Test Report

Project name	Purimar™
Study number	TW-Land(7)
Test number	LET-10-008
Title	Efficacy test of Treated Ballast Brackish water by Purimar™ Ballast Water Management System (Land scale)
Prepared by	Byung-Jun Ko (Sign)

Busan Techno-Park
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Statement of Quality Assurance

Data were reviewed by Quality Assurance Unit of DAU to assure that the study was performed in accordance with protocol and standard operating procedures (SOP) of Marine Bio-industry Development Center (MBDC). 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		September, 02, 2010	September, 02, 2010	September, 02, 2010
Sampling	1st	September, 06, 2010	September, 07, 2010	September, 07, 2010
	2nd	September, 11, 2010	September, 11, 2010	September, 11, 2010
Test substance	1st	September, 06, 2010	September, 07, 2010	September, 07, 2010
	2nd	September, 11, 2010	September, 11, 2010	September, 11, 2010
Test procedures (Bacteria test)	1st	September, 06, 2010	September, 07, 2010	September, 07, 2010
	2nd	September, 11, 2010	September, 11, 2010	September, 11, 2010
• TRO measurement • Observation and counting (≥50㎛, 10㎛-50㎛)	1st	September, 06, 2010	September, 07, 2010	September, 07, 2010
	2nd	September, 11, 2010	September, 11, 2010	September, 11, 2010
Observation and counting (Bacteria test)	1st	September, 07, 2010	September, 07, 2010	September, 07, 2010
	2nd	September, 08, 2010	September, 08, 2010	September, 08, 2010
	3rd	September, 13, 2010	September, 13, 2010	September, 13, 2010
	4th	September, 14, 2010	September, 14, 2010	September, 14, 2010
Raw data		September, 14, 2010	September, 14, 2010	September, 14, 2010
Test report		September, 24, 2010 ~ September, 27, 2010	September, 28, 2010	September, 28, 2010

Eun-Young, Kang (Sign)

Eun-Young, Kang / Quality Assurance

September, 28, 2010

Date

Study Personnel and Participants

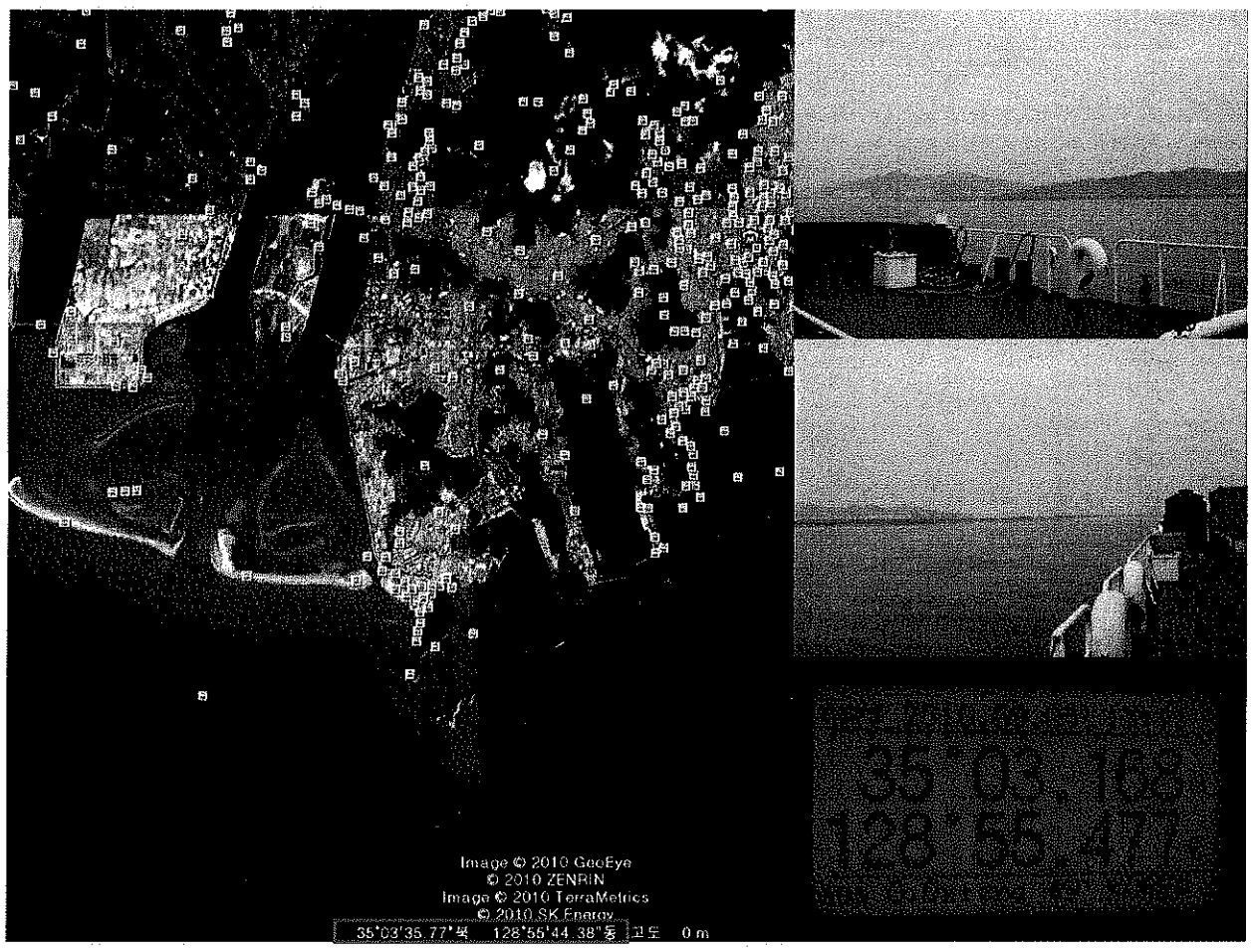
The test participants recognized the study plan, manual, procedure, guide of Marine Bio-industry Development Center in performing the test.

	Name	Date
Study Personnel	Jae Woo, Lee (sign)	September . 28 . 2010
	Sun Ju. Choi (sign)	september. 28 . 2010
	Hana. Song (sign)	September . 28 . 2010
	Eun-Jung. Jung (sign)	September. 28 , 2010
QA/QC	Eunyoung. Kang (sign)	September, 28, 2010
Efficacy Testing Manager	Byong-Jun Ko (sign)	September. 28th, 2010

1. Results

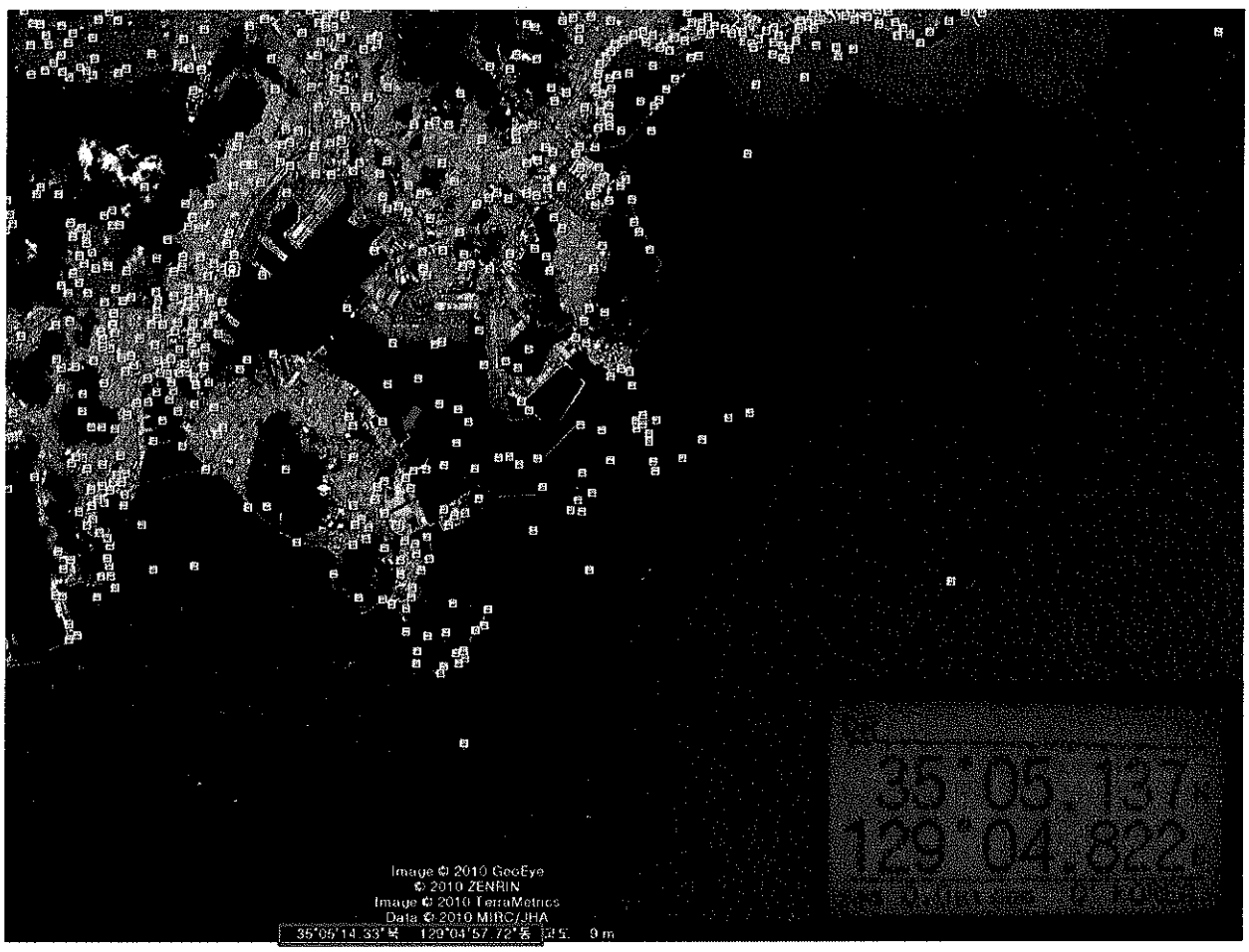
1.1 Sampling point

GPS coordinate	35°03.168N 128°55.477E
Salinity	0.70±0.00 ‰



1.2 Sampling point

GPS coordinate	35°05.137N 129°04.822E
Salinity	34.00 ‰



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-0906	16.93±0.61	11.03±0.40	5.90	83.0±1.3
	OwM-0906	16.30±0.42	10.50±0.28	5.80	86.2±0.8
	OwB-0906	16.50±0.35	10.33±0.25	6.17	89.8±1.0
Acceptability (Salinity : 3 ~ 32 PSU)		-	Acceptable (> 5 mg/L)	Acceptable (> 5 mg/L)	Acceptable (> 50 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)	Chlorophyla
Day 0	OwT-0906	8.00±0.01	24.41±0.00	19.19±0.00	7.57±0.01	-	6.210±0.000
	OwM-0906	7.99±0.00	24.40±0.00	19.20±0.00	7.65±0.01	-	6.300±0.000
	OwB-0906	7.74±0.01	24.40±0.00	19.16±0.00	7.53±0.01	-	6.130±0.000
	C0T-0906	7.83±0.01	25.55±0.00	18.96±0.00	7.01±0.00	-	3.490±0.000
	C0M-0906	7.83±0.01	25.50±0.01	18.95±0.01	6.99±0.00	-	3.330±0.000
	C0B-0906	7.77±0.02	25.56±0.04	18.94±0.01	6.96±0.02	-	3.370±0.000
	T0T-0906	7.86±0.01	24.96±0.00	19.20±0.00	7.39±0.01	-	0.595±0.000
	T0M-0906	7.80±0.02	24.90±0.03	19.18±0.01	7.34±0.01	-	0.649±0.000
	T0B-0906	7.95±0.00	24.91±0.01	19.21±0.01	7.40±0.01	-	0.538±0.000
Day 2	C2M-0908	7.08±0.01	25.16±0.01	19.05±0.00	3.49±0.00	-	2.420±0.000
	T2M-0908	7.29±0.00	25.55±0.00	19.14±0.01	4.75±0.00	-	0.203±0.000
Day 5	C5T-0911	7.39±0.01	25.63±0.01	19.05±0.01	6.96±0.01	-	1.700±0.000
	C5M-0911	7.35±0.01	25.53±0.01	19.08±0.00	6.88±0.01	-	1.290±0.000
	C5B-0911	7.44±0.00	25.42±0.00	19.11±0.00	6.94±0.01	-	1.500±0.000
	T5B-0911	7.43±0.00	25.31±0.01	19.33±0.00	7.24±0.00	-	0.481±0.000
	T5M-0911	7.42±0.00	25.36±0.00	19.37±0.00	7.21±0.01	-	0.250±0.000
	T5B-0911	7.41±0.01	25.15±0.01	19.41±0.01	7.16±0.00	-	0.236±0.000

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

Table 3. Water parameters at MBDC lab

Date	Sample ID & lot No.	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)
Day 0	OwT-0906	8.39±0.01	14.4±0.1	18.89±0.01	9.59±0.02	14.13±0.21
	OwM-0906	8.35±0.00	16.9±0.0	18.97±0.03	8.89±0.01	14.40±0.40
	OwB-0906	8.38±0.00	15.3±0.1	18.67±0.02	8.76±0.01	14.57±0.21
	C0T-0906	8.26±0.00	15.6±0.0	18.63±0.01	8.09±0.01	13.67±0.12
	C0M-0906	8.29±0.00	16.0±0.0	18.68±0.00	8.97±0.01	13.30±0.17
	C0B-0906	8.32±0.00	16.1±0.0	18.70±0.01	8.54±0.03	13.33±0.29
	T0T-0906	8.28±0.01	14.2±0.1	18.65±0.04	9.21±0.01	12.00±0.00
	T0M-0906	8.35±0.00	13.8±0.1	18.88±0.01	9.30±0.07	11.30±0.00
	T0B-0906	8.40±0.00	10.5±0.1	18.55±0.04	9.41±0.01	12.20±0.00
Day 2	C2M-0908	7.44±0.00	22.0±0.0	18.77±0.01	6.93±0.01	11.03±0.21
	T2M-0908	8.19±0.00	21.9±0.0	18.95±0.00	8.15±0.00	10.77±0.83
Day 5	C5T-0911	7.40±0.00	12.0±0.0	18.56±0.00	7.98±0.01	4.94±0.04
	C5M-0911	7.42±0.00	11.8±0.1	18.86±0.01	8.08±0.01	3.13±0.02
	C5B-0911	7.43±0.00	12.4±0.0	18.99±0.01	8.28±0.01	3.71±0.03
	T5B-0911	7.56±0.01	12.4±0.0	19.42±0.01	8.35±0.01	8.84±0.03
	T5M-0911	7.60±0.00	13.0±0.1	19.45±0.00	8.23±0.01	3.48±0.02
	T5B-0911	7.61±0.01	10.7±0.1	18.82±0.00	8.08±0.01	3.02±0.02

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

Table 4. Change of TRO concentration of test substances

Sample ID [a)]	TRO con. (ppm)	CV(%)
C0	N.D	-
T0	0.68±0.02	2.24
C2	N.D	-
T2	0.14±0.01	4.03
C5	N.D	-
T5	N.D	-

All tests of laboratory were performed in triplicate and data shown were the mean ± S.D.
[a)] C0, C2, C5: Control (untreated) brackish water at day 0, day 2 and day 5
T0, T2, T5: Treated ballast brackish water at day 0, day 2 and day 5

1.4 Influent water : Original water

1) ≥ 50 μm organism

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

Sampling	Phyla/Divisions	Species	Survival number/m^3	Minimum Dimension (μm)
Top	Arthropoda	*Artemia salina*	165833 ± 5033	150 ~ 200
		Crustacean nauplii	4333 ± 289	120 ~ 160
		Oithona sp.	2833 ± 577	98 ~ 150
	Rotifera	*Brachionus* sp.	4167 ± 764	80 ~ 110
	Dinophyta	*Protoperidinium* sp.	20000 ± 5000	53 ~ 60
Middle	Arthropoda	*Artemia salina*	223500 ± 4583	150 ~ 200
		Crustacean nauplii	3167 ± 289	120 ~ 160
		Oithona sp.	3000 ± 0	98 ~ 150
		Evadne sp.	333 ± 289	160 ~ 180
		Centrophages sp.	1500 ± 500	150 ~ 180
	Rotifera	*Brachionus* ssp.	3833 ± 289	80 ~ 110
	Dinophyta	*Protoperidinium* sp.	18333 ± 7638	53 ~ 60
Bottom	Arthropoda	*Artemia salina*	210500 ± 3000	150 ~ 200
		Crustacean nauplii	4500 ± 500	120 ~ 160
		Oithona sp.	2667 ± 764	250 ~ 270
		Acartia sp.	833 ± 289	160 ~ 170
	Rotifera	*Brachionus* ssp.	2500 ± 500	80 ~ 110
	Dinophyta	*Protoperidinium* sp.	13333 ± 2887	53 ~ 60
Total	8 species 3 phyla/divisions		228389 ± 28715	-
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 6. 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*	2093.33 ± 49.33	11 ~ 12
	Bacillariophyta	*Thalassiosira* sp.	5.33 ± 1.15	20 ~ 45
		Chaetoceros sp.	5.33 ± 0.58	15 ~ 40
		Ceratium sp.	2.33 ± 0.58	15 ~ 45
	Dinophyta	*Protoperidinium* sp.	4.67 ± 0.58	20 ~ 45
Middle	Chlorophyta	*Tetraselmis suecica*	1910.00 ± 70.00	11 ~ 12
	Bacillariophyta	*Thalassiosira* sp.	5.00 ± 1.00	20 ~ 45
		Chaetoceros sp.	2.67 ± 0.58	15 ~ 40
		Ceratium sp.	4.67 ± 0.58	15 ~ 45
	Dinophyta	*Protoperidinium* sp.	5.00 ± 1.00	20 ~ 45
Bottom	Chlorophyta	*Tetraselmis suecica*	2006.67 ± 66.58	11 ~ 12
	Bacillariophyta	*Thalassiosira* sp.	2.67 ± 0.58	20 ~ 45
		Chaetoceros sp.	1.67 ± 0.58	15 ~ 40
		Ceratium sp.	4.33 ± 0.58	15 ~ 45
	Dinophyta	*Protoperidinium* sp.	2.33 ± 0.58	20 ~ 45
Total	5 species 3 phyla/divisions		2018.67 ± 91.84	-
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 7. Survival number of the organism larger than 50 μm

Test substance	Sampling		Survival number/m^3	Acceptibility	Elimination efficacy (%)
Original water	Day 0 (Ow)	T [a)]	197167 ± 9674	Influent condition: Acceptable (≥10^5 ind./m^3)	
		M [b)]	253667 ± 8694		
		B [c)]	234333 ± 2754		
Control (untreated) brackish water	Day 0 (C0)	T	38833 ± 4252	-	-
		M	39167 ± 1041		
		B	33167 ± 2255		
	Day 5 (C5)	T	667 ± 289	Effluent condition: Acceptable (≥10^2 ind./m^3)	
		M	333 ± 144		
		B	500 ± 250		
Treated ballast brackish water	Day 0 (T0)	T	0.0 ± 0.0	Effluent condition : Acceptable (<10 ind./m^3)	100.0 [d)]
		M	0.0 ± 0.0		
		B	0.0 ± 0.0		
	Day 5 (T5)	T	0.0 ± 0.0	Effluent condition : Acceptable (<10 ind./m^3)	100.0 [e)]
		M	0.0 ± 0.0		
		B	0.0 ± 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 8. Survival number of the organism between 10 and 50 μm

Test substance	Sampling		Survival number/mL	Acceptibility	Elimination efficacy (%)
Original water	Day 0 (Ow)	T [a)]	2111.00 ± 50.59	Influent condition: Acceptable ($\geq 10^3$ ind./mL)	-
		M [b)]	1927.33 ± 70.22		
		B [c)]	2017.67 ± 66.58		
Control (untreated) brackish water	Day 0 (C0)	T	983.33 ± 55.08	-	-
		M	1016.00 ± 30.00		
		B	981.00 ± 45.03		
	Day 5 (C5)	T	148.00 ± 7.21	Effluent condition: Acceptable ($\geq 10^2$ ind./ ml)	
		M	162.00 ± 7.00		
		B	141.67 ± 7.51		
Treated ballast brackish water	Day 0 (T0)	T	0.00 ± 0.00	Effluent condition : Acceptable (<10 ind./ ml)	100.0 [d)]
		M	0.00 ± 0.00		
		B	0.00 ± 0.00		
	Day 5 (T5)	T	0.00 ± 0.00	Effluent condition : Acceptable (<10 ind./ ml)	100.0 [e)]
		M	0.00 ± 0.00		
		B	0.00 ± 0.00		

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.

3) Heterotrophic bacteria

Table 9. Survival number of heterotrophic bacteria

Test substance	Sampling		CFU / mL	Acceptibility	Elimination efficacy (%)
Original water	Day 0 (Ow)	T [a)]	47200.0 ± 5600.0	Influent condition: Acceptable ($\geq 10^4$ CFU/mL)	-
		M [b)]	36733.3 ± 896.3		
		B [c)]	22766.7 ± 2227.9		
Control (untreated) brackish water	Day 0 (C0)	T	76766.7 ± 2050.2	-	-
		M	38766.7 ± 2250.2		
		B	23066.7 ± 850.5		
	Day 5 (C5)	T	123733.3 ± 3233.2	-	
		M	83666.7 ± 3092.5		
		B	103200.0 ± 20133.8		
Treated ballast brackish water	Day 0 (T0)	T	63.3 ± 35.1	-	99.9 [d)]
		M	33.3 ± 11.5		
		B	36.7 ± 15.3		
	Day 5 (T5)	T	93333.3 ± 12957.4	-	-59.2 [e)]
		M	61500.0 ± 7410.1		
		B	65766.7 ± 6646.3		

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 10. Survival number of *Escherichia coli*

Test substance	Sampling		CFU / 100 mL	Acceptibility	Elimination efficacy (%)
Original water	Day 0 (Ow)	T [a)]	106.0 ± 15.9	-	
		M [b)]	102.7 ± 5.0		
		B [c)]	106.7 ± 6.4		
Control (untreated) brackish water	Day 0 (C0)	T	126.0 ± 9.2	-	-
		M	142.7 ± 24.4		
		B	133.3 ± 24.1		
	Day 5 (C5)	T	2.7 ± 2.3	-	
		M	1.0 ± 1.0		
		B	3.0 ± 1.0		
Treated ballast brackish water	Day 0 (T0)	T	0.0 ± 0.0	Effluent condition: Acceptable (<250 CFU/ 100ml)	100.0 [d)]
		M	0.0 ± 0.0		
		B	0.0 ± 0.0		
	Day 5 (T5)	T	3.3 ± 0.6	Effluent condition: Acceptable (<250 CFU/ 100ml)	98.6 [e)]
		M	2.3 ± 2.3		
		B	0.0 ± 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 11. Survival number of *Enterococcus faecalis*

Test substance	Sampling		CFU / 100 mL	Acceptability	Elimination efficacy (%)
Original water	Day 0 (Ow)	T [a)]	45.3 ± 18.1	-	
		M [b)]	38.7 ± 7.6		
		B [c)]	37.3 ± 3.1		
Control (untreated) brackish water	Day 0 (C0)	T	348.7 ± 79.2	-	-
		M	388.7 ± 12.9		
		B	348.7 ± 49.2		
	Day 5 (C5)	T	12.0 ± 8.0	-	
		M	9.3 ± 0.6		
		B	20.0 ± 7.2		
Treated ballast brackish water	Day 0 (T0)	T	0.0 ± 0.0	Effluent condition: Acceptable (<100 CFU/ 100ml)	100.0 [d)]
		M	0.0 ± 0.0		
		B	0.0 ± 0.0		
	Day 5 (T5)	T	0.7 ± 1.7	Effluent condition: Acceptable (<100 CFU/ 100ml)	99.8 [e)]
		M	0.3 ± 1.7		
		B	0.7 ± 1.2		

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.

6) *Vibrio cholera* O1, O139

Table 12. 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 ± 0.0	-	-
		M [b)]	0.0 ± 0.0		
		B [c)]	0.0 ± 0.0		
Control (untreated) brackish water	Day 0 (C0)	T	0.0 ± 0.0	-	-
		M	0.0 ± 0.0		
		B	0.0 ± 0.0		
	Day 5 (C5)	T	0.0 ± 0.0	-	
		M	0.0 ± 0.0		
		B	0.0 ± 0.0		
Treated ballast brackish water	Day 0 (T0)	T	0.0 ± 0.0	Effluent condition: Acceptable (<1 CFU/ 100ml)	N.D [d)]
		M	0.0 ± 0.0		
		B	0.0 ± 0.0		
	Day 5 (T5)	T	0.0 ± 0.0	Effluent condition: Acceptable (<1 CFU/ 100ml)	N.D
		M	0.0 ± 0.0		
		B	0.0 ± 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: 3 ~ 32 PSU
  - DOC: > 5 mg/L
  - POC: > 5 mg/L
  - TSS: > 50 mg/L

Date	Sample ID & lot No.	Salinity [a] (‰)	DOC (mg/L)	POC (mg/L)	TSS (mg/L)
Day 0	OwT-0906	19.19±0.00	11.03±0.40	5.90	83.0±1.3
	OwM-0906	19.20±0.00	10.50±0.28	5.80	86.2±0.8
	OwB-0906	19.16±0.00	10.33±0.25	6.17	89.8±1.0

a) Salinity: data at field

- All measurements were tested more than three times.
- Sample was analyzed as soon as possible after arrival at MBDC 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: ≥ 10^5 individuals/m^3
  - The organism between 10 μm and 50 μm: ≥ 10^3 individuals / mL
  - Heterotrophic bacteria: ≥ 10^4 CFU/ mL

Sample		≥ 50 μm (individuals/m^3)	10 μm - 50 μm (individuals/mL)	Heterotrophic bacteria (CFU/mL)
Field	OwT	234500	1646	-
Lab	OwT	197167 ± 9674	2111.00 ± 50.59	47200.0 ± 5600.0
	OwM	253667 ± 8694	1927.33 ± 70.22	36733.3 ± 896.3
	OwB	234333 ± 2754	2017.67 ± 66.58	22766.7 ± 2227.9

- 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	14:40~14:52	19:10
	OwM	14:41~14:52	19:10
	OwB	14:40~14:51	19:10
	C0T	14:58~15:05	19:32
	C0M	14:58~16:06	19:32
	C0B	14:58~15:05	19:32
	T0T	17:03~17:05	20:10
	T0M	16:32~17:03	20:10
	T0B	16:15~17:02	20:10
Day 5	C5T	15:12~15:18	19:50
	C5M	15:12~15:21	19:50
	C5B	15:12~15:18	19:50
	T5T	16:21~16:28	20:00
	T5M	15:54~16:21	20:00
	T5B	15:48~16:08	20:00
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	667 ± 289	148.00 ± 7.21
Middle	333 ± 144	162.00 ± 7.00
Bottom	500 ± 250	141.67 ± 7.51

3. Conclusion

3.1 Biological efficacy in treated ballast brackish water by Purimar™ BWMS

- Treated ballast brackish water by Purimar™ BWMS were capable of eliminating organism larger than 50 μm with an efficiency of 100%.
- Treated ballast brackish water by Purimar™ BWMS were capable of eliminating organism between 10 and 50 μm with an efficiency of 100%.
- Treated ballast brackish water by Purimar™ BWMS was capable of eliminating heterotrophic bacteria with an efficiency of 99.9 %. at day 0
- But the number of heterotrophic bacteria in treated ballast brackish water was increased at day 5 compared to control brackish water at day 0. Therefore, elimination efficacy of heterotrophic bacteria was reduced at day 5.
- Treated ballast brackish water by Purimar™ BWMS were capable of eliminating *Escherichia coli* with an efficiency of 100, 98.6 % at day 0, 5.
- Treated ballast brackish water by Purimar™ BWMS were capable of eliminating *Enterococcus faecalis* with an efficiency of 100, 99.8 % at day 0, 5.
- *Vibrio cholera* O1, O139 were not detected.
- Therefore, treated ballast brackish water by Purimar™ BWMS was capable of removing organism(> 50 μm, 10 ~ 50 μm) 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-0906	R1	16.40	10.80	81.5
		R2	17.60	11.50	84.0
		R3	16.80	10.80	83.5
	OwM-0906	R1	16.10	10.10	85.5
		R2	16.70	10.50	86.0
		R3	16.10	10.90	87.0
	OwB-0906	R1	16.10	10.30	89.5
		R2	16.70	10.60	89.0
		R3	16.70	10.10	91.0

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)	Chlorophyla
Day 0	OwT-0906	R1	8.00	24.41	19.19	7.56	-	6.210
		R2	8.00	24.41	19.19	7.57	-	6.210
		R3	8.01	24.41	19.19	7.57	-	6.210
	OwM-0906	R1	7.99	24.40	19.20	7.65	-	6.300
		R2	7.99	24.40	19.20	7.66	-	6.300
		R3	7.99	24.40	19.20	7.65	-	6.300
	OwB-0906	R1	7.73	24.40	19.16	7.53	-	6.130
		R2	7.74	24.40	19.16	7.53	-	6.130
		R3	7.74	24.40	19.16	7.52	-	6.130
	C0T-0906	R1	7.82	25.55	18.96	7.01	-	3.490
		R2	7.83	25.55	18.96	7.01	-	3.490
		R3	7.84	25.55	18.96	7.01	-	3.490
	C0M-0906	R1	7.83	25.49	18.95	6.99	-	3.330
		R2	7.83	25.50	18.95	6.99	-	3.330
		R3	7.84	25.50	18.96	6.99	-	3.330
	C0B-0906	R1	7.75	25.52	18.95	6.97	-	3.370
		R2	7.77	25.57	18.94	6.96	-	3.370
		R3	7.78	25.59	18.94	6.94	-	3.370
	T0T-0906	R1	7.86	24.96	19.20	7.40	-	0.595
		R2	7.86	24.96	19.20	7.38	-	0.595
		R3	7.87	24.96	19.20	7.38	-	0.595
	T0M-0906	R1	7.78	24.93	19.17	7.33	-	0.649
		R2	7.80	24.89	19.19	7.34	-	0.649
		R3	7.82	24.88	19.19	7.35	-	0.649
	T0B-0906	R1	7.95	24.92	19.21	7.40	-	0.538
		R2	7.95	24.91	19.21	7.40	-	0.538
		R3	7.95	24.90	19.22	7.41	-	0.538
Day 2	C2M-0908	R1	7.09	25.16	19.05	3.49	-	2.420
		R2	7.08	25.16	19.05	3.49	-	2.420
		R3	7.08	25.17	19.05	3.49	-	2.420
	T2M-0908	R1	7.29	25.55	19.13	4.75	-	0.203
		R2	7.29	25.55	19.14	4.75	-	0.203
		R3	7.29	25.55	19.14	4.75	-	0.203
Day 5	C5T-0911	R1	7.39	25.62	19.05	6.96	-	1.700
		R2	7.39	25.62	19.05	6.95	-	1.700
		R3	7.38	25.64	19.04	6.96	-	1.700
	C5M-0911	R1	7.36	25.52	19.08	6.87	-	1.290
		R2	7.35	25.53	19.08	6.88	-	1.290
		R3	7.35	25.53	19.08	6.88	-	1.290
	C5B-0911	R1	7.44	25.42	19.11	6.94	-	1.500
		R2	7.44	25.42	19.11	6.95	-	1.500
		R3	7.44	25.42	19.11	6.94	-	1.500
	T5T-0911	R1	7.43	25.30	19.33	7.24	-	0.481
		R2	7.43	25.31	19.33	7.24	-	0.481
		R3	7.43	25.32	19.33	7.24	-	0.481
	T5M-0911	R1	7.42	25.36	19.37	7.21	-	0.250
		R2	7.42	25.36	19.37	7.21	-	0.250
		R3	7.42	25.36	19.37	7.20	-	0.250
	T5B-0911	R1	7.42	25.14	19.41	7.16	-	0.236
		R2	7.41	25.15	19.41	7.16	-	0.236
		R3	7.41	25.16	19.40	7.16	-	0.236

a) R: Replicate

Appendix 3. Water parameters at MBDC lab.

Date	Sample ID & lot No.	R [a)]	pH	Temp (°C)	Salinity (‰)	DO (mg/L)	Turbidity (NTU)
Day 0	OwT-0906	R1	8.38	14.5	18.90	9.57	13.90
		R2	8.39	14.4	18.89	9.60	14.20
		R3	8.39	14.4	18.89	9.60	14.30
	OwM-0906	R1	8.35	16.9	19.00	8.90	14.00
		R2	8.35	16.9	18.98	8.90	14.80
		R3	8.35	16.9	18.94	8.88	14.40
	OwB-0906	R1	8.38	15.3	18.66	8.75	14.40
		R2	8.38	15.3	18.66	8.77	14.50
		R3	8.38	15.2	18.69	8.76	14.80
	C0T-0906	R1	8.26	15.6	18.62	8.10	13.60
		R2	8.26	15.6	18.63	8.08	13.80
		R3	8.26	15.6	18.63	8.09	13.60
	C0M-0906	R1	8.29	16.0	18.68	8.98	13.10
		R2	8.29	16.0	18.68	8.97	13.40
		R3	8.29	16.0	18.68	8.97	13.40
	C0B-0906	R1	8.32	16.1	18.70	8.53	13.00
		R2	8.32	16.1	18.69	8.52	13.50
		R3	8.32	16.1	18.71	8.57	13.50
	T0T-0906	R1	8.28	14.1	18.61	9.20	12.00
		R2	8.28	14.1	18.65	9.22	12.00
		R3	8.29	14.3	18.68	9.22	12.00
	T0M-0906	R1	8.35	13.8	18.87	9.23	11.30
		R2	8.35	13.8	18.88	9.36	11.30
		R3	8.35	13.9	18.89	9.30	11.30
	T0B-0906	R1	8.40	10.4	18.51	9.42	12.20
		R2	8.40	10.5	18.56	9.41	12.20
		R3	8.40	10.5	18.58	9.40	12.20
Day2	C2M-0908	R1	7.44	22.0	18.77	6.94	10.80
		R2	7.44	22.0	18.77	6.93	11.20
		R3	7.44	22.0	18.76	6.92	11.10
	T2M-0908	R1	8.19	21.9	18.95	8.15	10.10
		R2	8.19	21.9	18.95	8.15	11.70
		R3	8.19	21.9	18.95	8.15	10.50
Day 5	C5T-0911	R1	7.40	12.0	18.56	7.99	4.89
		R2	7.40	12.0	18.56	7.98	4.96
		R3	7.40	12.0	18.56	7.98	4.96
	C5M-0911	R1	7.42	11.8	18.86	8.08	3.12
		R2	7.42	11.8	18.86	8.08	3.15
		R3	7.42	11.9	18.85	8.09	3.13
	C5B-0911	R1	7.43	12.4	18.98	8.28	3.68
		R2	7.43	12.4	18.99	8.29	3.73
		R3	7.43	12.4	18.99	8.28	3.73
	T5T-0911	R1	7.56	12.4	19.42	8.36	8.81
		R2	7.57	12.4	19.43	8.35	8.86
		R3	7.56	12.4	19.42	8.35	8.85
	T5M-0911	R1	7.60	13.0	19.45	8.24	3.49
		R2	7.60	13.0	19.45	8.23	3.48
		R3	7.60	13.1	19.45	8.23	3.46
	T5B-0911	R1	7.61	10.8	18.82	8.09	3.01
		R2	7.62	10.7	18.82	8.08	3.04
		R3	7.61	10.7	18.82	8.08	3.02

a) R: Replicate

Appendix 4. Change of TRO concentration of test substances

Date	Sample ID	R [a)]	TRO con. (ppm)[b)]
Day 0	C0	R1	N.D
		R2	N.D
		R3	N.D
	T0	R1	0.68
		R2	0.70
		R3	0.67
Day 2	C2	R1	N.D
		R2	N.D
		R3	N.D
	T2	R1	0.15
		R2	0.14
		R3	0.14
Day 5	C5	R1	N.D
		R2	N.D
		R3	N.D
	T5	R1	N.D
		R2	N.D
		R3	N.D

a) R: Replicate

Appendix 5. 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-0906	*Artemia salina*	160500	166500	170500	165833	5033
		Crustacean nauplii	4500	4500	4000	4333	289
		Oithona sp.	2500	2500	3500	2833	577
		Brachionus ssp.	3500	4000	5000	4167	764
		Protoperidinium ssp.	15000	25000	20000	20000	5000
	OwM-0906	*Artemia salina*	224500	227500	218500	223500	4583
		Crustacean nauplii	3500	3000	3000	3167	289
		Oithona sp.	3000	3000	3000	3000	0
		Evadne sp.	500	0	500	333	289
		Centrophages sp.	1500	1000	2000	1500	500
		Brachionus ssp.	4000	4000	3500	3833	289
		Protoperidinium ssp.	10000	25000	20000	18333	7638
	OwB-0906	*Artemia salina*	210500	207500	213500	210500	3000
		Crustacean nauplii	5000	4000	4500	4500	500
		Oithona sp.	3500	2500	2000	2667	764
		Acartia sp.	1000	1000	500	833	289
		Brachionus ssp.	2500	3000	2000	2500	500
		Pediastrum sp.	15000	15000	10000	13333	2887

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

Appendix 6. Survival number of ≥ 50μm organism in control (untreated) brackish water

Date	Sample ID	Classification	Survival number /m^3			Mean	SD [b)]
			R1[a)]	R2	R3		
Day 0	C0T - 0906	*Artemia salina*	16000	16500	15500	16000	500
		Crustacean nauplii	1500	1500	1000	1333	289
		Oithona sp.	1000	2000	1000	1333	577
		Brachionus ssp.	2000	2000	1500	1833	289
		Protoperidinium ssp.	20000	20000	15000	18333	2887
	C0M- 0906	*Artemia salina*	34000	33000	33000	33333	577
		Crustacean nauplii	2500	2500	2000	2333	289
		Centrophages sp.	500	500	500	500	0
		Oithona sp.	1500	1000	1500	1333	289
		Brachionus ssp.	1500	1000	2500	1667	764
	C0B- 0906	*Artemia salina*	27000	30500	32500	30000	2784
		Crustacean nauplii	2000	1000	1000	1333	577
		Oithona sp.	1000	1000	1000	1000	0
		Brachionus ssp.	1000	1000	1000	1000	0
Day 5	C5T - 0911	*Brachionus* ssp.	0	0	250	83	144
		Crustacean nauplii	250	250	500	333	144
		Oithona sp.	250	250	250	250	0
	C5M- 0911	*Brachionus* ssp.	250	0	0	83	144
		Crustacean nauplii	250	500	250	333	144
		Oithona sp.	250	250	500	333	144
	C5B- 0911	*Brachionus* ssp.	250	0	250	167	144
		Crustacean nauplii	250	250	250	250	0
		Oithona sp.	0	0	250	83	144

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

Appendix 7. Survival number of ≥ 50㎛ organism in treated ballast brackish water by treatment of Purimar™ BWMS

Date	Sample ID	Classification	Survival number /m³			Mean	SD [b]
			R1[a]	R2	R3		
Day 0	T0T - 0906	-	0	0	0	0.0	0.0
	T0M- 0906	-	0	0	0	0.0	0.0
	T0B- 0906	-	0	0	0	0.0	0.0
Day 5	T5T - 0911	-	0	0	0	0.0	0.0
	T5M- 0911	-	0	0	0	0.0	0.0
	T5B- 0911	-	0	0	0	0.0	0.0

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

Appendix 8. 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-0906	*Tetraselmis suecica*	2060	2150	2070	2093.33	49.33
		Thalassiosira sp.	4	6	6	5.33	1.15
		Chaetoceros sp.	5	6	5	5.33	0.58
		Ceratium sp.	3	2	2	2.33	0.58
		Protoperidinium sp.	4	5	5	4.67	0.58
	OwM-0906	*Tetraselmis suecica*	1960	1830	1940	1910.00	70.00
		Thalassiosira sp.	5	4	6	5.00	1.00
		Chaetoceros sp.	3	2	3	2.67	0.58
		Ceratium sp.	4	5	5	4.67	0.58
		Protoperidinium sp.	5	6	4	5.00	1.00
	OwB-0906	*Tetraselmis suecica*	2040	1930	2050	2006.67	66.58
		Thalassiosira sp.	3	2	3	2.67	0.58
		Chaetoceros sp.	1	2	2	1.67	0.58
		Ceratium sp.	4	5	4	4.33	0.58
		Protoperidinium sp.	3	2	2	2.33	0.58

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 control (untreated) brackish water

Date	Sample ID	Classification	Survival number / ml			Mean	SD [b)]
			R1[a)]	R2	R3		
Day 0	C0T - 0906	*Tetraselmis suecica*	1030	920	970	973.33	55.08
		Thalassiosira sp.	3	4	3	3.33	0.58
		Ceratium sp.	2	2	3	2.33	0.58
		Chaetoceros sp.	2	2	1	1.67	0.58
		Protoperidinium sp.	3	2	3	2.67	0.58
	C0M- 0906	*Tetraselmis suecica*	980	1010	1040	1010.00	30.00
		Thalassiosira sp.	3	2	2	2.33	0.58
		Chaetoceros sp.	1	1	2	1.33	0.58
		Protoperidinium sp.	2	3	2	2.33	0.58
	C0B- 0906	*Tetraselmis suecica*	930	970	1020	973.33	45.09
		Ceratium sp.	2	2	3	2.33	0.58
		Chaetoceros sp.	3	4	2	3.00	1.00
		Protoperidinium sp.	2	3	2	2.33	0.58
Day 5	C5T- 0911	*Tetraselmis suecica*	148	153	139	146.67	7.09
		Chaetoceros sp.	2	1	1	1.33	0.58
	C5M- 0911	*Tetraselmis suecica*	162	169	155	162.00	7.00
	C5B- 0911	*Tetraselmis suecica*	133	142	148	141.00	7.55
		Chaetoceros sp.	1	0	1	0.67	0.58

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

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

Date	Sample ID	Classification	Survival number / ml			Mean	SD [b)]
			R1[a)]	R2	R3		
Day 0	T0T - 0906	-	0	0	0	-	-
	T0M- 0906	-	0	0	0	-	-
	T0B- 0906	-	0	0	0	-	-
Day 5	T5T - 0911	-	0	0	0	-	-
	T5M- 0911	-	0	0	0	-	-
	T5B- 0911	-	0	0	0	-	-

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

Appendix 11. Number of heterotrophic bacteria in original water, control (untreated) brackish water, treated ballast brackish water by treatment of Purimar™ BWMS

Date	Sample ID		CFU/mL			Mean	SD [b]
			R1[a]	R2	R3		
Day 0 (09/06)	Ow-0906	Top	53600	44800	43200	47200.0	5600.0
		Middle	37200	35700	37300	36733.3	896.3
		Bottom	20200	24200	23900	22766.7	2227.9
	C0-906	Top	78000	77900	74400	76766.7	2050.2
		Middle	39700	36200	40400	38766.7	2250.2
		Bottom	23900	23100	22200	23066.7	850.5
	T0-0906	Top	60	100	30	63.3	35.1
		Middle	40	40	20	33.3	11.5
		Bottom	20	40	50	36.7	15.3
Day5 (09/11)	C5-0911	Top	120800	127200	123200	123733.3	3233.2
		Middle	82800	81100	87100	83666.7	3092.5
		Bottom	92900	90300	126400	103200.0	20133.8
	T5-0911	Top	101600	100000	78400	93333.3	12957.4
		Middle	56400	70000	58100	61500.0	7410.1
		Bottom	69900	69300	58100	65766.7	6646.3

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

Appendix 12. Number of *Escherichia coli* in original water, control (untreated) brackish water, treated ballast brackish water by treatment of Purimar™ BWMS

Date	Sample ID		CFU /100ml			Mean	SD [b]
			R1[a]	R2	R3		
Day 0 (09/06)	Ow-0906	Top	100	124	94	106.0	15.9
		Middle	98	102	108	102.7	5.0
		Bottom	102	114	104	106.7	6.4
	C0-0906	Top	134	116	128	126.0	9.2
		Middle	164	148	116	142.7	24.4
		Bottom	156	136	108	133.3	24.1
	T0-0906	Top	0	0	0	0.0	0.0
		Middle	0	0	0	0.0	0.0
		Bottom	0	0	0	0.0	0.0
Day5 (09/11)	C5-0911	Top	4	4	0	2.7	2.3
		Middle	1	2	0	1.0	1.0
		Bottom	4	2	3	3.0	1.0
	T5-0911	Top	3	4	3	3.3	0.6
		Middle	1	1	5	2.3	2.3
		Bottom	0	0	0	0.0	0.0

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

Appendix 13. Number of *Enterococcus faecalis* in original water, control (untreated) brackish water, treated ballast brackish water by treatment of Purimar™ BWMS

Date	Sample ID		CFU/100ml			Mean	SD [b]
			R1[a]	R2	R3		
Day 0 (09/06)	Ow-0906	Top	32	38	66	45.3	18.1
		Middle	30	44	42	38.7	7.6
		Bottom	34	40	38	37.3	3.1
	C0-0906	Top	300	440	306	348.7	79.2
		Middle	394	398	374	388.7	12.9
		Bottom	344	400	302	348.7	49.2
	T0-0906	Top	0	0	0	0.0	0.0
		Middle	0	0	0	0.0	0.0
		Bottom	0	0	0	0.0	0.0
Day5 (09/11)	C5-0911	Top	20	12	4	12.0	8.0
		Middle	9	10	9	9.3	0.6
		Bottom	18	28	14	20.0	7.2
	T5-0911	Top	0	2	0	0.7	1.7
		Middle	1	0	0	0.3	1.7
		Bottom	2	0	0	0.7	1.2

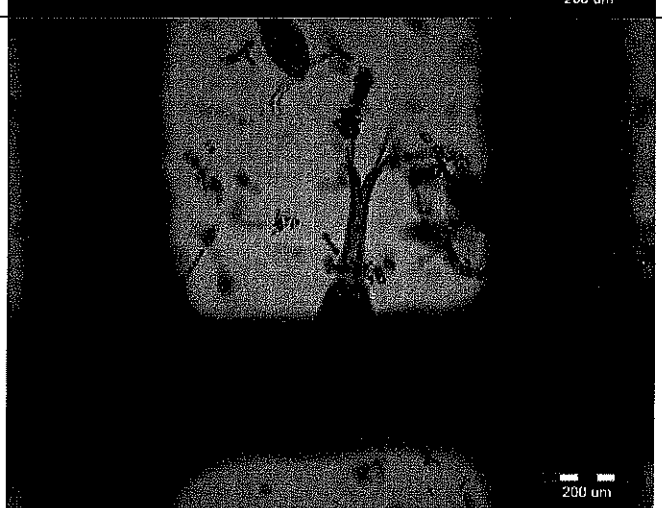
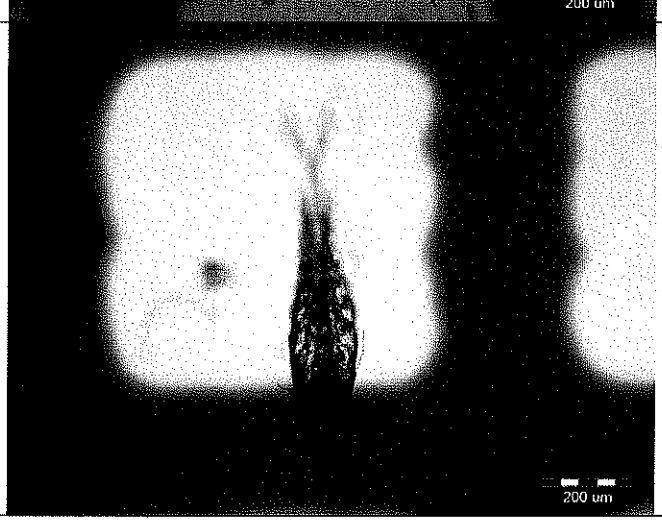
a) R: Replicate
b) S.D: Standard deviation

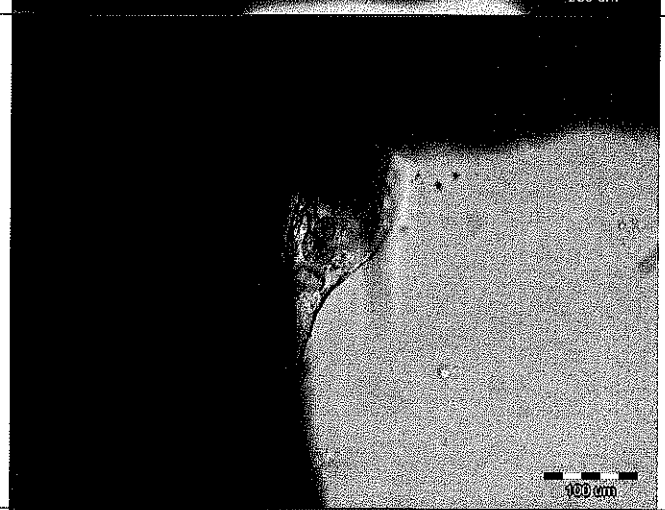
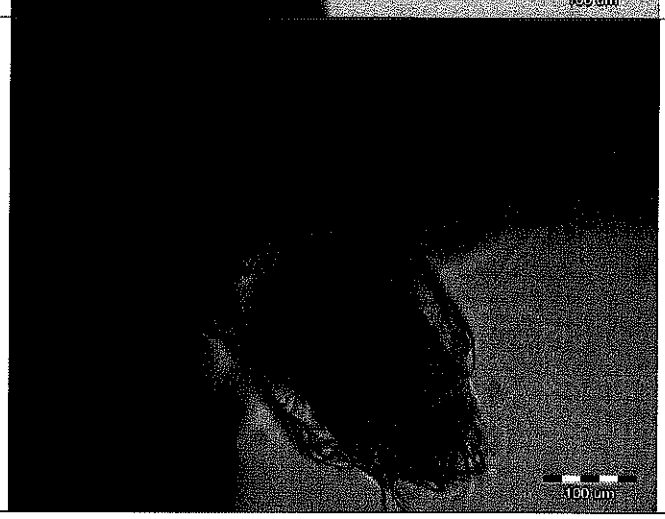
Appendix 14. Number of *Vibrio cholera* O1, O139 in original water, control (untreated) brackish water, treated ballast brackish water by treatment of Purimar™ BWMS

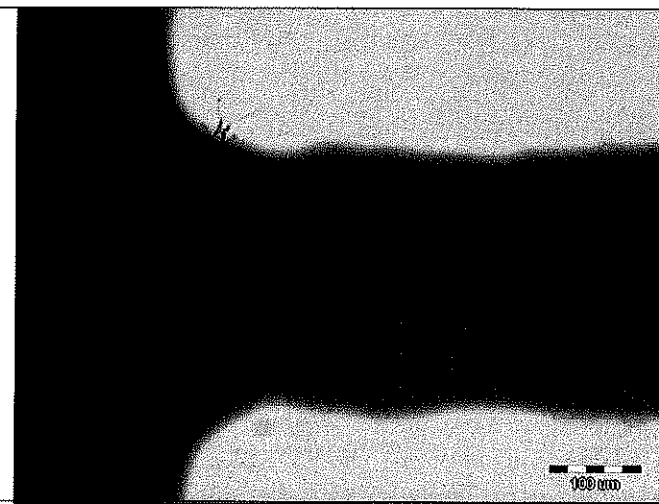
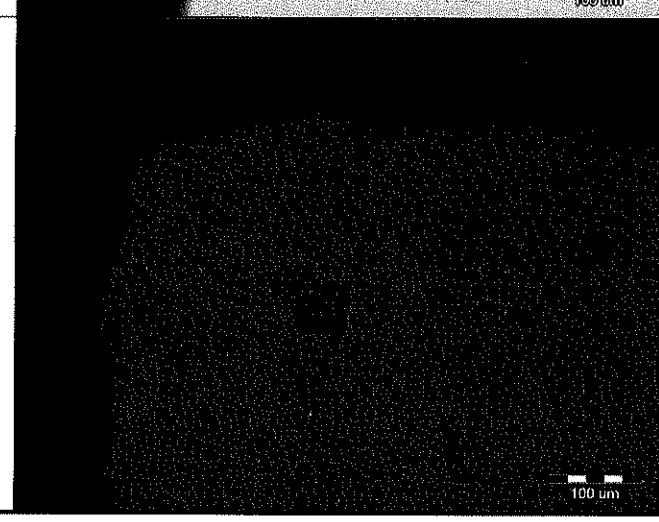
Date	Sample ID		CFU/100ml			Mean	SD [b]
			R1[a]	R2	R3		
Day 0 (09/06)	Ow-0906	Top	0	0	0	0.0	0.0
		Middle	0	0	0	0.0	0.0
		Bottom	0	0	0	0.0	0.0
	C0-0906	Top	0	0	0	0.0	0.0
		Middle	0	0	0	0.0	0.0
		Bottom	0	0	0	0.0	0.0
	T0-0906	Top	0	0	0	0.0	0.0
		Middle	0	0	0	0.0	0.0
		Bottom	0	0	0	0.0	0.0
Day5 (09/11)	C5-0911	Top	0	0	0	0.0	0.0
		Middle	0	0	0	0.0	0.0
		Bottom	0	0	0	0.0	0.0
	T5-0911	Top	0	0	0	0.0	0.0
		Middle	0	0	0	0.0	0.0
		Bottom	0	0	0	0.0	0.0

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

Appendix 15. The microscope image of ≥ 50μm in original water (Day0)

Specific Name	Original water
*Artemia salina**	
*Oithona sp.**	
*Centrophages sp.**	

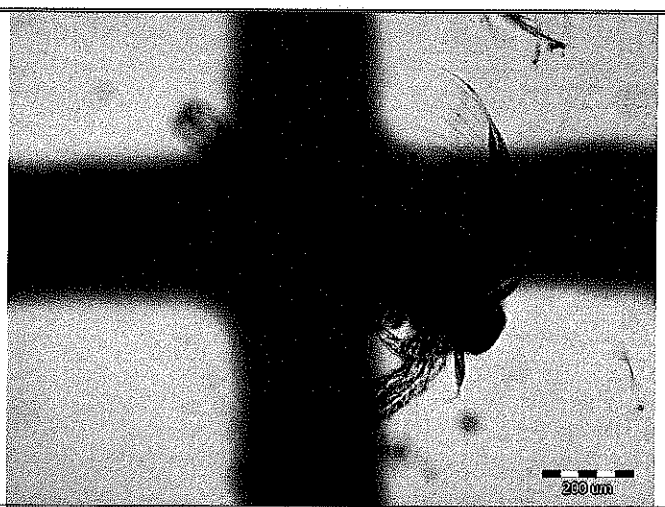
*Acartia sp.**	
**Crustacean nauplii ** **	
***Evadne* sp.** **	

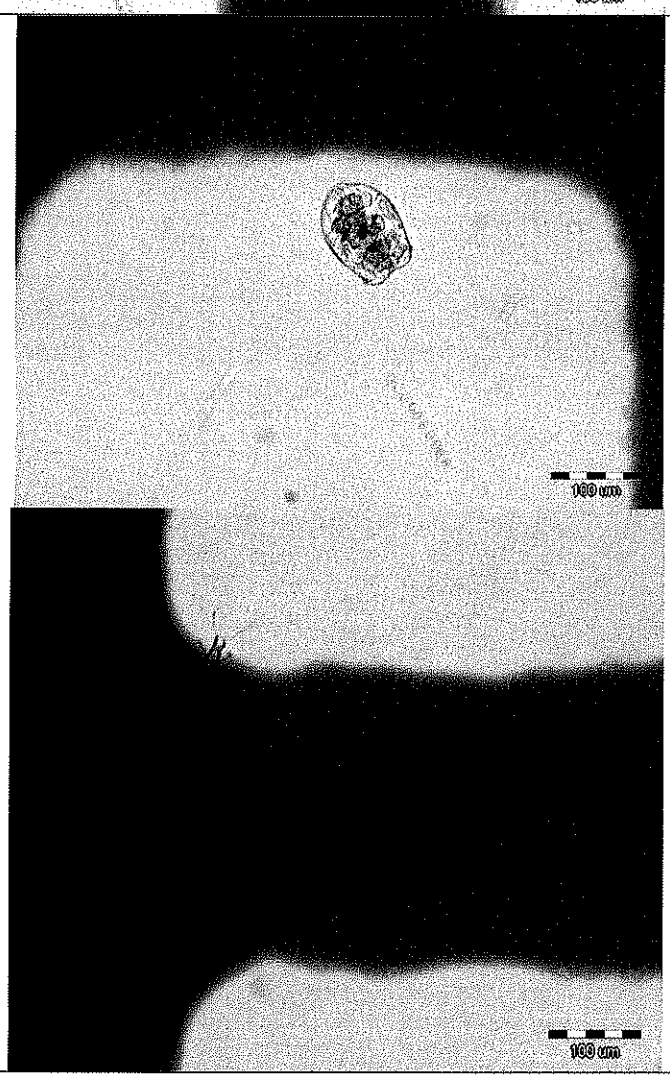
Brachionus* sp.*	
Protoperidinium* sp.*	

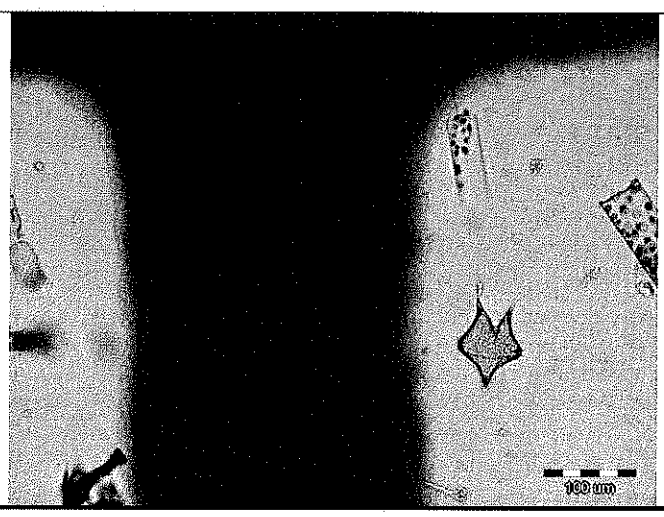
* Magnification : 100

** Magnification : 200

Appendix 16. The microscope image of ≥ 50㎛ in control (untreated) brackish water by treatment of Purimar™ BWMS (Day0)

Specific Name	Control (untreated) brackish water
*Artemia salina**	
*Oithona sp.***	
Crustacean nauplii **	

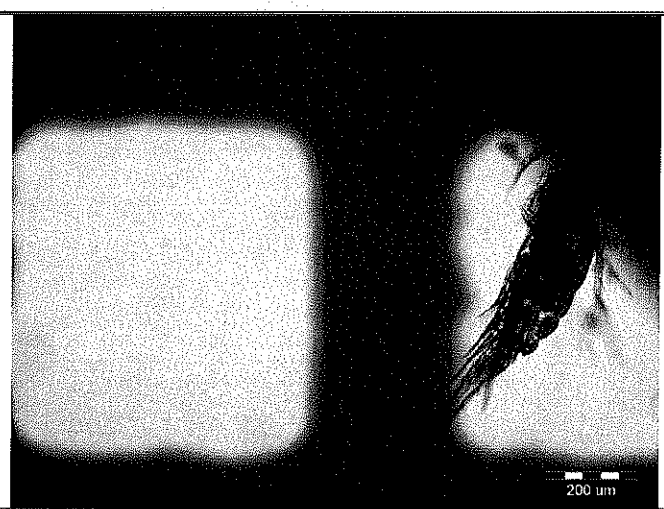
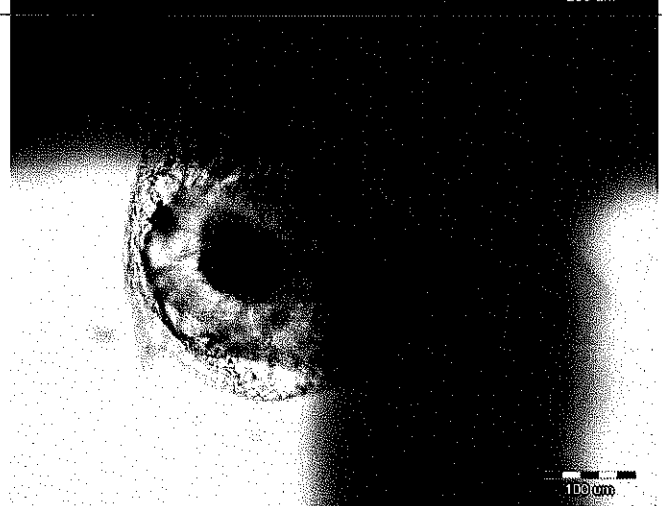
*Centrophages sp.**	
Brachionus sp.**	

Protoperidinium* sp.*	

* Magnification : 100

** Magnification : 200

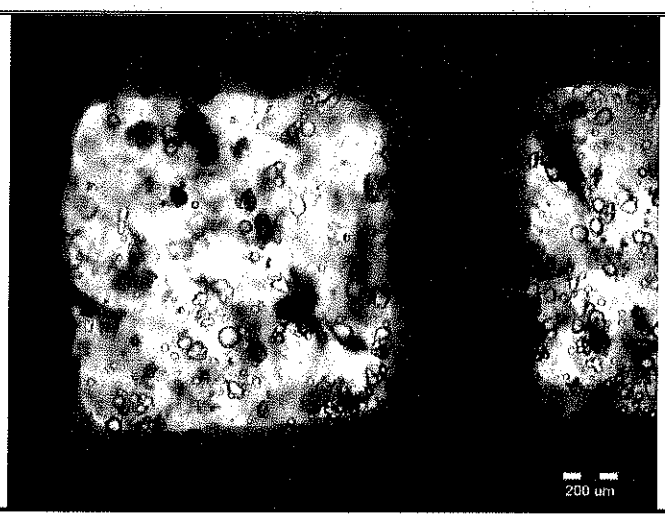
Appendix 17. The microscope image of ≥ 50㎛ in control (untreated) brackish water by treatment of Purimar™ BWMS (Day5)

Specific Name	Control (untreated) brackish water
Oithona sp. *	
Crustacean nauplii **	
Brachionus sp.**	

* Magnification : 100

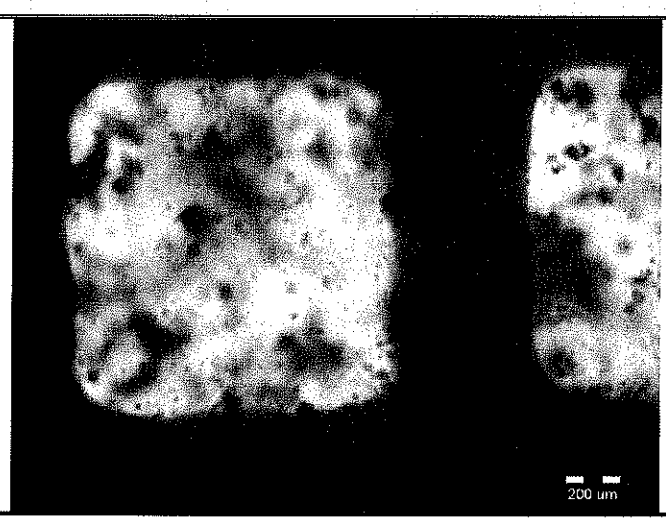
** Magnification : 200

Appendix 18. The microscope image of ≥ 50㎛ in treated ballast brackish water by treatment of Purimar™ BWMS (Day0)

Specific Name	Treated ballast brackish water
-	

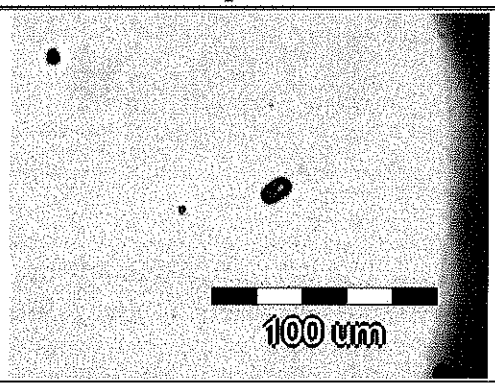
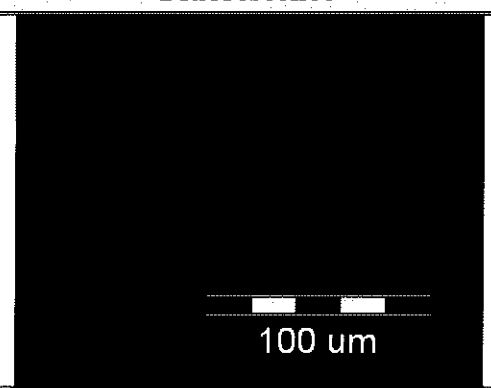
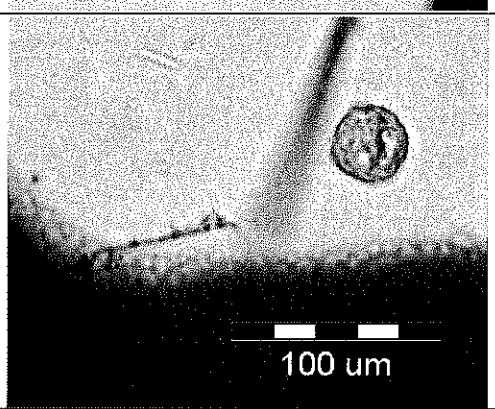
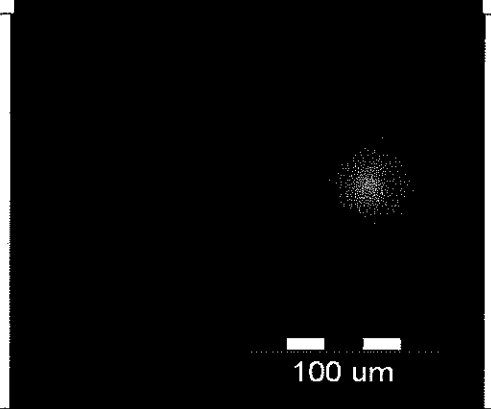
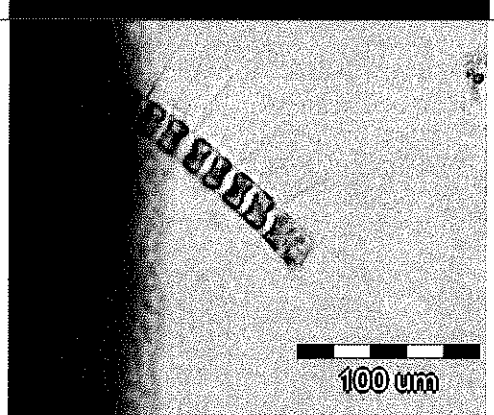
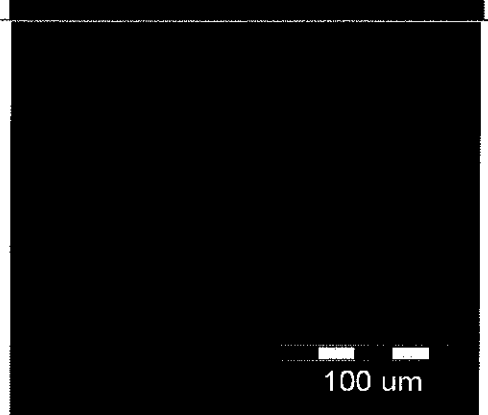
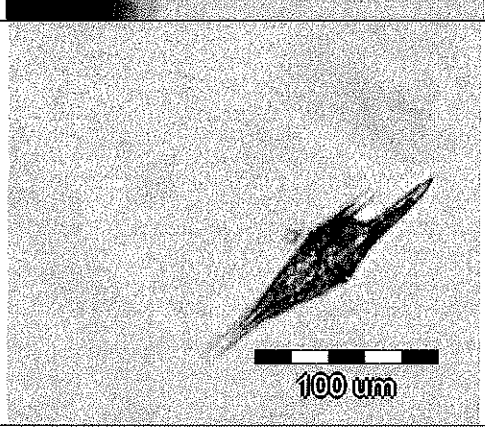
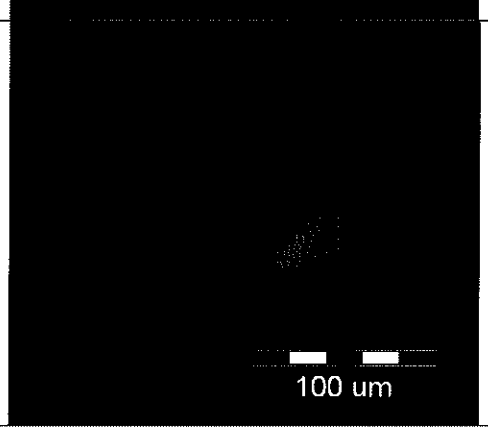
Magnification : 100

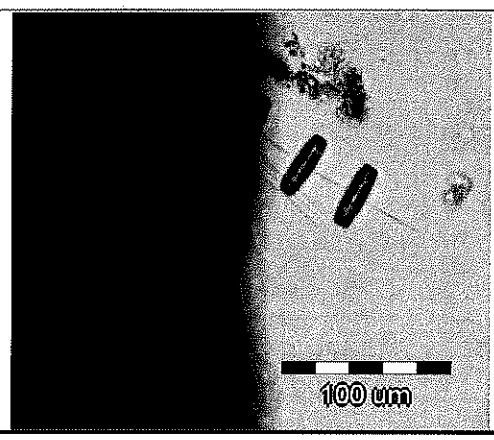
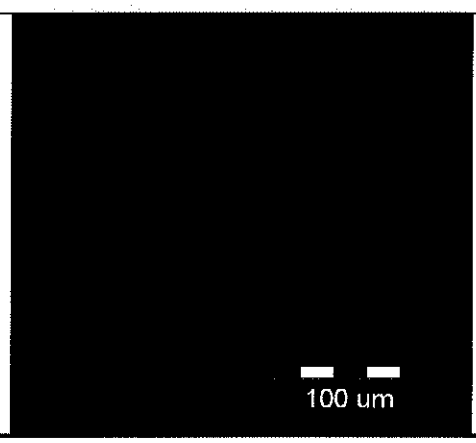
Appendix 19. The microscope image of ≥ 50㎛ in treated ballast brackish water by treatment of Purimar™ BWMS (Day5)

Specific Name	Treated ballast brackish water
-	

Magnification : 100

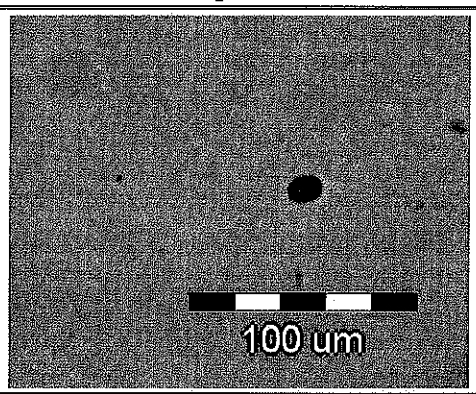
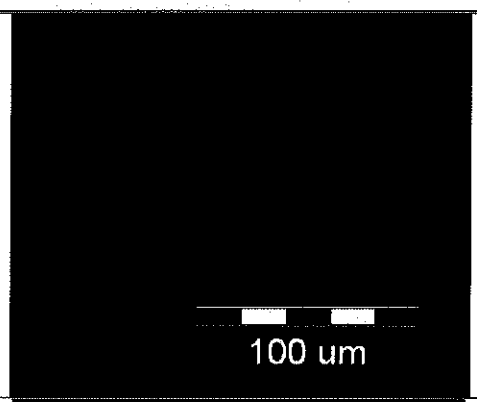
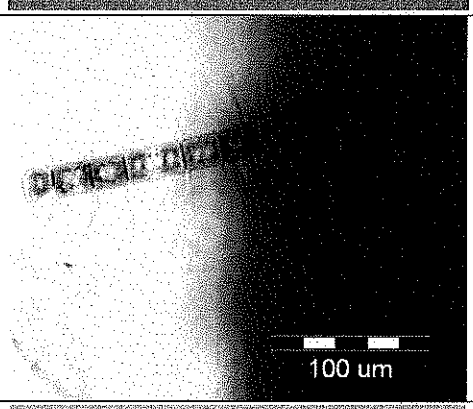
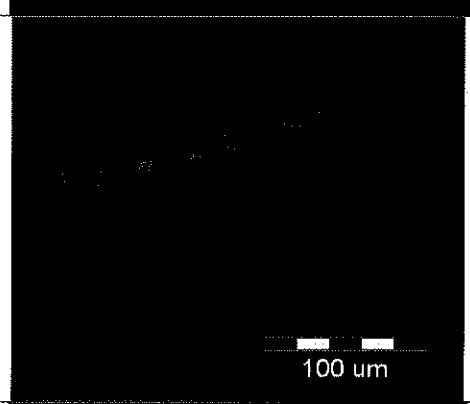
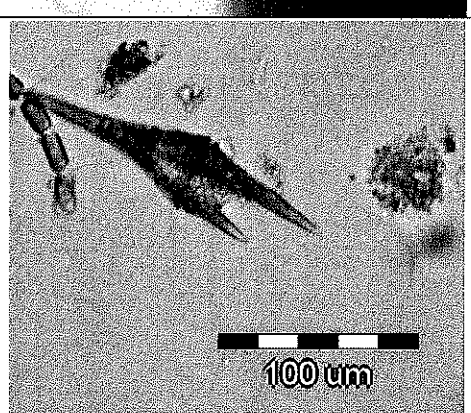
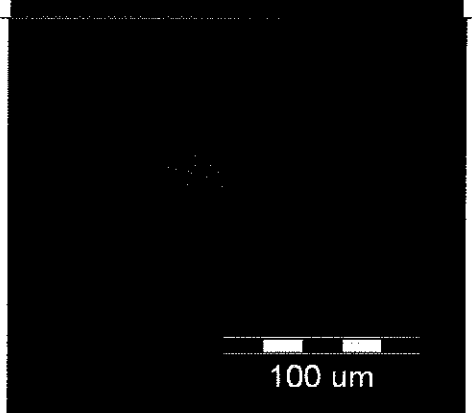
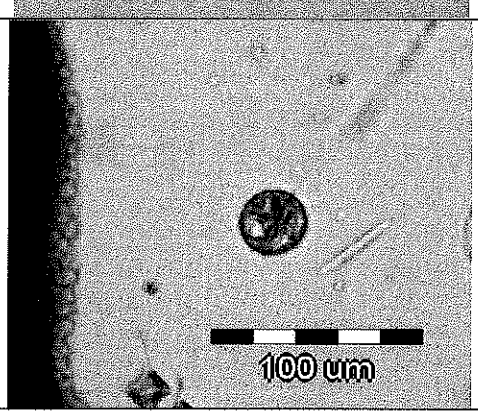
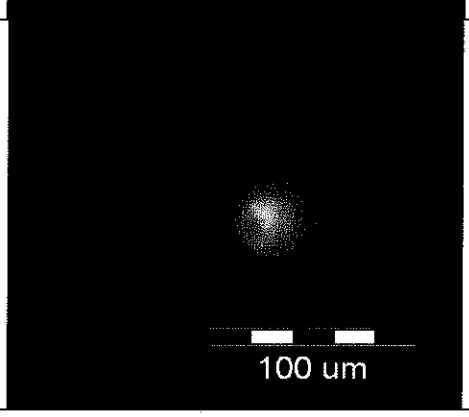
Appendix 20. The microscope image of 10㎛−50㎛ in original water (Day0)

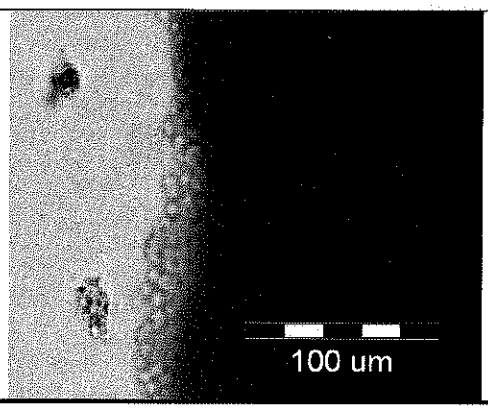
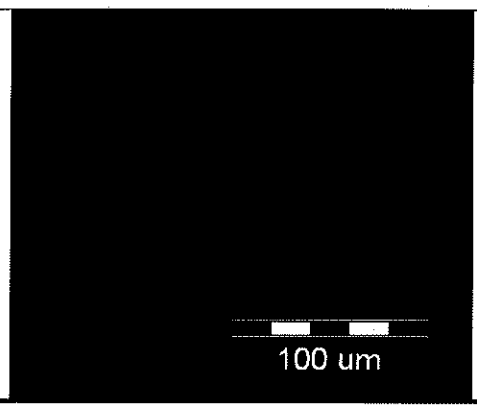
Specific Name	Control (untreated) brackish water	
	Optical	Fluorescence
Tetraselmis suecica		
Protoperidinium sp.		
Chaetoceros sp.		
Ceratium sp.		

***Thalassiosira* sp.**		

Magnification : 200

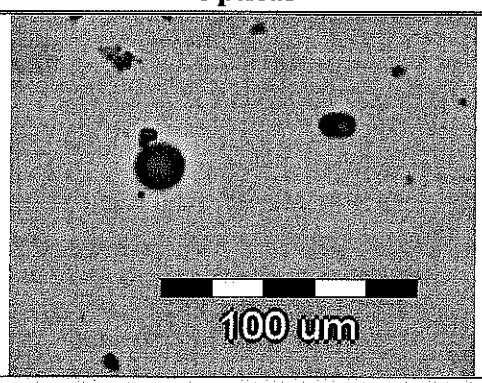
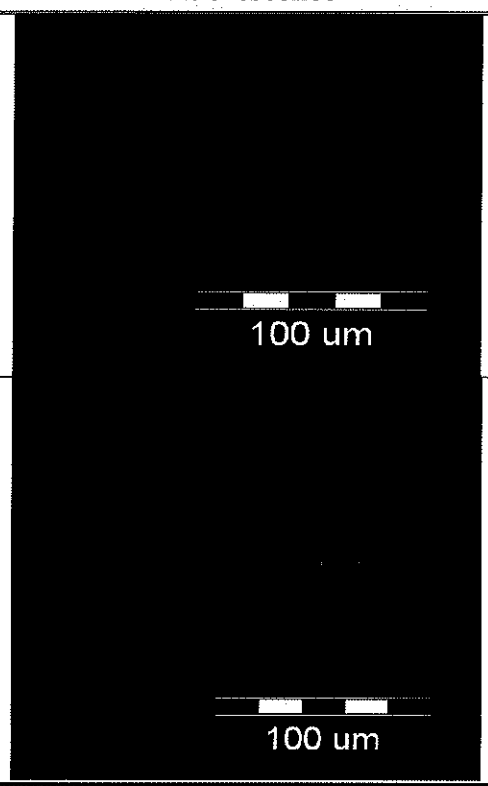
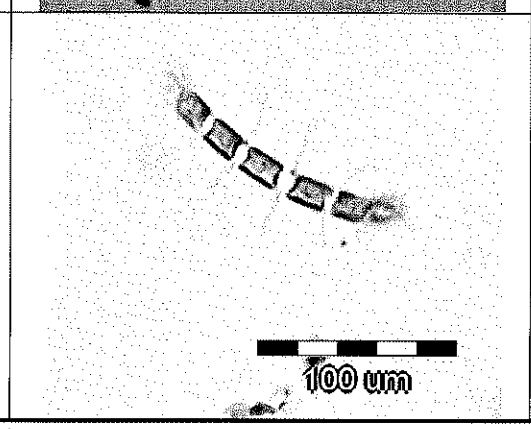
Appendix 21. The microscope image of 10㎛−50㎛ in control (untreated) brackish water by treatment of Purimar™ BWMS (Day0)

Specific Name	Control (untreated) brackish water	
	Optical	Fluorescence
Tetraselmis suecica		
Chaetoceros sp.		
Ceratium sp.		
Protoperidinium sp.		

***Thalassiosira* sp.**		

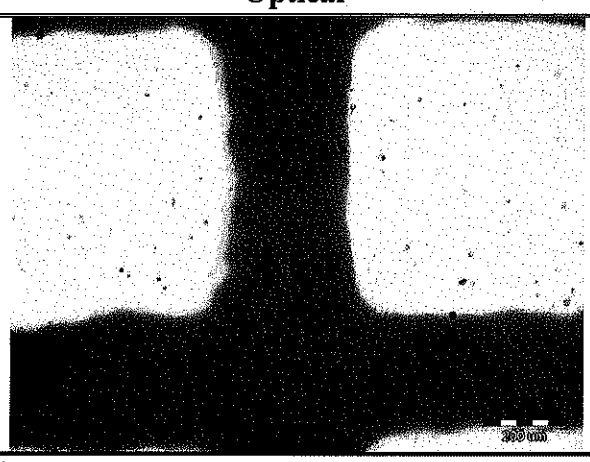
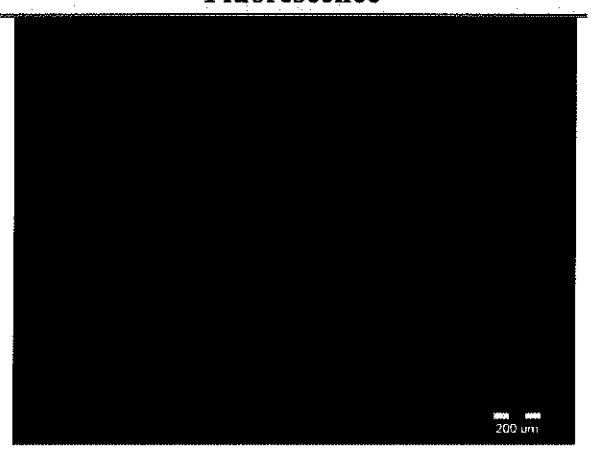
Magnification : 200

Appendix 22. The microscope image of 10㎛−50㎛ in control (untreated) brackish water by treatment of Purimar™ BWMS (Day5)

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

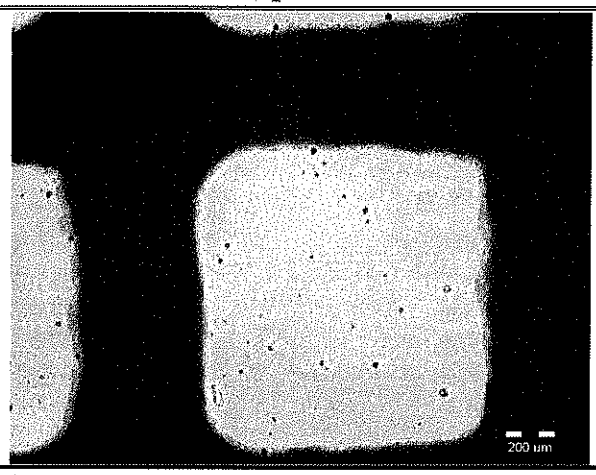
Magnification : 200

Appendix 23. The microscope image of 10㎛−50㎛ in treated ballast brackish water by treatment of Purimar™ BWMS (Day0)

Specific Name	Treated ballast brackish water	
	Optical	Fluorescence
-		

Magnification : 100

Appendix 24. The microscope image of 10 ㎛–50 ㎛ in neutralized water by treatment of Purimar™ BWMS (Day5)

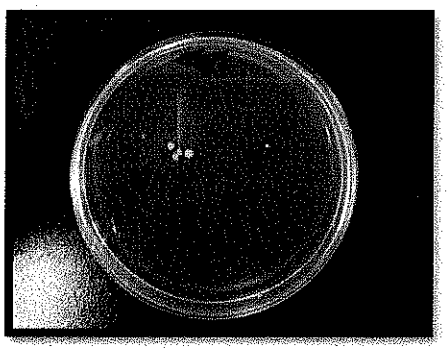
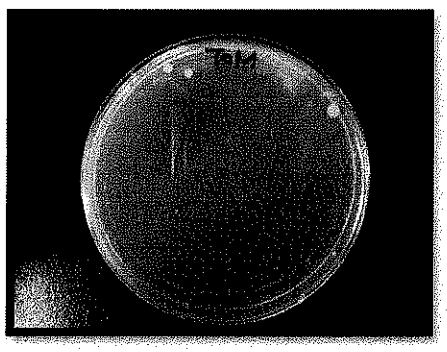
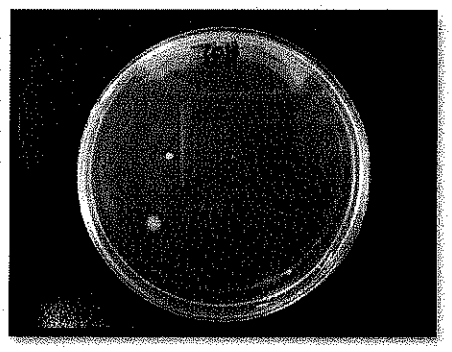
Specific Name	Neutralized water	
	Optical	Fluorescence
-		

Magnification : 100

Appendix 25. The image of heterotrophic bacteria: Day 0

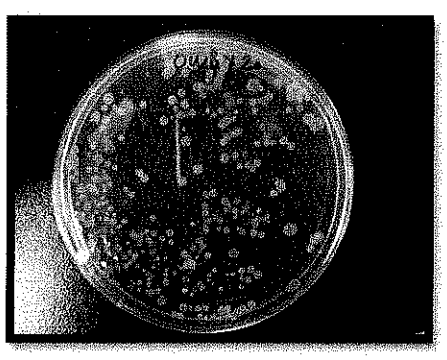
Treated ballast brackish water

Top **Middle** **Bottom**

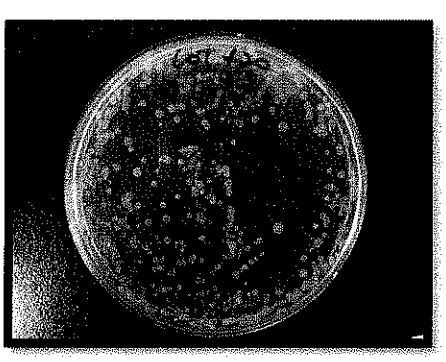
Original water

Top **Middle** **Bottom**



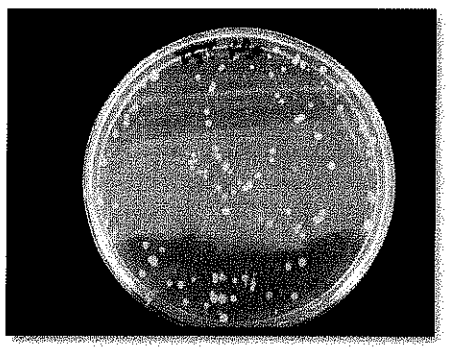
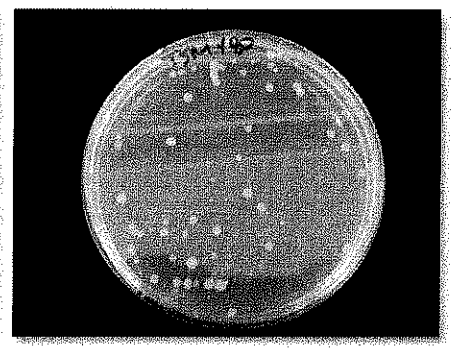
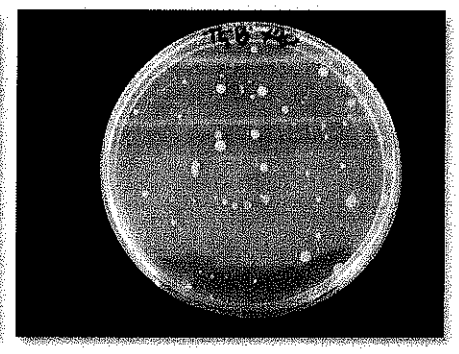
Control (untreated) brackish water

Top **Middle** **Bottom**

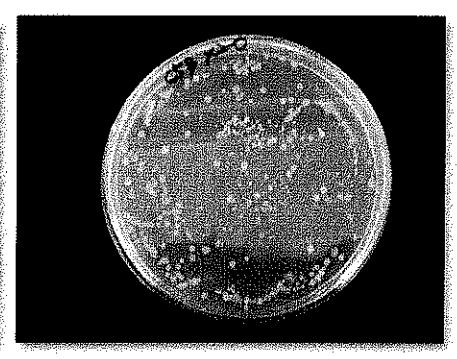


Appendix 26. The image of heterotrophic bacteria: Day 5

Treated ballast brackish water

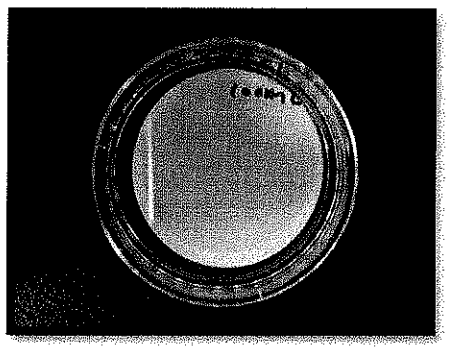
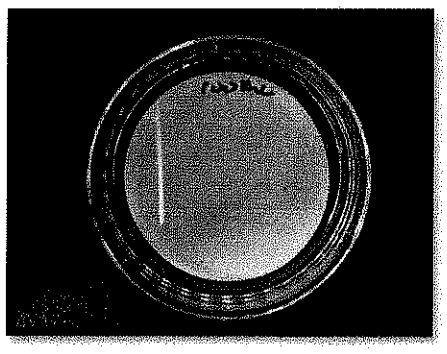
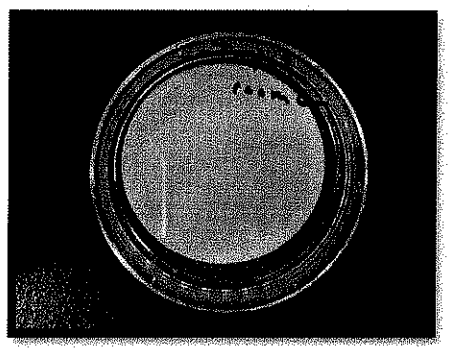
Top	Middle	Bottom
		

Control (untreated) brackish water

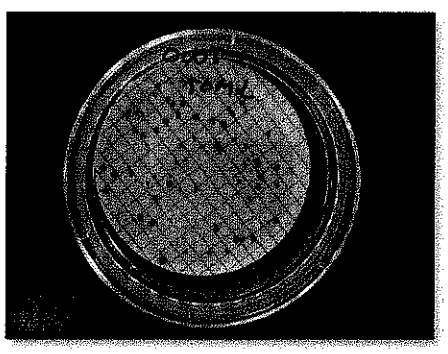
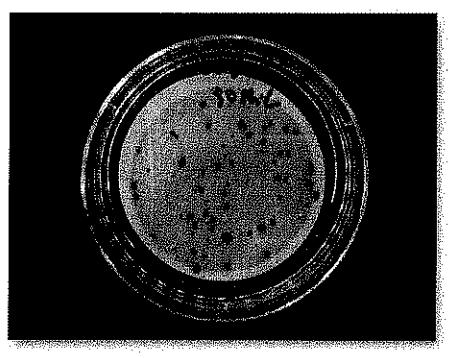
Top	Middle	Bottom
		

Appendix 27. The image of *Escherichia coli*: Day 0

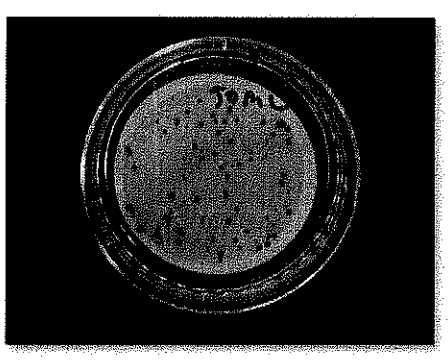
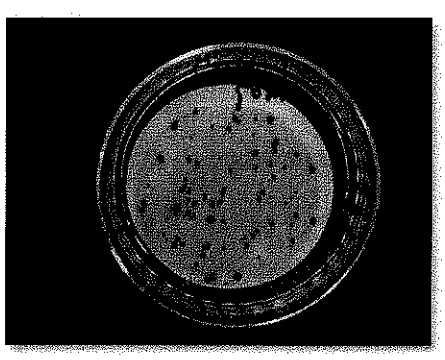
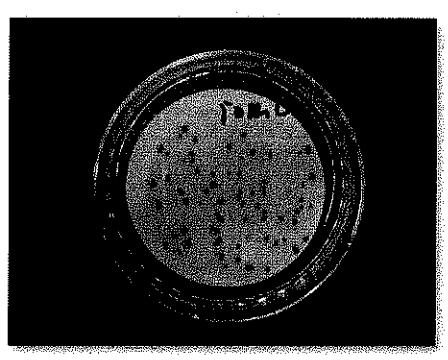
Treated ballast brackish water

Top	Middle	Bottom
		

Original water

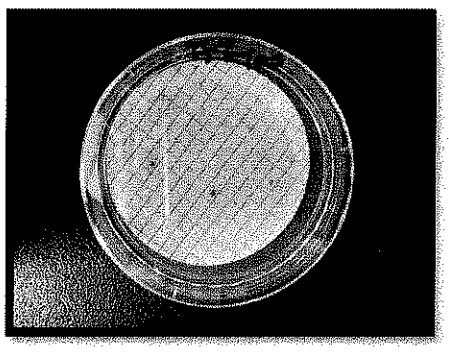
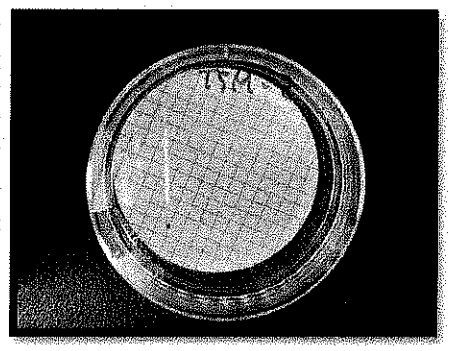
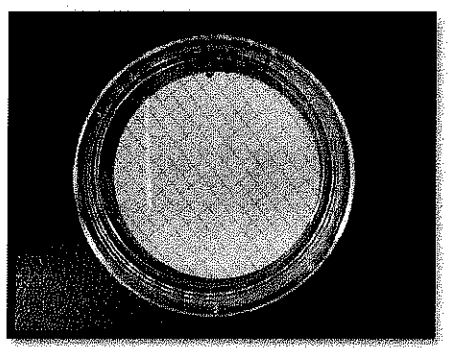
Top	Middle	Bottom
		

Control (untreated) brackish water

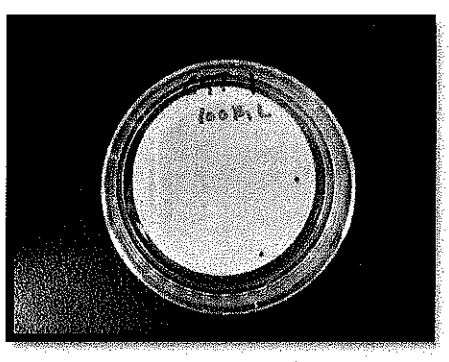
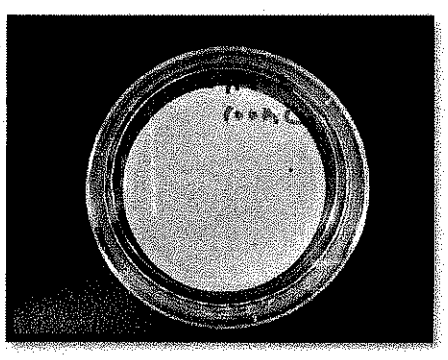
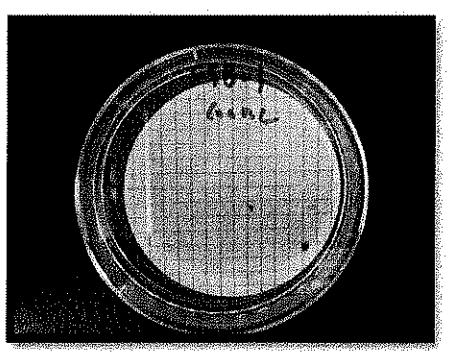
Top	Middle	Bottom
		

Appendix 28. The image of *Escherichia coli*: Day 5

Treated ballast brackish water

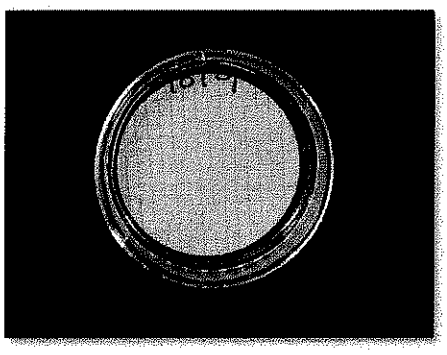
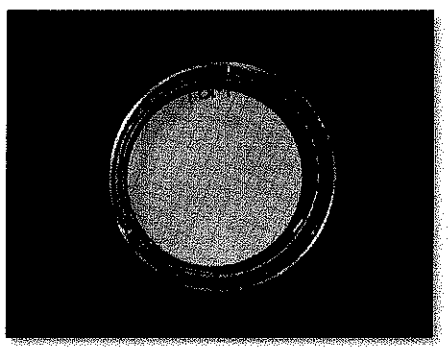
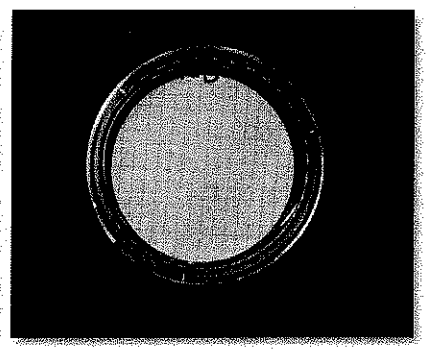
Top	Middle	Bottom
		

Control (untreated) brackish water

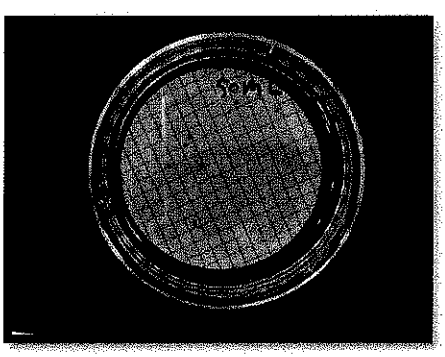
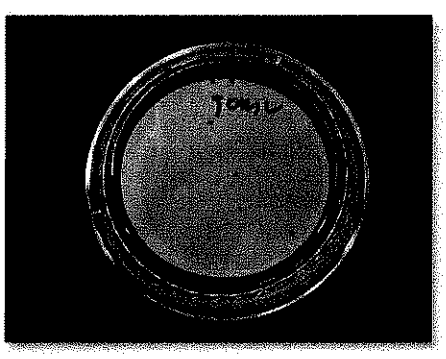
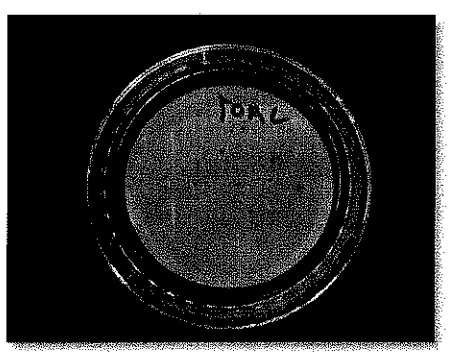
Top	Middle	Bottom
		

Appendix 29. The image of *Enterococcus faecalis*: Day 0

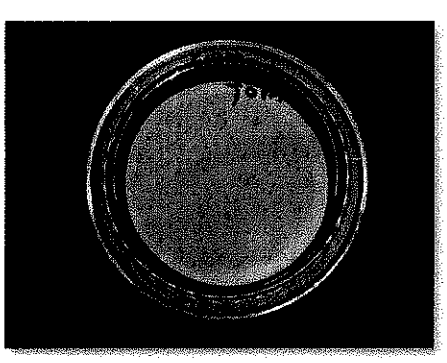
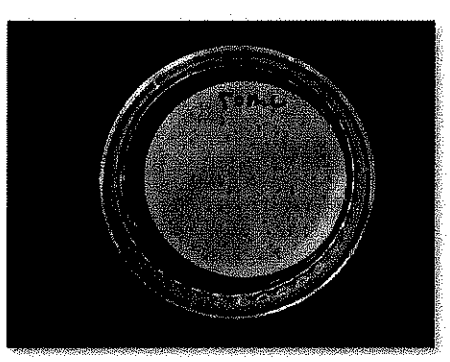
Treated ballast brackish water

Top	Middle	Bottom
		

Original water

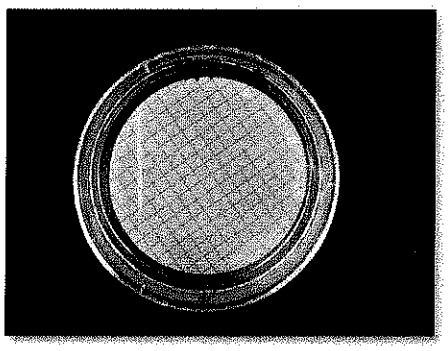
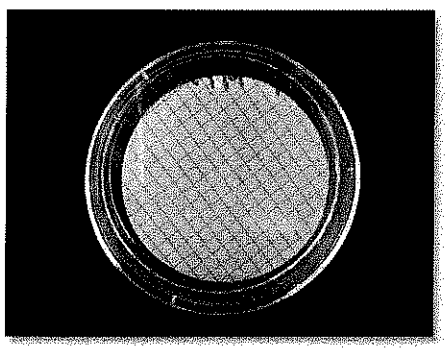
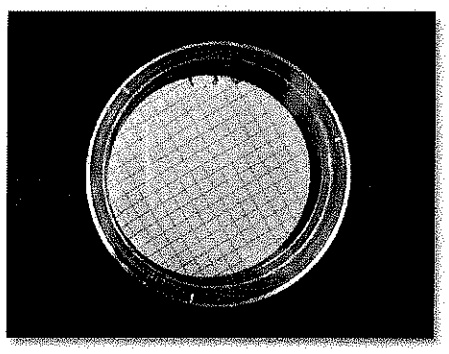
Top	Middle	Bottom
		

Control (untreated) brackish water

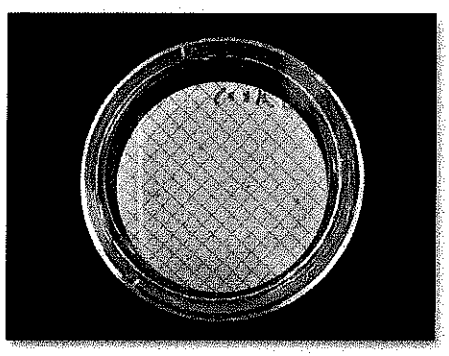
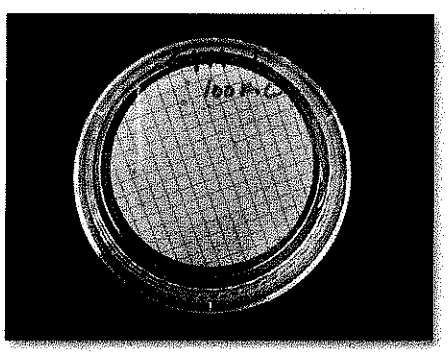
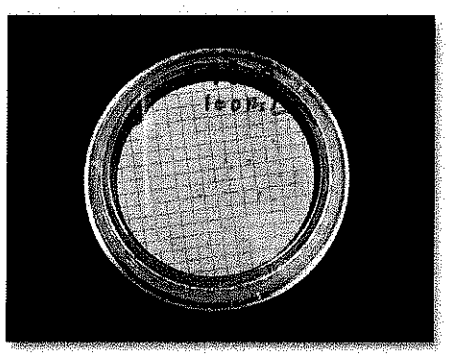
Top	Middle	Bottom
		

Appendix 30. The image of *Enterococcus faecalis*: Day 5

Treated ballast brackish water

Top	Middle	Bottom
		

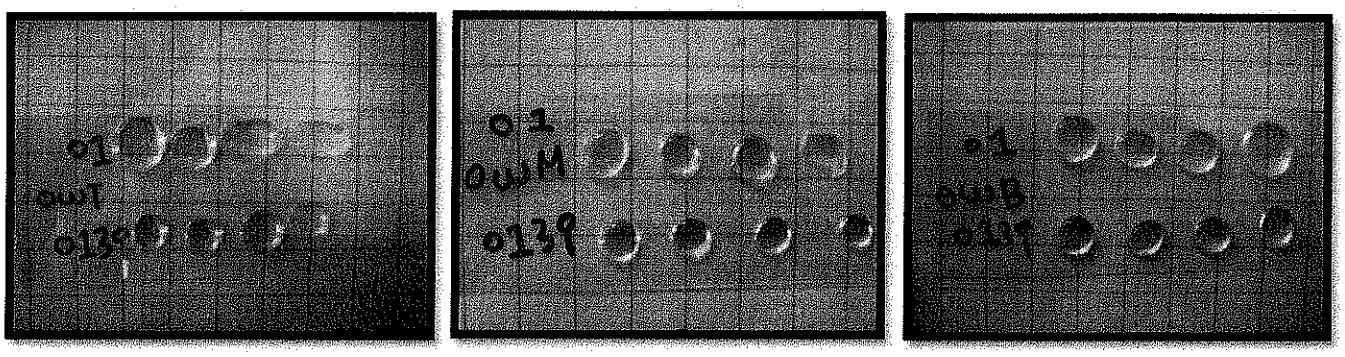
Control (untreated) brackish water

Top	Middle	Bottom
		

Appendix 31. The image of *Vibrio cholera* O1, O139: Day 0

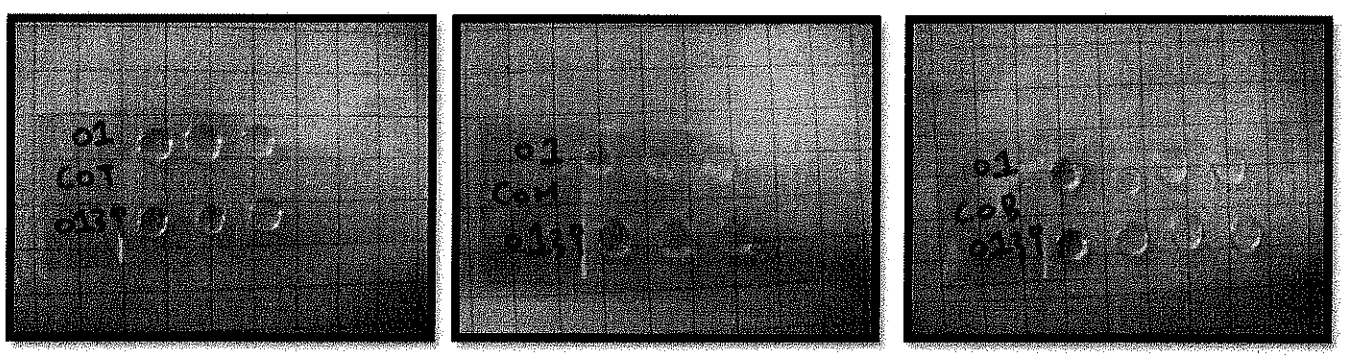
Original water

Top **Middle** **Bottom**



Control (untreated) brackish water

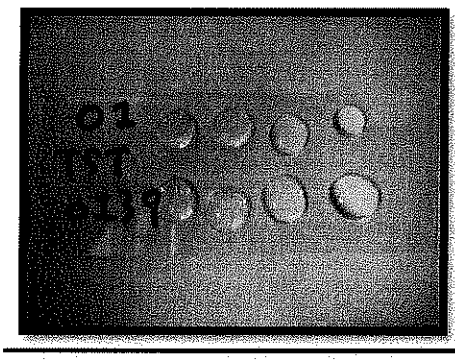
Top **Middle** **Bottom**



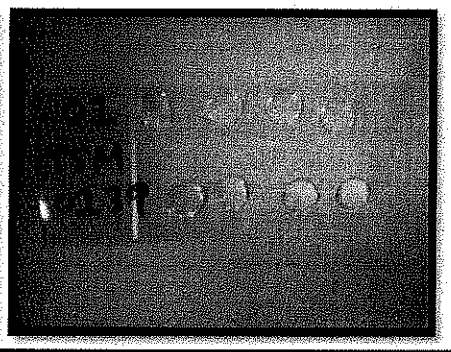
Appendix 32. The image of *Vibrio cholera* O1, O139: Day 5

Treated ballast brackish water

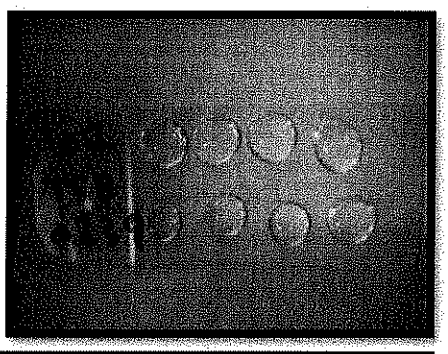
Top



Middle

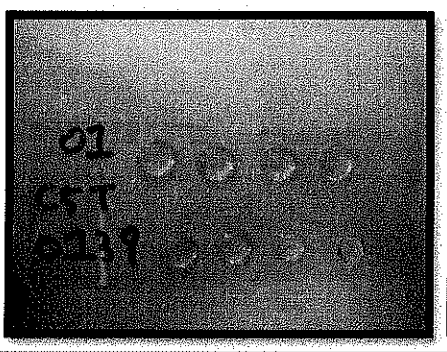


Bottom

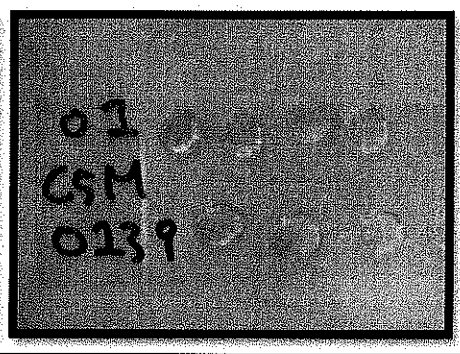


Control (untreated) brackish water

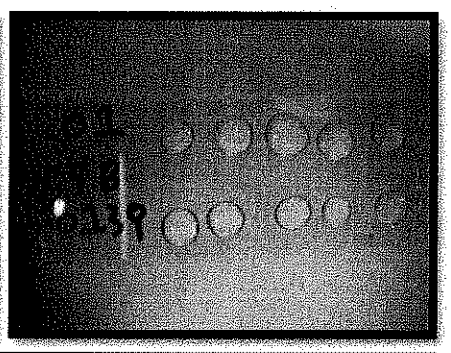
Top



Middle



Bottom



5. Attachment

5.1 Filtered natural brackish water(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 MBDC 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