Test Report

Project name	Purimar™
Study number	TW-Land(9)
Test number	LET-11-003
Title	Efficacy test of Purimar™ Ballast Water Management System (Land scale)
Prepared by	Byong-Jin, Kim

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 MBDC. 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 Study Director	Report to Project manager
Test plan		Jun, 01~03, 2011	Jun, 03, 2011	Jun, 03, 2011
Sampling	1st	Jun, 09, 2011	Jun, 09, 2011	Jun, 09, 2011
	2nd	Jun, 14, 2011	Jun, 14, 2011	Jun, 14, 2011
Test substance	1st	Jun, 09, 2011	Jun, 09, 2011	Jun, 09, 2011
	2nd	Jun, 14, 2011	Jun, 14, 2011	Jun, 14, 2011
Test procedures (Bacteria test)	1st	Jun, 09, 2011	Jun, 09, 2011	Jun, 09, 2011
	2nd	Jun, 14, 2011	Jun, 14, 2011	Jun, 14, 2011
Observation and counting (≥50㎛, 10㎛-50㎛)	1st	Jun, 09, 2011	Jun, 09, 2011	Jun, 09, 2011
	2nd	Jun, 14, 2011	Jun, 14, 2011	Jun, 14, 2011
Observation and counting (Bacteria test)	1st	Jun, 10, 2011	Jun, 10, 2011	Jun, 10, 2011
	2nd	Jun, 12, 2011	Jun, 12, 2011	Jun, 12, 2011
	3rd	Jun, 15, 2011	Jun, 15, 2011	Jun, 15, 2011
	4th	Jun, 16, 2011	Jun, 16, 2011	Jun, 16, 2011
Raw data		Jun, 20, 2011	Jun, 20, 2011	Jun, 20, 2011
Test report		Jun, 20~22, 2011	Jun, 22, 2011	Jun, 22, 2011

Eun-Young, Kang (Sign) — Jun, 22th, 2011

Eun-Young, Kang / Quality Assurance — 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	Ha-na. Song (sign)	Jun. 22th. 2011
	Sun Ju. Cha (sign)	Jun. 22th. 2011
	Eun-Jung. Jung (sign)	Jun. 22th. 2011
	Yeon Su. Park (sign)	Jun. 22th. 2011
QA/QC	Eun-Young. Kang (sign)	Jun, 22th, 2011
Efficacy Testing Manager	Byong-Jun Ko (sign)	22th, Jun. 2011

Contents

Test Report 1

Statement of Quality Assurance 2

1. Results 5

1.1 Sampling point 5

1.3 Water parameters 6

1.4 Influent water : Original water 9

1.5 Elimination efficacy 11

2. Validity 17

3. Conclusion 20

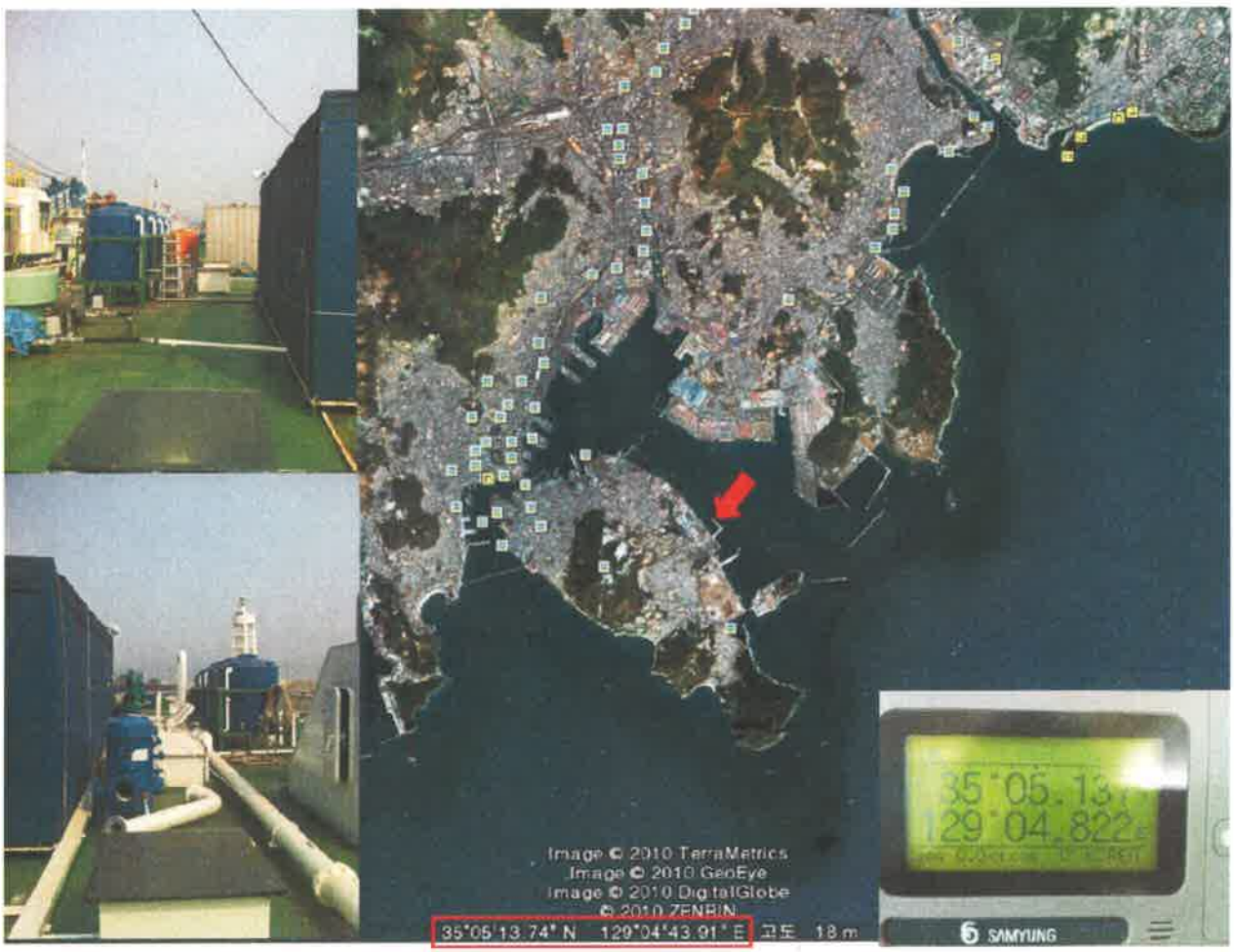
4. Appendix 21

5. Attachment 57

1. Results

1.1 Sampling point

GPS coordinate	35°05.137N 129°04.822E



1.3 Water parameters

Table 1. Results of TOC, DOC, POC, TSS

Date	Sample ID & lot No.	TOC [a)] (mg/L)	DOC [b)] (mg/L)	POC [c)] (mg/L)	TSS [d)] (mg/L)
Day 0	OwT-0609	6.55±0.49	4.62±0.50	1.93	21.9±2.0
	OwM-0609	6.74±0.43	4.83±0.19	1.91	20.6±2.1
	OwB-0609	6.61±0.44	4.78±0.43	1.84	15.3±1.4
Acceptability (Salinity : > 32 PSU)		-	Acceptable (> 1 mg/L)	Acceptable (> 1 mg/L)	Acceptable (> 1 mg/L)

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

Table 2. Water parameters at field

Date	Sample ID & lot No.	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)	TRC (ppm)	Chlorophyl a
Day 0	OwT-0609	8.13±0.00	18.00±0.00	33.53±0.00	6.83±0.02	4.2±0.1	0.00±0.00	1.06±0.01
	OwM-0609	8.12±0.00	17.84±0.00	33.60±0.01	6.84±0.02	3.8±0.1	0.00±0.00	1.09±0.01
	OwB-0609	8.13±0.00	17.80±0.01	33.48±0.00	6.93±0.04	4.2±0.1	0.00±0.00	1.13±0.01
	C0T-0609	8.13±0.00	18.32±0.06	33.51±0.03	5.73±0.04	4.3±0.2	0.00±0.00	1.31±0.01
	C0M-0609	8.13±0.00	18.34±0.02	33.57±0.01	5.68±0.04	3.7±0.2	0.00±0.00	1.21±0.01
	C0B-0609	8.13±0.01	18.47±0.07	33.55±0.03	5.68±0.02	3.9±0.2	0.00±0.00	1.18±0.01
	T0T-0609	8.18±0.00	18.89±0.13	33.53±0.02	5.38±0.21	3.1±0.1	2.67±0.06	0.124±0.002
	T0M-0609	8.17±0.00	18.81±0.04	33.51±0.03	5.43±0.05	3.2±0.4	2.93±0.06	0.145±0.002
	T0B-0609	8.13±0.00	18.63±0.06	33.52±0.06	6.52±0.27	3.2±0.2	3.13±0.06	0.094±0.002
Day 5	C5T-0614	7.59±0.01	19.86±0.01	33.55±0.02	6.17±0.02	2.8±0.1	0.0±0.0	0.313±0.002
	C5M-0614	7.56±0.00	19.89±0.03	33.56±0.01	6.27±0.05	2.1±0.0	0.0±0.0	0.271±0.004
	C5B-0614	7.41±0.06	19.97±0.08	33.61±0.05	5.96±0.06	2.4±0.1	0.0±0.0	0.270±0.001
	T5T-0614	7.97±0.00	19.32±0.01	33.51±0.01	5.96±0.07	1.8±0.2	0.0±0.0	0.000±0.000
	T5M-0614	7.97±0.00	19.34±0.08	33.56±0.04	6.10±0.08	0.6±0.1	0.0±0.0	0.000±0.000
	T5B-0614	7.89±0.02	19.30±0.03	33.67±0.05	6.61±0.04	0.6±0.1	0.0±0.0	0.000±0.000

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

Table 3. Water parameters at BTP lab

Date	Sample ID & lot No.	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)
Day 0	OwT-0609	8.27±0.00	14.8±0.0	34.0±0.1	9.13±0.01	4.12±0.01
	OwM-0609	8.25±0.01	16.1±0.0	34.2±0.0	9.16±0.02	3.60±0.01
	OwB-0609	8.26±0.00	13.8±0.1	33.3±0.1	8.90±0.05	4.25±0.02
	C0T-0609	8.27±0.00	14.1±0.1	33.3±0.0	9.17±0.04	4.89±0.01
	C0M-0609	8.27±0.00	13.7±0.0	33.1±0.1	9.16±0.05	4.28±0.02
	C0B-0609	8.26±0.01	14.6±0.1	32.9±0.1	8.52±0.02	4.14±0.03
	T0T-0609	8.12±0.00	12.4±0.0	33.1±0.1	9.23±0.01	4.42±0.01
	T0M-0609	8.18±0.00	14.2±0.0	33.2±0.0	9.35±0.01	4.19±0.01
	T0B-0609	8.11±0.01	13.4±0.0	33.0±0.0	9.40±0.00	3.86±0.02
Day 5	C5T-0614	7.80±0.01	12.0±0.0	33.6±0.0	8.82±0.04	3.27±0.05
	C5M-0614	7.74±0.00	14.1±0.1	34.4±0.1	8.32±0.03	2.75±0.03
	C5B-0614	7.73±0.00	11.8±0.1	33.3±0.0	8.47±0.02	3.22±0.02
	T5T-0614	8.12±0.00	11.8±0.1	33.6±0.1	9.22±0.06	2.39±0.03
	T5M-0614	8.10±0.00	11.8±0.0	33.5±0.0	9.65±0.03	1.20±0.02
	T5B-0614	8.10±0.00	12.2±0.0	33.3±0.1	9.10±0.03	1.28±0.01

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

1.4 Influent water : Original water

1) ≥ 50 μm organism

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

Sampling	Phyla/Divisions	Species	Survival number/m^3	Minimum Dimension (μm)
Top	Arthropoda	*Artemia salina*	22500 ± 1323	158~165
		Euterpina sp.	667 ± 764	165~168
		Paracalanus sp.	333 ± 289	304~306
		Acartia sp.	500 ± 500	163~170
		Crustacean nauplii	13333 ± 2887	155~160
		Copepoda nauplii	5000 ± 5000	152~156
	Rotifera	*Brachionus plicatilis*	353333 ± 18930	70~80
	Dinophyta	*Protoperidinium* sp.	13333 ± 2887	55~65
Middle	Arthropoda	*Artemia salina*	28667 ± 2021	158~165
		Acartia sp.	333 ± 289	163~170
		Crustacean nauplii	8333 ± 2887	155~160
		Copepoda nauplii	3333 ± 2887	152~156
	Rotifera	*Brachionus plicatilis*	361667 ± 22546	70~80
	Dinophyta	*Protoperidinium* sp.	13333 ± 5774	55~65
Bottom	Arthropoda	*Artemia salina*	39333 ± 2021	158~165
		Crustacean nauplii	10000 ± 5000	155~160
		Copepoda nauplii	6667 ± 2887	152~156
	Rotifera	*Brachionus plicatilis*	400000 ± 18028	70~80
	Dinophyta	*Protoperidinium* sp.	11667 ± 5774	55~65
Total	8 species 3 phyla/divisions		430778 ± 32120	-
Acceptability	Influent condition: Acceptable (≥ 5 species from 3 different phyla/divisions)		Influent condition: Acceptable (≥10^5 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 5. Survival number of the organism between 10 to 50 µm

Sampling	Phyla/Divisions	Species	Survival number/mL (Mean)	Minimum Dimension (µm)
Top	Chlorophyta	*Tetraselmis suecica*	1910 ± 70	11 ~ 12
	Bacillariophyta	*Melosiosira* sp.	8 ± 2	15 ~ 40
		Chaetoceros sp.	5 ± 1	15 ~ 45
	Dinophyta	*Gymnodinium* sp.	10 ± 2	20 ~ 40
		Protoperidinium sp.	6 ± 1	20 ~ 45
Middle	Chlorophyta	*Tetraselmis suecica*	2053 ± 86	11 ~ 12
	Bacillariophyta	*Melosiosira* sp.	7 ± 2	15 ~ 40
		Chaetoceros sp.	3 ± 1	15 ~ 45
	Dinophyta	*Gymnodinium* sp.	4 ± 1	20 ~ 40
		Protoperidinium sp.	5 ± 2	20 ~ 45
Bottom	Chlorophyta	*Tetraselmis suecica*	1807 ± 76	11 ~ 12
	Bacillariophyta	*Melosiosira* sp.	5 ± 1	15 ~ 40
		Chaetoceros sp.	7 ± 1	15 ~ 45
	Dinophyta	*Gymnodinium* sp.	5 ± 1	20 ~ 40
		Protoperidinium sp.	7 ± 1	20 ~ 45
Total	5 species 3 phyla/divisions		1947 ± 121	-
Acceptability	Influent condition: Acceptable (≥ 5 species from 3 different phyla/divisions)		Influent condition: Acceptable (≥ 10^3 ind./mL)	-

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

Some species were rare, the standard deviation was high

1.5 Elimination efficacy

1) ≥ 50 μm organism

Table 6. Survival number of the organism larger than 50 μm

Test substance	Sampling		Survival number/m^3	Acceptability	Elimination efficacy (%)
Original water	Day 0 (Ow)	T [a)]	409000 ± 18255	Influent condition: Acceptable ($\geq 10^5$ ind./m^3)	
		M [b)]	415667 ± 34530		
		B [c)]	467667 ± 6252		
Control (untreated) seawater	Day 0 (C0)	T	321833 ± 10300	-	-
		M	306333 ± 14092		
		B	374167 ± 21922		
	Day 5 (C5)	T	108333 ± 10408	Effluent condition: Acceptable ($\geq 10^2$ ind./m^3)	
		M	131667 ± 7638		
		B	151667 ± 12583		
Treated ballast seawater	Day 0 (T0)	T	0 ± 0	Effluent condition : Acceptable (<10 ind./m^3)	100.0 [d)]
		M	0 ± 0		
		B	0 ± 0		
	Day 5 (T5)	T	0 ± 0	Effluent condition : Acceptable (<10 ind./m^3)	100.0 [e)]
		M	0 ± 0		
		B	0 ± 0		

a) T: Top, b) M: Middle c) B: Bottom, d) Calculation = (C0-T0)/C0*100, e) Calculation = (C0-T5)/C0*100

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

2) 10 μm - 50 μm organism

Table 7. Survival number of the organism between 10 and 50 μm

Test substance	Sampling		Survival number/mL	Acceptability	Elimination efficacy (%)
Original water	Day 0 (Ow)	T [a)]	1939 ± 68	Influent condition: Acceptable ($\geq 10^3$ ind./mL)	-
		M [b)]	2071 ± 87		
		B [c)]	1830 ± 77		
Control (untreated) seawater	Day 0 (C0)	T	1837 ± 79	-	-
		M	1898 ± 41		
		B	1872 ± 107		
	Day 5 (C5)	T	158 ± 9	Effluent condition: Acceptable ($\geq 10^2$ ind./ ml)	
		M	146 ± 9		
		B	167 ± 12		
Treated ballast seawater	Day 0 (T0)	T	0 ± 0	Effluent condition : Acceptable (<10 ind./ ml)	100.0 [d)]
		M	0 ± 0		
		B	0 ± 0		
	Day 5 (T5)	T	0 ± 0	Effluent condition : Acceptable (<10 ind./ ml)	100.0 [e)]
		M	0 ± 0		
		B	0 ± 0		

a) T: Top, b) M: Middle c) B: Bottom, d) Calculation = (C0-T0)/C0*100, e) Calculation = (C0-Tn)/C0*100

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

3) Heterotrophic bacteria

Table 8. Survival number of heterotrophic bacteria

Test substance	Sampling		CFU / mL	Acceptability	Elimination efficacy (%)
Original water	Day 0 (Ow)	T [a)]	15667 ± 2053	Influent condition: Acceptable ($\geq 10^4$ CFU/mL)	-
		M [b)]	20267 ± 1793		
		B [c)]	20933± 1206		
Control (untreated) seawater	Day 0 (C0)	T	12733 ± 1747	-	-
		M	26567 ± 2371		
		B	25067 ± 2601		
	Day 5 (C5)	T	49567 ± 10101	-	
		M	39367 ± 3782		
		B	42133 ± 6599		
Treated ballast seawater	Day 0 (T0)	T	1 ± 0	-	100.0 [d)]
		M	0 ± 0		
		B	1 ± 0		
	Day 5 (T5)	T	119733 ± 15270	-	-406.3 [e)]
		M	98667 ± 6004		
		B	107467 ± 13418		

a) T: Top, b) M: Middle c) B: Bottom, d) Calculation = (C0-T0)/C0*100, e) Calculation = (C0-T5)/C0*100

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

4) *Escherichia coli*

Table 9. Survival number of *Escherichia coli*

Test substance	Sampling		CFU / 100 mL	Acceptability	Elimination efficacy (%)
Original water	Day 0 (Ow)	T [a)]	9 ± 2	-	
		M [b)]	9 ± 1		
		B [c)]	9 ± 1		
Control (untreated) seawater	Day 0 (C0)	T	8 ± 1	-	-
		M	6 ± 1		
		B	6 ± 1		
	Day 5 (C5)	T	0 ± 0	-	
		M	0 ± 0		
		B	0 ± 0		
Treated ballast seawater	Day 0 (T0)	T	0 ± 0	Effluent condition: Acceptable (<250 CFU/ 100ml)	100.0 [d)]
		M	0 ± 0		
		B	0 ± 0		
	Day 5 (T5)	T	0 ± 0	Effluent condition: Acceptable (<250 CFU/ 100ml)	100.0 [e)]
		M	0 ± 0		
		B	0 ± 0		

a) T: Top, b) M: Middle c) B: Bottom, d) Calculation = (C0-T0)/C0*100, e) Calculation = (C0-T5)/C0*100

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

5) *Enterococcus faecalis*

Table 10. Survival number of *Enterococcus faecalis*

Test substance	Sampling		CFU / 100 mL	Acceptability	Elimination efficacy (%)
Original water	Day 0 (Ow)	T [a)]	71 ± 6	-	
		M [b)]	84 ± 3		
		B [c)]	132 ± 10		
Control (untreated) seawater	Day 0 (C0)	T	51 ± 3	-	-
		M	64 ± 4		
		B	94 ± 7		
	Day 5 (C5)	T	0 ± 0	-	
		M	0 ± 0		
		B	0 ± 0		
Treated ballast seawater	Day 0 (T0)	T	0 ± 0	Effluent condition: Acceptable (<100 CFU/ 100ml)	100.0 [e)]
		M	0 ± 0		
		B	0 ± 0		
	Day 5 (T5)	T	0 ± 0	Effluent condition: Acceptable (<100 CFU/ 100ml)	100.0 [f)]
		M	0 ± 0		
		B	0 ± 0		

a) T: Top, b) M: Middle c) B: Bottom,
d) Colonies were too numerous to count (TNTC), used upper limit count with smallest filtration volume,
e) Calculation = (C0-T0)/C0*100, f) Calculation = (C0-T5)/C0*100

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

6) *Vibrio cholera* O1, O139

Table 11. Survival number of *Vibrio cholera* O1, O139

Test substance	Sampling		CFU / 100 mL	Acceptability	Elimination efficacy (%)
Original water	Day 0 (Ow)	T a)	0 ± 0	-	-
		M b)	0 ± 0		
		B c)	0 ± 0		
Control (untreated) seawater	Day 0 (C0)	T	0 ± 0	-	-
		M	0 ± 0		
		B	0 ± 0		
	Day 5 (C5)	T	0 ± 0	-	
		M	0 ± 0		
		B	0 ± 0		
Treated ballast seawater	Day 0 (T0)	T	0 ± 0	Effluent condition: Acceptable (<1 CFU/ 100ml)	N.D d)
		M	0 ± 0		
		B	0 ± 0		
	Day 5 (T5)	T	0 ± 0	Effluent condition: Acceptable (<1 CFU/ 100ml)	N.D
		M	0 ± 0		
		B	0 ± 0		

a) T: Top, b) M: Middle c) B: Bottom, d) N.D: Not detected

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

2. Validity

2.1 Water parameters measurement

- Influent condition in DOC, POC, TSS was acceptable for IMO standards.
  - Salinity: > 32 PSU (Salinity should be separated by at least 10 PSU)
  - DOC: > 1 mg/L
  - POC: > 1 mg/L
  - TSS: > 1 mg/L

Date	Sample ID & lot No.	Salinity [a)] (‰)	DOC (mg/L)	POC (mg/L)	TSS (mg/L)
Day 0	OwT-0609	33.53±0.00	4.62±0.50	1.93	21.9±2.0
	OwM-0609	33.60±0.00	4.83±0.19	1.91	20.6±2.1
	OwB-0609	33.48±0.00	4.78±0.43	1.84	15.3±1.4

a) Salinity: data at field

- All measurements were tested more than three times.
- Sample was analyzed as soon as possible after arrival at BTP lab.

2.2 Biological efficacy test

- Influent condition in all tests was acceptable for IMO standards (MEPC58/2/4).
  - The organism larger than 50 μm: $\geq 10^5$ individuals/m^3
  - The organism between 10 μm and 50 μm: $\geq 10^3$ individuals / mL
  - Heterotrophic bacteria: $\geq 10^4$ CFU/ mL

Sample		≥ 50 μm (individuals/m^3)	10 μm - 50 μm (individuals/mL)	Heterotrophic bacteria (CFU/mL)
Field	OwT	252000	2456	-
Lab	OwT	409000 ± 18255	1939 ± 68	15667 ± 2053
	OwM	415667 ± 34530	2071 ± 87	20267 ± 1793
	OwB	467667 ± 6252	1830 ± 77	20933± 1206

- The organism larger than 50 μm: ≥ 5 species from 3 different phyla/divisions
- The organism between 10 μm and 50 μm: ≥ 5 species from 3 different phyla/divisions

Sample	≥ 50 μm	10 μm - 50 μm
Ow	8 species 3 phyla/divisions	5 species 3 phyla/divisions

• All samples were tested within 6 hours after sampling

Date	Sample	Sampling time	Test ending time
Day 0	OwT	09:50~09:59	14:30
	OwM	09:48~09:58	
	OwB	09:49~10:02	
	C0T	10:52~10:59	14:30
	C0M	10:51~10:57	
	C0B	10:50~10:56	
	T0T	12:40~12:57	15:20
	T0M	12:24~12:43	
	T0B	12:05~12:17	
Day 5	C5T	12:05~12:10	16:00
	C5M	12:04~12:09	
	C5B	12:03~12:08	
	T5T	12:57~13:10	16:00
	T5M	12:35~12:56	
	T5B	12:19~12:34	
Acceptability		Acceptable : analyzed live within 6 hours	

- Discharge results from the control water were a concentration more than 10 times the values in regulation D2.1.
  - The organism larger than 50 μm: ≥ 100 individuals/m^3
  - The organism between 10 μm and 50 μm: ≥ 100 individuals/mL

Sample	≥ 50 μm organism	10 μm - 50 μm organism
Top	108333 ± 10408	158 ± 9
Middle	131667 ± 7638	146 ± 9
Bottom	151667 ± 12583	167 ± 12

3. Conclusion

3.1 Biological efficacy in treated ballast seawater by Purimar™ BWMS

- Treated ballast seawater by Purimar™ BWMS were capable of eliminating organism larger than 50 μm with an efficiency of 100%.
- Treated ballast seawater by Purimar™ BWMS were capable of eliminating organism between 10 and 50 μm with an efficiency of 100%.
- Treated ballast seawater by Purimar™ BWMS was capable of eliminating heterotrophic bacteria with an efficiency of 100 % at day 0.
- But treated ballast sea water by Purimar™ BWMS was incapable of eliminating heterotrophic bacteria at day 5.
- Treated ballast seawater by Purimar™ BWMS were capable of eliminating *Escherichia coli* with an efficiency of 100 % at day 0, 5.
- Treated ballast seawater by Purimar™ BWMS were capable of eliminating *Enterococcus faecalis* with an efficiency of 100 % at day 0, 5.
- *Vibrio cholera* O1, O139 were not detected.
- Therefore, treated ballast seawater by Purimar™ BWMS was capable of removing zooplankton, phytoplankton and a part of bacteria.

4. Appendix

Appendix 1. Water parameters (TOC, DOC, TSS) of original water (Ow)

Date	Sample ID & lot No.	R [a)]	TOC [b)] (mg/L)	DOC [c)] (mg/L)	TSS [d)] (mg/L)
Day 0	OwT-0525	R1	6.32	4.79	24.2
		R2	6.21	4.06	21.0
		R3	7.11	5.01	20.6
	OwM-0525	R1	6.33	4.66	18.4
		R2	7.18	5.03	20.8
		R3	6.70	4.79	22.6
	OwB-0525	R1	6.30	5.19	14.0
		R2	6.42	4.81	16.8
		R3	7.12	4.33	15.0

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

Appendix 2. Water parameters at field

Date	Sample ID & lot No.	R [a)]	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)	TRC (ppm)	Chlorophyl a
Day 0	OwT-0609	R1	8.13	18.00	33.53	6.81	4.1	0.00	1.06
		R2	8.13	18.00	33.53	6.83	4.1	0.00	1.07
		R3	8.13	18.00	33.53	6.84	4.3	0.00	1.05
	OwM-0609	R1	8.12	17.84	33.59	6.85	3.8	0.00	1.08
		R2	8.12	17.84	33.60	6.84	3.9	0.00	1.09
		R3	8.12	17.84	33.60	6.82	3.8	0.00	1.10
	OwB-0609	R1	8.13	17.80	33.48	6.93	4.2	0.00	1.12
		R2	8.13	17.80	33.48	6.89	4.2	0.00	1.14
		R3	8.13	17.80	33.48	6.96	4.1	0.00	1.14
	C0T-0609	R1	8.13	18.25	33.54	5.76	4.4	0.00	1.32
		R2	8.13	18.33	33.49	5.75	4.5	0.00	1.30
		R3	8.13	18.37	33.50	5.69	4.1	0.00	1.31
	C0M-0609	R1	8.13	18.32	33.57	5.64	3.9	0.00	1.22
		R2	8.13	18.35	33.56	5.69	3.5	0.00	1.21
		R3	8.13	18.35	33.57	5.71	3.7	0.00	1.20
	C0B-0609	R1	8.12	18.39	33.58	5.70	4.0	0.00	1.17
		R2	8.13	18.51	33.54	5.66	3.7	0.00	1.18
		R3	8.13	18.52	33.52	5.68	3.9	0.00	1.19
	T0T-0609	R1	8.18	18.74	33.50	5.51	3.2	2.60	0.122
		R2	8.18	18.95	33.54	5.14	3.2	2.70	0.124
		R3	8.18	18.97	33.54	5.49	3.0	2.70	0.126
	T0M-0609	R1	8.17	18.76	33.52	5.48	3.1	2.90	0.147
		R2	8.17	18.84	33.48	5.39	2.8	2.90	0.143
		R3	8.17	18.82	33.53	5.42	3.6	3.00	0.145
	T0B-0609	R1	8.13	18.57	33.58	6.83	3.1	3.20	0.094
		R2	8.13	18.66	33.49	6.42	3.2	3.10	0.096
		R3	8.13	18.67	33.48	6.31	3.4	3.10	0.093
Day 5	C5T-0614	R1	7.58	19.85	33.57	6.17	2.9	0.0	0.311
		R2	7.59	19.86	33.55	6.18	2.7	0.0	0.315
		R3	7.59	19.86	33.53	6.15	2.8	0.0	0.314
	C5M-0614	R1	7.56	19.87	33.57	6.32	2.1	0.0	0.267
		R2	7.56	19.89	33.57	6.23	2.1	0.0	0.274
		R3	7.56	19.92	33.55	6.25	2.1	0.0	0.272
	C5B-0614	R1	7.34	19.88	33.67	5.90	2.5	0.0	0.269
		R2	7.44	20.01	33.58	5.97	2.4	0.0	0.271
		R3	7.45	20.02	33.58	6.02	2.3	0.0	0.270
	T5T-0614	R1	7.97	19.31	33.51	5.99	2.0	0.0	0.000
		R2	7.97	19.33	33.51	6.01	1.9	0.0	0.000
		R3	7.97	19.33	33.52	5.88	1.6	0.0	0.000
	T5M-0614	R1	7.97	19.29	33.59	6.14	0.7	0.0	0.000
		R2	7.97	19.31	33.57	6.15	0.6	0.0	0.000
		R3	7.97	19.43	33.52	6.00	0.6	0.0	0.000
	T5B-0614	R1	7.88	19.33	33.71	6.61	0.7	0.0	0.000
		R2	7.89	19.28	33.68	6.64	0.6	0.0	0.000
		R3	7.91	19.29	33.61	6.57	0.6	0.0	0.000

a) R: Replicate

Appendix 3. Water parameters at BTP lab.

Date	Sample ID & lot No.	R [a)]	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)
Day 0	OwT-0609	R1	8.27	14.8	34.1	9.12	4.12
		R2	8.27	14.8	34.0	9.12	4.11
		R3	8.27	14.8	34.0	9.14	4.12
	OwM-0609	R1	8.25	16.1	34.2	9.16	3.59
		R2	8.25	16.1	34.2	9.17	3.61
		R3	8.26	16.1	34.2	9.14	3.61
	OwB-0609	R1	8.26	13.9	33.3	8.94	4.28
		R2	8.26	13.7	33.2	8.85	4.24
		R3	8.26	13.8	33.3	8.92	4.24
	C0T-0609	R1	8.27	14.1	33.3	9.20	4.90
		R2	8.27	14.1	33.3	9.17	4.89
		R3	8.27	14.2	33.3	9.13	4.89
	C0M-0609	R1	8.27	13.7	33.2	9.11	4.28
		R2	8.27	13.7	33.1	9.17	4.26
		R3	8.27	13.7	33.0	9.20	4.29
	C0B-0609	R1	8.26	14.6	32.9	8.50	4.12
		R2	8.26	14.5	32.9	8.53	4.14
		R3	8.27	14.7	33.0	8.54	4.17
	T0T-0609	R1	8.12	12.4	33.2	9.24	4.41
		R2	8.12	12.4	33.1	9.22	4.42
		R3	8.12	12.4	33.1	9.23	4.42
	T0M-0609	R1	8.18	14.2	33.2	9.34	4.19
		R2	8.18	14.2	33.2	9.35	4.20
		R3	8.18	14.2	33.2	9.35	4.18
	T0B-0609	R1	8.11	13.4	33.0	9.40	3.84
		R2	8.11	13.4	33.0	9.40	3.87
		R3	8.12	13.4	33.0	9.40	3.88
Day 5	C5T-0614	R1	7.80	12.0	33.6	8.83	3.32
		R2	7.80	12.0	33.6	8.86	3.28
		R3	7.79	12.0	33.6	8.78	3.22
	C5M-0614	R1	7.74	14.1	34.3	8.35	2.78
		R2	7.74	14.1	34.5	8.32	2.74
		R3	7.74	14.2	34.5	8.29	2.73
	C5B-0614	R1	7.73	11.9	33.3	8.46	3.22
		R2	7.73	11.8	33.3	8.47	3.23
		R3	7.73	11.8	33.3	8.49	3.20
	T5T-0614	R1	8.12	11.8	33.6	9.28	2.42
		R2	8.12	11.8	33.5	9.22	2.36
		R3	8.12	11.9	33.6	9.17	2.40
	T5M-0614	R1	8.10	11.8	33.5	9.68	1.22
		R2	8.10	11.8	33.5	9.64	1.19
		R3	8.10	11.8	33.5	9.62	1.20
	T5B-0614	R1	8.10	12.2	33.2	9.06	1.28
		R2	8.10	12.2	33.4	9.11	1.27
		R3	8.10	12.2	33.4	9.12	1.28

a) R: Replicate

Appendix 4. Survival number of ≥ 50㎛ organism in original water(Influent water)

Date	Sample ID	Classification	Survival number /m^3			Mean	SD [b)]
			R1[a)]	R2	R3		
Day 0	OwT-0609	*Artemia salina*	21000	23000	23500	22500	1323
		Euterpina sp.	1500	0	500	667	764
		Paracalanus sp.	500	500	0	333	289
		Acartia sp.	0	1000	500	500	500
		Crustacean nauplii	15000	15000	10000	13333	2887
		Copepoda nauplii	5000	0	10000	5000	5000
		Brachionus plicatilis	345000	375000	340000	353333	18930
		Protoperidinium sp.	15000	15000	10000	13333	2887
	OwM-0609	*Artemia salina*	26500	29000	30500	28667	2021
		Acartia sp.	500	0	500	333	289
		Crustacean nauplii	5000	10000	10000	8333	2887
		Copepoda nauplii	0	5000	5000	3333	2887
		Brachionus plicatilis	340000	360000	385000	361667	22546
		Protoperidinium sp.	10000	10000	20000	13333	5774
	OwB-0609	*Artemia salina*	39000	37500	41500	39333	2021
		Crustacean nauplii	10000	5000	15000	10000	5000
		Copepoda nauplii	5000	5000	10000	6667	2887
		Brachionus plicatilis	415000	405000	380000	400000	18028
		Protoperidinium sp.	5000	15000	15000	11667	5774

a) R: Replicate

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

Appendix 5. Survival number of ≥ 50μm organism in control (untreated) seawater

Date	Sample ID	Classification	Survival number/m^3			Mean	SD [b)]
			R1[a)]	R2	R3		
Day 0	C0T - 0609	*Artemia salina*	11000	13000	11500	11833	1041
		Crustacean nauplii	5000	0	0	1667	2887
		Brachionus plicatilis	295000	310000	320000	308333	12583
	C0M- 0609	*Artemia salina*	12500	10500	11000	11333	1041
		Copepoda nauplii	5000	5000	5000	5000	0
		Brachionus plicatilis	300000	275000	295000	290000	13229
	C0B- 0609	*Artemia salina*	9000	6000	7500	7500	1500
		Brachionus plicatilis	390000	360000	350000	366667	20817
Day 5	C5T - 0614	*Brachionus plicatilis*	100000	120000	105000	108333	10408
	C5M- 0614	*Brachionus plicatilis*	140000	130000	125000	131667	7638
	C5B- 0614	*Brachionus plicatilis*	165000	140000	150000	151667	12583

a) R: Replicate

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

Appendix 6. Survival number of ≥ 50㎛ organism in treated ballast seawater by treatment of Purimar™ BWMS

Date	Sample ID	Classification	Survival number /m³			Mean	SD [b)]
			R1[a)]	R2	R3		
Day 0	T0T - 0609	-	0	0	0	0	0
	T0M- 0609	-	0	0	0	0	0
	T0B- 0609	-	0	0	0	0	0
Day 5	T5T - 0614	-	0	0	0	0	0
	T5M- 0614	-	0	0	0	0	0
	T5B- 0614	-	0	0	0	0	0

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

Appendix 7. Survival number of 10㎛ - 50㎛ organism in original water(Influent water)

Date	Sample ID	Classification	Survival number / ml			Mean	SD [b)]
			R1[a)]	R2	R3		
Day 0	OwT-0609	*Tetraselmis suecica*	1980	1840	1910	1910	70
		Melosiosira sp.	10	8	7	8	2
		Chaetoceros sp.	5	6	4	5	1
		Gymnodinium sp.	8	11	12	10	2
		Protoperidinium sp.	5	7	5	6	1
	OwM-0609	*Tetraselmis suecica*	2070	2130	1960	2053	86
		Melosiosira sp.	9	5	6	7	2
		Chaetoceros sp.	4	2	2	3	1
		Gymnodinium sp.	3	5	4	4	1
		Protoperidinium sp.	3	6	5	5	2
	OwB-0609	*Tetraselmis suecica*	1790	1890	1740	1807	76
		Melosiosira sp.	5	6	4	5	1
		Chaetoceros sp.	7	8	6	7	1
		Gymnodinium sp.	4	5	5	5	1
		Protoperidinium sp.	7	6	8	7	1

a) R: Replicate

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

Appendix 8. Survival number of 10㎛ - 50㎛ organism in control (untreated) seawater

Date	Sample ID	Classification	Survival number / ml			Mean	SD [b]
			R1[a]	R2	R3		
Day 0	C0T - 0609	*Tetraselmis suecica*	1730	1840	1880	1817	78
		Melosiosira sp.	5	3	5	4	1
		Chaetoceros sp.	2	4	4	3	1
		Gymnodinium sp.	7	8	6	7	1
		Protoperidinium sp.	4	7	5	5	2
	C0M- 0609	*Tetraselmis suecica*	1920	1840	1880	1880	40
		Chaetoceros sp.	12	8	9	10	2
		Gymnodinium sp.	4	5	3	4	1
		Protoperidinium sp.	3	5	4	4	1
	C0B- 0609	*Tetraselmis suecica*	1980	1770	1820	1857	110
		Chaetoceros sp.	3	5	6	5	2
		Melosiosira sp.	4	7	4	5	2
		Protoperidinium sp.	5	6	6	6	1
Day 5	C5T- 0614	*Tetraselmis suecica*	163	147	158	156	8
		Gymnodinium sp.	2	1	2	2	1
	C5M- 0614	*Tetraselmis suecica*	139	156	143	146	9
	C5B- 0614	*Tetraselmis suecica*	169	173	152	165	11
		Chaetoceros sp.	2	3	1	2	1

a) R: Replicate

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

Appendix 9. Survival number of 10 ㎛ - 50 ㎛ organism in treated ballast seawater by treatment of Purimar™ BWMS

Date	Sample ID	Classification	Survival number / ml			Mean	SD [b]
			R1[a]	R2	R3		
Day 0	T0T-0609	-	0	0	0	0	0
	T0M-0609	-	0	0	0	0	0
	T0B-0609	-	0	0	0	0	0
Day 5	T5T-0614	-	0	0	0	0	0
	T5M-0614	-	0	0	0	0	0
	T5B-0614	-	0	0	0	0	0

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

Appendix 10. Number of heterotrophic bacteria in original water, control (untreated) seawater, treated ballast seawater by treatment of Purimar™ BWMS

Date	Sample ID		CFU/mL			Mean	SD [b]
			R1[a]	R2	R3		
Day 0	Ow-0609	Top	13400	16200	17400	15667	2053
		Middle	18200	21200	21400	20267	1793
		Bottom	19800	20800	22200	20933	1206
	C0-0609	Top	13200	10800	14200	12733	1747
		Middle	26200	29100	24400	26567	2371
		Bottom	25000	27700	22500	25067	2601
	T0-0609	Top	1	1	1	1	0
		Middle	0	0	0	0	0
		Bottom	1	1	0	1	0
Day 5	C5-0614	Top	39400	49700	59600	49567	10101
		Middle	41600	35000	41500	39367	3782
		Bottom	34700	44400	47300	42133	6599
	T5-0614	Top	102400	125600	131200	119733	15270
		Middle	95200	95200	105600	98667	6004
		Bottom	92000	114400	116000	107467	13418

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

Appendix 11. Number of *Escherichia coli* in original water, control (untreated) seawater, treated ballast seawater by treatment of Purimar™ BWMS

Date	Sample ID		CFU /100ml			Mean	SD [b]
			R1[a]	R2	R3		
Day 0	Ow-0609	Top	11	9	7	9	2
		Middle	10	9	8	9	1
		Bottom	9	9	8	9	1
	C0-0609	Top	9	7	7	8	1
		Middle	6	7	6	6	1
		Bottom	6	6	7	6	1
	T0-0609	Top	0	0	0	0	0
		Middle	0	0	0	0	0
		Bottom	0	0	0	0	0
Day 5	C5-0614	Top	0	0	0	0	0
		Middle	0	0	0	0	0
		Bottom	0	0	0	0	0
	T5-0614	Top	0	0	0	0	0
		Middle	0	0	0	0	0
		Bottom	0	0	0	0	0

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

Appendix 12. Number of *Enterococcus faecalis* in original water, control (untreated) seawater, treated ballast seawater by treatment of Purimar™ BWMS

Date	Sample ID		CFU /100ml			Mean	SD [b]
			R1[a]	R2	R3		
Day 0	Ow-0609	Top	64	74	74	71	6
		Middle	85	86	81	84	3
		Bottom	120	139	137	132	10
	C0-0609	Top	48	54	50	51	3
		Middle	60	64	67	64	4
		Bottom	86	99	97	94	7
	T0-0609	Top	0	0	0	0	0
		Middle	0	0	0	0	0
		Bottom	0	0	0	0	0
Day 5	C5-0614	Top	0	0	0	0	0
		Middle	0	0	0	0	0
		Bottom	0	0	0	0	0
	T5-0614	Top	0	0	0	0	0
		Middle	0	0	0	0	0
		Bottom	0	0	0	0	0

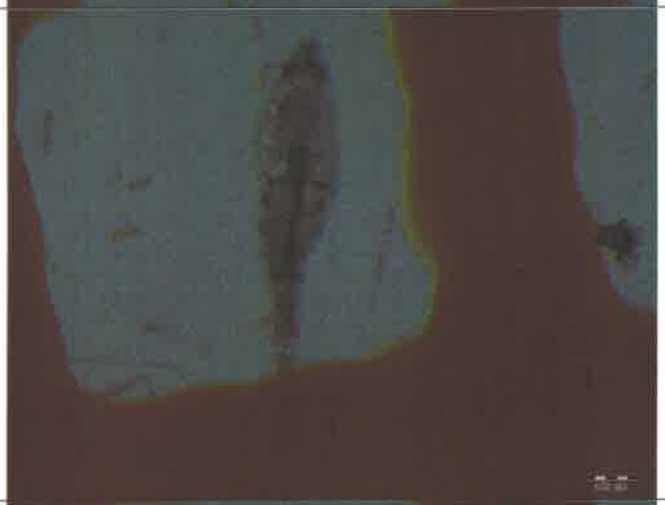
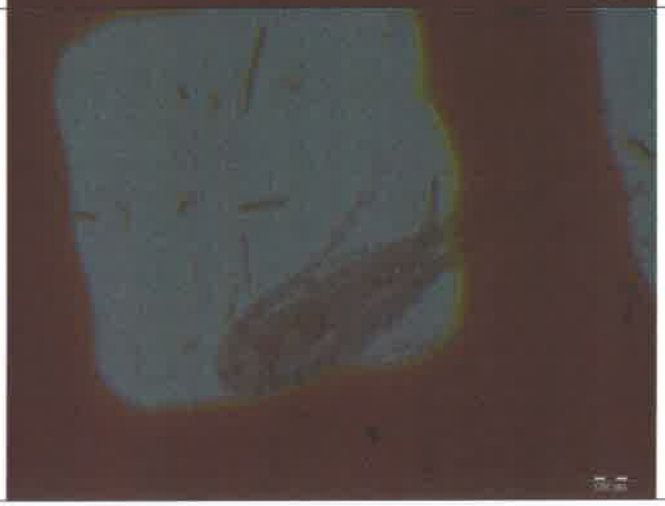
a) R: Replicate
b) S.D: Standard deviation
c) Colonies were too numerous to count (TNTC), used upper limit count with smallest filtration volume

Appendix 13. Number of *Vibrio cholera* O1, O139 in original water, control (untreated) seawater, treated ballast seawater by treatment of Purimar™ BWMS

Date	Sample ID		CFU /100ml			Mean	SD [b]
			R1[a]	R2	R3		
Day 0	Ow-0609	Top	0	0	0	0	0
		Middle	0	0	0	0	0
		Bottom	0	0	0	0	0
	C0-0609	Top	0	0	0	0	0
		Middle	0	0	0	0	0
		Bottom	0	0	0	0	0
	T0-0609	Top	0	0	0	0	0
		Middle	0	0	0	0	0
		Bottom	0	0	0	0	0
Day 5	C5-0614	Top	0	0	0	0	0
		Middle	0	0	0	0	0
		Bottom	0	0	0	0	0
	T5-0614	Top	0	0	0	0	0
		Middle	0	0	0	0	0
		Bottom	0	0	0	0	0

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

Appendix 14. The microscope image of ≥ 50㎛ in original water (Day0)

Specific Name	Original water
*Artemia salina**	
Euterpina sp.*	
Acartia sp.*	

Paracalanus sp. *	
Crustacean nauplii**	
Copepoda nauplii**	

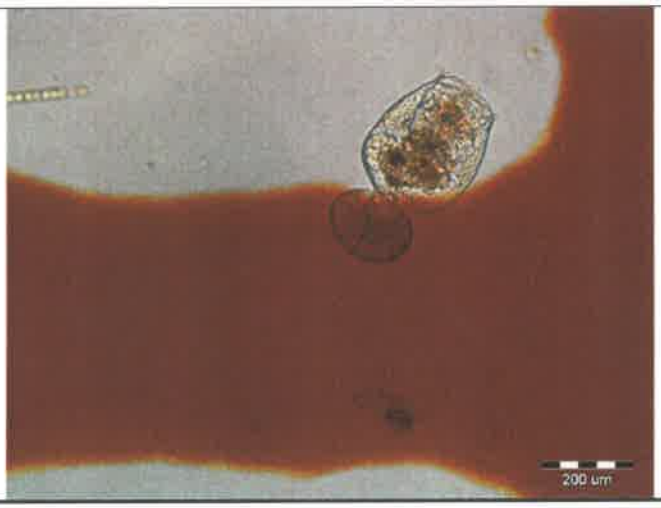
Brachionus plicatilis **	
***Protoperidinium* sp.** **	

* Magnification : 115

**Magnification : 200

Appendix 15. The microscope image of ≥ 50㎛ in control (untreated) seawater by treatment of Purimar™ BWMS (Day0)

Specific Name	Control (untreated) seawater
*Artemia salina**	
Crustacean nauplii**	
Copepoda nauplii**	

*Brachionus plicatilis***	

*Magnification : 115

**Magnification : 200

Appendix 16. The microscope image of ≥ 50㎛ in control (untreated) seawater by treatment of Purimar™ BWMS (Day5)

Specific Name	Control (untreated) seawater
Brachionus plicatilis*	

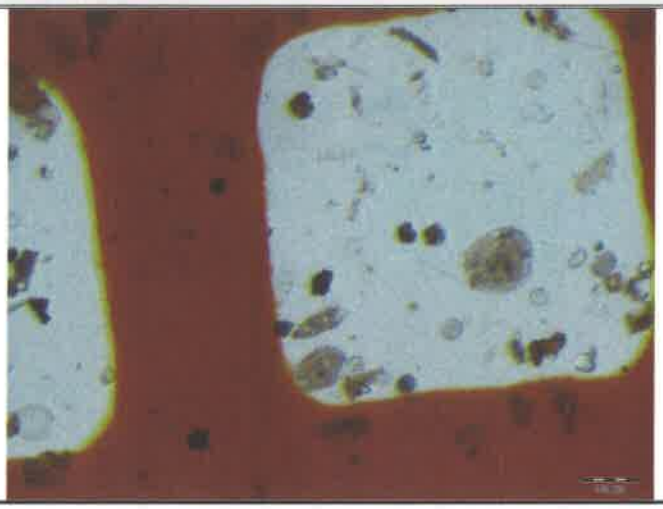
*Magnification : 115

Appendix 17. The microscope image of ≥ 50㎛ in treated ballast seawater by treatment of Purimar^{TM} BWMS (Day0)

Specific Name	Treated ballast seawater
-	

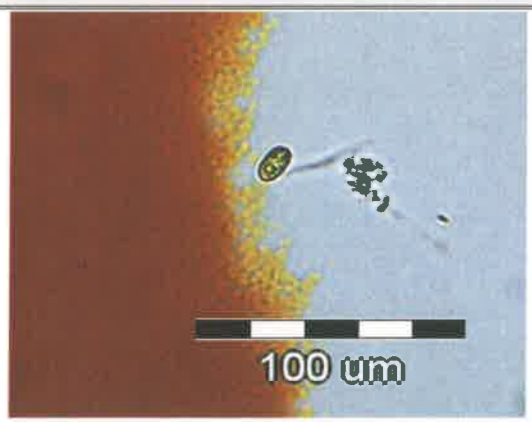
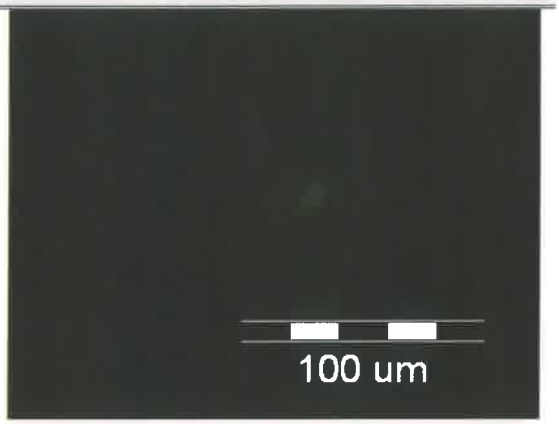
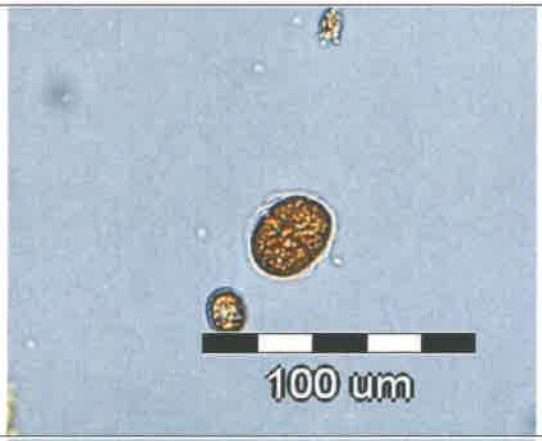
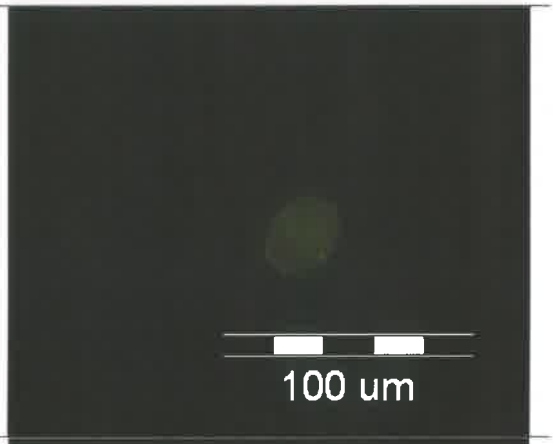
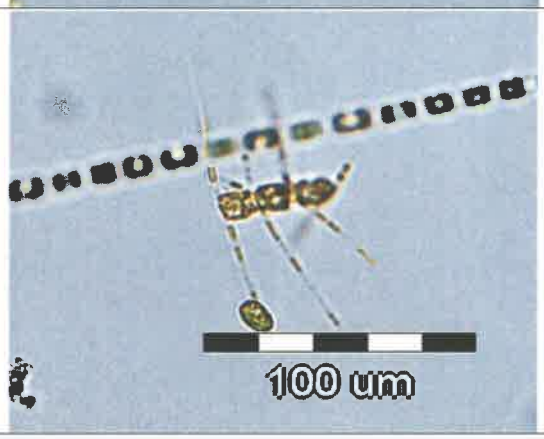
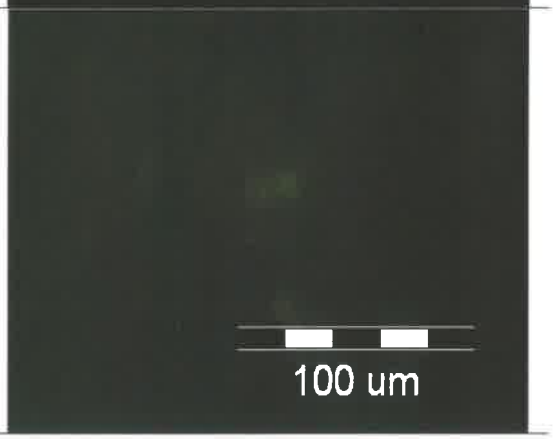
Magnification : 115

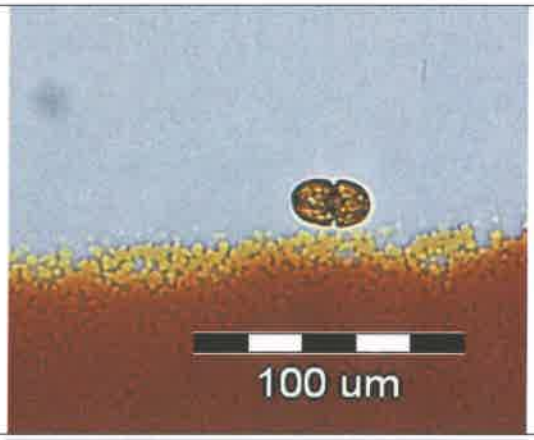
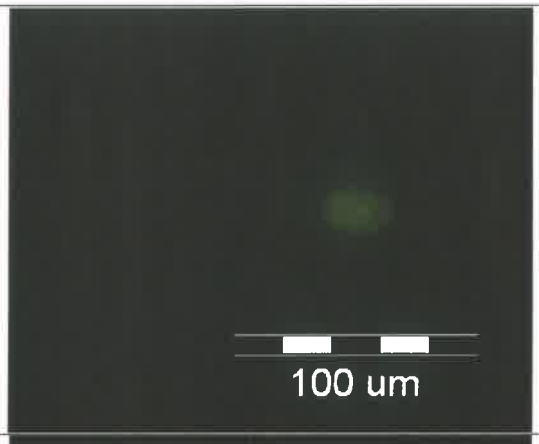
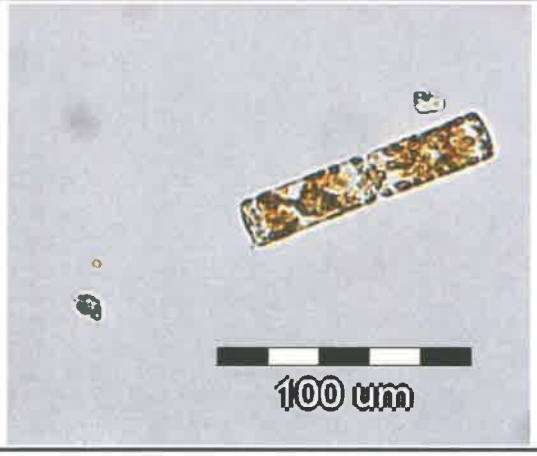
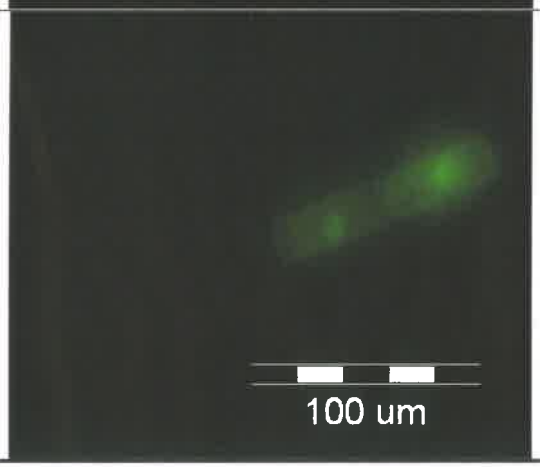
Appendix 18. The microscope image of ≥ 50㎛ in treated ballast seawater by treatment of Purimar™ BWMS (Day5)

Specific Name	Treated ballast seawater
-	

Magnification : 115

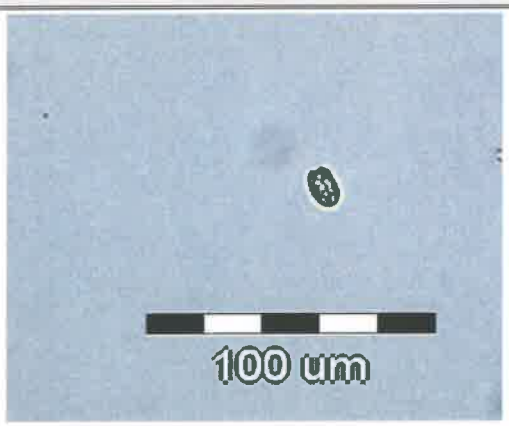
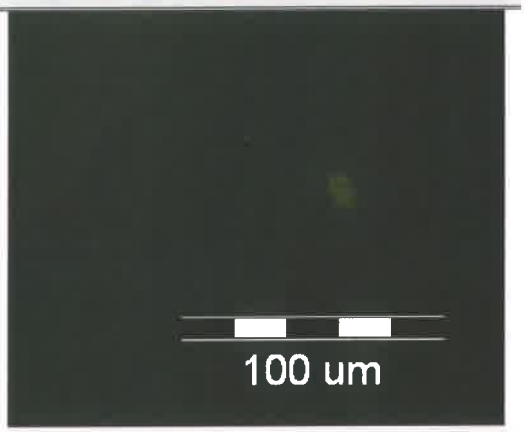
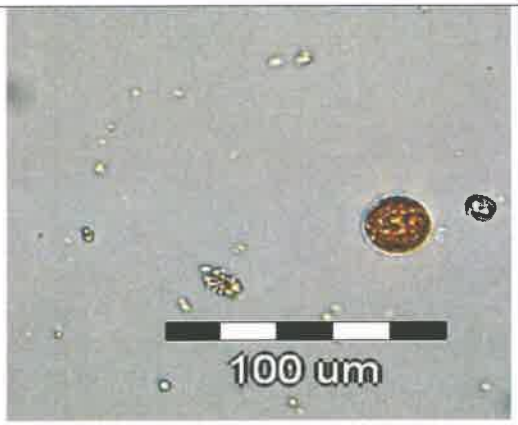
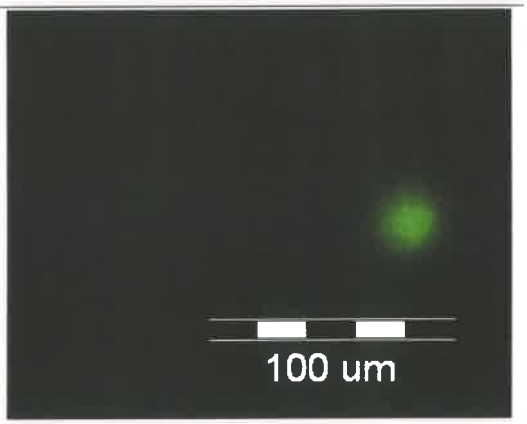
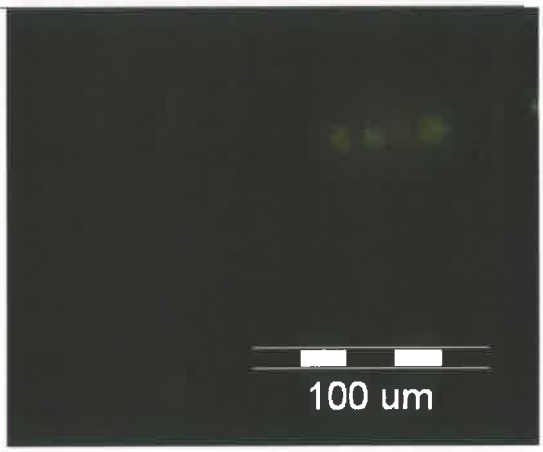
Appendix 19. The microscope image of 10㎛−50㎛ in original water (Day0)

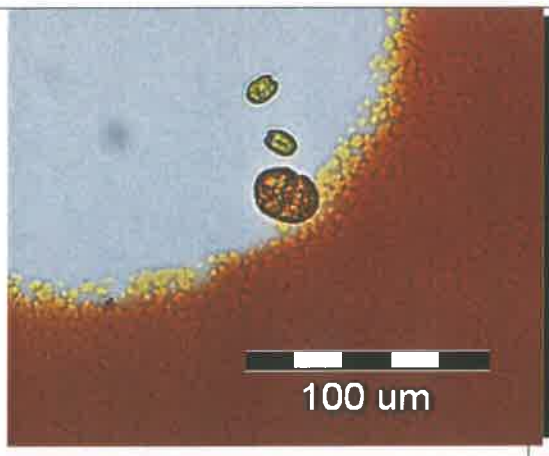
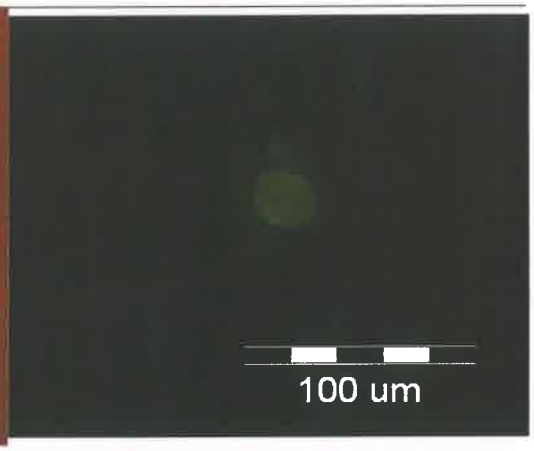
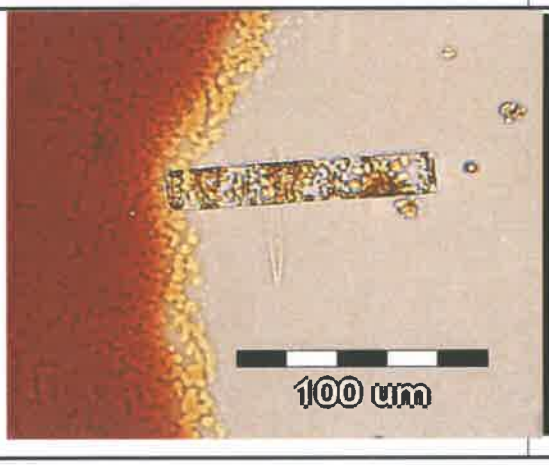
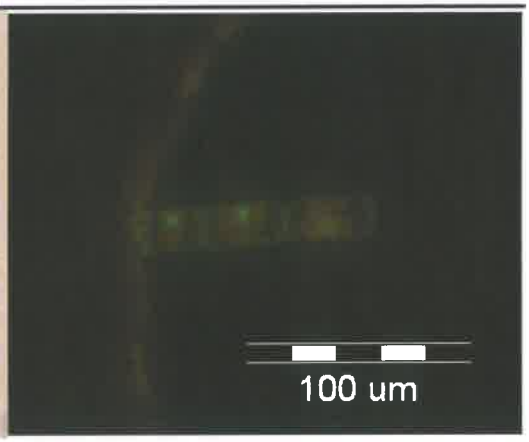
Specific Name	Control (untreated) seawater	
	Optical	Fluorescence
Tetraselmis suecica		
Protoperidinium sp.		
Chaetoceros sp.		

***Gymnodinium* sp.**		
***Melosiosira* sp.**		

Magnification : 200

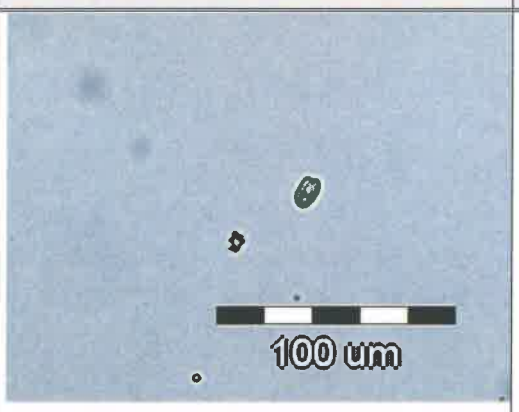
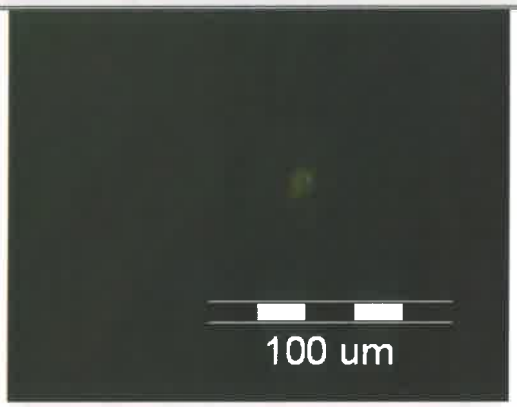
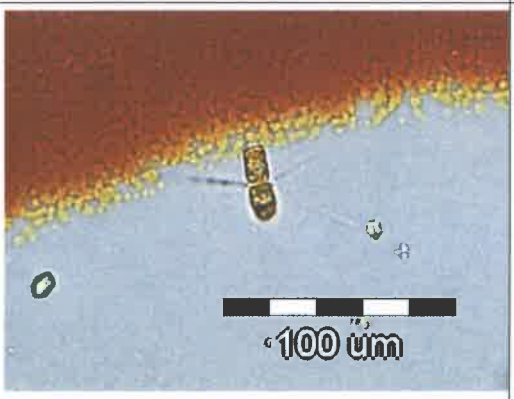
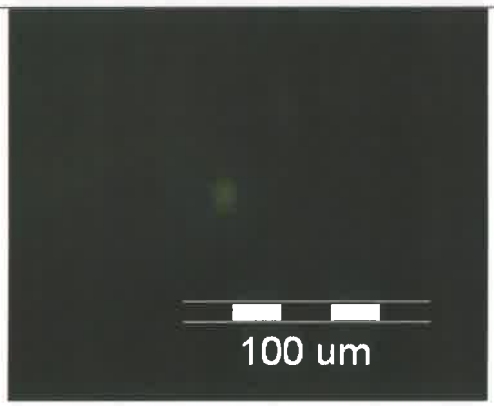
Appendix 20. The microscope image of 10㎛−50㎛ in control (untreated) seawater by treatment of Purimar™ BWMS (Day0)

Specific Name	Control (untreated) seawater	
	Optical	Fluorescence
Tetraselmis suecica		
Protoperidinium sp.		
Chaetoceros sp.		

***Gymnodinium* sp.**		
***Melosiosira* sp.**		

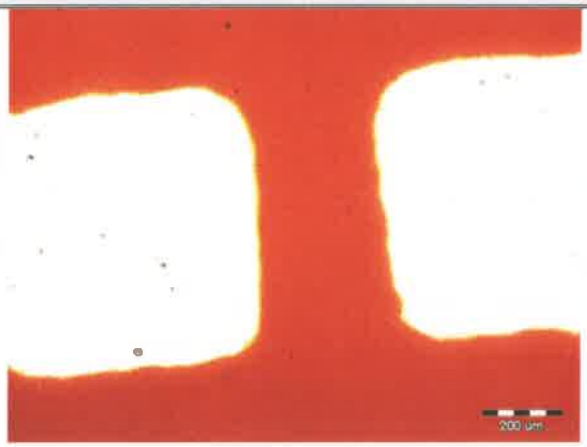
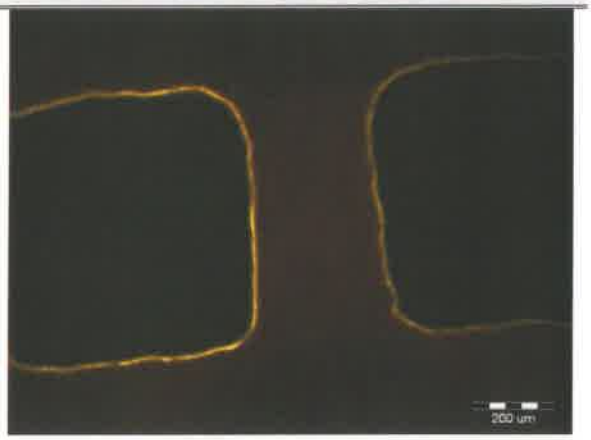
Magnification : 200

Appendix 21. The microscope image of 10㎛−50㎛ in control (untreated) seawater by treatment of Purimar™ BWMS (Day5)

Specific Name	Control (untreated) seawater	
	Optical	Fluorescence
Tetraselmis suecica		
Chaetoceros sp.		

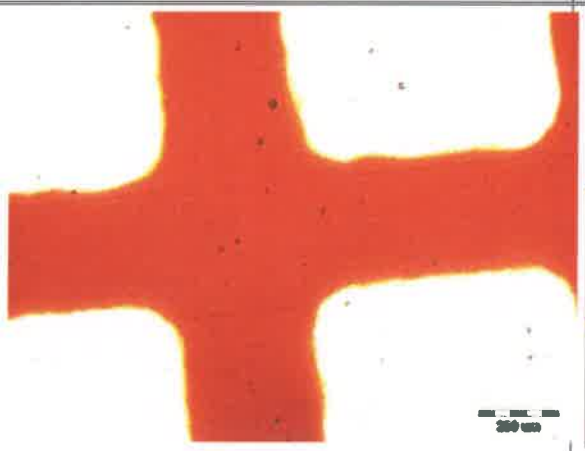
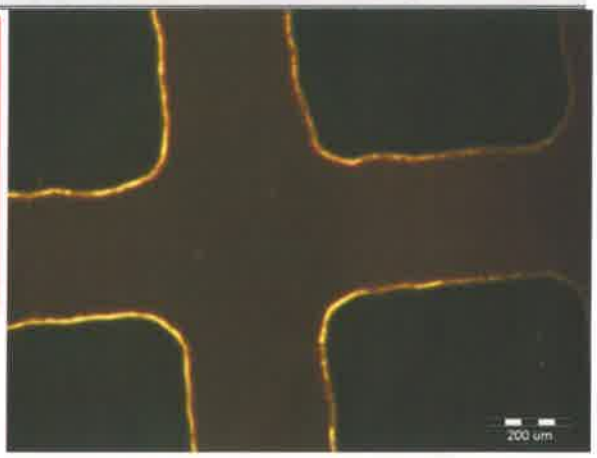
Magnification : 200

Appendix 22. The microscope image of 10㎛−50㎛ in treated ballast seawater by treatment of Purimar™ BWMS (Day0)

Specific Name	Treated ballast seawater	
	Optical	Fluorescence
-		

Magnification : 100

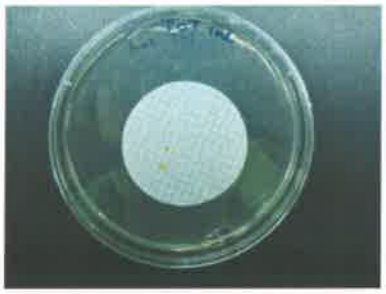
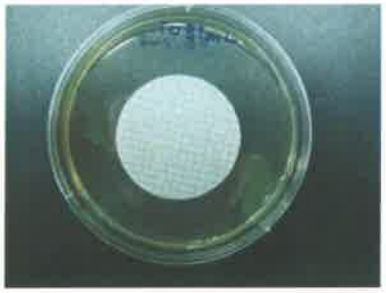
Appendix 23. The microscope image of 10 ㎛–50 ㎛ in neutralized water by treatment of Purimar™ BWMS (Day5)

Specific Name	Neutralized water	
	Optical	Fluorescence
-		

Magnification : 100

Appendix 24. The image of heterotrophic bacteria: Day 0

Treated ballast seawater

Top	Middle	Bottom
		

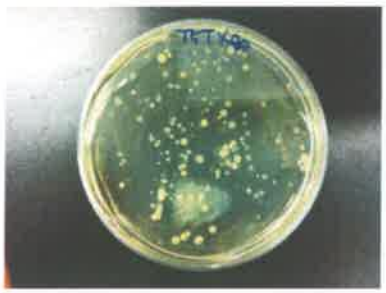
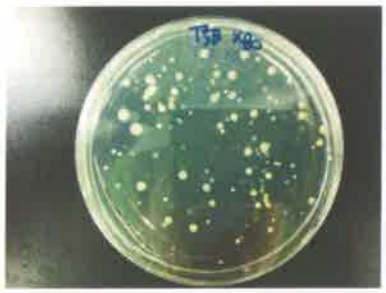
Original water

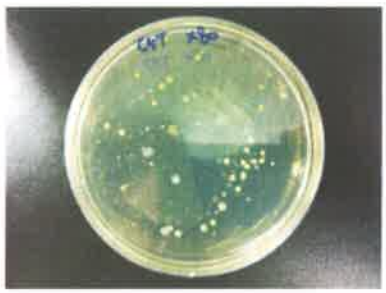
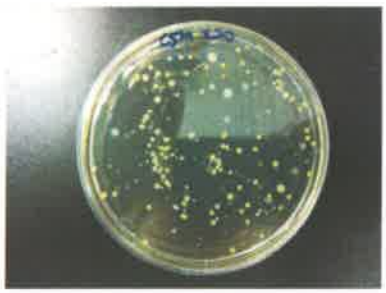
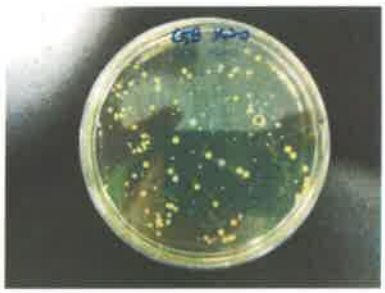
Top	Middle	Bottom

Control (untreated) seawater

Top	Middle	Bottom

Appendix 25. The image of heterotrophic bacteria: Day 5

Treated ballast seawater		
Top	**Middle**	**Bottom**
		

Control (untreated) seawater		
Top	**Middle**	**Bottom**
		

Appendix 26. The image of *Escherichia coli*: Day 0

Treated ballast seawater

Top	Middle	Bottom

Original water

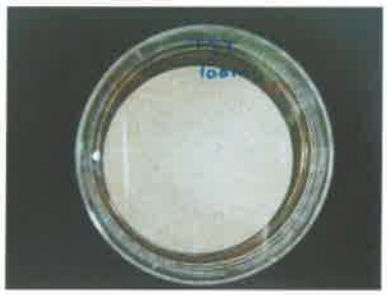
Top	Middle	Bottom

Control (untreated) seawater

Top	Middle	Bottom

Appendix 27. The image of *Escherichia coli*: Day 5

Treated ballast seawater

Top	Middle	Bottom
		

Control (untreated) seawater

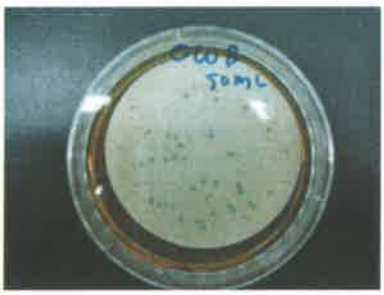
Top	Middle	Bottom

Appendix 28. The image of *Enterococcus faecalis*: Day 0

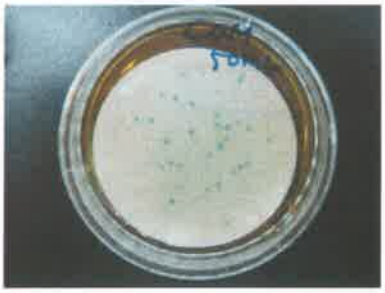
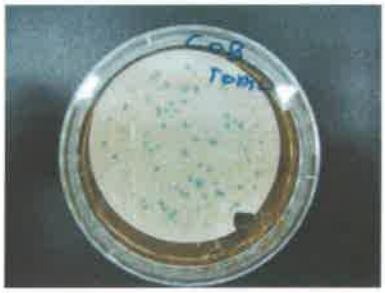
Treated ballast seawater

Top	Middle	Bottom

Original water

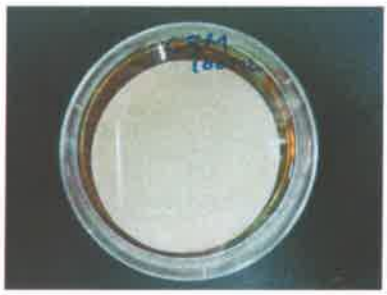
Top	Middle	Bottom
		

Control (untreated) seawater

Top	Middle	Bottom
		

Appendix 29. The image of *Enterococcus faecalis*: Day 5

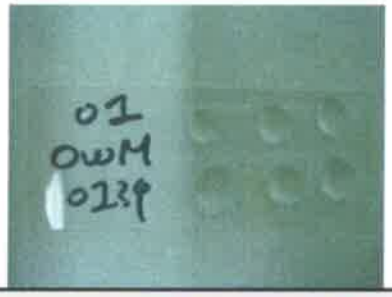
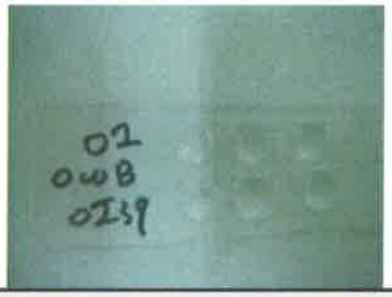
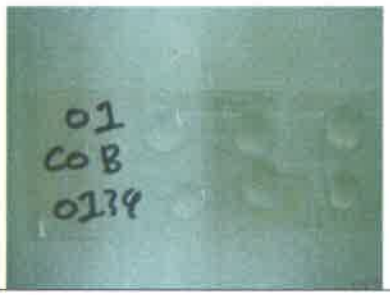
Treated ballast seawater

Top	Middle	Bottom
		

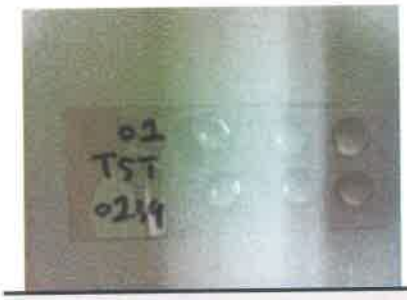
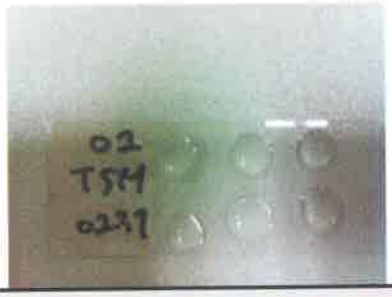
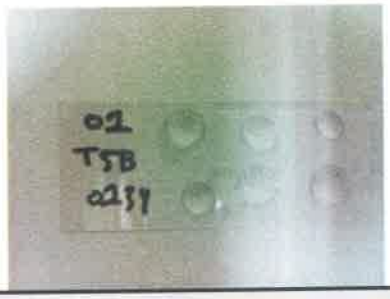
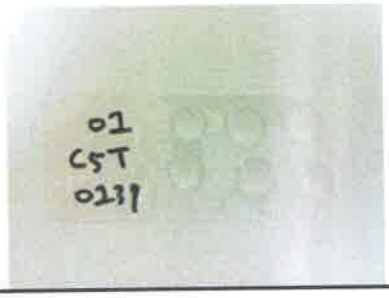
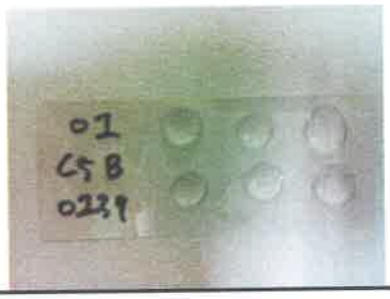
Control (untreated) seawater

Top	Middle	Bottom

Appendix 30. The image of *Vibrio cholera* O1, O139: Day 0

Original water		
Top	**Middle**	**Bottom**
		
Control (untreated) seawater		
Top	**Middle**	**Bottom**
		

Appendix 31. The image of *Vibrio cholera* O1, O139: Day 5

Treated ballast seawater		
Top	**Middle**	**Bottom**
		
Control (untreated) seawater		
Top	**Middle**	**Bottom**
		

5. Attachment

5.1 Filtered natural seawater(FNS) receipt sheet

5.2 Entrance recode sheet

5.3 Flowmeter, seals and power consumption confirming sheet

5.4 Land-based test sheet

5.5 Organism certificate

5.6 Organism check sheet

5.7 Sampling check sheet

5.8 Chain of custody record

5.9 Sample receipt form

5.10 Water parameter measurement sheet (at a field)

5.11 Water parameter measurement sheet (After arrival at the BTP lab)

5.12 TOC measurement sheet

5.13 TSS(Total suspended solid) measurement sheet

5.14 Microbiology test sheet

5.15 Test results sheet – Classification

5.16 Test result sheet with microbiology