)

2014

Sample	Test water	Sampling time	Day 0
Storage place	Freezing room	Storage Condition	-20 ℃
Study number		Test number	SET-14-006

No.	Sample ID	Labeling	Storage Date & time	Personnel
1	HL-S06UW-B	A / B /( )	9.16 / 10:00	Lee Seok Ju (sign)
2	HL-S06UW-M	A / B /( )	9.16 / 10:00	
3	HL-S06UW-E	A / B /( )	9.16 / 10:00	
4		A / B /( )	/	
5		A / B /( )	/	
6		A / B /( )	/	
7		A / B /( )	/	(sign)
8		A / B /( )	/	
9		A / B /( )	/	
10		A / B /( )	/	
11		A / B /( )	/	
12		A / B /( )	/	
13		A / B /( )	/	(sign)
14		A / B /( )	/	
15		A / B /( )	/	
16		A / B /( )	/	
17		A / B /( )	/	
18		A / B /( )	/	

Remarks

*

Confirming date	Sep. 16	Confirmed by	Lee Seok Ju (sign)

2014

Water parameter measurement sheet (I)

Study Number		Test number	SET-14-006
Sampling time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □Day ( )		
Equipment	□ pH, Temp., Salinity, DO / YSI 6920 □ Turbidity / YSI 6920		

Sample	Replicate	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
☑ Uptake water □ Discharge control water □ Discharge treated water □ Discharge treated water (Neutralized water) □B(V)□M( )□E( )	R1	7.69	24.42	29.82	6.30	8.0	
	R2	8.00	24.42	30.00	6.28	7.8	
	R3	8.03	24.41	30.36	5.99	7.6	
	Measuring time	07:00		07:03			
☑ Uptake water □ Discharge control water □ Discharge treated water □ Discharge treated water (Neutralized water) □B( )□M(V)□E( )	R1	8.06	24.44	29.99	6.14	7.1	
	R2	8.10	24.43	30.21	6.07	7.5	
	R3	8.13	24.42	30.26	5.98	7.4	
	Measuring time	08:05		08:08			
☑ Uptake water □ Discharge control water □ Discharge treated water □ Discharge treated water (Neutralized water) □B( )□M( )□E(V)	R1	8.09	24.45	29.93	6.19	6.5	
	R2	8.10	24.42	30.08	5.91	6.6	
	R3	8.18	24.42	30.15	5.97	6.6	
	Measuring time	09:14		09:17			
□ Uptake water □ Discharge control water □ Discharge treated water □ Discharge treated water (Neutralized water) □B( )□M( )□E( )	R1						
	R2						
	R3						
	Measuring time						
□ Uptake water □ Discharge control water □ Discharge treated water □ Discharge treated water (Neutralized water) □B( )□M( )□E( )	R1						
	R2						
	R3						
	Measuring time						
□ Uptake water □ Discharge control water □ Discharge treated water □ Discharge treated water (Neutralized water) □B( )□M( )□E( )	R1						
	R2						
	R3						
	Measuring time						

Remarks			
Working Date	2014.9.16	Study Personnel	Park Na Kyung (sign)
Certificate Date	2014.9.16	Study Director	Park Na Kyung (sign)

Water parameter measurement sheet (I)

20 14

Study Number		Test number	SET-14-006
Sampling time	□ Day 0 □ Day 1 ☑ Day 2 ☑ Day 3 □ Day 4 □ Day 5 □ Day ( )		
Equipment	□ pH, Temp., Salinity, DO / □ Turbidity /		

Sample	Replicate	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
□ Uptake water ☑ Discharge control water □ Discharge treated water □ Discharge treated water (Neutralized water) ☑ B( ) □ M( ) □ E( )	R1	7.46	24.53	30.30	5.26	6.1	
	R2	7.96	24.45	30.34	5.31	6.1	
	R3	8.01	24.40	30.35	5.45	6.5	
	Measuring time	09:16 / 09:17					
□ Uptake water ☑ Discharge control water □ Discharge treated water □ Discharge treated water (Neutralized water) □ B( ) ☑ M( ) □ E( )	R1	7.79	24.50	30.20	5.96	6.9	
	R2	7.96	24.43	30.27	5.67	6.8	
	R3	8.10	24.40	30.29	5.66	6.2	
	Measuring time	10:29 / 10:31					
□ Uptake water ☑ Discharge control water □ Discharge treated water □ Discharge treated water (Neutralized water) □ B( ) □ M( ) ☑ E( )	R1	7.91	24.51	30.21	5.80	6.6	
	R2	8.05	24.46	30.28	5.59	6.5	
	R3	8.13	24.44	30.27	5.60	6.2	
	Measuring time	11:33 / 11:34					
□ Uptake water □ Discharge control water □ Discharge treated water ☑ Discharge treated water (Neutralized water) ☑ B( ) □ M( ) □ E( )	R1	7.94	24.76	30.47	5.37	7.6	0.09
	R2	8.07	24.62	30.63	5.99	8.2	0.10
	R3	8.18	24.62	30.63	5.97	8.3	0.13
	Measuring time	13:22 / 13:24					
□ Uptake water □ Discharge control water □ Discharge treated water ☑ Discharge treated water (Neutralized water) ☑ B( ) □ M( ) □ E( )	R1	8.07	24.62	30.47	5.95	6.6	
	R2	8.20	24.57	30.62	6.09	6.9	
	R3	8.24	24.56	30.62	6.06	6.8	
	Measuring time	13:29 / 13:30					
□ Uptake water □ Discharge control water □ Discharge treated water ☑ Discharge treated water (Neutralized water) ☑ B( ) □ M( ) □ E( )	R1	7.98	24.62	30.52	5.84	6.5	
	R2	8.22	24.58	30.62	5.94	6.9	
	R3	8.29	24.57	30.64	5.99	6.9	
	Measuring time	13:37 / 13:39					

Remarks			
Working Date	sep. 18th	Study Personnel	Youngjin Song (sign)
Certificate Date	Sep. 18th	Study Director	Sun ok Lee (sign)

Water parameter measurement sheet (I)

20 1-t

Study Number		Test number	SET-14-006
Sampling time	□ Day 0 □ Day 1 ☒ Day 2 ☒ Day 3 □ Day 4 □ Day 5 □ Day ( )		
Equipment	□ pH, Temp., Salinity, DO / □ Turbidity /		

Sample	Replicate	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)	TRO (mg/L)
□ Uptake water □ Discharge control water □ Discharge treated water ☒ Discharge treated water (Neutralized water) □ B( ) ☒ M(1) □ E( )	R1	7.94	24.64	30.48	5.94	6.7	0.08
	R2	8.21	24.58	30.61	5.99	6.9	0.09
	R3	8.28	24.59	30.64	6.25	7.0	0.09
	Measuring time	13:46 / 13:48					
□ Uptake water □ Discharge control water □ Discharge treated water ☒ Discharge treated water (Neutralized water) □ B( ) ☒ M(2) □ E( )	R1	8.30	24.57	30.63	5.72	7.0	
	R2	8.28	24.57	30.65	5.72	6.9	
	R3	8.20	24.72	30.09	5.61	6.5	
	Measuring time	13:54 / 13:57					
□ Uptake water □ Discharge control water □ Discharge treated water ☒ Discharge treated water (Neutralized water) □ B( ) ☒ M(3) □ E( )	R1	8.25	24.64	30.53	5.78	7.0	
	R2	8.12	24.60	30.62	5.89	7.0	
	R3	8.22	24.58	30.63	5.93	7.1	
	Measuring time	14:03 / 14:05					
□ Uptake water □ Discharge control water □ Discharge treated water ☒ Discharge treated water (Neutralized water) □ B( ) □ M( ) ☒ E(1)	R1	7.99	24.62	30.61	5.84	7.2	0.05
	R2	8.06	24.59	30.63	5.86	7.5	0.08
	R3	8.14	24.57	30.63	5.93	7.4	0.09
	Measuring time	14:12 / 14:14					
□ Uptake water □ Discharge control water □ Discharge treated water ☒ Discharge treated water (Neutralized water) □ B( ) □ M( ) ☒ E(2)	R1	7.92	24.65	30.47	5.81	7.7	
	R2	8.03	24.59	30.62	5.96	9.3	
	R3	8.13	24.58	30.63	5.98	12.1	
	Measuring time	14:21 / 14:23					
□ Uptake water □ Discharge control water □ Discharge treated water ☒ Discharge treated water (Neutralized water) □ B( ) □ M( ) ☒ E(3)	R1	7.99	24.67	30.58	6.04	8.1	
	R2	8.15	24.62	30.62	6.27	10.7	
	R3	8.16	24.60	30.62	6.26	8.9	
	Measuring time	14:32 / 14:34					

Remarks			
Working Date	Sep. 18th	Study Personnel	Young-In Song (sign)
Certificate Date	Sep. 18th	Study Director	Sunok Lee (sign)

TOC measurement sheet

2014

Study number		Test number	SET-14-006
Method	High Temperature combustion	Equipment	Vario TOC cube
Sampling day	Day 0	Reception time of test substances	
Measuring start time	Sep. 19th 10:00	Measuring end time	Sep. 19th 21:00

Parameter / Sample ID & lot No.	TOC (mg/L)	DOC (mg/L)	POC (mg/L)	Remarks
HL-S06UW-B	2.685 2.994 2.785 Aver. : 2.840	1.732 1.706 1.771 Aver. : 1.737	1.103	
HL-S06UW-M	2.542 2.752 2.775 Aver. : 2.690	1.671 1.529 1.845 Aver. : 1.682	1.008	
HL-S06UW-E	2.911 2.998 2.945 Aver. : 2.911	1.793 1.765 1.835 Aver. : 1.791	1.120	
	Aver. :	Aver. :		
	Aver. :	Aver. :		
	Aver. :	Aver. :		
Remarks	* POC = TOC - DOC			

Working date	Sep. 19th	Study personnel	Lee JT-Sun (sign)
Confirmation date		Confirmed by	(sign)
Certificate date	Sep. 19th	Study director	Lee JT-Sun (sign)

TSS(Total suspended solid) measurement sheet

20 14

Study number		Test number	SET- 14- 006
Test period	Sep. 18 ~ Sep. 19	Equipments	Dry oven, Balance, Desiccator
Reception time of test substances	Sep. 18 19: 20	Sample pretreatment time	20:00

Sample ID (Lot No.)	R[1]	Sample Volume (mL)	Filter paper Weight - ① (g)	① + SS Weight (g)	SS Weight (g)	Result (mg/L)	Average (mg/L)
HL-S06UW-B	R1	250	24.3122	24.3317	0.0195	78.0	76.8
	R2	250	25.9504	25.9694	0.0190	76.0	
	R3	250	25.0223	25.0414	0.0191	76.4	
HL-S06UW-M	R1	250	24.4016	24.4215	0.0199	79.6	78.4
	R2	250	26.3113	26.3309	0.0196	78.4	
	R3	250	26.4897	26.5090	0.0193	77.2	
HL-S06UW-E	R1	250	27.0510	27.0702	0.0192	76.8	75.5
	R2	250	25.0538	25.0723	0.0185	74.0	
	R3	250	26.3338	26.3527	0.0189	75.6	
	R1						
	R2						
	R3						
	R1						
	R2						
	R3						
	R1						
	R2						
	R3						

Remarks

Working Date	20th, sep	Study Personnel	Young-Im, Song (sign)
Certificate Date	20th, Sep	Study Director	Lee Ji-Sun (sign)

[1] Replicate

Microbiology Test Sheet

2014

Study number	–	Test number	SET-14-006
Sampling Time	☑ Day 0 ☐ Day 1 ☐ Day 2 ☐ Day 3 ☐ Day 4 ☐ Day 5 ☐ Other( )		
Test substance	☑ Uptake water ☐ Discharge control water ☐ Discharge treated water ☐ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team. 28 ℃, Humidity : 40 % P.H. /End : Team. 28 ℃, Humidity : 41 % P.H.		

Test condition

Medium name	☐ Marine agar ☑ Aerobic Counter Plate ☐ mTEC ☐ mEI ☐ TCBS	☐ Marine agar ☐ Aerobic Counter Plate ☑ mTEC ☐ mEI ☐ TCBS	☐ Marine agar ☐ Aerobic Counter Plate ☐ mTEC ☑ mEI ☐ TCBS	☐ Marine agar ☐ Aerobic Counter Plate ☐ mTEC ☐ mEI ☑ TCBS
Manufacturing date		9.5	9.5	9.5
Test method	☐ Membrane filter ☐ Spread method ☑ 3M™ Petri film	☑ Membrane filter ☐ Spread method ☐ 3M™ Petri film	☑ Membrane filter ☐ Spread method ☐ 3M™ Petri film	☑ Membrane filter ☐ Spread method ☐ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	☐ 25 ℃ ☑ 35.0 ℃ ( ) ☐ 41 ℃ ☐ 44.5 ℃ ( )	☐ 25 ℃ ☑ 35.0 ℃ (1) ☐ 41 ℃ ☑ 44.5 ℃ (2)	☐ 25 ℃ ☐ 35.0 ℃ ( ) ☑ 41 ℃ ☐ 44.5 ℃ ( )	☐ 25 ℃ ☑ 35.0 ℃ ( ) ☐ 41 ℃ ☐ 44.5 ℃ ( )
Culture period	☐ 2 hr ( ) ☐ 22 hr ( ) ☑ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )	☑ 2 hr (1) ☑ 22 hr (2) ☐ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )	☐ 2 hr ( ) ☐ 22 hr ( ) ☑ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )	☐ 2 hr ( ) ☐ 22 hr ( ) ☑ 24 hr ☐ ( ) hr ( ) ☐ ( ) hr ( )
Time (Start/End)	8:46 8:52 8:54 / 8:52 8:58 9:00	8:34 8:27 9:35 / 8:02 8:42 9:51	8:39 8:27 9:35 / 8:02 8:42 9:54	8:39 8:27 9:35 / 8:02 8:42 9:54
Volume (mL)	1 1 1	25 25 25 100 100 100	25 25 25 100 100 100	100 100 100
Dilution factor	x50 x50 x50 x100 x100 x100			
Test substance	B M E	B M E	B M E	B M E

Remarks: The test of bacteria can have sample holding time.

(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	2014. 9. 16	Personnel	Min-Ji Kim (sign)
Confirming date	2014. 09. 16	Confirmed by	Lee Seok Jin (sign)

Microbiology Test Sheet

2014

Study number	–	Test number	SET-14-006
Sampling Time	□ Day 0 □ Day 1 ☑ Day 2 ☑ Day 3 □ Day 4 □ Day 5 □ Other( )		
Test substance	□ Uptake water ☑ Discharge control water □ Discharge treated water □ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team. 23.4℃, Humidity : 52 % P.H. /End : Team. 26.1℃, Humidity : 53 % P.H.		

Test condition

Medium name	□ Marine agar ☑ Aerobic Counter Plate □ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate ☑ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC ☑ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC □ mEI ☑ TCBS
Manufacturing date	a) ~~9.5~~	9. 5	9. 5	9. 5
Test method	□ Membrane filter □ Spread method ☑ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ (1) □ 41 ℃ ☑ 44.5 ℃ (2)	□ 25 ℃ □ 35.0 ℃ ( ) ☑ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )
Culture period	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	☑ 2 hr (1) ☑ 22 hr (2) □ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )
Time (Start/End)	9:33 / 10:41 / 11:49 9:41 / 10:49 / 11:57	9:22 / 10:32 / 11:36 9:29 / 10:41 / 11:49	9:22 / 10:32 / 11:36 9:29 / 10:41 / 11:49	9:22 / 10:32 / 11:36 9:29 / 10:41 / 11:49
Volume (mL)	1 / 1 / 1	100 / 100 / 100	100 / 100 / 100	100 / 100 / 100
Dilution factor	x25 x50 / x25 x50 / x25 x50			
Test substance	B / M / E	B / M / E	B / M / E	B / M / E

Remarks: The test of bacteria can have sample holding time.

a) 시험일 9.18 기입 KSJ

(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	2014. 9. 18	Personnel	Min-Ji Kim (sign)
Confirming date	9. 18	Confirmed by	Sun ok Lee (sign)

Microbiology Test Sheet

20 14

Study number	—	Test number	SET-14-006
Sampling Time	□ Day 0 □ Day 1 □ Day 2 ☑ Day 3 □ Day 4 □ Day 5 □ Other( )		
Test substance	□ Uptake water □ Discharge control water ☑ Discharge treated water □ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team. 25.3 ℃, Humidity : 53 % P.H. /End : Team. 26.4 ℃, Humidity : 51 % P.H.		

Test condition

Medium name	□ Marine agar ☑ Aerobic Counter Plate □ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate ☑ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC ☑ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC □ mEI ☑ TCBS
Manufacturing date		9.5	9.5	9.5
Test method	□ Membrane filter □ Spread method ☑ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ (/) □ 41 ℃ ☑ 44.5 ℃ (2)	□ 25 ℃ □ 35.0 ℃ ( ) ☑ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )
Culture period	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	☑ 2 hr (/) ☑ 22 hr (2) □ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( ) a)	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( ) a)
Time (Start/End)	2:53 2:55 2:58 / 2:55 2:58 3:00	2:22 2:33 2:43 / ~~2:33~~ 2:33 2:43 2:52 a)	2:22 2:33 2:43 / ~~2:33~~ 2:33 2:43 2:52 a)	2:22 2:33 2:43 / ~~2:33~~ 2:33 2:43 2:52 a)
Volume (mL)	1 / 1 / 1	100 / 100 / 100	100 / 100 / 100 / ~~100~~ a)	100 / 100 / 100
Dilution factor	– / – / –			
Test substance	B_1 / B_2 / B_3	B_1 / B_2 / B_3	B_1 / B_2 / B_3	B_1 / B_2 / B_3

Remarks: The test of bacteria can have sample holding time. a), b) deleted by Min-Ji Kim
(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	2014. 9. 18	Personnel	Min-Ji Kim (sign)
Confirming date	2014. 9. 18	Confirmed by	Sun ok Lee (sign)

Microbiology Test Sheet

2014

Study number	—	Test number	SET-14-006
Sampling Time	□ Day 0 □ Day 1 □ Day 2 ☑ Day 3 □ Day 4 □ Day 5 □ Other( )		
Test substance	□ Uptake water □ Discharge control water ☑ Discharge treated water □ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team. 26.4℃, Humidity : 51 % P.H. /End : Team. 27 ℃, Humidity : 47 % P.H.		

Test condition

Medium name	□ Marine agar ☑ Aerobic Counter Plate □ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate ☑ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC ☑ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC □ mEI ☑ TCBS
Manufacturing date		9.5	9.5	9.5
Test method	□ Membrane filter □ Spread method ☑ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ ☑ 44.5 ℃ (2)	□ 25 ℃ □ 35.0 ℃ ( ) ☑ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )
Culture period	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	☑ 2 hr (1) ☑ 22 hr (2) □ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )
Time (Start/End)	3:35 3:38 3:41 / 3:38 3:41 3:44	3:04 3:15 3:24 / 3:15 3:24 3:35	3:04 3:15 3:24 / 3:15 3:24 3:35	3:04 3:15 3:24 / 3:15 3:24 3:35
Volume (mL)	1 / 1 / 1	100 / 100 / 100	100 / 100 / 100	100 / 100 / 100
Dilution factor	– / – / –			
Test substance	M_1 / M_2 / M_3	M_1 / M_2 / M_3	M_1 / M_2 / M_3	M_1 / M_2 / M_3

Remarks: The test of bacteria can have sample holding time.

(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	2014.09.18	Personnel	Min-Ji Kim (sign)
Confirming date	2014.09.18	Confirmed by	Sun ok Lee (sign)

Microbiology Test Sheet

2014

Study number	—	Test number	SET-14-006
Sampling Time	□ Day 0 □ Day 1 □ Day 2 ☑ Day 3 □ Day 4 □ Day 5 □ Other( )		
Test substance	□ Uptake water □ Discharge control water ☑ Discharge treated water □ Other( )		
Dilution water/Lot No.	Autoclaved Distilled water/ADW-131122		
Test facility condition	Start : Team.21.1 ℃, Humidity : 41 % P.H. /End : Team.21.4℃, Humidity : 45 % P.H.		

Test condition				
Medium name	□ Marine agar ☑ Aerobic Counter Plate □ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate ☑ mTEC □ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC ☑ mEI □ TCBS	□ Marine agar □ Aerobic Counter Plate □ mTEC □ mEI ☑ TCBS
Manufacturing date		9.5	9.5	9.5
Test method	□ Membrane filter □ Spread method ☑ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film	☑ Membrane filter □ Spread method □ 3M™ Petri film
Replicate	3	3	3	3
Culture temperature	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ (1) □ 41 ℃ ☑ 44.5 ℃ (2)	□ 25 ℃ □ 35.0 ℃ ( ) ☑ 41 ℃ □ 44.5 ℃ ( )	□ 25 ℃ ☑ 35.0 ℃ ( ) □ 41 ℃ □ 44.5 ℃ ( )
Culture period	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	☑ 2 hr (1) ☑ 22 hr (2) □ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )	□ 2 hr ( ) □ 22 hr ( ) ☑ 24 hr □ ( ) hr ( ) □ ( ) hr ( )
Time (Start/End)	4:22 / 4:24 4:25 / 4:28 4:28 / 4:31	3:53 / 4:03 4:03 / 4:14 4:14 / 4:22	3:53 / 4:03 4:03 / 4:14 4:14 / 4:22	3:53 / 4:03 4:03 / 4:14 4:14 / 4:22
Volume (mL)	/ / /	100 100 100	100 100 100	100 100 100
Dilution factor	– – –			
Test substance	E1 E2 E3	E1 E2 E3	E1 E2 E3	E1 E2 E3

Remarks: The test of bacteria can have sample holding time.

(If it has, Refer to holding time(storage time) of "sampling check & custody sheet")

Working date	2014. 09.18	Personnel	Min-Ji Kim (sign)
Confirming date	2014. 09. 18	Confirmed by	Sun okLee (sign)

Test Result Sheet with Microbiology

2014

Study number	-	Test number	SET-14-006
Sample type	☑1. Uptake water □2. Discharge control water □3. Discharge treated water □4. Other( )		
Sampling time	☑Day 0 □Day 1 □Day 2 □Day 3 □Day 4 □Day 5 □Other ( )		
Medium name	□A-1. Marine agar(Heterotrophic bacteria) ☑A-2. Aerobic Counter Plate(Heterotrophic bacteria) ☑B. mTEC(*E.coli*) ☑C. mEI(Intestinal Enterococci) □D. TCBS (Vibrio cholera)		

Test Result

Sample Type	Medium name	Test substance	Test method	Sample vol. (mL)	D[a] factor	CFU/Plate R1	R2	R3
1	A-2	HL-SO6UW-B	□M.F.[b] □S[c] ☑P.F.[d]	1	50	0	0	0
		HL-SO6UW-B	□M.F.[b] □S[c] ☑P.F.[d]	1	100	0	1	0
		HL-SO6UW-M	□M.F.[b] □S[c] ☑P.F.[d]	1	50	1	1	0
		HL-SO6UW-M	□M.F.[b] □S[c] ☑P.F.[d]	1	100	0	0	0
		HL-SO6UW-E	□M.F.[b] □S[c] ☑P.F.[d]	1	50	1	3	2
		HL-SO6UW-E	□M.F.[b] □S[c] ☑P.F.[d]	1	100	0	0	0
	B	HL-SO6UW-B	☑M.F.[b] □S[c] □P.F.[d]	100	-	12	17	26
			☑M.F.[b] □S[c] □P.F.[d]	25	-	5	8	2
		HL-SO6UW-M	☑M.F.[b] □S[c] □P.F.[d]	100	-	27	36	31
			☑M.F.[b] □S[c] □P.F.[d]	25	-	7	5	5
		HL-SO6UW-E	☑M.F.[b] □S[c] □P.F.[d]	100	-	62	52	43
			☑M.F.[b] □S[c] □P.F.[d]	25	-	9	16	13
	C	HL-SO6UW-B	☑M.F.[b] □S[c] □P.F.[d]	100	-	1	2	3
			☑M.F.[b] □S[c] □P.F.[d]	25	-	2	0	0
		HL-SO6UW-M	☑M.F.[b] □S[c] □P.F.[d]	100	-	6	10	34
			☑M.F.[b] □S[c] □P.F.[d]	25	-	0	1	1
		HL-SO6UW-E	☑M.F.[b] □S[c] □P.F.[d]	100	-	17	24	26
			☑M.F.[b] □S[c] □P.F.[d]	25	-	7	5	5

Remaks a) detected by Min-Ji Kim

Working date	2014. 9. 17	Personnel	Min-Ji Kim (sign)
Confirming date	2014. 09. 17	Confirmed by	Lee Seok Jin (sign)

a) dilution, b) membrane filter, c) spreading, d) petri film

Test Result Sheet with Microbiology

2014

Study number	—	Test number	SET-14-006
Sample type	□ 1. Uptake water ☑ 2. Discharge control water □ 3. Discharge treated water □ 4. Other( )		
Sampling time	□ Day 0 □ Day 1 □ Day 2 ☑ Day 3 □ Day 4 □ Day 5 □Other ( )		
Medium name	□ A-1. Marine agar(Heterotrophic bacteria) □ A-2. Aerobic Counter Plate(Heterotrophic bacteria) ☑ B. mTEC(*E.coli*) ☑ C. mEI(Intestinal Enterococci) □ D. TCBS (Vibrio cholera)		

Test Result

Sample Type	Medium name	Test substance	Test method	Sample vol. (mL)	D[a] factor	CFU/Plate R1	R2	R3
2	A-2	HL-S06CD3-B	□ M.F.[b] □ S[c] ☑ P.F.[d]	1 ml	25	12	15	11
			□ M.F.[b] □ S[c] ☑ P.F.[d]	1	50	2	2	1
		HL-S06CD3-M	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	25	4	4	5
			□ M.F.[b] □ S[c] ☑ P.F.[d]	1	50	3	3	2
		HL-S06CD3-E	□ M.F.[b] □ S[c] ☑ P.F.[d]	1	25	7	7	4
			□ M.F.[b] □ S[c] ☑ P.F.[d]	1	50	0	1	0
	B	HL-S06CD3-B	☑ M.F.[b] □ S[c] □ P.F.[d]	100		4	2	4
		HL-S06CD3-M	☑ M.F.[b] □ S[c] □ P.F.[d]	100		5	3	1
		HL-S06CD3-E	☑ M.F.[b] □ S[c] □ P.F.[d]	100		2	2	0
	C	HL-S06CD3-B	☑ M.F.[b] □ S[c] □ P.F.[d]	100		Kwy ~~3~~ 0 a)	4	2
		HL-S06CD3-M	☑ M.F.[b] □ S[c] □ P.F.[d]	100		3	4	1
		HL-S06CD3-E	☑ M.F.[b] □ S[c] □ P.F.[d]	100		2	2	0
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					

Remaks a) deleted by Min-Ji Kim Kwy

Working date	2014. 09. 19	Personnel	Min-Ji Kim (sign)
Confirming date	9. 19	Confirmed by	Kim Hui-Jeong (sign)

a) dilution, b) membrane filter, c) spreading, d) petri film

BSMB-QS-06-05(2)

Test Result Sheet with Microbiology

2014

Study number	-	Test number	SET-14-006
Sample type	□ 1. Uptake water □ 2. Discharge control water ☑ 3. Discharge treated water □ 4. Other( )		
Sampling time	□ Day 0 □ Day 1 □ Day 2 ☑ Day 3 □ Day 4 □ Day 5 □Other ( )		
Medium name	□ A-1. Marine agar(Heterotrophic bacteria) ☑ A-2. Aerobic Counter Plate(Heterotrophic bacteria) □ B. mTEC(*E.coli*) □ C. mEI(Intestinal Enterococci) □ D. TCBS (Vibrio cholera)		

Test Result

Sample Type	Medium name	Test substance	Test method	Sample vol. (mL)	D[a] factor	CFU/Plate R1	R2	R3
3	A-2	HL-SDBTD3-B1	□ M.F.[b] □ S[c] ☑ P.F.[d]	1		TNTC	TNTC	TNTC
		HL-SDBTD3-B2	□ M.F.[b] □ S[c] ☑ P.F.[d]	1		TNTC	TNTC	TNTC
		HL-SDBTD3-B3	□ M.F.[b] □ S[c] ☑ P.F.[d]	1		TNTC	TNTC	TNTC
		HL-SDBTD3-M1	□ M.F.[b] □ S[c] ☑ P.F.[d]	1		TNTC	TNTC	TNTC
		HL-SDBTD3-M2	□ M.F.[b] □ S[c] ☑ P.F.[d]	1		208	182	201
		HL-SDBTD3-M3	□ M.F.[b] □ S[c] ☑ P.F.[d]	1		154	149	142
		HL-SDBTD3-E1	□ M.F.[b] □ S[c] ☑ P.F.[d]	1		TNTC	TNTC	TNTC
		HL-SDBTD3-E2	□ M.F.[b] □ S[c] ☑ P.F.[d]	1		TNTC	TNTC	TNTC
		HL-SDBTD3-E3	□ M.F.[b] □ S[c] ☑ P.F.[d]	1		TNTC	TNTC	TNTC
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					
			□ M.F.[b] □ S[c] □ P.F.[d]					

Remaks

Working date	2014. 09. 19	Personnel	Min-Ji Kim (sign)
Confirming date	9. 19	Confirmed by	Kim Hui-Jeong (sign)

a) dilution, b) membrane filter, c) spreading, d) petri film

BSMB-QS-06-05(2)

Test Result Sheet with Microbiology

2014

Study number	-	Test number	SET-14-066
Sample type	□ 1. Uptake water □ 2. Discharge control water ☑ 3. Discharge treated water □ 4. Other( )		
Sampling time	□ Day 0 □ Day 1 □ Day 2 ☑ Day 3 □ Day 4 □ Day 5 □Other ( )		
Medium name	□ A-1. Marine agar(Heterotrophic bacteria) □ A-2. Aerobic Counter Plate(Heterotrophic bacteria) ☑ B. mTEC(*E.coli*) ☑ C. mEI(Intestinal Enterococci) □ D. TCBS (Vibrio cholera)		

Test Result

Sample Type	Medium name	Test substance	Test method	Sample vol. (mL)	D[a] factor	CFU/Plate R1	R2	R3
3	B	HL-S06TD3-B1	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		HL-S06TD3-B2	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		HL-S06TD3-B3	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		HL-S06TD3-M1	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		HL-S06TD3-M2	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		HL-S06TD3-M3	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		HL-S06TD3-E1	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		HL-S06TD3-E2	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		HL-S06TD3-E3	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
	C	HL-S06TD3-B1	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		HL-S06TD3-B2	☑ M.F.[b] □ S[c] □ P.F.[d]	100		1	0	0
		HL-S06TD3-B3	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		HL-S06TD3-M1	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		HL-S06TD3-M2	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		HL-S06TD3-M3	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		HL-S06TD3-E1	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		HL-S06TD3-E2	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0
		HL-S06TD3-E3	☑ M.F.[b] □ S[c] □ P.F.[d]	100		0	0	0

Remaks

Working date	2014. 09. 19	Personnel	Min-Ji Kim (sign)
Confirming date	9. 19	Confirmed by	Kim Hui-Jeong (sign)

a) dilution, b) membrane filter, c) spreading, d) petri film

BSMB-QS-06-05(2)

Vibrio cholerae O1, O139

2014

Study Number	-	Test Number	SET-14-006
Sample type	☑ Uptake water □ Discharge control water □ Discharge treated water □ Other( )		
Sampling time	☑ Day 0 □ Day 1 □ Day 2 □ Day 3 □ Day 4 □ Day 5 □ Other( )		

1. Procedures

☑ Each yellow sucrose fermenting colonies are placed on Non-salt Alkaline Pepton water.

☑ Incubate at 36°C ± 1 °C for 6-18 hours.

☑ Presumptive positive colonies are performed using slide agglutination assays by O1 and O139 antiserum for serological identification.

2. Results

Test substance	O1	O139	Sum
HL-S06DW-B	O	O	O
HL-S06DW-M	O	O	O
HL-S06DW-E	O	O	O

3. Remarks

Working date	2014. 9. 17	Study personnel	Min-Ji Kim (sign)
Confirming date	2014. 09. 17	Confirmed by	Lee Seok Jin (sign)

Busan Techno-Park
Marine Bio-industry Development Center

Vibrio cholerae O1, O139

20 14

Study Number	–	Test Number	SET-14-006
Sample type	□ Uptake water ☑ Discharge control water □ Discharge treated water □ Other( )		
Sampling time	□ Day 0 □ Day 1 □ Day 2 ☑ Day 3 □ Day 4 □ Day 5 □ Other( )		

1. Procedures

☑ Each yellow sucrose fermenting colonies are placed on Non-salt Alkaline Pepton water.

☑ Incubate at 36°C ± 1 °C for 6-18 hours.

☑ Presumptive positive colonies are performed using slide agglutination assays by O1 and O139 antiserum for serological identification.

2. Results

Test substance	O1	O139	Sum
HL-S06CD3-B	O	O	O
HL-S06CD3-M	O	O	O
HL-S06CD3-E	O	O	O

3. Remarks

Working date	2014.9.19	Study personnel	Min-Ji Kim (sign)
Confirming date	9.19	Confirmed by	Kim Hui Jeong (sign)

Vibrio cholerae O1, O139

20 14

Study Number	–	Test Number	SET-14-006
Sample type	□ Uptake water □ Discharge control water ☑ Discharge treated water □ Other( )		
Sampling time	□ Day 0 □ Day 1 □ Day 2 ☑ Day 3 □ Day 4 □ Day 5 □ Other( )		

1. Procedures

☑ Each yellow sucrose fermenting colonies are placed on Non-salt Alkaline Pepton water.

☑ Incubate at 36°C ± 1 °C for 6-18 hours.

☑ Presumptive positive colonies are performed using slide agglutination assays by O1 and O139 antiserum for serological identification.

2. Results

Test substance	O1	O139	Sum
HL-S06TD3-B1	0	0	0
HL-S06TD3-B2	0	0	0
HL-S06TD3-B3	0	0	0
HL-S06TD3-M1	0	0	0
HL-S06TD3-M2	0	0	0
HL-S06TD3-M3	0	0	0
HL-S06TD3-E1	0	0	0
HL-S06TD3-E2	0	0	0
HL-S06TD3-E3	0	0	0

3. Remarks

Working date	2014. 9. 20	Study personnel	Min-Ji Kim (sign)
Confirming date	9. 20	Confirmed by	Kim Hui Joong (sign)

Test Result Sheet - Classification (II)

20 14

Study number		Test number	SET-14-006
Test substance	Uptake water	Lot. No.	
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	Method	☐ Direct ☑ Dye (FDA)
Concentration	—	Receive time of test substance	07:08
Test start time	07:10	Test end time	08:30

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S06W-B	1 ml.	prorocentrum sp.	13	21	7	
		Tintinnopsis sp.	2	1	2	
		Rhizosolenia sp.	3			
		stephanopyxis sp.	12	5	8	
		Thalassiothrix sp.	42	36	30	
		Ceratium sp.	7	2	10	
		Chaetoceros sp.	22	40	32	
		Eucampia sp.		7	26	
		Pleurosigma sp.	5	4	2	
		Unknown		1	2	

Remark	24.7°C 42%	24.8°C 42%	
Date	16th Sep.	Study personnel	Park Na Kyung (sign)
Certificate date	16th Sep.	Study director	Park Na Kyung (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Worksheet-Plankton-003(1)

Test Result Sheet - Classification (II)

20 14

Study number		Test number	SET-14-006
Test substance	Uptake water	Lot. No.	
Organism	☑ ≥ 10 to 50 µm ☐ ≥ 50 µm	Method	☐ Direct ☑ Dye (FDA)
Concentration	—	Receive time of test substance	8:10
Test start time	8:30	Test end time	9:40

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (µm)
HL-SdVW-M	1 ml.	Pleurosigma sp.	6	6	9	
		Lectocylindrus sp.	6	9	5	
		Thalassiosira sp.	37	42	22	
		Eucampia sp.	6		9	
		Tintinnopsis sp.	3	1	1	
		Chaetoceros sp.	16	20	36	
		Ceratium sp.	13	10	7	
		Prorocentrum sp.	24	26	23	
		Stephanopyxis sp.		14	12	
		unknown.	2	2	1	
		Rhizosolenia sp.			1	

Remark	Start < 25.5°C 41% End < 25°C 41%		
Date	16th Sep.	Study personnel	Park Na Kyung (sign)
Certificate date	16th Sep.	Study director	Park Na Kyung (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Test Result Sheet - Classification (II)

20 14

Study number		Test number	SET-14-006
Test substance	Uptake water	Lot. No.	
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	Method	☐ Direct ☑ Dye (FDA)
Concentration	—	Receive time of test substance	9:20
Test start time	9:40	Test end time	11:10

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-GOBUW-E	1ml.	prorocentrum sp.	32	36	26	
		Leptocylindrus sp.	6	2	8	
		Diploneis sp.	1			
		Thalassiosira sp.	32	40	36	
		Ceratium sp.	9	8	9	
		Chaetoceros sp.	36	22	32	
		Eucampia sp.	9	6	14	
		Tintinnopsis sp.	2	1	1	
		Pleurosigma sp.			6	

Remark	Start < 26.5°C 4~1. End < 26.6°C 35~1.		
Date	16th Sep.	Study personnel	Park Na Kyung (sign)
Certificate date	16th Sep.	Study director	Park Na Kyung (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Worksheet-Plankton-003(1)

Test Result Sheet - Classification (II)

2014

Study number		Test number	SETET-14-006
Test substance	Control water	Lot. No.	–
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	Method	☐ Direct ☑ Dye (FDA)
Concentration	–	Receive time of test substance	OP: 20.
Test start time	OP: 27	Test end time	12:12

Test site	Counting volume	Classification	Number of organism R1	R2	R3	Minimum dimension (μm)
HL-S06CD3-B 10:12경	500mL	Thalassiosira sp.	6	3	7	
		Melosira sp.	2			
		unidentified dinoflagellate	1	3	1	
		ceratium sp	1	1	1	
		diatom			1	
HL-S06CD3-M 10:35~11:14 24.8°C 25.4°C 50% 51%	500mL	Thalassiosira sp	2	4	3	
		unidentified dinoflagellate	3	2	1	
		diatom	1	1	1	
		Chaetoceros sp	1			
		Melosira sp		1	2	
HL-S06CD3-E 11:37~12:12 25.4°C 25.6°C 50% 52%	500mL	Thalassiosira sp.	4	3	2	
		Melosira sp.	2	2		
		unidentified dinoflagellate	1		2	
		Ceratium sp.	2	1		
		Chaetoceros sp		2		
		Cochlodinium polykrikoides			5	

Remark	23.6 °C, 55% : OP: 27 a.m / 24.7°C, 52% 10:12경. a)		
Date	OP. 18	Study personnel	Sun ok Lee (sign)
Certificate date	OP. 18	Study director	Sun ok Lee (sign)

* R: Replicate

Worksheet-Plankton-003(1)

Busan Techno-Park
Marine Bio-industry Development Center

Test Result Sheet - Classification (II)

2014

Study number		Test number	ET-14-006
Test substance	Treated water	Lot No.	—
Organism	☑ ≥ 10 to 50 μm ☐ ≥ 50 μm	Method	☐ Direct ☑ Dye (FDA)
Concentration	10L → 500 mL	Receive time of test substance	13:28.
Test start time	13:31	Test end time	16:30

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S06TD3-B-1	500μL	cochlodinium polykrikoides	3			
25°C, 55%		unidentified dinoflagellate			1	
13:31 ~ 14:42						
B2	500mL	—				
25°C, 48% B3	500mL	—				
HL-S06TD3-M1	500μL	unidentified dinoflagellate		1	1	
14:44 ~ M2		—				
25°C, 48% M3		—				
15:36 26°C, 45%						
HL-S06TD3-E1	500μL	—				
15:36, 26°C, 45% E2		—				
16:30, 27°C, 44% E3		—				

Remark			
Date	OP. 18	Study personnel	Sun ok Lee (sign)
Certificate date	OP. 18	Study director	Sun ok Lee (sign)

* R: Replicate

Worksheet-Plankton-003(1)

Busan Techno-Park
Marine Bio-industry Development Center

Test Result Sheet - Classification (II)

2014

Study number		Test number	SET-14-006
Test substance	Uptake water	Lot No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 250ml	Receive time of test substance	7:35
Test start time	7:40	Test end time	8:45

Test site	Counting volume	Classification	Number of organism R1	R2	R3	Minimum dimension (μm)
HL-506UW-B	5ml	Parvocalanus crassirostris	7	3	4	
		Acartia sp. (ohtsukai).	7	6	7	
		Cirriped larvae	4	5	5	
		Paracalanus parvus s. l.	6	2	7	
		Oithona sp.	6	9	7	
		nauplius	15	15	13	
		Polychaeta larvae	1	2		
		Corycaeus sp. (affinis)	2	2		
		Labidocera sp.			2	

Remark	start: 25.1°C 45%RH end: 25.9°C 44%RH		
Date	Sep. 16th	Study performed	Lee Seok Ju (sign)
Certificate date	Sep. 16th	Study director	Lee Seok Ju (sign)

* R: Replicate

Busan Techno-Park
Marine Bio-industry Development Center

Worksheet-Plankton-003(1)

Test Result Sheet - Classification (II)

2014

Study number		Test number	SET-14-006
Test substance	Uptake water	Lot No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1 ton → 250ml	Receive time of test substance	8:25
Test start time	8:46	Test end time	9:59

Test site	Counting volume	Classification	Number of organism R1	R2	R3	Minimum dimension (μm)
HL-S060W-M	5ml	Paracalanus crassirostris	4		2	
		Acartia sp.	4	6	9	
		cirriped larvae	3	4	4	
		Paracalanus parvus s. l.	3	1	5	
		Oithona sp.	12	15	16	
		nauplius	14	19	12	
		Polychaeta larvae	1	3	3	
		Labidocera sp.		1		
		Centropages sp. (dorsispinatus)		1		

Remark	start: 26.1°C 41PSU	end: 26.9°C 40PSU	
Date	Sep. 16th	Study performed	Lee Seok Ju (sign)
Certificate date	Sep. 16th	Study director	Lee Seok Ju (sign)

* R: Replicate

Test Result Sheet - Classification (II)

2014

Study number		Test number	SET-14-006
Test substance	Uptake water	Lot No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1 ton → 880ml	Receive time of test substance	9:58
Test start time	10:01	Test end time	10:29

Test site	Counting volume	Classification	Number of organism R1	R2	R3	Minimum dimension (μm)
HC-5060W-E	5ml	Paracalanus crassirostris	4	8	4	
		Acartia sp.	6	6	8	
		Cirripod larvae		1	4	
		Paracalanus parvus s.l.	17	15	20	
		Oithona sp.	21	20	23	
		nauplius	3	3	2	
		Polychaeta larvae	3	4	2	
		Cathropages sp. (aculeospinosus)		1		
		Cathropages sp. (tenuiremis)	1	1		
		Labidocera sp. (rotunda)	1	2	3	
		Corycaeus sp. (affinis)		3	3	

Remark	start: 20.0°C 39PSU	end 20.2°C 39PSU	
Date	Sep. 16th	Study performed	Lee Seola Jin (sign)
Confirmation date	Sep. 16th	Study director	Lee Seola Jin (sign)

* R: Replicate

Test Result Sheet - Classification (II)

20114

Study number		Test number	SET-14-006
Test substance	Control	Lot. No	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 250ml	Receive time of test substance	9:20
Test start time	9:28	Test end time	9:57

Test site	Counting volume	Classification	Number of organism R1	R2	R3	Minimum dimension (μm)
HL-S06 CD -B	5ml	Paracalanus parvus s.l	3	6	6	
		Acartia sp.	5	2	3	
		Parvocalanus crassirostris	4	6	2	
		Oithona sp.	21	25	24	
		Corycaeus affinis	2	0	2	
		Labidocera sp.	3	0	2	
		Nauplius	0	1	0	
		Polychaeta larvae	0	1	1	
		Centropages sp.	0	0	1	
			38	41	41	
				≒ 200		

Remark	Start 23.6°C 55% End 24.4°C 53%		
Date	Sep. 18	Study personnel	Cho Yukyeong (sign)
Certificate date	Sep. 18	Study director	Sun ok Lee (sign)

* R: Replicate

Test Result Sheet - Classification (II)

20

Study number		Test number	GET-14-006
Test substance	Control	Lot. No	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 250ml	Receive time of test substance	10:35
Test start time	10:42	Test end time	11:02

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S06CD-M	5ml	Paracalanus parvus s.l	7	10	7	
		Acartia sp.	6	2	2	
		Parvocalanus crassirostris	3	3	4	
		Oithona sp.	20	16	15	
		Labidocera sp.	5	5	6	
		Polychaeta larvae	1	0	3	
		Cirriped larvae	1	0	1	
		Corycaeus affinis	0	1	1	
		Centropages sp.	0	1	1	

Remark	Start 24.9°C 51%	End 25.3°C 51%	
Date	Sep. 18	Study personnel	Cho Yukyeong (sign)
Certificate date	Sep. 18	Study director	Sunok Lee (sign)

* R: Replicate

Test Result Sheet - Classification (II)

2014

Study number		Test number	4ET-14-006
Test substance	Control	Lot. No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 250ml	Receive time of test substance	11:40
Test start time	11:46	Test end time	12:07

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S06CD-E	5ml	Paracalanus parvus s.l.	18	19	17	
		Acartia sp.	4	6	7	
		Parvocalanus crassirostris	7	8	13	
		Oithona sp.	10	10	9	
		Corycaeus affinis	2	0	2	
		Labidocera sp.	4	3	3	
		Cirriped larvae	3	7	4	
		Centropages sp.	1	1	0	
		Polychaeta larvae	0	1	1	
			47	55	56	53.3
				≒	2665	

Remark	Start 25.6°C 51% End 25.6°C 51%		
Date	Sep. 18	Study personnel	Cho Yukyeong (sign)
Certificate date	Sep. 18	Study director	Sun ok Lee (sign)

* R: Replicate

Test Result Sheet - Classification (II)

2014

Study number		Test number	SET-14-006
Test substance	Treated water	Lot. No.	
Organism	□ ≥ 10 to 50 μm ☑ ≥ 50 μm	Method	☑ Direct □ Dye ( )
Concentration	1ton → 250ml	Receive time of test substance	13:40.
Test start time	13:48	Test end time	14:04

Test site	Counting volume	Classification	Number of organism R*1	R2	R3	Minimum dimension (μm)
HL-S06-TD3-B1	250ml	-	-	-	-	
HL-S06-TD3-B2	250ml	-	-	-	-	
HL-S06-TD3-B3	250ml	"	"	"	"	
HL-S06-TD3-M1	250ml	"	"	"	"	
HL-S06-TD3-M2	250ml	"	"	"	"	
HL-S06-TD3-M3	250ml	Nauplius	1			
HL-S06-TD3-E1	250ml	"	"	"	"	
HL-S06-TD3-E2	250ml	-	"	"	"	
HL-S06-TD3-E3	250ml	"	"	"	"	

Remark	Start 25.1°C 54%	End 26.5°C 52%	
Date	Sep. 18	Study personnel	Cho Yukyeong (sign)
Certificate date	Sep. 18	Study director	Pan of Lee (sign)

* R: Replicate

4.7 Operating Data (Written by HANLA IMS)

Operating Data

2014. 10. 17

Copyright (c) by HANLA IMS. All rights reserved.

Index

1	Overview of the test participants	3
2	System Overview	4
3	Information regarding the installation and inspection	6
4	Overview of the test vessels	7
5	Information regarding the performance and evaluation	9
6	Test locations and Validity	10

Appendix

Ⅰ	Test Proceeding	11
Ⅱ	Operating results of valid test cycles	17
Ⅲ	Test Report and Baording List	32

Copyright (c) by HANLA IMS. All rights reserved.

1. Overview of the test participants

1) System Developer

① Company Name : HANL IMS CO., LTD.

② Conpany Location : 115, Hwajeonsandan 1-ro, Gangseo-gu, Busan, Korea

③ Product Name : EcoGuardian™ BWTS

2) Organization of performing the Quality Assurance (QA)

① Name : Korea Institute of Ocean Sceince and Technology (KIOST)

② Location : 41, Jangmok 1-gil, Jangmok-myeon, Geoje-si,
Gyeongsangnam-do, Korea

③ Role : Quality Assurance for shipboard test

3) Organization of performing the test

① Name : Busan Techno Park (BTP),
Marine Bio-Industry Development Centre

② Location : 7, Hoenggye-gil, Ilgwang-myeon, Gijang-gun, Busan, Korea

③ Role : Perform the test

4) Organization of performing the installation inspection

① Name : Korean Register (KR)

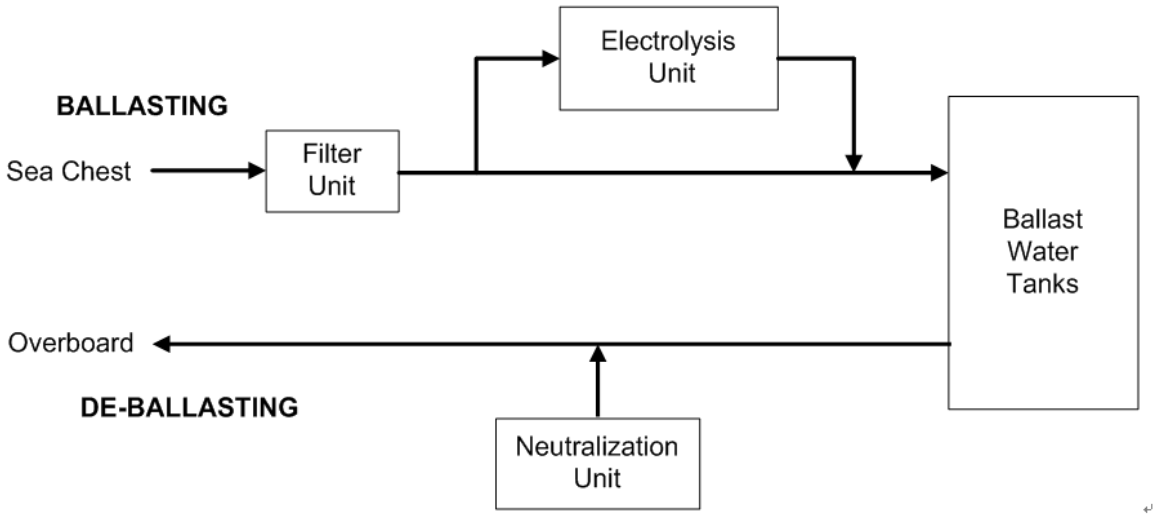
② Location : 36, Myeongji ocean city 9-ro, Gangseo-gu, Busan, Korea

③ Role : Check the installation onboard and Commissioning

Copyright (c) by HANLA IMS. All rights reserved.

2. EcoGuardian™ BWTS Overview

1) System Configuration



Mode	Process
Ballasting	Sea Chest → Ballast pump → Filter(50㎛) → Electrolysis(side-stream) → Ballast Water Tank
De-ballasting	Ballast Water Tank → Neutralization(sodium thiosulfate) → Ballast pump → Overboard
By-pass	• Sea Chest → Ballast pump → Ballast Water Tank • Ballast Water Tank → Ballast pump → Overboard

Copyright (c) by HANLA IMS. All rights reserved.

2) Specification

Division	Specification
System Name	EcoGuardian™ Ballast Water Treatment System
System Capacity	350m^3/h
Treatment Method	- Ballasting : Filtration (50μm) + Electrolysis (Side-stream) - Deballasting : Neutralization (sodium thiosulfate)
Biological Efficiency	Compliance with IMO D2 performance standard
Pressure Drop	0.1 bar in general
Salinity	~ 42 PSU (Practical Salinity Unit)
Water Temperature	~ 40 ˚C
Operation Mode	Automatic / Manual operation by Remote Control Panel (option)
Operation S/W	Human Machine Interface (HMI)
Utility Required	- Control air(6~7kgf/㎠) for pneumatic valves and equipments - Fresh water for rectifier cooling : Less than 40˚C, Min. 3kgf/㎠
Installation type	Skid/Wall mounted type
Electric Source	3ph AC 440V 60Hz, 1ph AC 220V 60Hz

Copyright (c) by HANLA IMS. All rights reserved.

3. Installation Inspection

- Complete review of the drawings and installation check from Korea Register of Shipping (2014.05.07.)
- Complete review of the assessment of conformity test from Korea Register of Shipping (2014.08.14.)

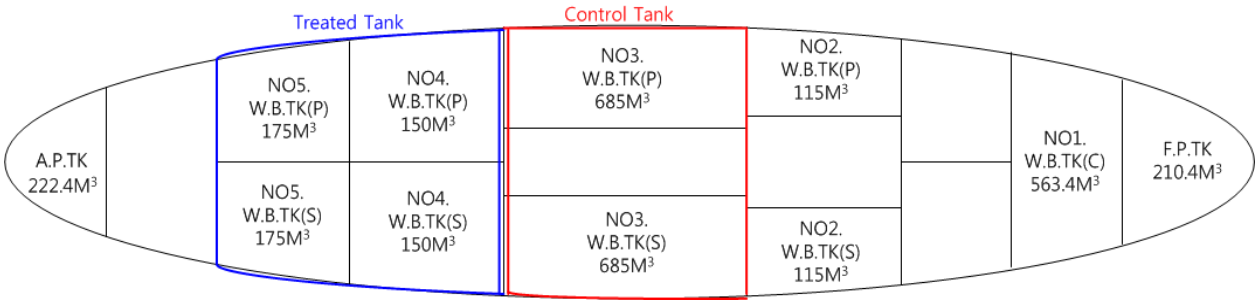
Copyright (c) by HANLA IMS. All rights reserved.

4. Overview of the test vessel

1) Information of the test vessel

Ship Name	CHANG YAHNG
Ship Owner	SSANG YONG SHIPPING
Ship Builder	SHINA SHIPBUILDING
Hull No.	SAS380
IMO No.	9121027
Ship Type	Bulk Carrier 10K
Ballast Pump Capacity	350m^3/h × 20m
Class	KR

2) Selection of the test tank



Treated Tank		Control Tank	
No.4 WBT(S)	152m^3	No.3 WBT(S)	685m^3
No.4 WBT(P)	152m^3		
No.5 WBT(S)	175m^3	No.3 WBT(P)	685m^3
No.5 WBT(P)	175m^3		
Total	**654m^3**	**Total**	**1370m^3**

Copyright (c) by HANLA IMS. All rights reserved.

3) Sampling

	Control Test	Treated Test
Ballasting	$1m^3$ X 3 times (Begin, Middle, End)	-
De-ballasting	$1m^3$ X 3 times (Begin, Middle, End)	$1m^3$ X 9 times (Begin 3, Middle 3, End 3)

4) Sampling Time

<table>
<tr><th></th><th colspan="3">Control Test</th><th colspan="3">Treated Test</th></tr>
<tr><td>Tank Name</td><td colspan="3">No.3 WBT(S)
+ No.3 WBT(P)</td><td colspan="3">No.4 WBT(S)
+ No.4 WBT(P)
+ No.5 WBT(S)
+ No.5 WBT(P)</td></tr>
<tr><td>Tank Volume</td><td colspan="3">$1370m^3$</td><td colspan="3">$654m^3$</td></tr>
<tr><td>Main ballast flow rate</td><td colspan="6">$350m^3/h$</td></tr>
<tr><td rowspan="2">Ballasting Sampling Time</td><td>Begin
(1 times)</td><td>Middle
(1 times)</td><td>End
(1 times)</td><td colspan="3" rowspan="2">-</td></tr>
<tr><td>20%</td><td>50%</td><td>80%</td></tr>
<tr><td rowspan="2">De-ballasting Sampling Time</td><td>Begin
(1 times)</td><td>Middle
(1 times)</td><td>End
(1 times)</td><td>Begin
(3 times)</td><td>Middle
(3 times)</td><td>End
(3 times)</td></tr>
<tr><td>20%</td><td>50%</td><td>80%</td><td>20%</td><td>50%</td><td>80%</td></tr>
</table>

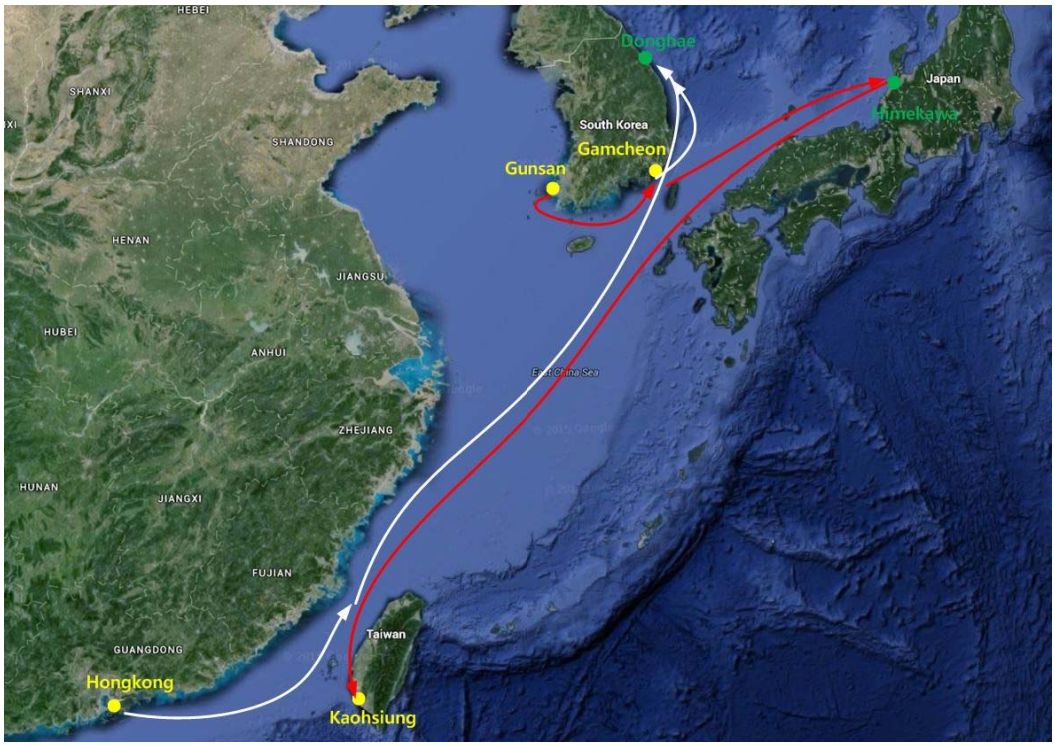
Copyright (c) by HANLA IMS. All rights reserved.

5. Information regarding the performance evaluation

1) Standard
- IMO : Guidelines for Approval of ballast water management system (G8)
- Ministry of Oceans and Fisheries, Korea : Type Approval of ballast water management Provision Reference

Copyright (c) by HANLA IMS. All rights reserved.

6. Test locations and Validity



[Passage of the test ship]

	Ballasting	De-ballasting	Validity
Cycle 1	TOLO harbor in HK	Not Conducted	Invalid[1)]
Cycle 2	KAOSHIUNG in TAIWAN	Not Conducted	Invalid[2)]
Cycle 3	Gamcheon in KOREA	Donghae in KOREA	Valid
Cycle 4	Gunsan in KOREA	Not Conducted	Invalid[3)]
Cycle 5	TOLO harbor in HK	TOLO harbor in HK	Valid
Cycle 6	Gunsan in KOREA	Gamcheon in KOREA	Valid

1), 2), 3) Not satisfied organism of uptake water

Copyright (c) by HANLA IMS. All rights reserved.

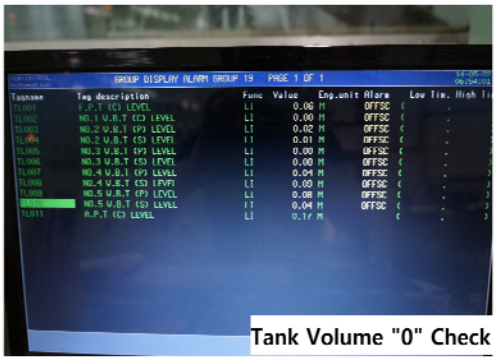
Appendix

Ⅰ. Test Proceeding

▼ Sounding (Test conducted by BTP, QA : KIOST)

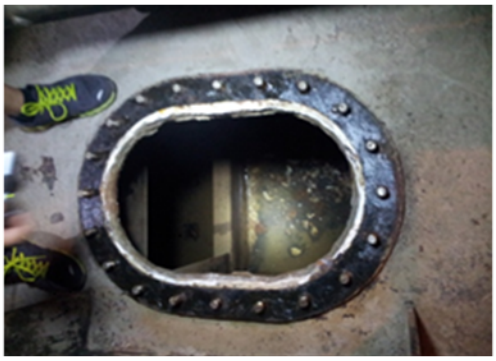
Sounding

Sounding Record



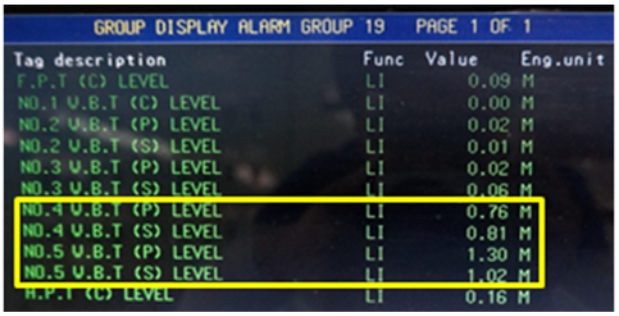
Tank Volume "0" Check

Level Gauge "0" Check



Copyright (c) by HANLA IMS. All rights reserved.

▼ Ballasting Treated (Test conducted by BTP, QA : KIOST)



GROUP DISPLAY ALARM GROUP 19 PAGE 1 OF 1

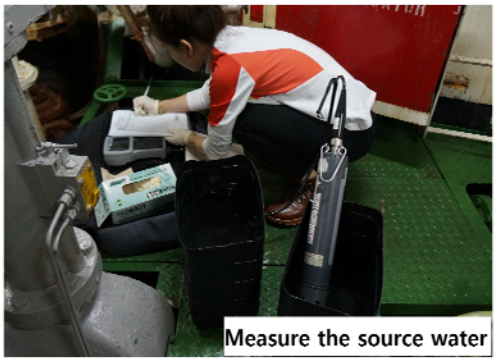
Tag description	Func	Value	Eng.unit
F.P.T (C) LEVEL	LI	0.09	M
NO.1 V.B.T (C) LEVEL	LI	0.00	M
NO.2 V.B.T (P) LEVEL	LI	0.02	M
NO.2 V.B.T (S) LEVEL	LI	0.01	M
NO.3 V.B.T (P) LEVEL	LI	0.02	M
NO.3 V.B.T (S) LEVEL	LI	0.06	M
NO.4 V.B.T (P) LEVEL	LI	0.76	M
NO.4 V.B.T (S) LEVEL	LI	0.81	M
NO.5 V.B.T (P) LEVEL	LI	1.30	M
NO.5 V.B.T (S) LEVEL	LI	1.02	M
H.P.T (C) LEVEL	LI	0.16	M

Copyright (c) by HANLA IMS. All rights reserved.

▼ Ballasting Control (Test conducted by BTP, QA : KIOST)

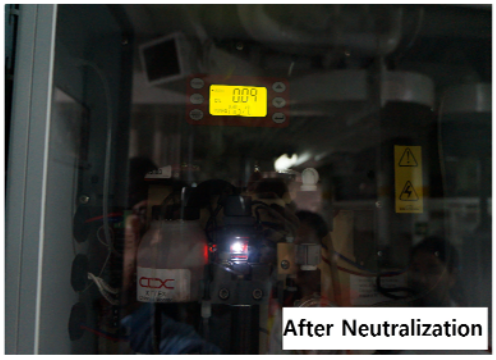
Phytoplankton Sampling (1L)

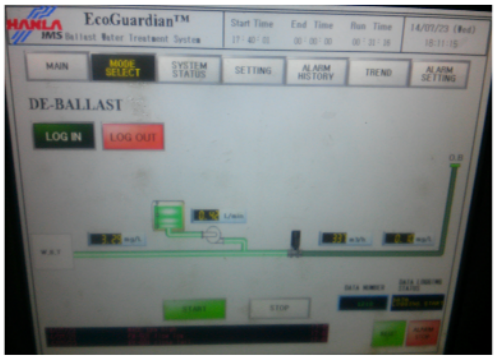
Zooplankton Sampling (1m3)


Measure the source water

Copyright (c) by HANLA IMS. All rights reserved.

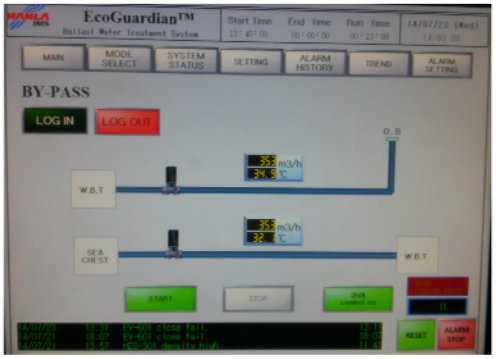
▼ De-ballasting Treated (Test conducted by BTP, QA : KIOST)





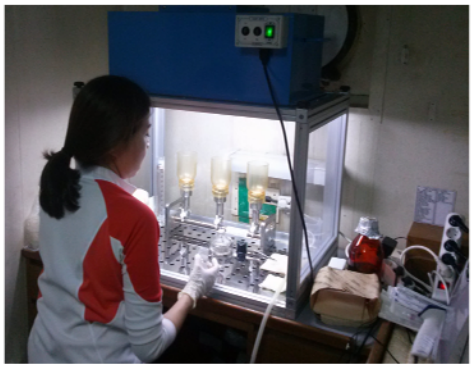
Copyright (c) by HANLA IMS. All rights reserved.

▼ De-ballasting Control (Test conducted by BTP, QA : KIOST)



Copyright (c) by HANLA IMS. All rights reserved.

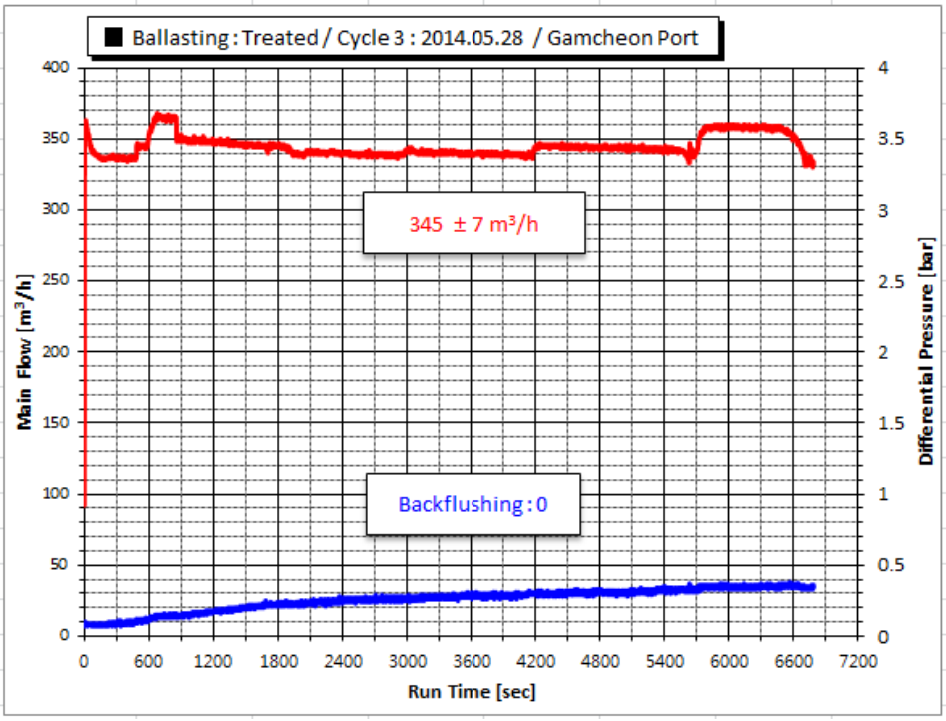
▼ Sample Analysis (Test conducted by BTP, QA : KIOST)

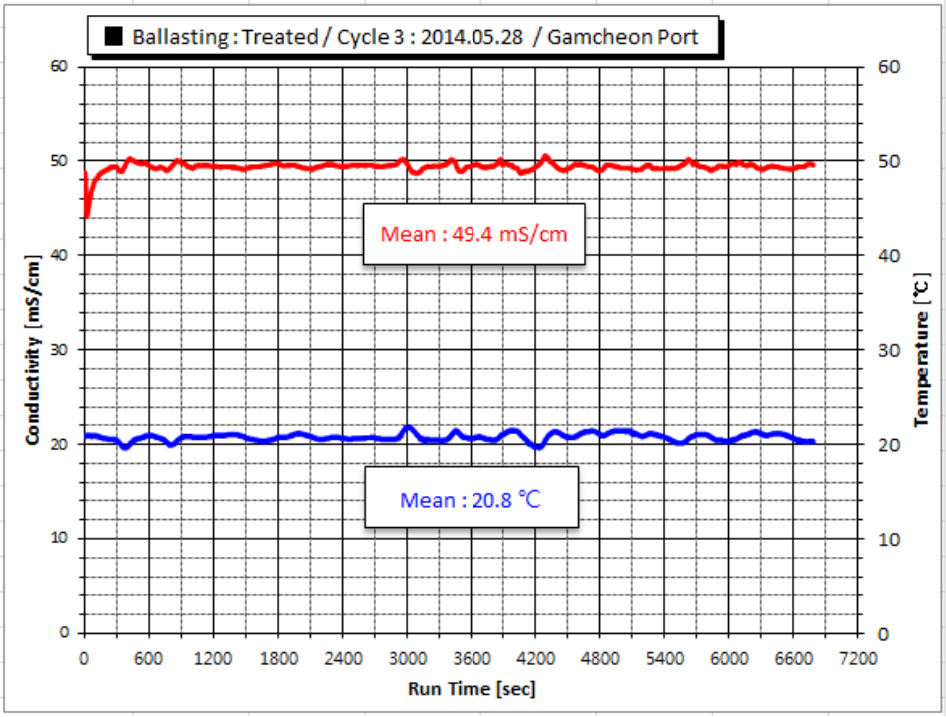


Copyright (c) by HANLA IMS. All rights reserved.

Ⅱ. Operating results of valid test cycles (Cycle 3)

▼ Ballasting : Treated (Test conducted by BTP, QA : KIOST)

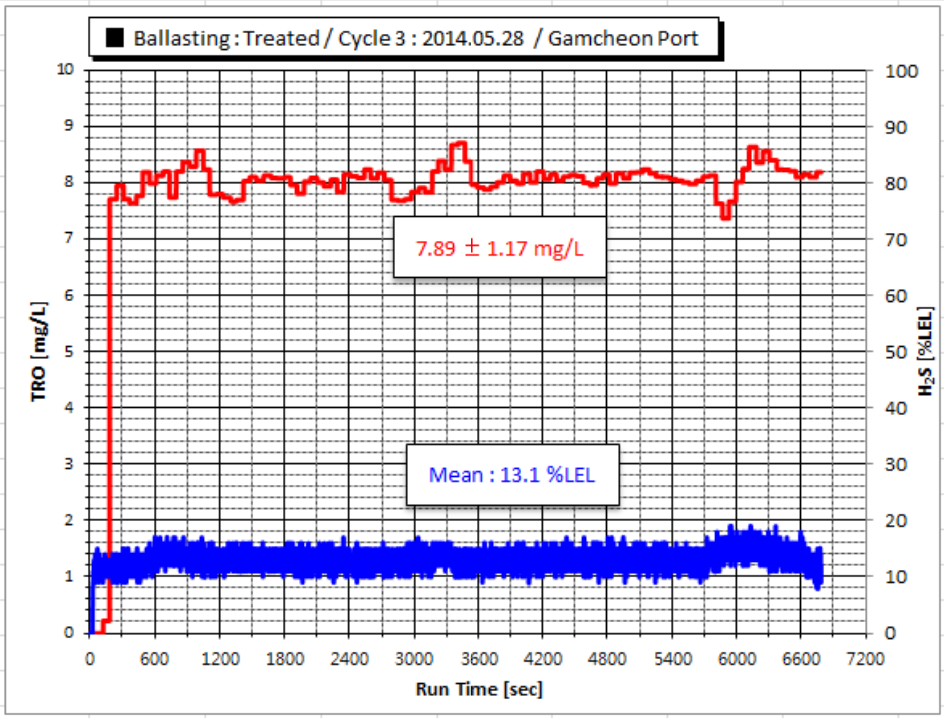


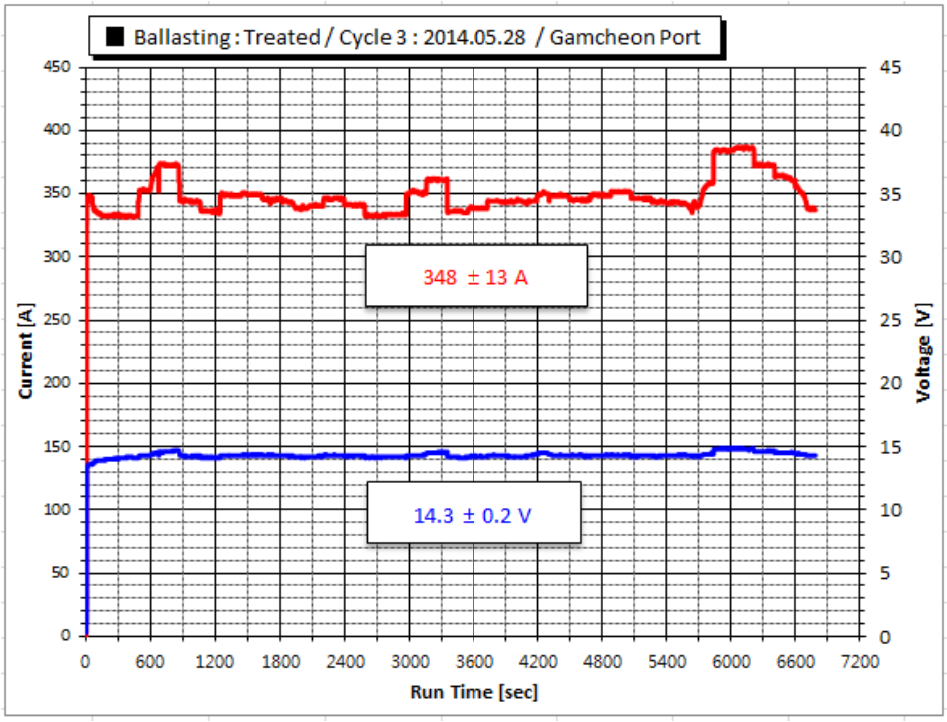


Copyright (c) by HANLA IMS. All rights reserved.

Ⅱ. Operating results of valid test cycles (Cycle 3)

▼ Ballasting : Treated (Test conducted by BTP, QA : KIOST)

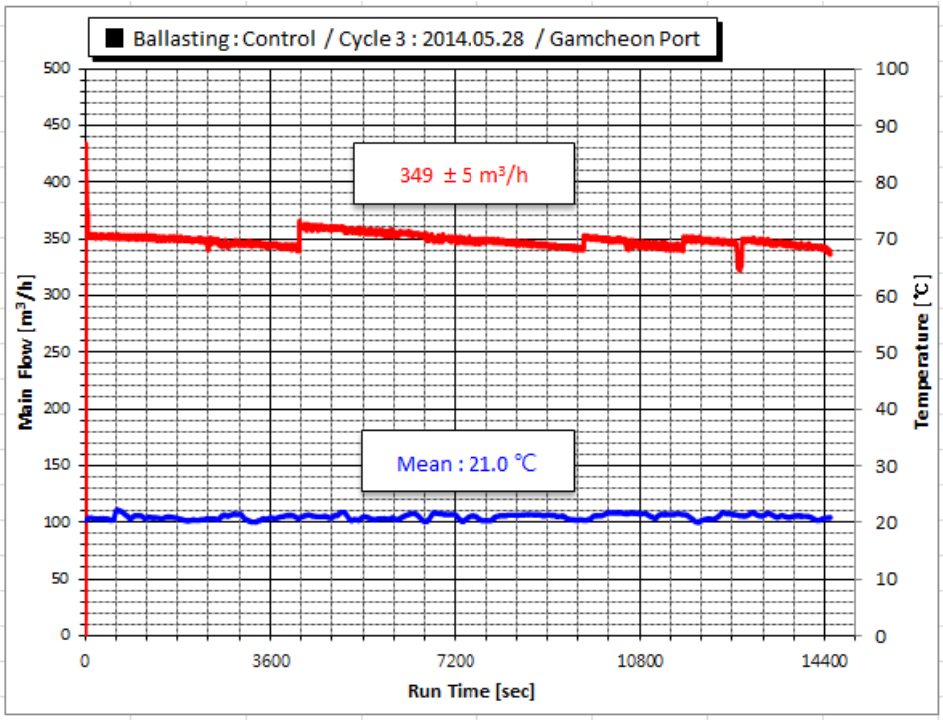




Copyright (c) by HANLA IMS. All rights reserved.

Ⅱ. Operating results of valid test cycles (Cycle 3)

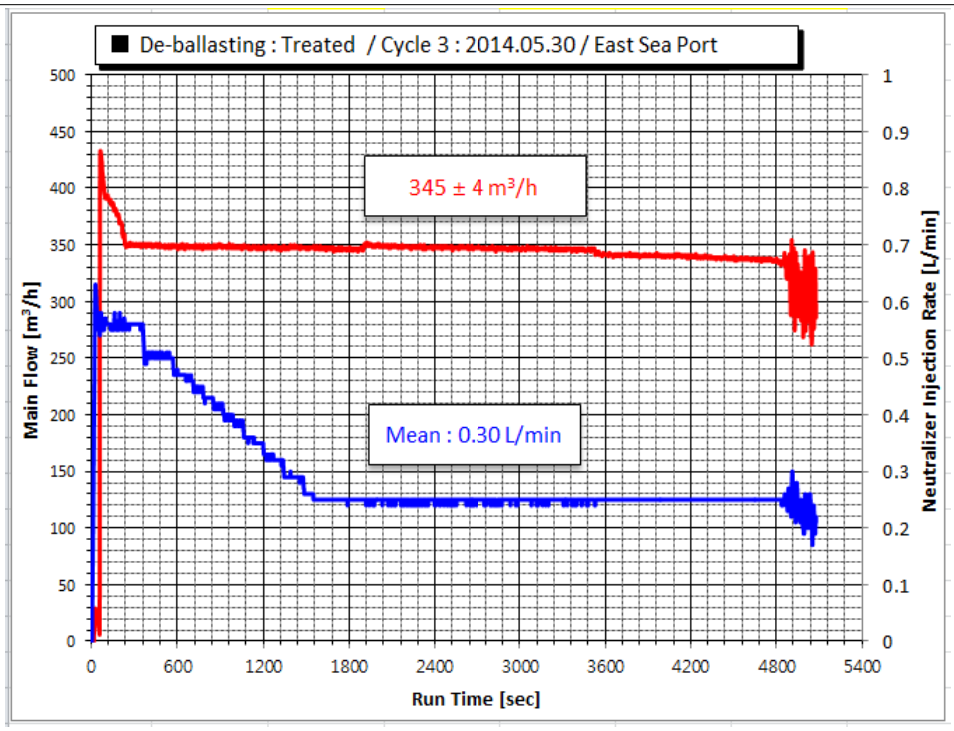
▼ Ballasting : Control (Test conducted by BTP, QA : KIOST)

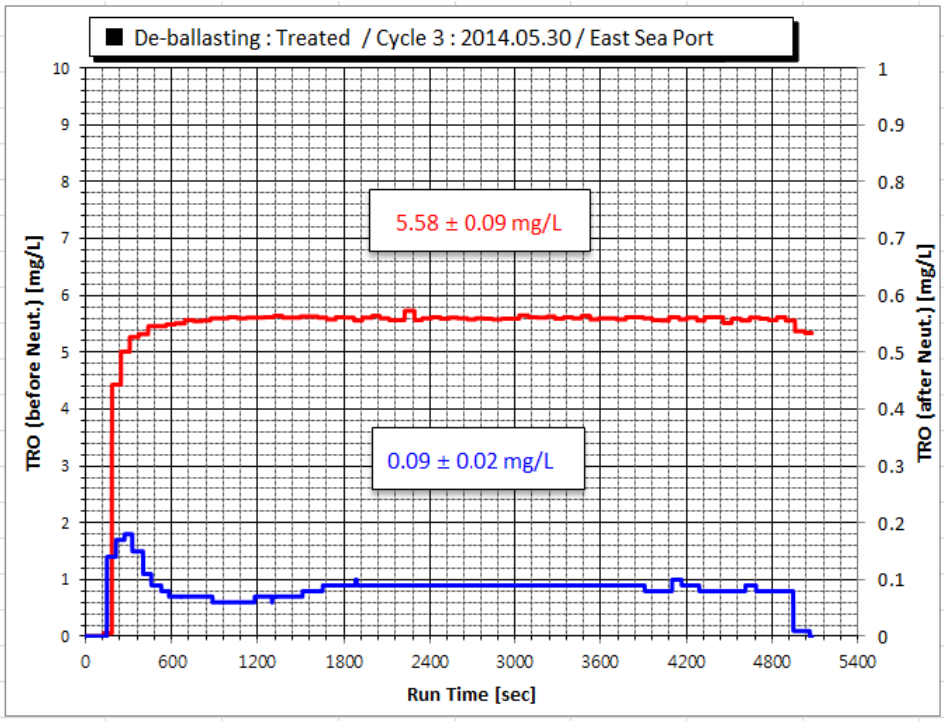


Copyright (c) by HANLA IMS. All rights reserved.

Ⅱ. Operating results of valid test cycles (Cycle 3)

▼ De-ballasting : Treated (Test conducted by BTP, QA : KIOST)

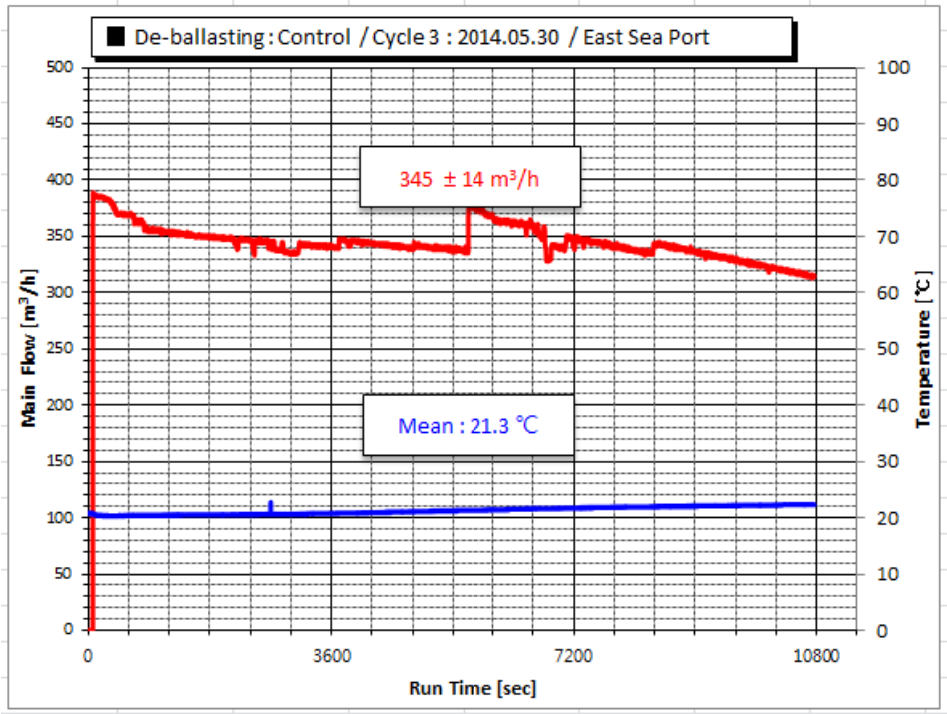




Copyright (c) by HANLA IMS. All rights reserved.

Ⅱ. Operating results of valid test cycles (Cycle 3)

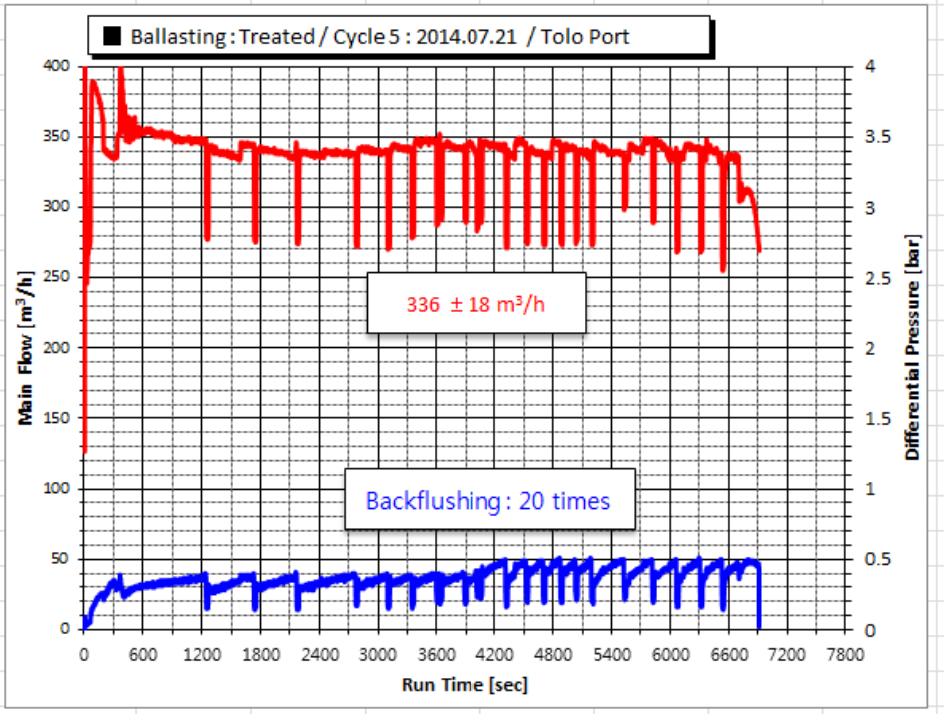
▼ De-ballasting : Control (Test conducted by BTP, QA : KIOST)

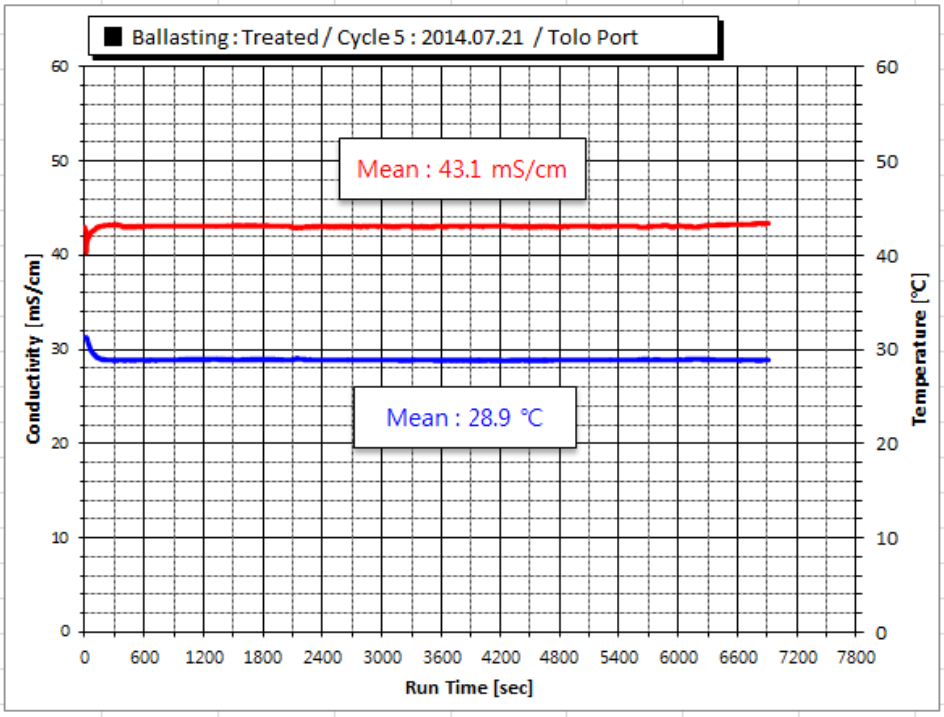


Copyright (c) by HANLA IMS. All rights reserved.

Ⅱ. Operating results of valid test cycles (Cycle 5)

▼ Ballasting : Treated (Test conducted by BTP, QA : KIOST)

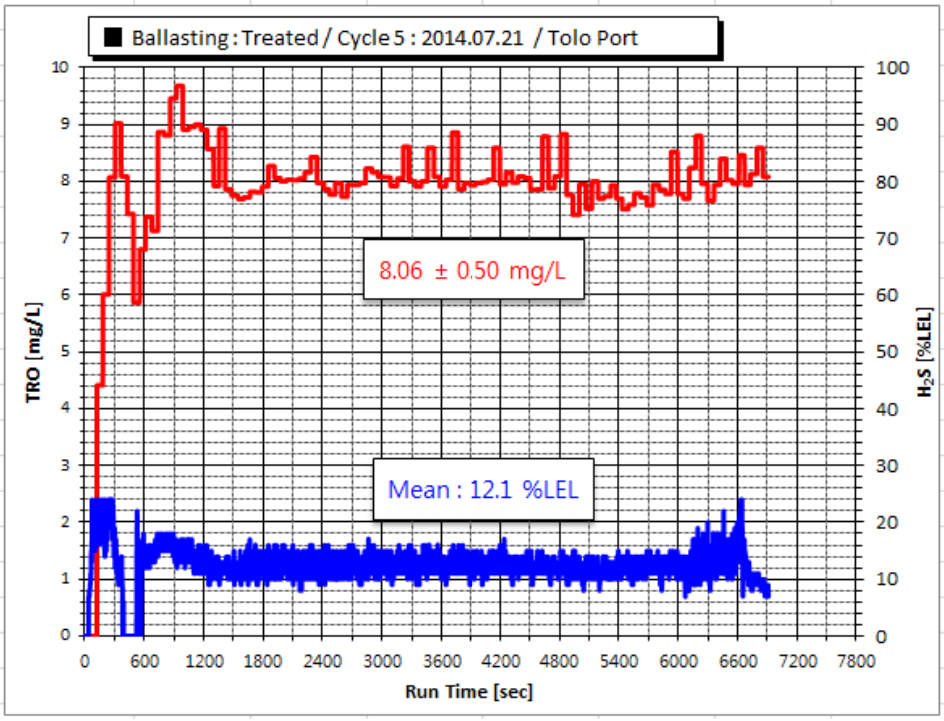


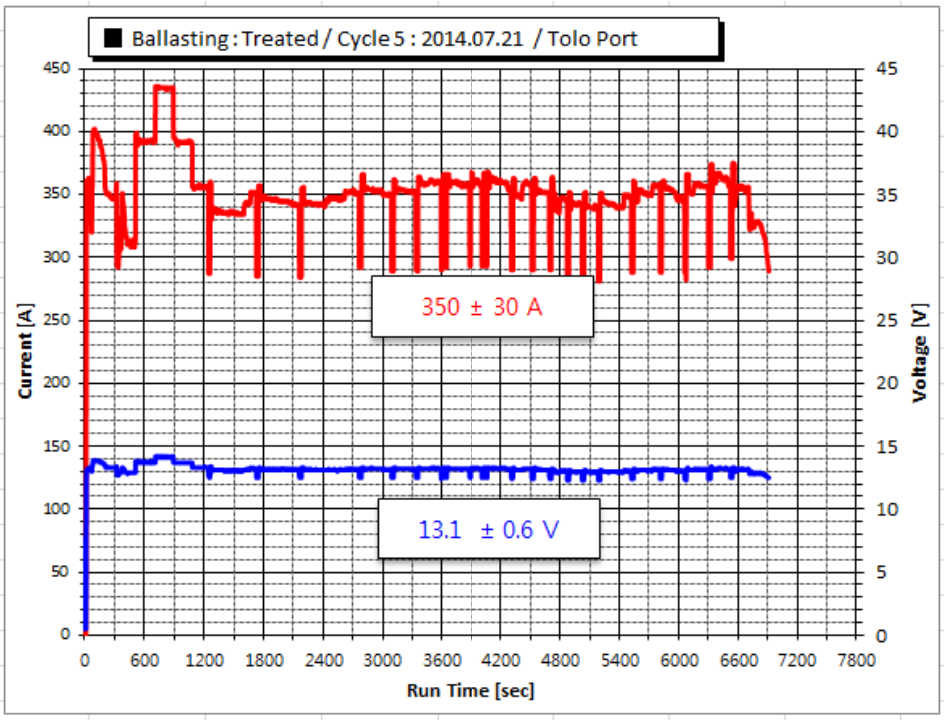


Copyright (c) by HANLA IMS. All rights reserved.

Ⅱ. Operating results of valid test cycles (Cycle 5)

▼ Ballasting : Treated (Test conducted by BTP, QA : KIOST)

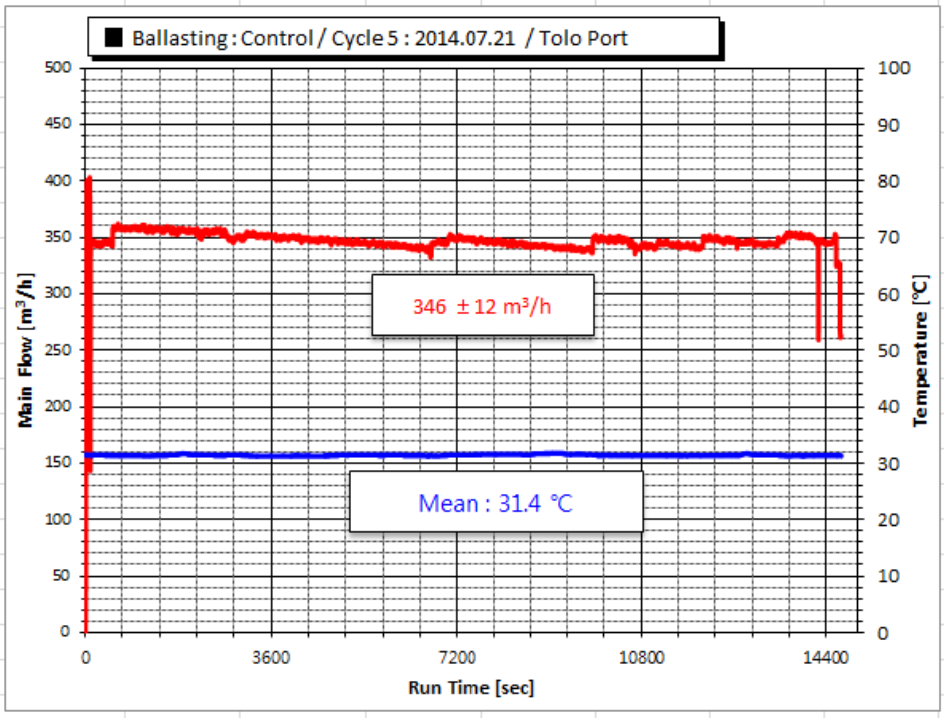




Copyright (c) by HANLA IMS. All rights reserved.

Ⅱ. Operating results of valid test cycles (Cycle 5)

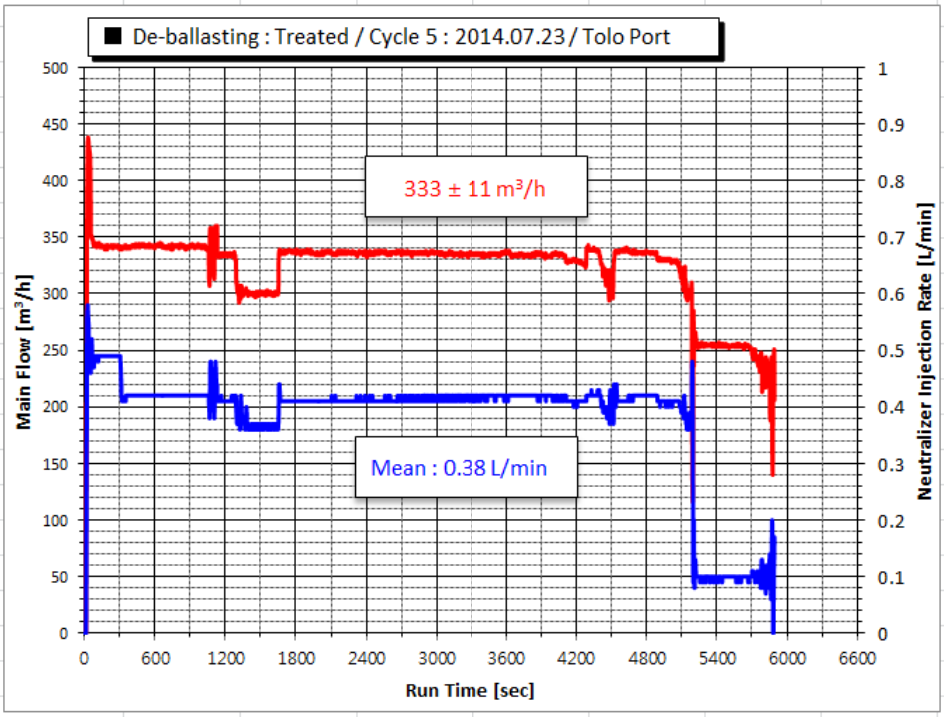
▼ Ballasting : Control (Test conducted by BTP, QA : KIOST)

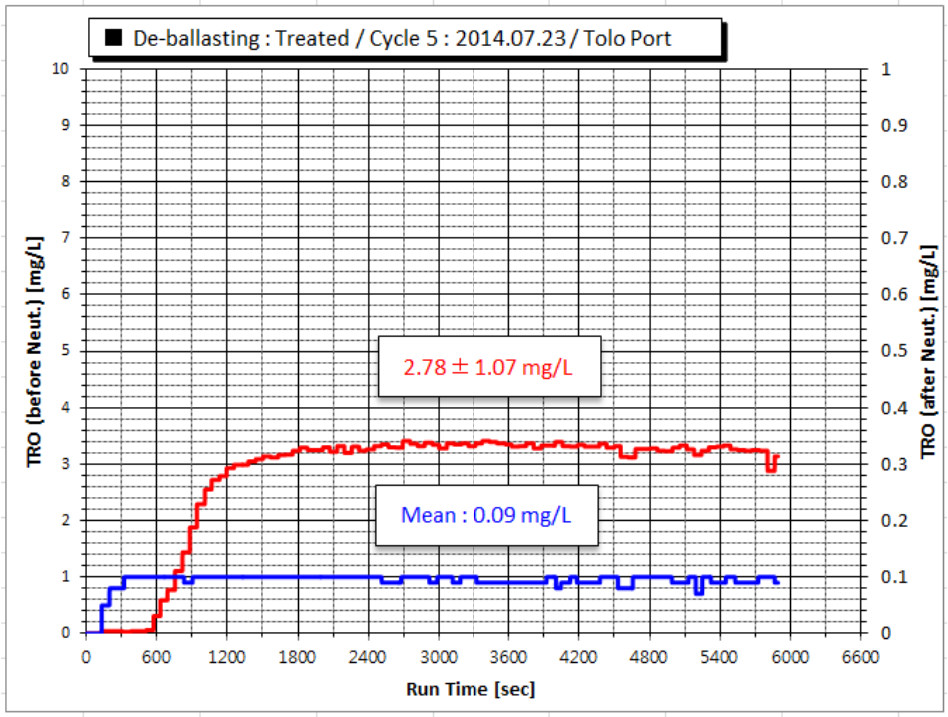


Copyright (c) by HANLA IMS. All rights reserved.

Ⅱ. Operating results of valid test cycles (Cycle 5)

▼ De-ballasting : Treated (Test conducted by BTP, QA : KIOST)

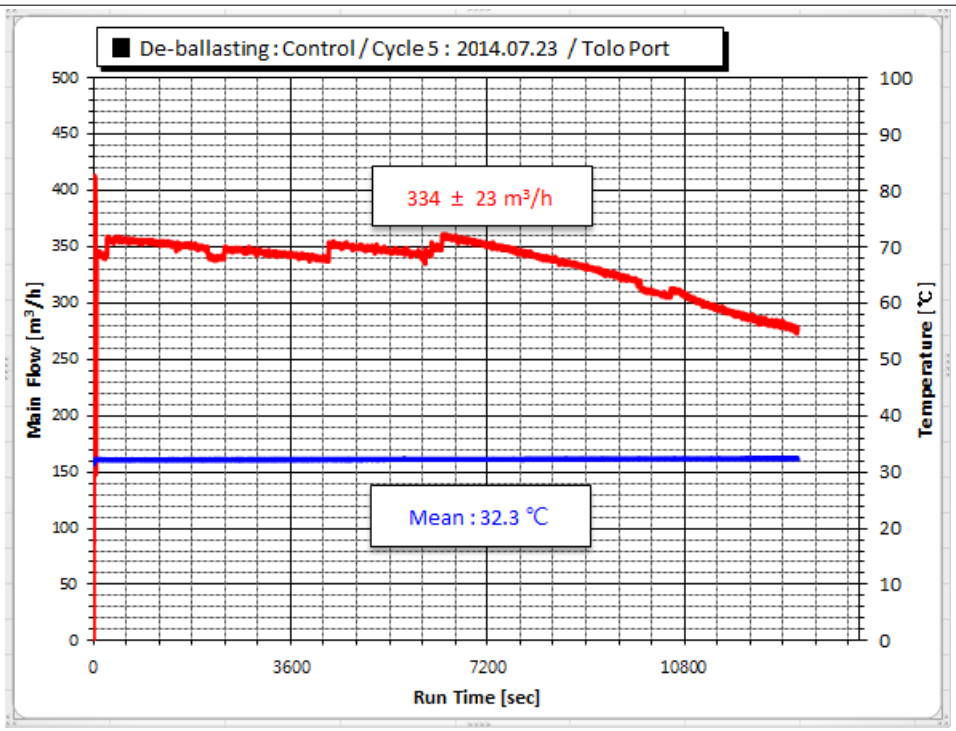




Copyright (c) by HANLA IMS. All rights reserved.

Ⅱ. Operating results of valid test cycles (Cycle 5)

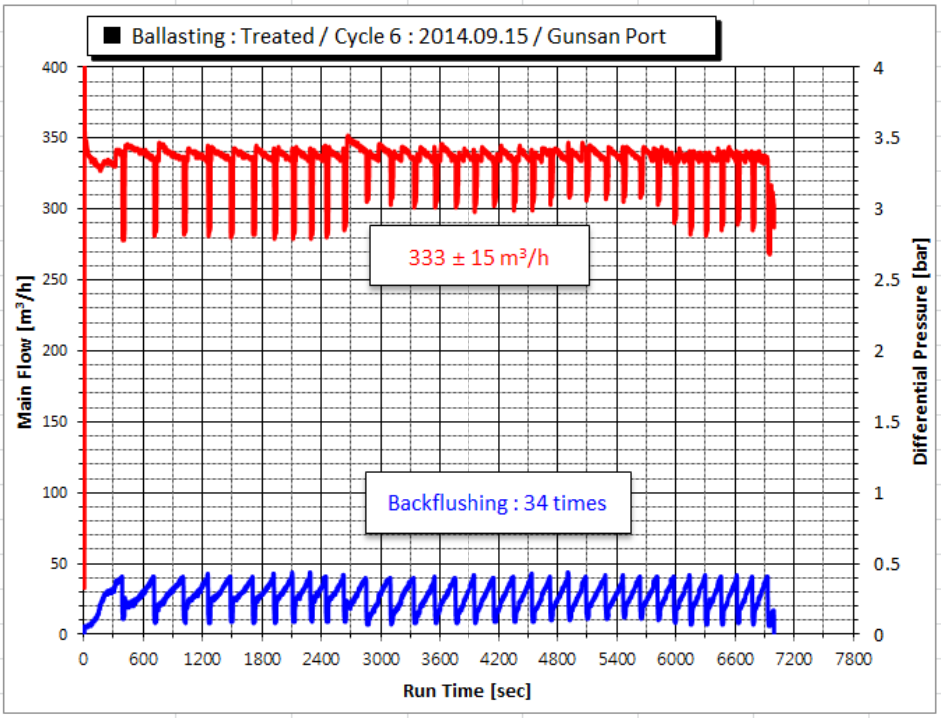
▼ De-ballasting : Control (Test conducted by BTP, QA : KIOST)

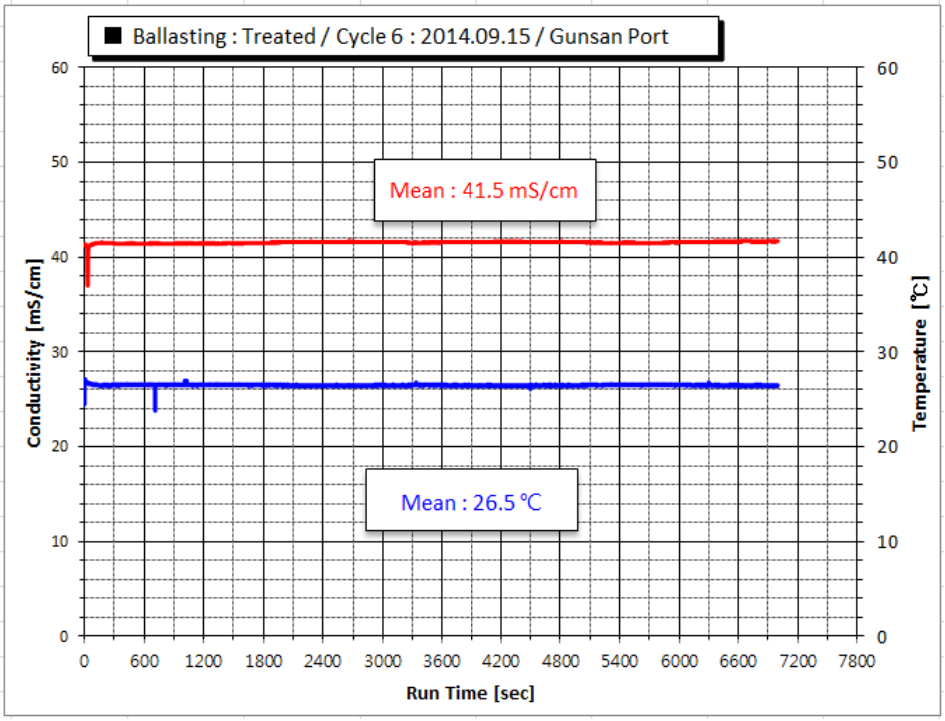


Copyright (c) by HANLA IMS. All rights reserved.

Ⅱ. Operating results of valid test cycles (Cycle 6)

▼ Ballasting : Treated (Test conducted by BTP, QA : KIOST)

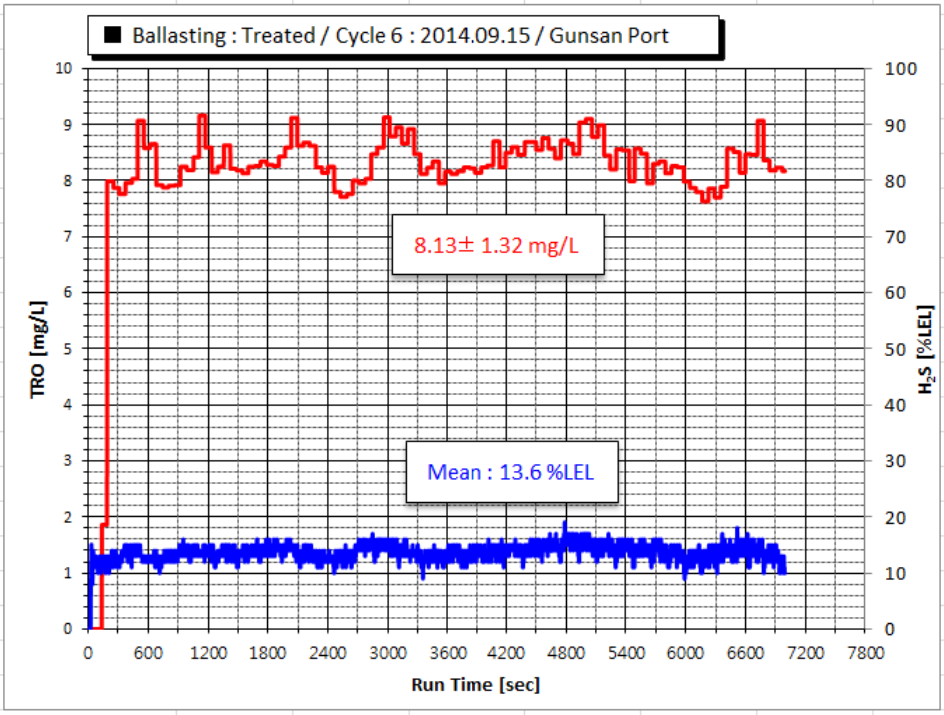


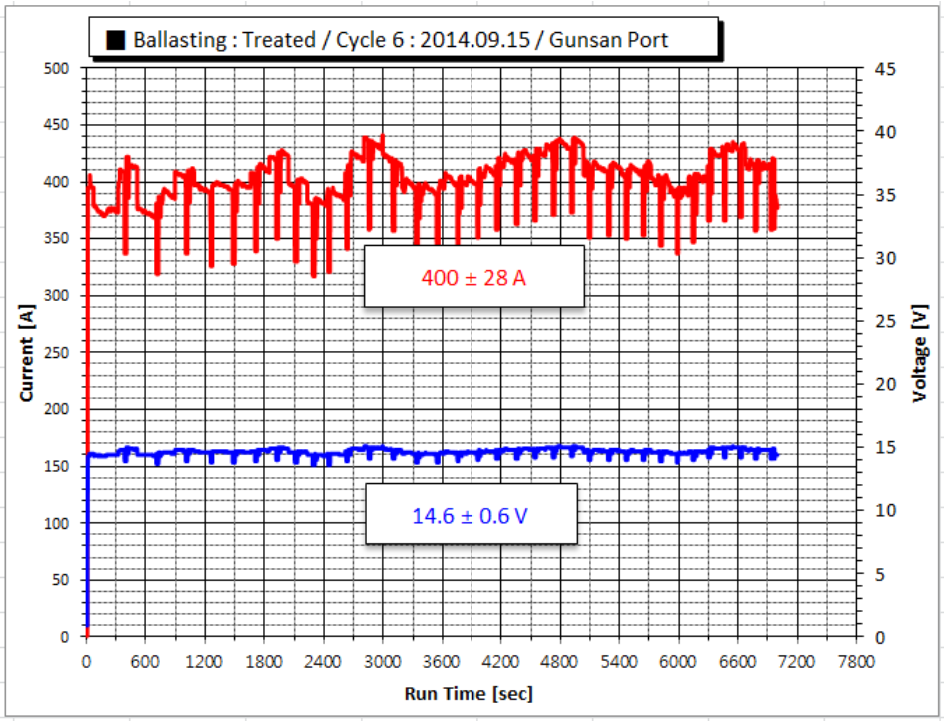


Copyright (c) by HANLA IMS. All rights reserved.

Ⅱ. Operating results of valid test cycles (Cycle 6)

▼ Ballasting : Treated (Test conducted by BTP, QA : KIOST)

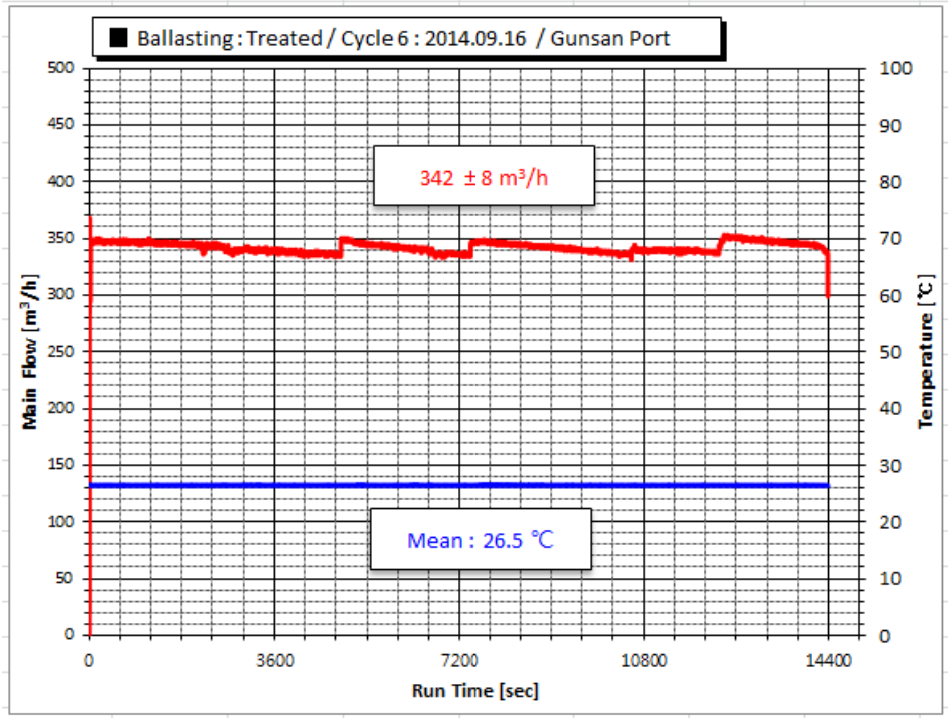




Copyright (c) by HANLA IMS. All rights reserved.

Ⅱ. Operating results of valid test cycles (Cycle 6)

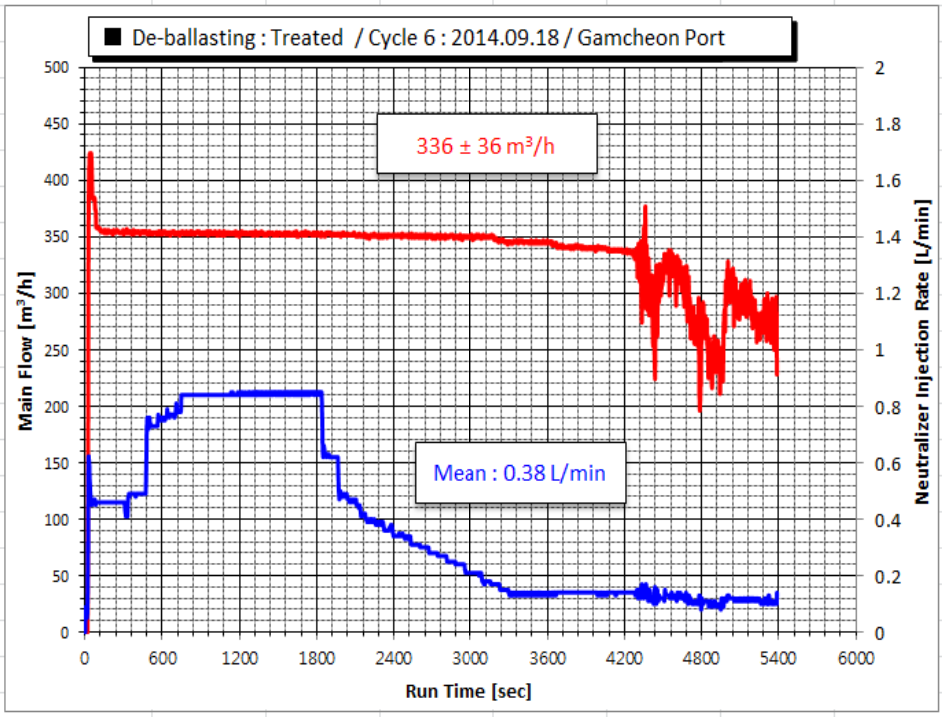
▼ Ballasting : Control (Test conducted by BTP, QA : KIOST)

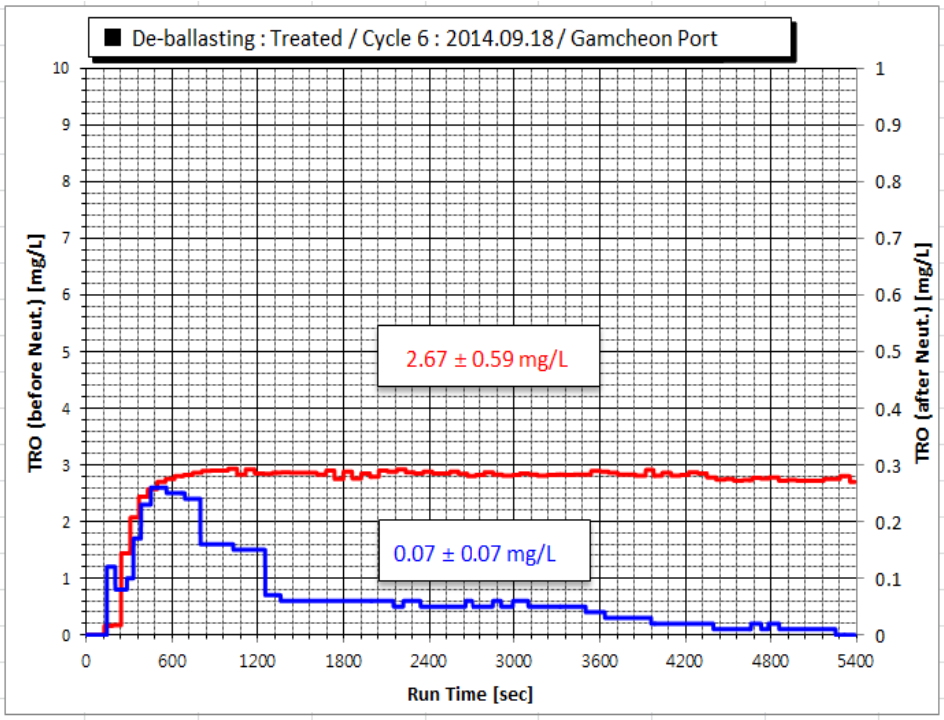


Copyright (c) by HANLA IMS. All rights reserved.

Ⅱ. Operating results of valid test cycles (Cycle 6)

▼ De-ballasting : Treated (Test conducted by BTP, QA : KIOST)

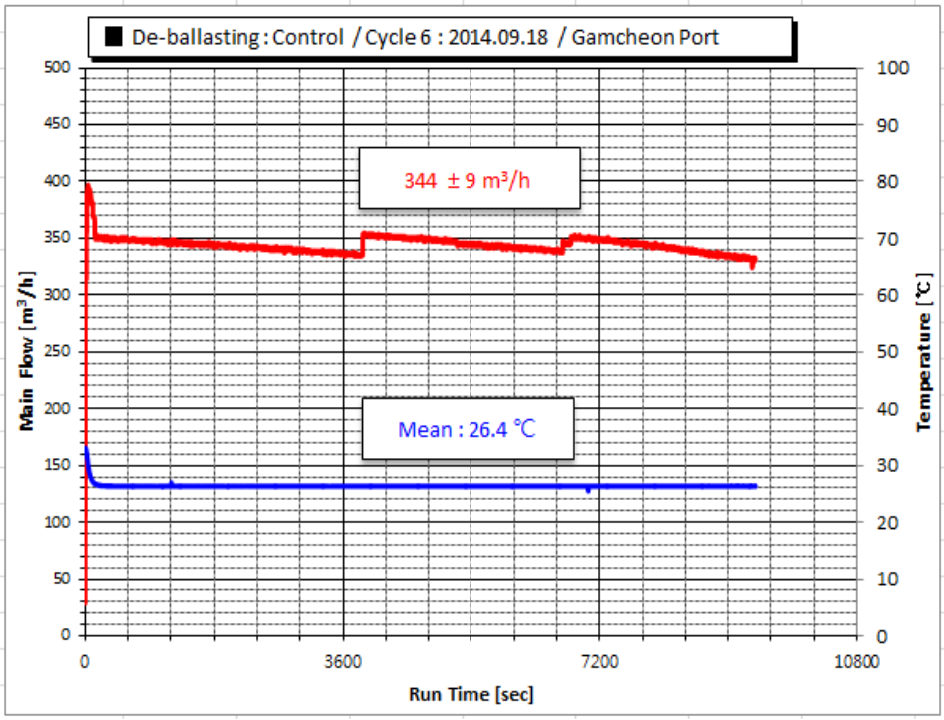




Copyright (c) by HANLA IMS. All rights reserved.

Ⅱ. Operating results of valid test cycles (Cycle 6)

▼ De-ballasting : Control (Test conducted by BTP, QA : KIOST)



Copyright (c) by HANLA IMS. All rights reserved.

Ⅲ. Test Report and Baording List

Copyright (c) by HANLA IMS. All rights reserved.

Ship Name	CHANG YAHNG
IMO No.	9121027
Date	2013 . 12 . 08

Test Report and Boarding List

HANLA IMS

Boarding List

No.	Group	Name	Signature
1	한라IMS(주)	박기영	
2	〃	이성민	
3	〃	서정우	
4	〃	황철연	
5	〃	윤승권	
6	KIOST	안영하	
7	BTP	정시진	
8	〃	강윤영	
9	〃	이재우	
10	〃	오광석	

BALLAST 운용 계획

위도 LATITUDE : 22°26.61N
위도: 경도 LONGITUDE : 114°14.46E

항 차 : 2013 -35 항구 : Hong Kong, To Lo 일시 : 2013 년 12월 08일

배출 / 주입 시						
TANK명	시작시간	종료시간	SOUNDING	잔 량	E/R SENSOR 잔량	VOID SPACE B/G
F.P.T	0230	1400 0911	FULL Cm	M/T	M/T	
NO.1	1828	1540	Full Cm	M/T	M/T	
NO.2(P)	1325 0911	1345 0911	Full Cm	M/T	M/T	
NO.2(S)	1325 0911	1345 0911	Full Cm	M/T	M/T	
NO.3(P)	2130	0240	Full Cm	M/T	M/T	
NO.3(S)	2150	0213	Full Cm	M/T	M/T	
NO.4(P)	19:30	2110	Full Cm	M/T	M/T	
NO.4(S)	19:30	2120	〃 Cm	M/T	M/T	
NO.5(P)	19:30	2110	Full Cm	M/T	M/T	
NO.5(S)	19:30	2120	〃 Cm	M/T	M/T	
A.P.T	21:00	21:50	〃 Cm	M/T	M/T	

하역작업 상황, 조석 간만, 육상 슈트 또는 본선 슈트 간격이상 등의 작업 중단 상황 시에는 필히 기관실에 연락할 것. (연락 즉시 밸러스트작업 중단)

밸러스트 배출시 – 초기 중력배출을 원칙(BOTTOM TANK제외)으로 하며, 이후 또는 시간상의 문제로 PUMP배출시 기관실 CONTROL LEVEL에 의한 EMPTY ALARM 후 일단 중지, 이후 각 TANK의 잔량 STRIPPING 시작, STRIPPING후 각 TANK 측심하여 잔량이 없도록 배출할 것.(STRIPPING 시작 직전 선외 배출 이상 징후를 확인할 수 있도록 갑판 당직자에게 연락 요함.)

밸러스트 주입시 – 초기 중력주입을 원칙으로 하며, 이후 또는 시간상의 문제로 PUMP주입시 기관실 CONTROL LEVEL에 의한 FULL ALARM 후 일시 중지, 이후 각 TANK의 측심 후 부족량 주입. (가능한 한 DECK상 OVERFLOW금지)

추가 지시사항 :

일항사 : 갑판당직사관 : 갑판당직자 :

CHY-0-002F(06/05/05)REV.NO.01

Shipboard Test
(Commissioning Check List)

Date	2013. 12. 08	Ship Name	CHANG YAHNG
Port	HongKong, TOLO	System Name	EcoGuardian™

No.	Check List	Check	
1	주배관의 유량계 및 sampling port 연결 상태 확인 Check connection status of flow meter & sampling port in main ballast line	☑ Good	☐ Not Good
2	필터 전후단 밸브 및 by-pass 밸브 개폐 상태 확인 Check opening and closing conditions of valves (front, rear and by-pass) connected with filter	☑ Good	☐ Not Good
3	전해조 유닛의 입출력 배관 연결 상태 확인 Check opening and closing conditions of isolation valves(inlet, outlet) between ECU(Electrochlorination Unit) and main ballast line	☑ Good	☐ Not Good
4	정류기의 냉각수 배관 연결 상태 확인 Check opening and closing conditions of isolation valves for rectifier cooling line	☑ Good	☐ Not Good
5	중화제 주입 배관 연결 상태 확인 Check opening and closing conditions of isolation valve for neutralizer injection line	☑ Good	☐ Not Good
6	TRO 측정을 위한 sampling 배관 연결 상태 확인 Check connection status about sampling port for measuring TRO value	☑ Good	☐ Not Good
7	중화제 잔량 확인 Check the remaining of neutralizer	☑ Good	☐ Not Good
8	TRO 센서 시약 잔량 및 교체 주기 확인 Check the remaining of TRO sensor agent and the exchanging period	☑ Good	☐ Not Good
9	최초 전원 입력 상태 확인 Check status of main power input	☑ Good	☐ Not Good
10	주배관 유량계 stand-by 확인 Check the stand-by of flow meter in main ballast line	☑ Good	☐ Not Good
11	필터 유닛의 센서 stand-by 확인 Check the stand-by of sensor in AFU(Auto Filter Unit)	☑ Good	☐ Not Good
12	전해조 유닛의 센서 stand-by 확인 Check the stand-by of sensor in ECU(ElectroChlorination Unit)	☑ Good	☐ Not Good
13	중화제 유닛의 센서 stand-by 확인 Check the stand-by of sensor in NEU(Neutralization Unit)	☑ Good	☐ Not Good
14	TRO 센서 유닛의 stand-by 확인 Check the stand-by of TSU(TRO Sensor Unit)	☑ Good	☐ Not Good

Remark

HANLA IMS	Shipboard Test (Ballasting : Treated)		Write	Check	Approval
			서정우	이재욱	안영규

Date	2013 . 12 . 08	Ship Name	CHANG YAHNG
Test Mode	Ballasting : Teated	System Name	EcoGaurdian™
File Name	HL - BT131208	Port	Hong Kong , TOLO
Latitude	22° 26.61N	Longitude	114° 14.46E
Start Time	19 : 01 : 13	Tank Name	NO.4 + NO.5
End Time	21 : 19 : 16	Test Volume	654 m^3
Run Time	02 : 18 : 03	Pump Room Temp.	24.5 °C
Ballast Ppump	ON	Water Temp.	20.7 °C
G/S Pump	OFF	Conductivity	46.6 mS/cm
Main Flow Rate	350 m^3/h	Sampling Time	Beginning / Middle / End
Target TRO	8.1 mg/L		: / : / :
Tb0	480 sec	TRO	mg/L / mg/L / mg/L
Tb1(Cyle)	190 sec		

REMARK

HANLA IMS	Shipboard Test (Ballasting : Control)		Write	Check	Approval
			서준우	이재우	안영규
Date	2013. 12. 08	Ship Name	CHANG YAHNG		
Test Mode	Ballasting : Control	System Name	EcoGaurdian™		
File Name	HL-BC131208	Port	Hong Kong, TOLO		
Latitude	22° 26.61N	Longitude	114° 14.46E		
Start Time	21 : 50 : 00	Tank Name	NO.3		
End Time	02 : 40 : 00	Test Volume	1370 m³		
Run Time	04 : 50 : 00	Pump Room Temp.	24.5 ℃		
Ballast Ppump	ON	Water Temp.	20.7 ℃		
G/S Pump	OFF	Conductivity	46.6 mS/cm		
Main Flow Rate	350 m³/h	Sampling Time	Beginning	Middle	End
			22:05	23:45	02:25

REMARK

Ship Name	CHANG YAHNG
IMO No.	9121027
Date	2014. 05. 21

Test Report and Boarding List

HANLA IMS

Boarding List

No.	Group	Name	Signature
1	한라IMS(주)	김창국	
2	〃	함천언	
3	〃	서준우	
4	〃	이성원	
5	KIOST	현봉기	
6	BTP	김희재	김희재
7	〃	김상현	
8	〃	이지선	
9	〃	박나경	
	〃		

BALLAST 운용 계획

L: 22-36.2A
C: 120-17.1F

항 차 : 20, 항구 : KAOHSIUNG. 일시 : 2014 년 5 월 22 일

배출 / 주입 시						
TANK명	시작시간	종료시간	SOUNDING	잔 량	E/R SENSOR 잔량	VOID SPACE B/G
F.P.T	0850	1055	Full Cm	M/T	M/T	
NO.1	0840	1715	Cm	M/T	M/T	
NO.2(P)	0840	1055	Cm	M/T	M/T	
NO.2(S)	0840	"	Cm	M/T	M/T	
NO.3(P)	1310	1710	Cm	M/T	M/T	
NO.3(S)	1310	1710	Cm	M/T	M/T	
NO.4(P)	0610	0810	Cm	M/T	M/T	
NO.4(S)	0610	"	Cm	M/T	M/T	
NO.5(P)	0610	"	Cm	M/T	M/T	
NO.5(S)	0610	"	Cm	M/T	M/T	
A.P.T			Cm	M/T	M/T	

하역작업 상황, 조석 간만, 육상 슈트 또는 본선 슈트 간격이상 등의 작업 중단 상황 시에는 필히 기관실에 연락할 것. (연락 즉시 밸러스트작업 중단)

밸러스트 배출시 – 초기 중력배출을 원칙(BOTTOM TANK제외)으로 하며, 이후 또는 시간상의 문제로 PUMP배출시 기관실 CONTROL LEVEL에 의한 EMPTY ALARM 후 일단 중지, 이후 각 TANK의 잔량 STRIPPING 시작, STRIPPING후 각 TANK 측심하여 잔량이 없도록 배출할 것.(STRIPPING 시작 직전 선외 배출 이상 징후를 확인할 수 있도록 갑판 당직자에게 연락 요함.)

밸러스트 주입시 – 초기 중력주입을 원칙으로 하며, 이후 또는 시간상의 문제로 PUMP주입시 기관실 CONTROL LEVEL에 의한 FULL ALARM 후 일시 중지, 이후 각 TANK의 측심 후 부족량 주입. (가능한 한 DECK상 OVERFLOW금지)

추가 지시사항 :

일항사 : 갑판당직사관 : 갑판당직자 :

CHY-D-002F(06/05/05)REV.NO.01

BALLAST CONDITION LOG

VOY NO. : 14-13 PORT : KAMISO DATE : 2014. 5 .13

TANK NAME	SOUNDING (Cm)	CAPACYTY (㎥)	DENSITY (S.G)	QUANTITY (M/T)	REMARK
F.P.T	42 Cm	㎥	1.024	1.03 M/T	
NO.1	1 Cm	㎥	〃	0.44 M/T	
NO.2 (P)	1 Cm	㎥	〃	2.60 M/T	
NO.2 (S)	NIL Cm	㎥	〃	NIL M/T	
NO.3 (P)	2 Cm	㎥	〃	3.57 M/T	
NO.3 (S)	1 Cm	㎥	〃	1.78 M/T	
NO.4 (P)	1 Cm	㎥	〃	2.89 M/T	
NO.4 (S)	2 Cm	㎥	〃	5.78 M/T	
NO.5 (P)	2 Cm	㎥	〃	8.08 M/T	
NO.5 (S)	2 Cm	㎥	〃	8.09 M/T	
A.P.T	0 Cm	㎥	〃	0.16 M/T	
SUM TOTAL	Cm	㎥		35. M/T	

REMARK :

* 1.024 × 34.42 ⇒ 35M/T

* Trim by bow ⇒ ~~[illegible]~~ 32 cm

CHIEF OFFICER : [signature]

CHY-D-003F(05/12/31)REV.NO.0

Shipboard Test
(Commissioning Check List)

Date	2014. 05. 22	Ship Name	CHANG YAHNG
Port	Taiwan. Koohsiung	System Name	EcoGuardian™

No.	Check List	Check	
1	주배관의 유량계 및 sampling port 연결 상태 확인 Check connection status of flow meter & sampling port in main ballast line	☑ Good	☐ Not Good
2	필터 전후단 밸브 및 by-pass 밸브 개폐 상태 확인 Check opening and closing conditions of valves (front, rear and by-pass) connected with filter	☑ Good	☐ Not Good
3	전해조 유닛의 입출력 배관 연결 상태 확인 Check opening and closing conditions of isolation valves(inlet, outlet) between ECU(Electrochlorination Unit) and main ballast line	☑ Good	☐ Not Good
4	정류기의 냉각수 배관 연결 상태 확인 Check opening and closing conditions of isolation valves for rectifier cooling line	☑ Good	☐ Not Good
5	중화제 주입 배관 연결 상태 확인 Check opening and closing conditions of isolation valve for neutralizer injection line	☑ Good	☐ Not Good
6	TRO 측정을 위한 sampling 배관 연결 상태 확인 Check connection status about sampling port for measuring TRO value	☑ Good	☐ Not Good
7	중화제 잔량 확인 Check the remaining of neutralizer	☑ Good	☐ Not Good
8	TRO 센서 시약 잔량 및 교체 주기 확인 Check the remaining of TRO sensor agent and the exchanging period	☐ Good	☑ Not Good
9	최초 전원 입력 상태 확인 Check status of main power input	☑ Good	☐ Not Good
10	주배관 유량계 stand-by 확인 Check the stand-by of flow meter in main ballast line	☑ Good	☐ Not Good
11	필터 유닛의 센서 stand-by 확인 Check the stand-by of sensor in AFU(Auto Filter Unit)	☑ Good	☐ Not Good
12	전해조 유닛의 센서 stand-by 확인 Check the stand-by of sensor in ECU(ElectroChlorination Unit)	☑ Good	☐ Not Good
13	중화제 유닛의 센서 stand-by 확인 Check the stand-by of sensor in NEU(Neutralization Unit)	☑ Good	☐ Not Good
14	TRO 센서 유닛의 stand-by 확인 Check the stand-by of TSU(TRO Sensor Unit)	☑ Good	☐ Not Good

Remark

8. TRO Sensor agent replaced.

HANLA IMS	Shipboard Test (Ballasting:Treated)		Write	Check	Approval
			서종우	김한기	정병길

Date	2014. 05. 22	Ship Name	CHANG YAHNG		
Test Mode	Ballasting : Treated	System Name	EcoGuardian™		
File Name	HLBT_140522	Port	대 만 항		
Latitude	22° 36.2 N	Longitude	120° 17.1 E		
Start Time	07 : 08 : 18	Tank Name	No.4 + No.5		
End Time	08 : 57 : 44	Test Volume	654 ton		
Run Time	01 : 49 : 25	Pump Room Temp.	33 ℃		
Ballast Pump	ON	Water Temp.	28 ℃		
GS Pump	OFF	Conductivity	45.9 mS/cm		
Main Flow Rate	350 m³/h		Beginning	Middle	End
Target TRO	8.1 mg/L	Sampling Time	:	:	:
Tb0	480 sec	TRO	mg/L	mg/L	mg/L
Tb1(Cycle)	190 sec				

Remark

HANLA IMS	Shipboard Test (Ballasting:Control)		Write	Check	Approval
			서근우	김의정	정병기
Date	2014 . 05 . 22	Ship Name	CHANG YAHNG		
Test Mode	Ballasting:Control	System Name	EcoGuardian™		
File Name	HL BC - 140522	Tank Name	NO. 3		
Latitude	22° 36.2 N	Longitude	120° 19.1 E		
Port	대 만 항	Test Volume	1278 ton		
Start Time	14 : 10 : 41	Pump Room Temp.	34 °C		
End Time	18 : 10 : 20	Water Temp.	30.2 °C		
Run Time	03 : 59 : 39	Conductivity	mS/cm		
Ballast Pump	ON		Beginning	Middle	End
GS Pump	OFF	Sampling Time	14:54	16:00	17:06
Main Flow Rate	350 m³/h				

Remark

Ship Name	CHANG YAHNG
IMO No.	9121027
Date	2014.05.28

Test Report and Boarding List

HANLA IMS

Boarding List

No.	Group	Name	Signature
1	한라IMS(주)	김창국	
2	〃	황철연	
3	〃	서진우	
4	〃	이성연	
5	㈜KIOST	권봉길	
6	BTP	강희재	
7	〃	이지선	
8	〃	이명희	
9	〃	박나경	
10	〃	이성국	

BALLAST 운용 계획

위도 35° 04.492N
경도 128° 59.708E

항 차 : 2014.05.28 항구 : BUSAN

일시 : 2014 년 05 월 28 일

배출 / 주입 시						
TANK명	시작시간	종료시간	SOUNDING	잔 량	E/R SENSOR 잔량	VOID SPACE B/G
F.P.T	21:05	22:45	Full Cm	M/T	M/T	
NO.1	21:05	00:20	Full Cm	M/T	M/T	
NO.2(P)	〃	22:10	Full Cm	M/T	M/T	
NO.2(S)	〃	22:10	Full Cm	M/T	M/T	
NO.3(P)	17:00	21:00	Full Cm	M/T	M/T	
NO.3(S)	17:00	21:00	FULL Cm	M/T	M/T	
NO.4(P)	14:55	16:55	Full Cm	M/T	M/T	
NO.4(S)	〃	〃	Full Cm	M/T	M/T	
NO.5(P)	14:55	16:55	Full Cm	M/T	M/T	
NO.5(S)	〃		Full Cm	M/T	M/T	
A.P.T	07:20 29.05	~~29.05~~ 05:05	Full Cm	M/T	M/T	

하역작업 상황, 조석 간만, 육상 슈트 또는 본선 슈트 간격이상 등의 작업 중단 상황 시에는 필히 기관실에 연락할 것. (연락 즉시 밸러스트작업 중단)

밸러스트 배출시 – 초기 중력배출을 원칙(BOTTOM TANK제외)으로 하며, 이후 또는 시간상의 문제로 PUMP배출시 기관실 CONTROL LEVEL에 의한 EMPTY ALARM 후 일단 중지, 이후 각 TANK의 잔량 STRIPPING 시작, STRIPPING후 각 TANK 측심하여 잔량이 없도록 배출할 것.(STRIPPING 시작 직전 선외 배출 이상 징후를 확인할 수 있도록 갑판 당직자에게 연락 요함.)

밸러스트 주입시 – 초기 중력주입을 원칙으로 하며, 이후 또는 시간상의 문제로 PUMP주입시 기관실 CONTROL LEVEL에 의한 FULL ALARM 후 일시 중지, 이후 각 TANK의 측심 후 부족량 주입. (가능한 한 DECK상 OVERFLOW금지)

추가 지시사항 :

일항사 : 갑판당직사관 : / 갑판당직자 : /

CHY-D-002F(06/05/05)REV.NO.01

Shipboard Test
(Commissioning Check List)

Date	2014. 05. 28	Ship Name	CHANG YAHNG
Port	Korea, Busan	System Name	EcoGuardian™

No.	Check List	Check	
1	주배관의 유량계 및 sampling port 연결 상태 확인 Check connection status of flow meter & sampling port in main ballast line	☑ Good	☐ Not Good
2	필터 전후단 밸브 및 by-pass 밸브 개폐 상태 확인 Check opening and closing conditions of valves (front, rear and by-pass) connected with filter	☑ Good	☐ Not Good
3	전해조 유닛의 입출력 배관 연결 상태 확인 Check opening and closing conditions of isolation valves(inlet, outlet) between ECU(Electrochlorination Unit) and main ballast line	☑ Good	☐ Not Good
4	정류기의 냉각수 배관 연결 상태 확인 Check opening and closing conditions of isolation valves for rectifier cooling line	☑ Good	☐ Not Good
5	중화제 주입 배관 연결 상태 확인 Check opening and closing conditions of isolation valve for neutralizer injection line	☑ Good	☐ Not Good
6	TRO 측정을 위한 sampling 배관 연결 상태 확인 Check connection status about sampling port for measuring TRO value	☑ Good	☐ Not Good
7	중화제 잔량 확인 Check the remaining of neutralizer	☑ Good	☐ Not Good
8	TRO 센서 시약 잔량 및 교체 주기 확인 Check the remaining of TRO sensor agent and the exchanging period	☑ Good	☐ Not Good
9	최초 전원 입력 상태 확인 Check status of main power input	☑ Good	☐ Not Good
10	주배관 유량계 stand-by 확인 Check the stand-by of flow meter in main ballast line	☑ Good	☐ Not Good
11	필터 유닛의 센서 stand-by 확인 Check the stand-by of sensor in AFU(Auto Filter Unit)	☑ Good	☐ Not Good
12	전해조 유닛의 센서 stand-by 확인 Check the stand-by of sensor in ECU(ElectroChlorination Unit)	☑ Good	☐ Not Good
13	중화제 유닛의 센서 stand-by 확인 Check the stand-by of sensor in NEU(Neutralization Unit)	☑ Good	☐ Not Good
14	TRO 센서 유닛의 stand-by 확인 Check the stand-by of TSU(TRO Sensor Unit)	☑ Good	☐ Not Good

Remark

HANLA IMS	Shipboard Test (Ballasting:Treated)		Write	Check	Approval
			서정우	김희재 김남재	김병기
Date	2014 . 05 . 28	Ship Name	CHANG YAHNG		
Test Mode	Ballasting : Treated	System Name	EcoGuardian™		
File Name	HL BT _ 140528	Port	부산 감천항		
Latitude	35° 04 . 492 N	Longitude	128° 59 . 708 E		
Start Time	14 : 58 : 11	Tank Name	No.4 + No.5		
End Time	16 : 51 : 19	Test Volume	654 ton		
Run Time	01 : 53 : 08	Pump Room Temp.	23.5 ℃		
Ballast Pump	ON	Water Temp.	21 . 2 ℃		
GS Pump	OFF	Conductivity	49.4 mS/cm		
Main Flow Rate	350 m^3/h		Beginning	Middle	End
Target TRO	8.1 mg/L	Sampling Time	*	*	*
Tb0	480 sec	TRO	mg/L	mg/L	mg/L
Tb1(Cycle)	190 sec				

Remark

HANLA IMS	Shipboard Test (Ballasting:Control)		Write	Check	Approval
			서효우	김호NO	정봉길

Date	2014 . 05 . 28	Ship Name	CHANG YAHNG		
Test Mode	Ballasting:Control	System Name	EcoGuardian™		
File Name	HL BC-140528	Tank Name	NO.3		
Latitude	35°04.492N	Longitude	128°59.708 E		
Port	부산 감천항	Test Volume	1278 ton		
Start Time	17 : 00 : 35	Pump Room Temp.	21.4 °C		
End Time	21 : 02 : 29	Water Temp.	20.9 °C		
Run Time	04 : 01 : 54	Conductivity	mS/cm		
Ballast Pump	ON		Beginning	Middle	End
GS Pump	OFF	Sampling Time	17:44	18:50	19:56
Main Flow Rate	350 m³/h				

Remark

Ship Name	CHANG YAHNG
IMO No.	9121027
Date	2014. 5. 29

Test Report and Boarding List

HANLA IMS

Boarding List

No.	Group	Name	Signature
1	한라IMS(주)	김 창 국	
2	〃	이 성 민	
3	〃	서 진 우	
4	〃	황 철 연	
5	한국해양과학기술원	정 홍 길	
6	〃	이 우 진	
7	BTP	이 지 선	
8	BTP	김 한 나	
9	BTP	이 명 희	
10	〃	이 석 국	
11	〃	홍 영 관	
12	〃	서 효 진	
13	〃	박 나 경	
14	〃	이 선 욱	

Shipboard Test
(Commissioning Check List)

Date	2014. 05. 29	Ship Name	CHANG YAHNG
Port	Korea, Dong Hae	System Name	EcoGuardian™

No.	Check List	Check	
1	주배관의 유량계 및 sampling port 연결 상태 확인 Check connection status of flow meter & sampling port in main ballast line	☑ Good	☐ Not Good
2	필터 전후단 밸브 및 by-pass 밸브 개폐 상태 확인 Check opening and closing conditions of valves (front, rear and by-pass) connected with filter	☑ Good	☐ Not Good
3	전해조 유닛의 입출력 배관 연결 상태 확인 Check opening and closing conditions of isolation valves(inlet, outlet) between ECU(Electrochlorination Unit) and main ballast line	☑ Good	☐ Not Good
4	정류기의 냉각수 배관 연결 상태 확인 Check opening and closing conditions of isolation valves for rectifier cooling line	☑ Good	☐ Not Good
5	중화제 주입 배관 연결 상태 확인 Check opening and closing conditions of isolation valve for neutralizer injection line	☑ Good	☐ Not Good
6	TRO 측정을 위한 sampling 배관 연결 상태 확인 Check connection status about sampling port for measuring TRO value	☑ Good	☐ Not Good
7	중화제 잔량 확인 Check the remaining of neutralizer	☑ Good	☐ Not Good
8	TRO 센서 시약 잔량 및 교체 주기 확인 Check the remaining of TRO sensor agent and the exchanging period	☑ Good	☐ Not Good
9	최초 전원 입력 상태 확인 Check status of main power input	☑ Good	☐ Not Good
10	주배관 유량계 stand-by 확인 Check the stand-by of flow meter in main ballast line	☑ Good	☐ Not Good
11	필터 유닛의 센서 stand-by 확인 Check the stand-by of sensor in AFU(Auto Filter Unit)	☑ Good	☐ Not Good
12	전해조 유닛의 센서 stand-by 확인 Check the stand-by of sensor in ECU(ElectroChlorination Unit)	☑ Good	☐ Not Good
13	중화제 유닛의 센서 stand-by 확인 Check the stand-by of sensor in NEU(Neutralization Unit)	☑ Good	☐ Not Good
14	TRO 센서 유닛의 stand-by 확인 Check the stand-by of TSU(TRO Sensor Unit)	☑ Good	☐ Not Good

Remark

HANLA IMS	Shipboard Test (Deballasting:Control)		Write	Check	Approval
			서종욱	김태기	최종고
Date	2014. 05. 29	Ship Name	CHANG YAHNG		
Test Mode	Deballasting:Control	System Name	EcoGuardian™		
File Name	HL DC - 140529	Tank Name	NO. 3		
Latitude	37° 29.4 N	Longitude	129° 08.0 E		
Port	동 해 항	Test Volume	1287 ton		
Start Time	23 : 48 : 28	Pump Room Temp.	25.8 °C		
End Time	02 : 48 : 15	Water Temp.	20.4 °C		
Run Time	02 : 59 : 47	Conductivity	mS/cm		
Ballast Pump	ON		Beginning	Middle	End
GS Pump	OFF	Sampling Time	24 : 32	01 : 38	02 : 44
Main Flow Rate	350 m³/h				

Remark

HANLA IMS	Shipboard Test (Deballasting:Treated)		Write	Check	Approval
			서정우	강희재	권홍길
				강희재	

Date	2014 . 05 . 30	Ship Name	CHANG YAHNG
Test Mode	Deballasting:Treated	System Name	EcoGuardian™
File Name	HL DT_140530	Port	동 해 항
Latitude	37° 29.4 N	Longitude	129° 08.0 E
Start Time	03 : 35 : 05	Tank Name	NO.4 + NO.5
End Time	04 : 59 : 43	Test Volume	654 ton
Run Time	01 : 24 : 38	Pump Room Temp.	25.1 ℃
Ballast Pump	ON	Water Temp.	20.2 ℃
GS Pump	OFF	Conductivity	mS/cm
Main Flow Rate	350 m³/h		
Initial TRO	9.0 mg/L	Sampling Time	
Cn	24.82 %	TRO(Before)	
SR	3.0 times		
Td0	360 sec	TRO(After)	
Td1	300 sec		

	Beginning	Middle	End
Sampling Time	03 : 39	04 : 06	04 : 33
TRO(Before)	5.53 mg/L	5.58 mg/L	5.56 mg/L
TRO(After)	0.07 mg/L	0.09 mg/L	0.08 mg/L

Remark

Ship Name	CHANG YAHNG
IMO No.	9121027
Date	2014 . 06 . 22

Test Report and Boarding List

HANLA IMS

Boarding List

No.	Group	Name	Signature
1	한라IMS(주)	김창국	
2	〃	이종태	
3	〃	함천연	
4	〃	서준우	
5	〃	황승용	
6	〃	이성민	
7	KIOST	서민호	
8	BTP	김병기	김병기
9	〃	이지호	
10	〃	이선욱	
11	〃	이명희	

BALLAST 운용 계획

항 차 : 20, 항구 : Donghae (L: 37°-29.45 N / λ: 129°-08.00 E) 일시 : 2014 년 06 월 19 일

배출 / 주입 시						
TANK명	시작시간	종료시간	SOUNDING	잔 량	E/R SENSOR 잔량	VOID SPACE B/G
F.P.T	0080	0935	83 Cm	M/T	M/T	
NO.1		05:20	8 Cm	M/T	M/T	
NO.2(P)		03:55	3 Cm	M/T	M/T	
NO.2(S)		08.55	4 Cm	M/T	M/T	
NO.3(P)		0880	2 Cm	M/T	M/T	
NO.3(S)		07:10	4 Cm	M/T	M/T	
NO.4(P)		06:20	4 Cm	M/T	M/T	
NO.4(S)		06:20	4 Cm	M/T	M/T	
NO.5(P)		07:05	5 Cm	M/T	M/T	
NO.5(S)		07:50	6 Cm	M/T	M/T	
A.P.T	0080	0935	5 Cm	M/T	M/T	

0080 PUMP

하역작업 상황, 조석 간만, 육상 슈트 또는 본선 슈트 간격이상 등의 작업 중단 상황 시에는 필히 기관실에 연락할 것. (연락 즉시 밸러스트작업 중단)

밸러스트 배출시 – 초기 중력배출을 원칙(BOTTOM TANK제외)으로 하며, 이후 또는 시간상의 문제로 PUMP배출시 기관실 CONTROL LEVEL에 의한 EMPTY ALARM 후 일단 중지, 이후 각 TANK의 잔량 STRIPPING 시작, STRIPPING후 각 TANK 측심하여 잔량이 없도록 배출할 것.(STRIPPING 시작 직전 선외 배출 이상 징후를 확인할 수 있도록 갑판 당직자에게 연락 요함.)

밸러스트 주입시 – 초기 중력주입을 원칙으로 하며, 이후 또는 시간상의 문제로 PUMP주입시 기관실 CONTROL LEVEL에 의한 FULL ALARM 후 일시 중지, 이후 각 TANK의 측심 후 부족량 주입. (가능한 한 DECK상 OVERFLOW금지)

추가 지시사항 :

일항사 : 갑판당직사관 : 갑판당직자 :

CHY-D-002F(06/05/05)REV.NO.01

Shipboard Test
(Commissioning Check List)

Date	2014 . 06 . 22	Ship Name	CHANG YAHNG
Port	Korea , Gun San	System Name	EcoGuardian™

No.	Check List	Check	
1	주배관의 유량계 및 sampling port 연결 상태 확인 Check connection status of flow meter & sampling port in main ballast line	☑ Good	☐ Not Good
2	필터 전후단 밸브 및 by-pass 밸브 개폐 상태 확인 Check opening and closing conditions of valves (front, rear and by-pass) connected with filter	☑ Good	☐ Not Good
3	전해조 유닛의 입출력 배관 연결 상태 확인 Check opening and closing conditions of isolation valves(inlet, outlet) between ECU(Electrochlorination Unit) and main ballast line	☑ Good	☐ Not Good
4	정류기의 냉각수 배관 연결 상태 확인 Check opening and closing conditions of isolation valves for rectifier cooling line	☑ Good	☐ Not Good
5	중화제 주입 배관 연결 상태 확인 Check opening and closing conditions of isolation valve for neutralizer injection line	☑ Good	☐ Not Good
6	TRO 측정을 위한 sampling 배관 연결 상태 확인 Check connection status about sampling port for measuring TRO value	☑ Good	☐ Not Good
7	중화제 잔량 확인 Check the remaining of neutralizer	☑ Good	☐ Not Good
8	TRO 센서 시약 잔량 및 교체 주기 확인 Check the remaining of TRO sensor agent and the exchanging period	☑ Good	☐ Not Good
9	최초 전원 입력 상태 확인 Check status of main power input	☑ Good	☐ Not Good
10	주배관 유량계 stand-by 확인 Check the stand-by of flow meter in main ballast line	☑ Good	☐ Not Good
11	필터 유닛의 센서 stand-by 확인 Check the stand-by of sensor in AFU(Auto Filter Unit)	☑ Good	☐ Not Good
12	전해조 유닛의 센서 stand-by 확인 Check the stand-by of sensor in ECU(ElectroChlorination Unit)	☑ Good	☐ Not Good
13	중화제 유닛의 센서 stand-by 확인 Check the stand-by of sensor in NEU(Neutralization Unit)	☑ Good	☐ Not Good
14	TRO 센서 유닛의 stand-by 확인 Check the stand-by of TSU(TRO Sensor Unit)	☑ Good	☐ Not Good

Remark

HANLA IMS	Shipboard Test (Ballasting:Treated)		Write	Check	Approval
			서준우	이영국	서범호
Date	2014 . 06.22	Ship Name	CHANG YAHNG		
Test Mode	Ballasting : Treated	System Name	EcoGuardian™		
File Name	HL_BT_140622_2	Port	군산항		
Latitude	35° 58.322 N	Longitude	126° 37.095 E		
Start Time	10 : 48 : 58	Tank Name	NO.4 + NO.5		
End Time	11 : 53 : 25	Test Volume	385 ton		
Run Time	01 : 04 : 27	Pump Room Temp.	30.6 °C		
Ballast Pump	ON	Water Temp.	23.7 °C		
GS Pump	OFF	Conductivity	41.6 mS/cm		
Main Flow Rate	350 m³/h		Beginning	Middle	End
Target TRO	8.1 mg/L	Sampling Time	:	:	:
Tb0	480 sec	TRO	mg/L	mg/L	mg/L
Tb1(Cycle)	190 sec				

Remark

HANLA IMS	Shipboard Test (Ballasting:Control)		Write	Check	Approval
			서정아	이선욱	서범조
Date	2014 . 06 . 22	Ship Name	CHANG YAHNG		
Test Mode	Ballasting:Control	System Name	EcoGuardian™		
File Name	HL-BC-140622	Tank Name	NO. 3		
Latitude	35° 58. 322 N	Longitude	126° 37. 095 E		
Port	군산항	Test Volume	1278 ton		
Start Time	12 : 10 : 01	Pump Room Temp.	31.2 °C		
End Time	16 : 12 : 17	Water Temp.	25.5 °C		
Run Time	04 : 02 : 16	Conductivity	mS/cm		
Ballast Pump	ON		Beginning	Middle	End
GS Pump	OFF	Sampling Time	12:54	14:00	15:06
Main Flow Rate	350 m³/h				

Remark

Ship Name	CHANG YAHNG
IMO No.	9121027
Date	2014. 07. 21

Test Report and Boarding List

HANLA IMS

Boarding List

No.	Group	Name	Signature
1	한라IMS(주)	김창국	
2	〃	서진우	
3	〃	이성민	
4	〃	황철연	
5	KIOST	권봉길	
6	BTP	김상현	
7	〃	이석주	
8	〃	이선욱	
9	〃	이명희	
10			

Shipboard Test
(Commissioning Check List)

Date	2014.07.21	Ship Name	CHANG YAHNG
Port	Hong Kong, TOLO	System Name	EcoGuardian™

No.	Check List	Check	
1	주배관의 유량계 및 sampling port 연결 상태 확인 Check connection status of flow meter & sampling port in main ballast line	☑ Good	☐ Not Good
2	필터 전후단 밸브 및 by-pass 밸브 개폐 상태 확인 Check opening and closing conditions of valves (front, rear and by-pass) connected with filter	☑ Good	☐ Not Good
3	전해조 유닛의 입출력 배관 연결 상태 확인 Check opening and closing conditions of isolation valves(inlet, outlet) between ECU(Electrochlorination Unit) and main ballast line	☑ Good	☐ Not Good
4	정류기의 냉각수 배관 연결 상태 확인 Check opening and closing conditions of isolation valves for rectifier cooling line	☑ Good	☐ Not Good
5	중화제 주입 배관 연결 상태 확인 Check opening and closing conditions of isolation valve for neutralizer injection line	☑ Good	☐ Not Good
6	TRO 측정을 위한 sampling 배관 연결 상태 확인 Check connection status about sampling port for measuring TRO value	☑ Good	☐ Not Good
7	중화제 잔량 확인 Check the remaining of neutralizer	☑ Good	☐ Not Good
8	TRO 센서 시약 잔량 및 교체 주기 확인 Check the remaining of TRO sensor agent and the exchanging period	☑ Good	☐ Not Good
9	최초 전원 입력 상태 확인 Check status of main power input	☑ Good	☐ Not Good
10	주배관 유량계 stand-by 확인 Check the stand-by of flow meter in main ballast line	☑ Good	☐ Not Good
11	필터 유닛의 센서 stand-by 확인 Check the stand-by of sensor in AFU(Auto Filter Unit)	☑ Good	☐ Not Good
12	전해조 유닛의 센서 stand-by 확인 Check the stand-by of sensor in ECU(ElectroChlorination Unit)	☑ Good	☐ Not Good
13	중화제 유닛의 센서 stand-by 확인 Check the stand-by of sensor in NEU(Neutralization Unit)	☑ Good	☐ Not Good
14	TRO 센서 유닛의 stand-by 확인 Check the stand-by of TSU(TRO Sensor Unit)	☑ Good	☐ Not Good

Remark

HANLA IMS	Shipboard Test (Ballasting:Treated)		Write	Check	Approval
			서경수	이성록	정호근
Date	2014.07.21	Ship Name	CHANG YAHNG		
Test Mode	Ballasting : Treated	System Name	EcoGuardian™		
File Name	HL_BT_140721	Port	홍콩 Tolo		
Latitude	22° 26. 619 N	Longitude	114° 14. 513 E		
Start Time	11 : 40 : 25	Tank Name	NO.4 + NO.5		
End Time	13 : 35 : 39	Test Volume	654		
Run Time	01 : 55 : 14	Pump Room Temp.	38 ℃		
Ballast Pump	ON	Water Temp.	31.4 ℃		
GS Pump	OFF	Conductivity	43.0 mS/cm		
Main Flow Rate	350 m³/h		Beginning	Middle	End
Target TRO	8.1 mg/L	Sampling Time	:	:	:
Tb0	480 sec	TRO	mg/L	mg/L	mg/L
Tb1(Cycle)	190 sec				

Remark

HANLA IMS	Shipboard Test (Ballasting:Control)		Write	Check	Approval
			서경수	이성욱	정봉기
Date	2014. 07. 21	Ship Name	CHANG YAHNG		
Test Mode	Ballasting:Control	System Name	EcoGuardian™		
File Name	HL_BC_140721	Tank Name	NO. 3		
Latitude	22° 26. 619 N	Longitude	114° 14. 513 E		
Port	홍콩 ToLo	Test Volume	1208 ton		
Start Time	14 : 00 : 01	Pump Room Temp.	38 °C		
End Time	18 : 04 : 52	Water Temp.	31.5 °C		
Run Time	4 : 4 : 51	Conductivity	mS/cm		
Ballast Pump	ON		Beginning	Middle	End
GS Pump	OFF	Sampling Time	14 : 44	15 : 50	16 : 56
Main Flow Rate	350 m³/h				

Remark

Ship Name	CHANG YAHNG
IMO No.	9121027
Date	2014.07.23

Test Report and Boarding List

HANLA IMS

Boarding List

No.	Group	Name	Signature
1	한라IMS(주)	김창국	
2	〃	황철연	
3	〃	서준우	
4	〃	이성민	
5	BTP	이명헌	
6	BTP	김상현	
7	〃	이민욱	
8	〃	이지선	
9	〃	강희재	
10	〃	이보국	
11	KIOST	현봉길	

Shipboard Test
(Commissioning Check List)

Date	2014. 07.23	Ship Name	CHANG YAHNG
Port	Hong Kong, TOLO	System Name	EcoGuardian™

No.	Check List	Check	
1	주배관의 유량계 및 sampling port 연결 상태 확인 Check connection status of flow meter & sampling port in main ballast line	☑ Good	☐ Not Good
2	필터 전후단 밸브 및 by-pass 밸브 개폐 상태 확인 Check opening and closing conditions of valves (front, rear and by-pass) connected with filter	☑ Good	☐ Not Good
3	전해조 유닛의 입출력 배관 연결 상태 확인 Check opening and closing conditions of isolation valves(inlet, outlet) between ECU(Electrochlorination Unit) and main ballast line	☑ Good	☐ Not Good
4	정류기의 냉각수 배관 연결 상태 확인 Check opening and closing conditions of isolation valves for rectifier cooling line	☑ Good	☐ Not Good
5	중화제 주입 배관 연결 상태 확인 Check opening and closing conditions of isolation valve for neutralizer injection line	☑ Good	☐ Not Good
6	TRO 측정을 위한 sampling 배관 연결 상태 확인 Check connection status about sampling port for measuring TRO value	☑ Good	☐ Not Good
7	중화제 잔량 확인 Check the remaining of neutralizer	☑ Good	☐ Not Good
8	TRO 센서 시약 잔량 및 교체 주기 확인 Check the remaining of TRO sensor agent and the exchanging period	☑ Good	☐ Not Good
9	최초 전원 입력 상태 확인 Check status of main power input	☑ Good	☐ Not Good
10	주배관 유량계 stand-by 확인 Check the stand-by of flow meter in main ballast line	☑ Good	☐ Not Good
11	필터 유닛의 센서 stand-by 확인 Check the stand-by of sensor in AFU(Auto Filter Unit)	☑ Good	☐ Not Good
12	전해조 유닛의 센서 stand-by 확인 Check the stand-by of sensor in ECU(ElectroChlorination Unit)	☑ Good	☐ Not Good
13	중화제 유닛의 센서 stand-by 확인 Check the stand-by of sensor in NEU(Neutralization Unit)	☑ Good	☐ Not Good
14	TRO 센서 유닛의 stand-by 확인 Check the stand-by of TSU(TRO Sensor Unit)	☑ Good	☐ Not Good

Remark

HANLA IMS	Shipboard Test (Deballasting:Treated)		Write	Check	Approval
			서정수	이명훈	홍봉식

Date	2014 . 07. 23	Ship Name	CHANG YAHNG		
Test Mode	Deballasting:Treated	System Name	EcoGuardian™		
File Name	HL-DT-140723	Port	홍콩(Tolo)		
Latitude	22° 26. 619 N	Longitude	114° 14. 513 E		
Start Time	17 : 40 : 01	Tank Name	NO.4+NO.5		
End Time	19 : 18 : 14	Test Volume	654 ton		
Run Time	01 : 38 : 14	Pump Room Temp.	38 °C		
Ballast Pump	ON	Water Temp.	34.5 °C		
GS Pump	OFF	Conductivity	mS/cm		
Main Flow Rate	350 m³/h		Beginning	Middle	End
Initial TRO	9.0 mg/L	Sampling Time	17:44	18:29	18:38
Cn	24.82 %	TRO(Before)	mg/L	mg/L	mg/L
SR	3.0 times				
Td0	360 sec	TRO(After)	mg/L	mg/L	mg/L
Td1	300 sec				

Remark

HANLA IMS	Shipboard Test (Deballasting:Control)		Write	Check	Approval
			서경수	이민욱	현봉길
Date	2014.07.23	Ship Name	CHANG YAHNG		
Test Mode	Deballasting:Control	System Name	EcoGuardian™		
File Name	HL_DC_140723	Tank Name	NO.3		
Latitude	22° 26.619 N	Longitude	114° 14.513 E		
Port	홍콩 (Tolo)	Test Volume	1287		
Start Time	13 : 40 : 00	Pump Room Temp.	38 ℃		
End Time	17 : 14 : 34	Water Temp.	34.9 ℃		
Run Time	03 : 35 : 35	Conductivity	mS/cm		
Ballast Pump	ON		Beginning	Middle	End
GS Pump	OFF	Sampling Time	14:14	15:20	16:26
Main Flow Rate	350 m³/h				

Remark

Ship Name	CHANG YAHNG
IMO No.	9121027
Date	2014.09.15

Test Report and Boarding List

HANLA IMS

Boarding List

No.	Group	Name	Signature
1	한라IMS	김창국	
2	〃	이준호	
3	〃	이성민	
4	〃	이준태	
5	〃	서재우	
6	〃	황천연	
7	KIOST	서빈호	
8	BTP	이석곤	
9	〃	김민지	
10	〃	박나경	

Shipboard Test
(Commissioning Check List)

Date	2014. 09. 15	Ship Name	CHANG YAHNG
Port	Korea, Gun San	System Name	EcoGuardian™

No.	Check List	Check	
1	주배관의 유량계 및 sampling port 연결 상태 확인 Check connection status of flow meter & sampling port in main ballast line	☑ Good	☐ Not Good
2	필터 전후단 밸브 및 by-pass 밸브 개폐 상태 확인 Check opening and closing conditions of valves (front, rear and by-pass) connected with filter	☑ Good	☐ Not Good
3	전해조 유닛의 입출력 배관 연결 상태 확인 Check opening and closing conditions of isolation valves(inlet, outlet) between ECU(Electrochlorination Unit) and main ballast line	☑ Good	☐ Not Good
4	정류기의 냉각수 배관 연결 상태 확인 Check opening and closing conditions of isolation valves for rectifier cooling line	☑ Good	☐ Not Good
5	중화제 주입 배관 연결 상태 확인 Check opening and closing conditions of isolation valve for neutralizer injection line	☑ Good	☐ Not Good
6	TRO 측정을 위한 sampling 배관 연결 상태 확인 Check connection status about sampling port for measuring TRO value	☑ Good	☐ Not Good
7	중화제 잔량 확인 Check the remaining of neutralizer	☑ Good	☐ Not Good
8	TRO 센서 시약 잔량 및 교체 주기 확인 Check the remaining of TRO sensor agent and the exchanging period	☑ Good	☐ Not Good
9	최초 전원 입력 상태 확인 Check status of main power input	☑ Good	☐ Not Good
10	주배관 유량계 stand-by 확인 Check the stand-by of flow meter in main ballast line	☑ Good	☐ Not Good
11	필터 유닛의 센서 stand-by 확인 Check the stand-by of sensor in AFU(Auto Filter Unit)	☑ Good	☐ Not Good
12	전해조 유닛의 센서 stand-by 확인 Check the stand-by of sensor in ECU(ElectroChlorination Unit)	☑ Good	☐ Not Good
13	중화제 유닛의 센서 stand-by 확인 Check the stand-by of sensor in NEU(Neutralization Unit)	☑ Good	☐ Not Good
14	TRO 센서 유닛의 stand-by 확인 Check the stand-by of TSU(TRO Sensor Unit)	☑ Good	☐ Not Good

Remark

HANLA IMS	Shipboard Test (Ballasting:Treated)		Write	Check	Approval
			김창국	이[illegible]	허[illegible]
Date	2014 . 09. 15	Ship Name	CHANG YAHNG		
Test Mode	Ballasting : Treated	System Name	EcoGuardian™		
File Name	HL-BT-140915	Port	군 산 항		
Latitude	35° 58.322 N	Longitude	126° 37.095 E		
Start Time	20 : 45 : 36	Tank Name	NO.4 + NO.5		
End Time	22 : 42 : 07	Test Volume	654		
Run Time	01 : 56 : 31	Pump Room Temp.	28 °C		
Ballast Pump	ON	Water Temp.	26.6 °C		
GS Pump	OFF	Conductivity	41.5 mS/cm		
Main Flow Rate	350 m³/h		Beginning	Middle	End
Target TRO	8.1 mg/L	Sampling Time	:	:	:
Tb0	480 sec	TRO	mg/L	mg/L	mg/L
Tb1(Cycle)	190 sec				

Remark

HANLA IMS	Shipboard Test (Ballasting:Control)		Write	Check	Approval
			김창국	이성국	서병수
Date	2014.09.16	Ship Name	CHANG YAHNG		
Test Mode	Ballasting:Control	System Name	EcoGuardian™		
File Name	HL_BC_140916	Tank Name	NO.3		
Latitude	35° 58.322 N	Longitude	126° 37.095 E		
Port	군산항	Test Volume	1270 ton		
Start Time	06 : 16 : 01	Pump Room Temp.	25 ℃		
End Time	10 : 15 : 51	Water Temp.	26.5 ℃		
Run Time	03 : 59 : 50	Conductivity	mS/cm		
Ballast Pump	ON		Beginning	Middle	End
GS Pump	OFF	Sampling Time	07:00	08:06	09:12
Main Flow Rate	350 m³/h				

Remark

Ship Name	CHANG YAHNG
IMO No.	9121027
Date	2014.09.15

Test Report and Boarding List

HANLA IMS

Boarding List

No.	Group	Name	Signature
1	한라IMS(주)	김창욱	
2	〃	어준태	
3	〃	황철연	
4	〃	서정우	
5	〃	이성민	
6	KIOST	이우진	
7	〃	안영기	
8	BTP	조현호	
9	〃	김상현	
10	〃	송영은	
11	〃	이선록	
12	〃	김민지	
13	〃	조유경	

Shipboard Test
(Commissioning Check List)

Date	2014. 09. 18	Ship Name	CHANG YAHNG
Port	Korea, Busan	System Name	EcoGuardian™

No.	Check List	Check	
1	주배관의 유량계 및 sampling port 연결 상태 확인 Check connection status of flow meter & sampling port in main ballast line	☑ Good	☐ Not Good
2	필터 전후단 밸브 및 by-pass 밸브 개폐 상태 확인 Check opening and closing conditions of valves (front, rear and by-pass) connected with filter	☑ Good	☐ Not Good
3	전해조 유닛의 입출력 배관 연결 상태 확인 Check opening and closing conditions of isolation valves(inlet, outlet) between ECU(Electrochlorination Unit) and main ballast line	☑ Good	☐ Not Good
4	정류기의 냉각수 배관 연결 상태 확인 Check opening and closing conditions of isolation valves for rectifier cooling line	☑ Good	☐ Not Good
5	중화제 주입 배관 연결 상태 확인 Check opening and closing conditions of isolation valve for neutralizer injection line	☑ Good	☐ Not Good
6	TRO 측정을 위한 sampling 배관 연결 상태 확인 Check connection status about sampling port for measuring TRO value	☑ Good	☐ Not Good
7	중화제 잔량 확인 Check the remaining of neutralizer	☑ Good	☐ Not Good
8	TRO 센서 시약 잔량 및 교체 주기 확인 Check the remaining of TRO sensor agent and the exchanging period	☐ Good	☑ Not Good
9	최초 전원 입력 상태 확인 Check status of main power input	☑ Good	☐ Not Good
10	주배관 유량계 stand-by 확인 Check the stand-by of flow meter in main ballast line	☑ Good	☐ Not Good
11	필터 유닛의 센서 stand-by 확인 Check the stand-by of sensor in AFU(Auto Filter Unit)	☑ Good	☐ Not Good
12	전해조 유닛의 센서 stand-by 확인 Check the stand-by of sensor in ECU(ElectroChlorination Unit)	☑ Good	☐ Not Good
13	중화제 유닛의 센서 stand-by 확인 Check the stand-by of sensor in NEU(Neutralization Unit)	☑ Good	☐ Not Good
14	TRO 센서 유닛의 stand-by 확인 Check the stand-by of TSU(TRO Sensor Unit)	☑ Good	☐ Not Good

Remark

6. TRO Sensor agent replaced.

HANLA IMS	Shipboard Test (Deballasting:Control)		Write	Check	Approval
			김창수	이선우	이우진
Date	2014.09.18	Ship Name	CHANG YAHNG		
Test Mode	Deballasting:Control	System Name	EcoGuardian™		
File Name	HL-DC-140918	Tank Name	NO.3		
Latitude	35° 04.492N	Longitude	128° 59.708E		
Port	강 원 항	Test Volume	1278 ton		
Start Time	08 : 30 : 01	Pump Room Temp.	23.5 ℃		
End Time	12 : 11 : 10	Water Temp.	26.5 ℃		
Run Time	03 : 41 : 09	Conductivity	mS/cm		
Ballast Pump	ON		Beginning	Middle	End
GS Pump	OFF	Sampling Time	09 : 14	10 : 20	11 : 26
Main Flow Rate	350 m³/h				

Remark

HANLA IMS	Shipboard Test (Deballasting:Treated)		Write	Check	Approval
			장찬수	이성우	이우진
Date	2014. 09. 18	Ship Name	CHANG YAHNG		
Test Mode	Deballasting:Treated	System Name	EcoGuardian™		
File Name	HL_DT_140918	Port	감 천 항		
Latitude	35° 04. 492N	Longitude	128° 59. 708 E		
Start Time	13 : 15 :	Tank Name	NO.4 + NO.5		
End Time	14 : 47 :	Test Volume	654 ton		
Run Time	1 : 32 :	Pump Room Temp.	23.5 ℃		
Ballast Pump	ON	Water Temp.	26.5 ℃		
GS Pump	OFF	Conductivity	mS/cm		
Main Flow Rate	350 m³/h		Beginning	Middle	End
Initial TRO	9.0 mg/L	Sampling Time	13:20	13:44	14:11
Cn	24.82 %	TRO(Before)	mg/L	mg/L	mg/L
SR	3.0 times				
Td0	360 sec	TRO(After)	mg/L	mg/L	mg/L
Td1	300 sec				

Remark