Test Report

Project name	Purimar™
Study number	TW-Land(12)
Test number	LET-11-008
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		Aug, 19, 2011	Aug, 19, 2011	Aug, 19, 2011
Sampling	1st	Aug, 25, 2011	Aug, 26, 2011	Aug, 26, 2011
	2nd	Aug, 30, 2011	Aug, 30, 2011	Aug, 30, 2011
Test substance	1st	Aug, 25, 2011	Aug, 26, 2011	Aug, 26, 2011
	2nd	Aug, 30, 2011	Aug, 30, 2011	Aug, 30, 2011
Test procedures (Bacteria test)	1st	Aug, 25, 2011	Aug, 26, 2011	Aug, 26, 2011
	2nd	Aug, 30, 2011	Aug, 30, 2011	Aug, 30, 2011
Observation and counting (≥50㎛, 10㎛-50㎛)	1st	Aug, 25, 2011	Aug, 26, 2011	Aug, 26, 2011
	2nd	Aug, 30, 2011	Aug, 30, 2011	Aug, 30, 2011
Observation and counting (Bacteria test)	1st	Aug, 26, 2011	Aug, 26, 2011	Aug, 26, 2011
	2nd	Aug, 27, 2011	Aug, 29, 2011	Aug, 29, 2011
	3rd	Aug, 31, 2011	Aug, 31, 2011	Aug, 31, 2011
Raw data		Sep, 05, 2011	Sep, 05, 2011	Sep, 05, 2011
Test report		Sep, 05~07, 2011	Sep, 08, 2011	Sep, 08, 2011

Eun-young, Kang (Sign) — Sep, 08, 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)	Sep. 08th. 2011
	Eun-Jung. Jung (sign)	Sep. 08th. 2011
	Sun-Ju. Choi (sign)	Sep. 08th. 2011
	Yeon Su. Park (sign)	Sep. 08th. 2011
QA/QC	Eun-young, Kang (sign)	Sep. 08th. 2011
Efficacy Testing Manager	Byong-Jik (sign)	08th. Sep. 2011

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1. Results

1.1 Sampling point (Seawater & Freshwater[a])

GPS coordinate	35°05.151N 129°04.824E

a) We draw fresh water from Nakdong- river the previous day.

1.2 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-0825	15.53±0.60	9.07±0.15	6.47	54.8±1.0
	OwM-0825	16.27±0.80	9.17±0.32	7.10	50.3±1.5
	OwB-0825	16.03±0.55	9.20±0.44	6.83	52.0±0.5
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)	TRC (ppm)	Chlorophyl a
Day 0	OwT-0825	7.91±0.05	22.69±0.02	19.81±0.02	4.65±0.08	10.0±0.3	0.00±0.00	0.991±0.011
	OwM-0825	8.01±0.01	22.63±0.01	19.85±0.02	4.64±0.02	9.8±0.1	0.00±0.00	0.869±0.051
	OwB-0825	8.03±0.01	22.62±0.01	19.86±0.00	4.63±0.05	9.5±0.2	0.00±0.00	0.859±0.016
	C0T-0825	8.03±0.03	22.99±0.02	20.05±0.01	4.58±0.01	12.2±0.2	0.00±0.00	1.30±0.05
	C0M-0825	8.07±0.00	22.94±0.02	19.97±0.01	4.61±0.01	10.1±0.5	0.00±0.00	1.09±0.01
	C0B-0825	8.07±0.00	23.03±0.02	19.97±0.01	4.56±0.03	10.4±0.3	0.00±0.00	0.973±0.010
	T0T-0825	8.08±0.01	24.14±0.57	19.95±0.01	4.39±0.02	8.9±0.1	2.84±0.03	0.397±0.001
	T0M-0825	8.05±0.01	24.09±0.08	19.92±0.01	4.39±0.03	7.3±0.3	2.73±0.03	0.430±0.009
	T0B-0825	8.06±0.00	23.61±0.01	19.87±0.04	4.61±0.03	6.9±0.7	2.98±0.05	0.375±0.003
Day 5	C5T-0830	7.23±0.01	25.45±0.02	20.02±0.00	3.70±0.05	9.9±0.3	0.0±0.0	0.588±0.023
	C5M-0830	7.25±0.01	25.63±0.04	20.02±0.00	3.67±0.06	8.3±0.1	0.0±0.0	0.444±0.002
	C5B-0830	7.27±0.01	25.86±0.03	20.02±0.01	3.68±0.03	5.8±0.1	0.0±0.0	0.343±0.003
	T5T-0830	7.22±0.01	25.22±0.05	19.92±0.01	4.02±0.01	7.6±0.2	0.01±0.00	0.141±0.003
	T5M-0830	7.29±0.01	25.11±0.02	19.92±0.01	4.13±0.02	3.8±0.0	0.02±0.00	0.088±0.001
	T5B-0830	7.18±0.01	25.33±0.07	19.89±0.04	3.90±0.01	3.9±0.1	0.01±0.00	0.100±0.003

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-0825	8.13±0.00	14.7±0.1	19.80±0.00	8.95±0.02	12.8±0.3
	OwM-0825	8.14±0.00	13.4±0.0	19.73±0.01	8.88±0.02	14.2±0.2
	OwB-0825	8.13±0.00	15.0±0.0	19.76±0.00	8.90±0.01	11.6±0.3
	C0T-0825	8.16±0.00	14.2±0.0	19.94±0.01	8.94±0.01	13.7±0.2
	C0M-0825	8.16±0.01	13.6±0.0	19.85±0.01	8.77±0.02	11.3±0.2
	C0B-0825	8.23±0.01	14.6±0.0	19.87±0.00	8.63±0.02	11.3±0.3
	T0T-0825	8.12±0.00	10.9±0.1	19.82±0.00	8.77±0.01	9.67±0.03
	T0M-0825	8.08±0.00	15.4±0.1	19.87±0.01	8.73±0.01	9.45±0.02
	T0B-0825	8.07±0.00	13.8±0.0	19.81±0.00	8.62±0.01	9.38±0.03
Day 5	C5T-0830	7.08±0.00	18.5±0.0	19.93±0.00	6.67±0.02	5.17±0.02
	C5M-0830	7.05±0.01	16.5±0.0	19.71±0.00	6.07±0.02	4.40±0.02
	C5B-0830	7.10±0.00	18.9±0.0	19.86±0.01	7.21±0.01	5.20±0.01
	T5T-0830	7.15±0.00	15.5±0.0	19.86±0.01	5.99±0.02	9.17±0.01
	T5M-0830	7.16±0.00	16.6±0.1	19.95±0.00	6.05±0.02	5.32±0.01
	T5B-0830	7.12±0.01	15.0±0.0	19.69±0.01	6.56±0.02	5.32±0.02

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

1.3 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*	135667 ± 3014	130~185
		Acartia sp.	7000 ± 500	104~150
		Paracalanus sp.	1667 ± 577	190~200
		Microsetella sp.	1167 ± 289	280~300
		Crustacean nauplii	43333 ± 10408	145~165
	Rotifera	*Brachionus plicatilis*	383333 ± 20817	65~88
	Bacillariophyta	*Coscinodiscus* sp.	3333 ± 2887	160~180
	Dinophyta	*Protoperidinium* sp.	8333 ± 2887	52~65
Middle	Arthropoda	*Artemia salina*	140833 ± 2021	130~185
		Acartia sp.	8667 ± 577	104~150
		Crustacean nauplii	45000 ± 5000	145~165
	Rotifera	*Brachionus plicatilis*	363333 ± 12583	65~88
Bottom	Arthropoda	*Artemia salina*	139500 ± 2000	130~185
		Acartia sp.	7667 ± 764	104~150
		Microsetella sp.	667 ± 289	280~300
		Crustacean nauplii	43333 ± 2887	145~165
	Rotifera	*Brachionus plicatilis*	421667 ± 16073	65~88
	Dinophyta	*Coscinodiscus* sp.	6667 ± 2887	160~180
Total	8 species 4 phyla/divisions		587056 ± 30959	-
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*	1403 ± 71	11 ~ 12
	Bacillariophyta	*Ceratium* sp.	9 ± 2	15 ~ 30
		Chaetoceros sp.	14 ± 2	15 ~ 40
		Melosira sp.	5 ± 1	20 ~ 40
	Dinophyta	*Ebria* sp.	7 ± 2	10 ~ 30
Middle	Chlorophyta	*Tetraselmis suecica*	1587 ± 86	11 ~ 12
	Bacillariophyta	*Ceratium* sp.	7 ± 1	15 ~ 30
		Chaetoceros sp.	12 ± 2	15 ~ 40
		Melosira sp.	8 ± 2	20 ~ 40
	Dinophyta	*Ebria* sp.	7 ± 1	10 ~ 30
Bottom	Chlorophyta	*Tetraselmis suecica*	1280 ± 95	11 ~ 12
	Bacillariophyta	*Ceratium* sp.	11 ± 3	15 ~ 30
		Chaetoceros sp.	4 ± 1	15 ~ 40
		Melosira sp.	4 ± 1	20 ~ 40
	Dinophyta	*Ebria* sp.	7 ± 1	10 ~ 30
Total	5 species 3 phyla/divisions		1455 ± 158	-
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

1.4 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)]	583833 ± 27154	Influent condition: Acceptable (≥10^5 ind./m^3)	
		M [b)]	557833 ± 18085		
		B [c)]	619500 ± 17037		
Control (untreated) brackish water	Day 0 (C0)	T	347833 ± 16855	-	-
		M	352000 ± 16023		
		B	315667 ± 13985		
	Day 5 (C5)	T	91167 ± 289	Effluent condition: Acceptable (≥10^2 ind./m^3)	
		M	93000 ± 3041		
		B	86000 ± 5268		
Treated ballast brackish water	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)]	1438 ± 73	Influent condition: Acceptable ($\geq 10^3$ ind./mL)	-
		M [b)]	1621 ± 87		
		B [c)]	1306 ± 97		
Control (untreated) brackish water	Day 0 (C0)	T	1243 ± 34	-	-
		M	1357 ± 51		
		B	1322 ± 111		
	Day 5 (C5)	T	118 ± 9	Effluent condition: Acceptable ($\geq 10^2$ ind./ ml)	
		M	136 ± 7		
		B	122 ± 7		
Treated ballast brackish water	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)]	32733 ± 3868	Influent condition: Acceptable ($\geq 10^4$ CFU/mL)	-
		M [b)]	40900 ± 985		
		B [c)]	44167± 4407		
Control (untreated) brackish water	Day 0 (C0)	T	31100 ± 1308	-	-
		M	38533 ± 643		
		B	33033 ± 2344		
	Day 5 (C5)	T	86600 ± 8848	-	
		M	90250 ± 5303		
		B	54533 ± 4661		
Treated ballast brackish water	Day 0 (T0)	T	19 ± 2	-	100.0 [d)]
		M	18 ± 1		
		B	12 ± 1		
	Day 5 (T5)	T	226400 ± 6788	-	-571.1 [e)]
		M	212000 ± 1697		
		B	195200 ± 9016		

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)]	127 ± 1	-	
		M[b)]	131 ± 9		
		B[c)]	133 ± 8		
Control (untreated) brackish water	Day 0 (C0)	T	168 ± 16	-	-
		M	147 ± 16		
		B	118 ± 11		
	Day 5 (C5)	T	0 ± 0	-	
		M	0 ± 0		
		B	0 ± 0		
Treated ballast brackish water	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)]	130 ± 14	-	
		M [b)]	94 ± 18		
		B [c)]	138 ± 9		
Control (untreated) brackish water	Day 0 (C0)	T	108 ± 6	-	-
		M	86 ± 23		
		B	112 ± 13		
	Day 5 (C5)	T	0 ± 0	-	
		M	0 ± 0		
		B	0 ± 0		
Treated ballast brackish water	Day 0 (T0)	T	12 ± 2	Effluent condition: Acceptable (<100 CFU/ 100ml)	100.0 [e)]
		M	6 ± 1		
		B	5 ± 2		
	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) brackish water	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 brackish water	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: 3 ~ 22 PSU (Salinity should be separated by at least 10 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-0825	19.81±0.02	9.07±0.15	6.47	54.8±1.0
	OwM-0825	19.85±0.02	9.17±0.32	7.10	50.3±1.5
	OwB-0825	19.86±0.00	9.20±0.44	6.83	52.0±0.5

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: ≥ 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	416500	1648	-
Lab	OwT	583833 ± 27154	1438 ± 73	32733 ± 3868
	OwM	557833 ± 18085	1621 ± 87	40900 ± 985
	OwB	619500 ± 17037	1306 ± 97	44167± 4407

- 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 4 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	10:05~10:17	14:20
	OwM	10:07~10:20	
	OwB	10:09~10:22	
	C0T	11:08~11:12	14:20
	C0M	11:03~11:08	
	C0B	10:55~11:01	
	T0T	12:25~12:48	15:40
	T0M	12:18~12:30	
	T0B	11:50~12:08	
Day 5	C5T	11:55~11:59	16:40
	C5M	11:40~11:44	
	C5B	11:36~11:39	
	T5T	13:05~13:38	16:40
	T5M	13:02~13:22	
	T5B	12:42~12:57	
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	91167 ± 289	118 ± 9
Middle	93000 ± 3041	136 ± 7
Bottom	86000 ± 5268	122 ± 7

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 100.0 % 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 % at day 0, 5.
- Treated ballast brackish water 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 brackish water 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-0825	R1	15.60	9.10	54.0
		R2	14.90	9.20	54.5
		R3	16.10	8.90	56.0
	OwM-0825	R1	16.20	9.30	50.0
		R2	15.50	9.40	49.0
		R3	17.10	8.80	52.0
	OwB-0825	R1	16.30	8.70	51.5
		R2	15.40	9.50	52.5
		R3	16.40	9.40	52.0

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)	Chlorophyll a
Day 0	OwT-0825	R1	7.86	22.67	19.83	4.74	10.3	0.00	0.997
		R2	7.92	22.69	19.81	4.61	9.7	0.00	0.978
		R3	7.95	22.70	19.80	4.60	9.9	0.00	0.997
	OwM-0825	R1	8.00	22.63	19.82	4.66	9.9	0.00	0.926
		R2	8.01	22.63	19.86	4.64	9.7	0.00	0.855
		R3	8.02	22.64	19.86	4.63	9.8	0.00	0.826
	OwB-0825	R1	8.03	22.61	19.86	4.69	9.3	0.00	0.878
		R2	8.03	22.62	19.86	4.60	9.5	0.00	0.849
		R3	8.04	22.63	19.86	4.60	9.6	0.00	0.850
	C0T-0825	R1	8.00	22.98	20.04	4.57	12.2	0.00	1.35
		R2	8.04	22.98	20.05	4.58	12.0	0.00	1.30
		R3	8.05	23.01	20.06	4.58	12.3	0.00	1.25
	C0M-0825	R1	8.07	22.92	19.97	4.62	9.6	0.00	1.08
		R2	8.07	22.95	19.96	4.61	10.0	0.00	1.10
		R3	8.07	22.95	19.98	4.60	10.6	0.00	1.10
	C0B-0825	R1	8.07	23.01	19.96	4.59	10.7	0.00	0.978
		R2	8.07	23.02	19.98	4.56	10.4	0.00	0.962
		R3	8.07	23.05	19.98	4.54	10.2	0.00	0.979
	T0T-0825	R1	8.07	24.48	19.94	4.39	9.0	2.87	0.398
		R2	8.08	24.46	19.95	4.38	8.8	2.82	0.398
		R3	8.08	23.48	19.95	4.41	8.8	2.83	0.396
	T0M-0825	R1	8.06	24.00	19.92	4.42	7.0	2.75	0.421
		R2	8.05	24.11	19.91	4.39	7.5	2.74	0.438
		R3	8.05	24.15	19.92	4.36	7.3	2.70	0.432
	T0B-0825	R1	8.06	23.62	19.83	4.61	6.3	2.94	0.378
		R2	8.06	23.62	19.89	4.58	6.6	3.03	0.376
		R3	8.06	23.60	19.90	4.64	7.7	2.98	0.372
Day 5	C5T-0830	R1	7.23	25.44	20.02	3.75	9.6	0.0	0.566
		R2	7.23	25.45	20.02	3.69	9.8	0.0	0.586
		R3	7.22	25.47	20.02	3.65	10.2	0.0	0.612
	C5M-0830	R1	7.25	25.59	20.02	3.74	8.3	0.0	0.446
		R2	7.25	25.62	20.02	3.65	8.3	0.0	0.444
		R3	7.24	25.67	20.02	3.63	8.2	0.0	0.443
	C5B-0830	R1	7.27	25.84	20.01	3.71	5.8	0.0	0.345
		R2	7.27	25.86	20.02	3.67	5.9	0.0	0.345
		R3	7.26	25.89	20.02	3.66	5.7	0.0	0.339
	T5T-0830	R1	7.23	25.19	19.91	4.03	7.4	0.01	0.143
		R2	7.22	25.20	19.92	4.02	7.7	0.01	0.137
		R3	7.22	25.28	19.92	4.01	7.8	0.01	0.143
	T5M-0830	R1	7.30	25.11	19.93	4.15	3.8	0.02	0.088
		R2	7.29	25.10	19.92	4.13	3.8	0.02	0.089
		R3	7.28	25.13	19.92	4.11	3.8	0.02	0.087
	T5B-0830	R1	7.18	25.25	19.85	3.90	4.0	0.01	0.104
		R2	7.18	25.39	19.90	3.90	3.9	0.01	0.098
		R3	7.19	25.36	19.92	3.91	3.9	0.01	0.099

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-0825	R1	8.13	14.7	19.80	8.96	12.7
		R2	8.13	14.7	19.80	8.95	13.1
		R3	8.13	14.8	19.80	8.93	12.6
	OwM-0825	R1	8.14	13.4	19.73	8.89	14.0
		R2	8.14	13.4	19.73	8.88	14.3
		R3	8.14	13.4	19.74	8.86	14.3
	OwB-0825	R1	8.13	15.0	19.76	8.91	11.8
		R2	8.13	15.0	19.76	8.91	11.8
		R3	8.13	15.0	19.76	8.89	11.3
	C0T-0825	R1	8.16	14.2	19.95	8.95	13.7
		R2	8.16	14.2	19.94	8.93	13.8
		R3	8.16	14.2	19.94	8.93	13.5
	C0M-0825	R1	8.16	13.6	19.84	8.75	11.5
		R2	8.16	13.6	19.86	8.78	11.1
		R3	8.17	13.6	19.86	8.79	11.4
	C0B-0825	R1	8.24	14.6	19.87	8.65	11.1
		R2	8.23	14.6	19.87	8.64	11.3
		R3	8.23	14.6	19.87	8.61	11.6
	T0T-0825	R1	8.12	11.0	19.82	8.76	9.68
		R2	8.12	10.9	19.82	8.77	9.64
		R3	8.12	10.9	19.82	8.77	9.70
	T0M-0825	R1	8.08	15.4	19.87	8.73	9.45
		R2	8.08	15.4	19.87	8.73	9.43
		R3	8.08	15.5	19.86	8.72	9.46
	T0B-0825	R1	8.07	13.8	19.81	8.62	9.35
		R2	8.07	13.8	19.81	8.62	9.37
		R3	8.07	13.8	19.81	8.63	9.41
Day 5	C5T-0830	R1	7.08	18.5	19.93	6.69	5.19
		R2	7.08	18.5	19.93	6.65	5.17
		R3	7.08	18.5	19.93	6.66	5.16
	C5M-0830	R1	7.05	16.5	19.71	6.09	4.39
		R2	7.05	16.5	19.71	6.07	4.39
		R3	7.06	16.5	19.71	6.06	4.42
	C5B-0830	R1	7.10	18.9	19.87	7.21	5.21
		R2	7.10	18.9	19.86	7.21	5.20
		R3	7.10	18.9	19.86	7.20	5.19
	T5T-0830	R1	7.15	15.5	19.87	6.01	9.17
		R2	7.15	15.5	19.85	5.98	9.18
		R3	7.15	15.5	19.86	5.97	9.16
	T5M-0830	R1	7.16	16.6	19.95	6.07	5.31
		R2	7.16	16.6	19.95	6.05	5.33
		R3	7.16	16.7	19.95	6.04	5.33
	T5B-0830	R1	7.11	15.0	19.69	6.58	5.31
		R2	7.12	15.0	19.69	6.56	5.30
		R3	7.12	15.0	19.70	6.54	5.34

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-0825	*Artemia salina*	132500	136000	138500	135667	3014
		Acartia sp.	7500	6500	7000	7000	500
		Paracalanus sp.	1000	2000	2000	1667	577
		Microsetella sp.	1500	1000	1000	1167	289
		Crustacean nauplii	35000	55000	40000	43333	10408
		Brachionus plicatilis	360000	390000	400000	383333	20817
		Coscinodiscus sp.	5000	0	5000	3333	2887
		Protoperidinium sp.	10000	10000	5000	8333	2887
	OwM-0825	*Artemia salina*	139000	140500	143000	140833	2021
		Acartia sp.	8000	9000	9000	8667	577
		Crustacean nauplii	40000	45000	50000	45000	5000
		Brachionus plicatilis	350000	375000	365000	363333	12583
	OwB-0825	*Artemia salina*	141500	139500	137500	139500	2000
		Acartia sp.	7000	7500	8500	7667	764
		Microsetella sp.	500	500	1000	667	289
		Crustacean nauplii	45000	45000	40000	43333	2887
		Brachionus plicatilis	440000	410000	415000	421667	16073
		Coscinodiscus sp.	5000	5000	10000	6667	2887

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) brackish water

Date	Sample ID	Classification	Survival number /m^3			Mean	SD [b]
			R1[a]	R2	R3		
Day 0	C0T - 0825	*Artemia salina*	22000	23000	20500	21833	1258
		Acartia sp.	6500	5000	5500	5667	764
		Paracalanus sp.	500	0	500	333	289
		Crustacean nauplii	25000	25000	30000	26667	2887
		Brachionus plicatilis	275000	300000	305000	293333	16073
	C0M- 0825	*Artemia salina*	20500	22000	21000	21167	764
		Acartia sp.	5000	6000	6500	5833	764
		Crustacean nauplii	30000	20000	30000	26667	5774
		Brachionus plicatilis	315000	295000	285000	298333	15275
	C0B- 0825	*Artemia salina*	15000	16500	17500	16333	1258
		Acartia sp.	5000	4000	4000	4333	577
		Crustacean nauplii	25000	20000	30000	25000	5000
		Brachionus plicatilis	260000	270000	280000	270000	10000
Day 5	C5T - 0830	*Acartia* sp.	1000	1000	1500	1167	289
		Crustacean nauplii	15000	10000	20000	15000	5000
		Brachionus plicatilis	75000	80000	70000	75000	5000
	C5M- 0830	*Acartia* sp.	1500	1500	1000	1333	289
		Crustacean nauplii	20000	25000	15000	20000	5000
		Brachionus plicatilis	70000	70000	75000	71667	2887
	C5B- 0830	*Acartia* sp.	1500	500	1000	1000	500
		Crustacean nauplii	20000	20000	25000	21667	2887
		Brachionus plicatilis	65000	60000	65000	63333	2887

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 brackish water by treatment of Purimar™ BWMS

Date	Sample ID	Classification	Survival number /m³			Mean	SD [b)]
			R1[a)]	R2	R3		
Day 0	T0T - 0825	-	0	0	0	0	0
	T0M- 0825	-	0	0	0	0	0
	T0B- 0825	-	0	0	0	0	0
Day 5	T5T - 0830	-	0	0	0	0	0
	T5M- 0830	-	0	0	0	0	0
	T5B- 0830	-	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-0825	*Tetraselmis suecica*	1390	1480	1340	1403	71
		Ceratium sp.	11	8	9	9	2
		Chaetoceros sp.	15	14	12	14	2
		Melosira sp.	4	6	6	5	1
		Ebria sp.	7	8	5	7	2
	OwM-0825	*Tetraselmis suecica*	1570	1510	1680	1587	86
		Ceratium sp.	6	8	8	7	1
		Chaetoceros sp.	12	11	14	12	2
		Melosira sp.	6	9	8	8	2
		Ebria sp.	6	8	7	7	1
	OwB-0825	*Tetraselmis suecica*	1290	1370	1180	1280	95
		Ceratium sp.	8	13	12	11	3
		Chaetoceros sp.	4	5	4	4	1
		Melosira sp.	5	3	4	4	1
		Ebria sp.	6	8	6	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) brackish water

Date	Sample ID	Classification	Survival number / ml			Mean	SD [b)]
			R1[a)]	R2	R3		
Day 0	C0T-0825	*Tetraselmis suecica*	1260	1190	1230	1227	35
		Ceratium sp.	3	6	5	5	2
		Chaetoceros sp.	7	5	8	7	2
		Ebria sp.	4	6	6	5	1
	C0M-0825	*Tetraselmis suecica*	1290	1390	1340	1340	50
		Ceratium sp.	5	8	7	7	2
		Chaetoceros sp.	8	5	5	6	2
		Ebria sp.	4	5	3	4	1
	C0B-0825	*Tetraselmis suecica*	1430	1260	1220	1303	112
		Ceratium sp.	3	4	2	3	1
		Chaetoceros sp.	9	7	8	8	1
		Ebria sp.	6	8	8	7	1
Day 5	C5T-0830	*Tetraselmis suecica*	113	104	124	114	10
		Ebria sp.	4	5	3	4	1
	C5M-0830	*Tetraselmis suecica*	127	131	122	127	5
		Ebria sp.	6	7	5	6	1
		Chaetoceros sp.	3	5	3	4	1
	C5B-0830	*Tetraselmis suecica*	119	126	112	119	7
		Chaetoceros sp.	2	3	3	3	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 brackish water by treatment of Purimar™ BWMS

Date	Sample ID	Classification	Survival number / ml			Mean	SD [b)]
			R1[a)]	R2	R3		
Day 0	T0T-0825	-	0	0	0	0	0
	T0M-0825	-	0	0	0	0	0
	T0B-0825	-	0	0	0	0	0
Day 5	T5T-0830	-	0	0	0	0	0
	T5M-0830	-	0	0	0	0	0
	T5B-0830	-	0	0	0	0	0

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

Appendix 10. 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	Ow-0825	Top	29100	36800	32300	32733.33	3868
		Middle	41200	39800	41700	40900	985
		Bottom	49200	41000	42300	44167	4407
	C0-0825	Top	30500	32600	30200	31100	1308
		Middle	38800	37800	39000	38533	643
		Bottom	35700	32100	31300	33033	2344
	T0-0825	Top	21	19	18	19	2
		Middle	19	18	18	18	1
		Bottom	13	12	12	12	1
Day 5	C5-0830	Top	96800	81000	82000	86600	8848
		Middle	86500	112000	94000	90250	5303
		Bottom	54900	59000	49700	54533	4661
	T5-0830	Top	232000	221600	231200	226400	6788
		Middle	220800	208800	206400	212000	1697
		Bottom	200800	200000	184800	195200	9016

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

Appendix 11. 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	Ow-0825	Top	126	127	128	127	1
		Middle	127	126	142	131	9
		Bottom	124	140	136	133	8
	C0-0825	Top	149	175	179	168	16
		Middle	131	162	150	147	16
		Bottom	105	124	124	118	11
	T0-0825	Top	0	0	0	0	0
		Middle	0	0	0	0	0
		Bottom	0	0	0	0	0
Day 5	C5-0830	Top	0	0	0	0	0
		Middle	0	0	0	0	0
		Bottom	0	0	0	0	0
	T5-0830	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) 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	Ow-0825	Top	116	144	132	130	14
		Middle	74	97	110	94	18
		Bottom	134	132	149	138	9
	C0-0825	Top	102	114	110	108	6
		Middle	62	90	107	86	23
		Bottom	97	117	122	112	13
	T0-0825	Top	0	0	0	0	0
		Middle	0	0	0	0	0
		Bottom	0	0	0	0	0
Day 5	C5-0830	Top	10	14	11	12	2
		Middle	7	6	6	6	1
		Bottom	7	5	4	5	2
	T5-0830	Top	0	0	0	0	0
		Middle	0	0	0	0	0
		Bottom	0	0	0	0	0

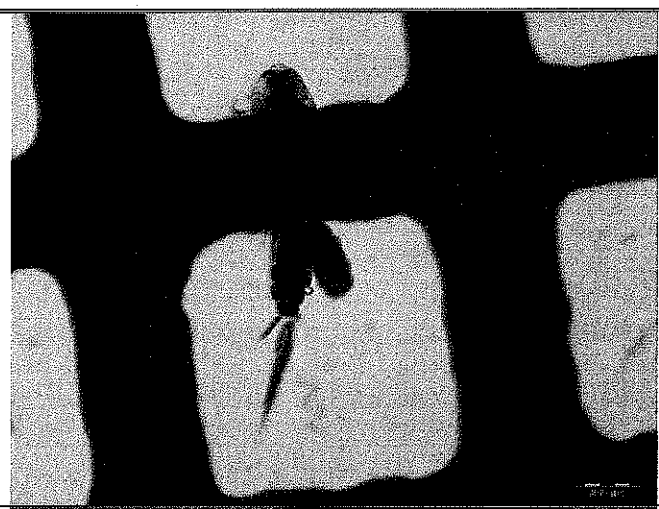
a) R: Replicate
b) S.D: Standard deviation
c) Colonies were too numerous to count (TNTC), used upper limit count with smallest filtration volume

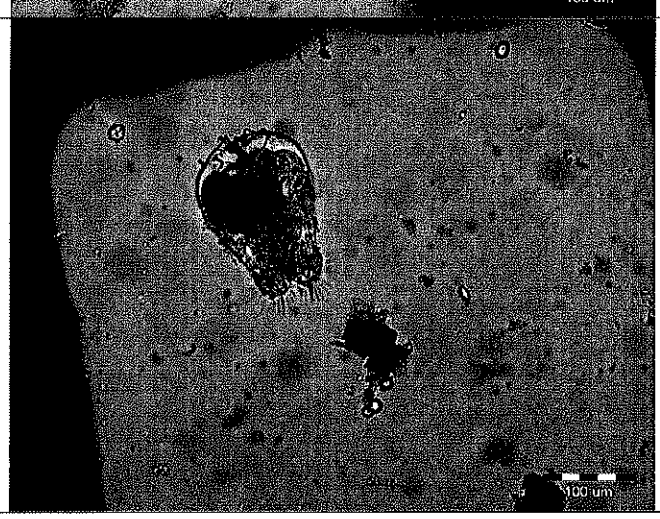
Appendix 13. Number of *Vibrio cholera* O1, O139 in original water, control (untreated) brackish water, treated ballast brackish water by treatment of Purimar™ BWMS

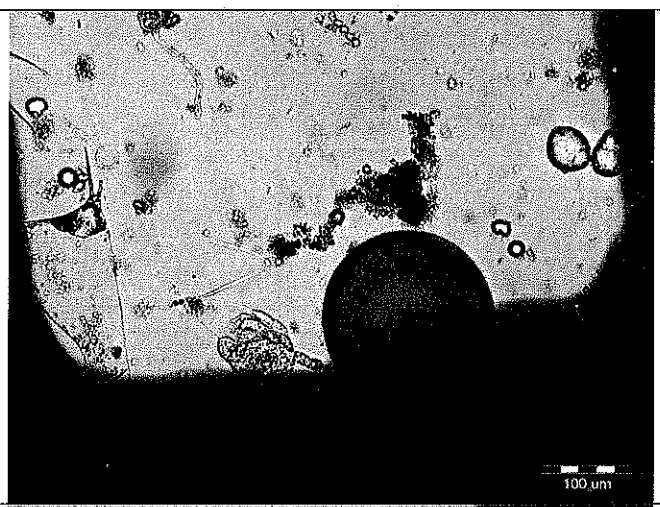
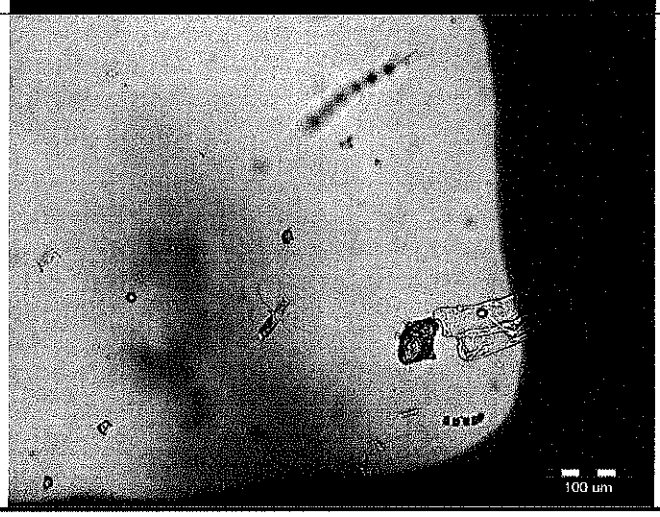
Date	Sample ID		CFU/100ml			Mean	SD [b]
			R1[a]	R2	R3		
Day 0	Ow-0825	Top	0	0	0	0	0
		Middle	0	0	0	0	0
		Bottom	0	0	0	0	0
	C0-0825	Top	0	0	0	0	0
		Middle	0	0	0	0	0
		Bottom	0	0	0	0	0
	T0-0825	Top	0	0	0	0	0
		Middle	0	0	0	0	0
		Bottom	0	0	0	0	0
Day 5	C5-0830	Top	0	0	0	0	0
		Middle	0	0	0	0	0
		Bottom	0	0	0	0	0
	T5-0830	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
*Microsetella sp.**	
*Artemia salina***	
Acartia sp.**	

*Paracalanus sp.***	
Crustacean nauplii***	
Brachionus plicatilis**	

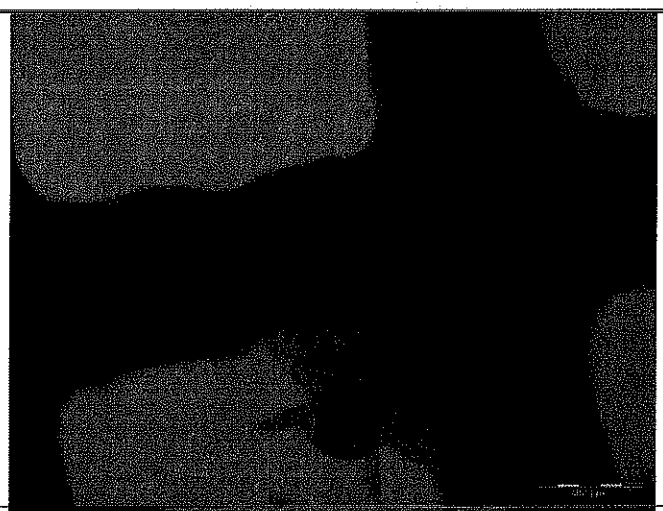
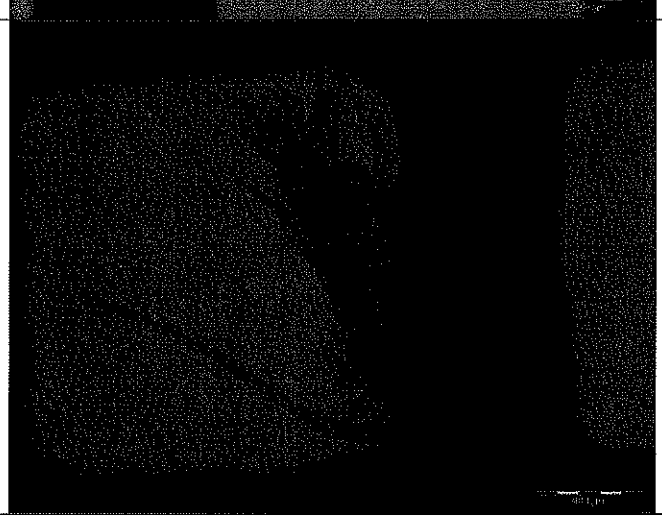
Coscinodiscus* sp.	
Protoperidinium* sp.	

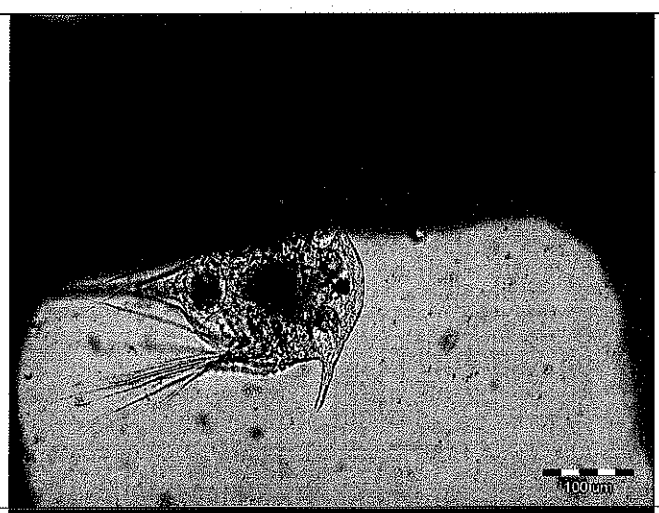
* Magnification : 80

**Magnification : 115

***Magnification : 200

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

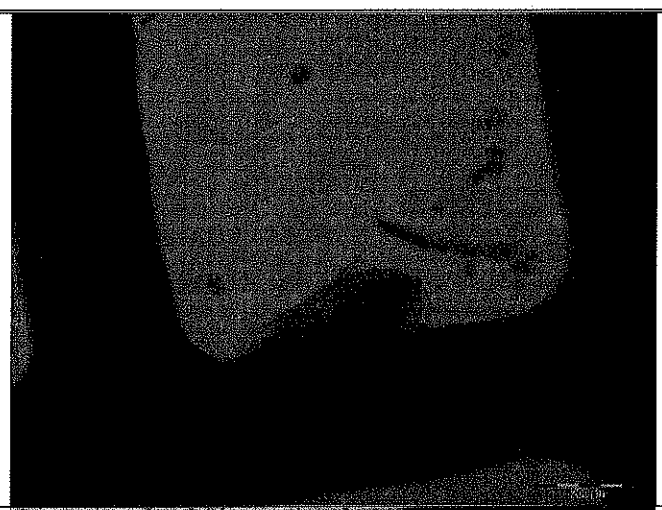
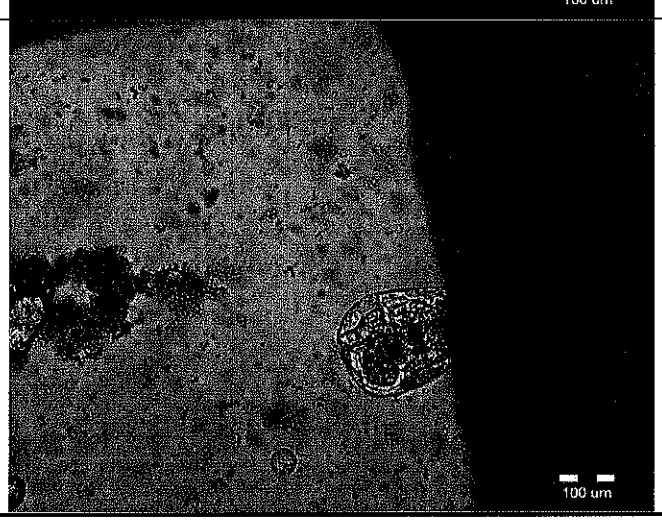
Specific Name	Control (untreated) brackish water
*Artemia salina**	
Acartia sp.*	
*Paracalanus sp.**	

Crustacean nauplii**	
Brachionus plicatilis*	

*Magnification : 115

**Magnification : 200

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

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

*Magnification : 115

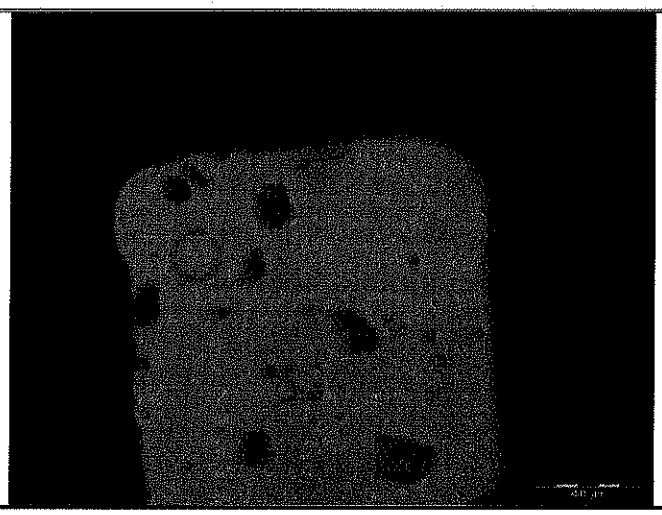
**Magnification : 200

Appendix 17. The microscope image of ≥ 50㎛ in treated ballast brackish water by treatment of Purimar™ BWMS (Day0)

Specific Name	Treated ballast brackish water
-	

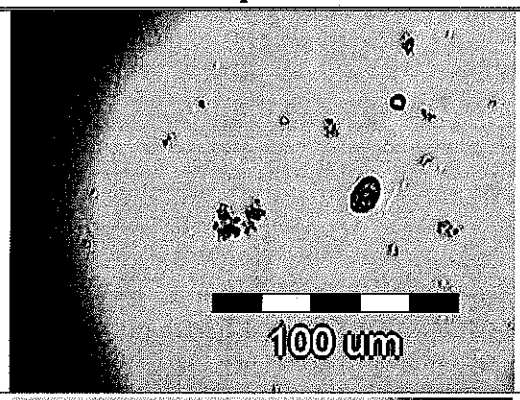
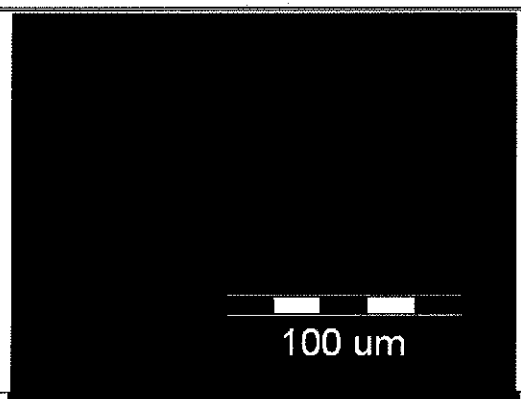
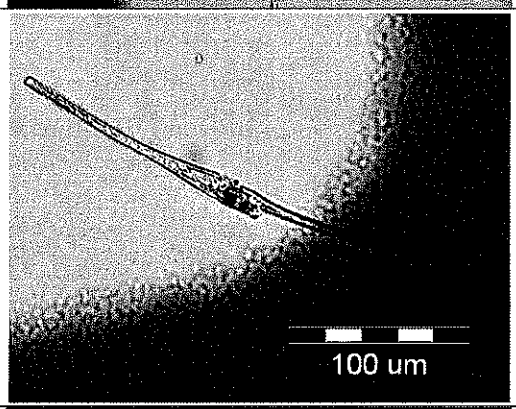
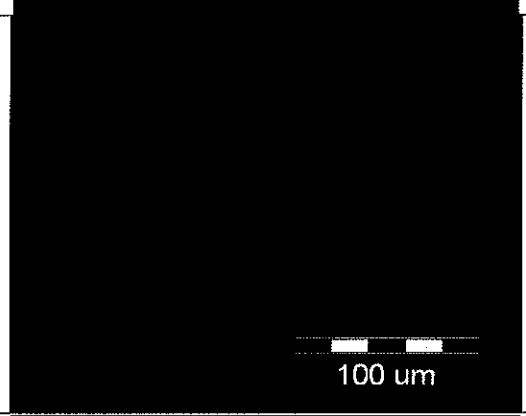
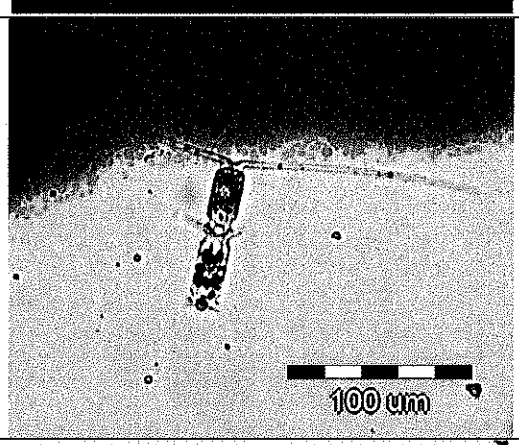
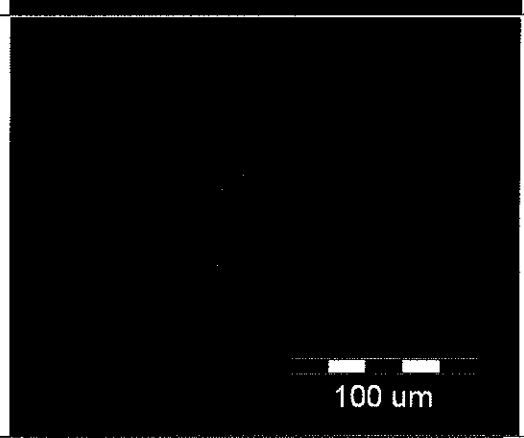
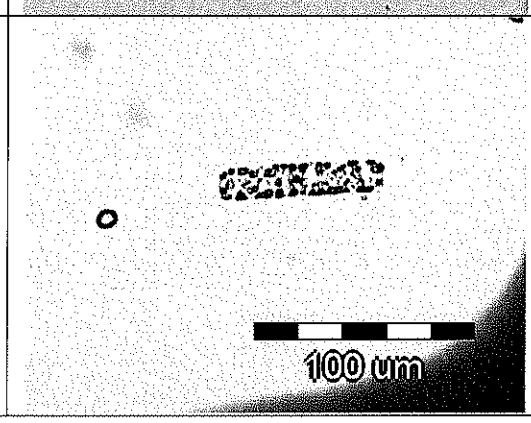
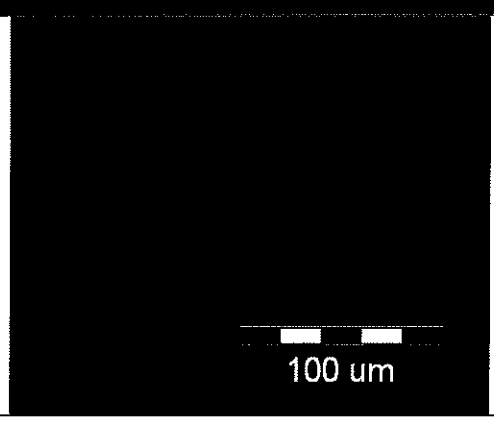
Magnification : 115

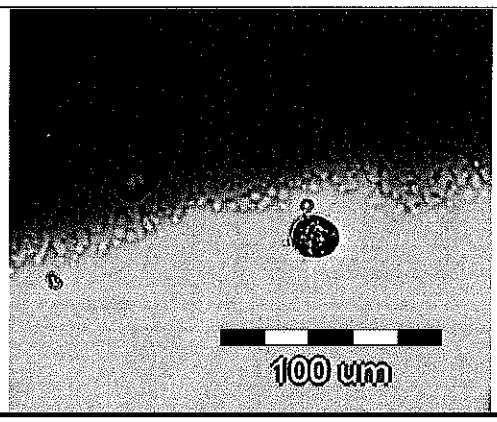
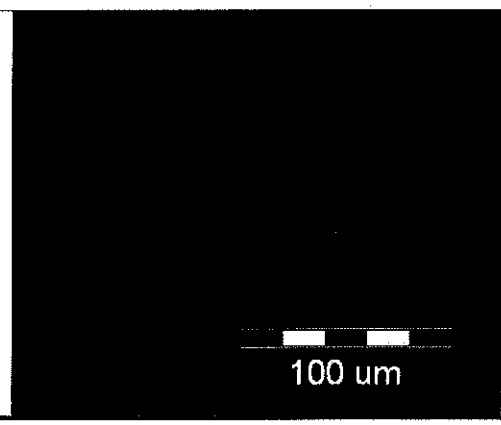
Appendix 18. The microscope image of ≥ 50㎛ in treated ballast brackish water by treatment of Purimar™ BWMS (Day5)

Specific Name	Treated ballast brackish water
-	

Magnification : 115

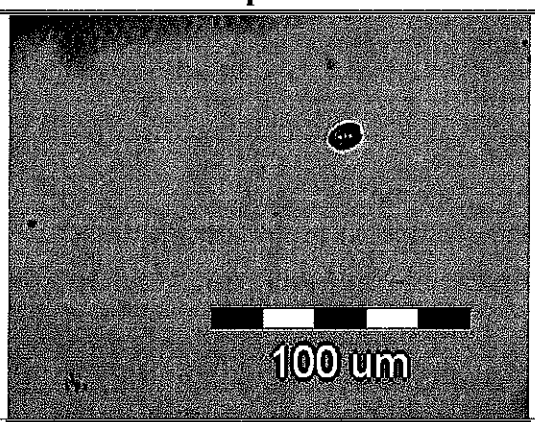
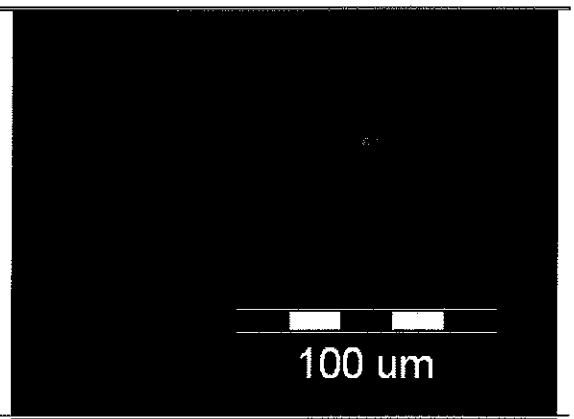
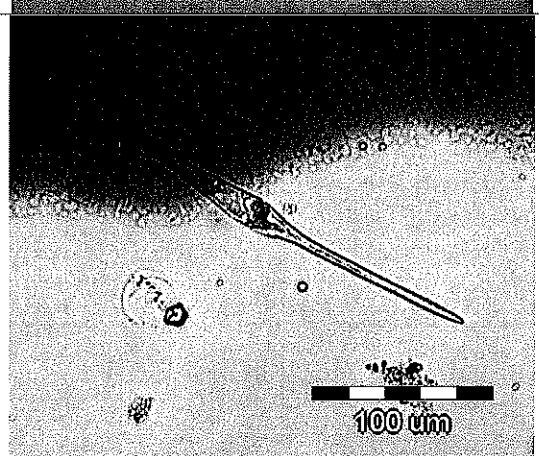
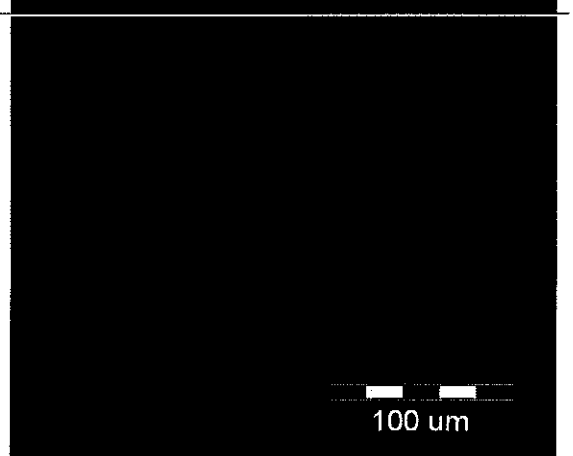
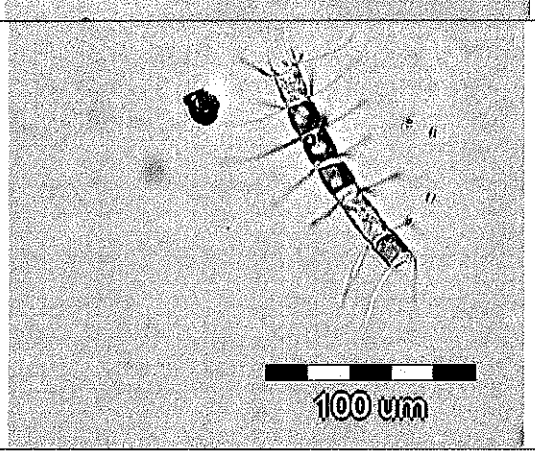
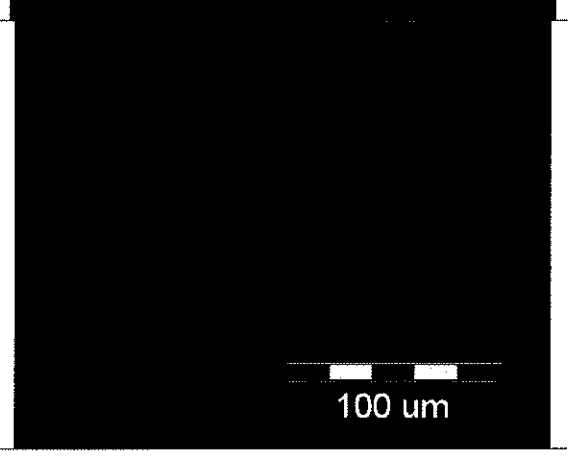
Appendix 19. The microscope image of 10㎛–50㎛ in original water (Day0)

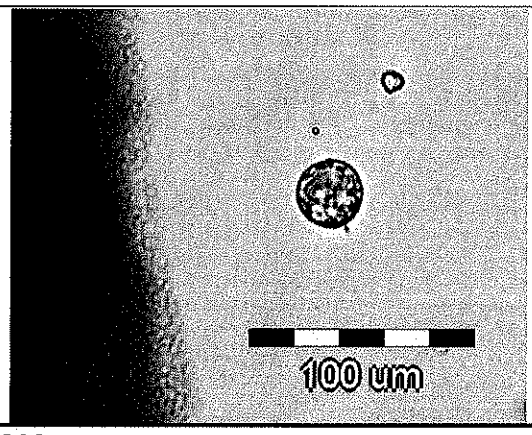
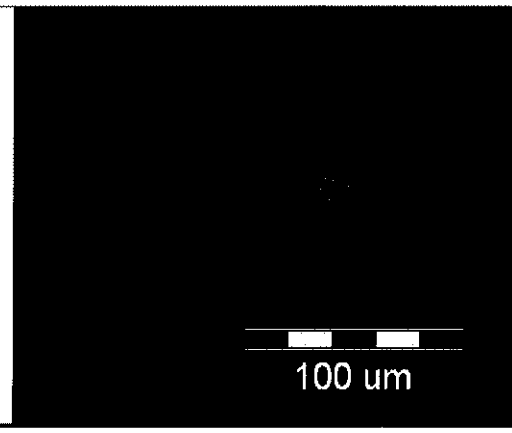
Specific Name	Control (untreated) brackish water	
	Optical	Fluorescence
Tetraselmis suecica		
Ceratium sp.		
Chaetoceros sp.		
Melosira sp.		

***Ebria* sp.**		

Magnification : 200

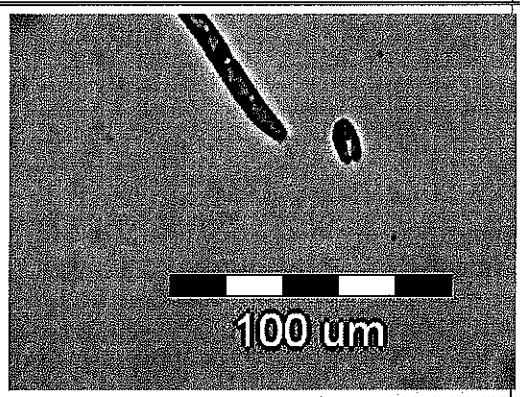
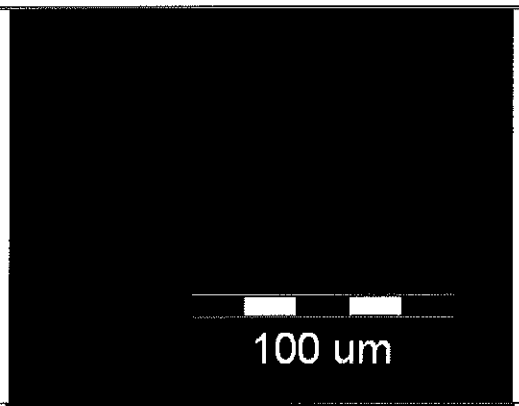
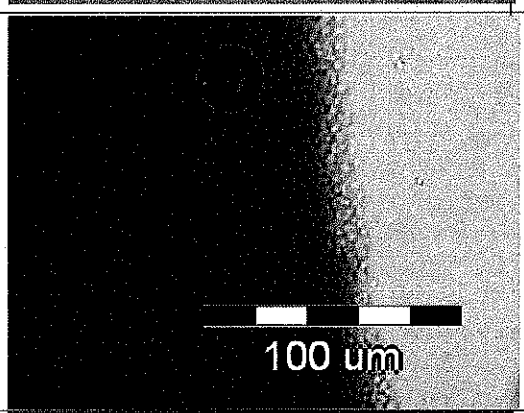
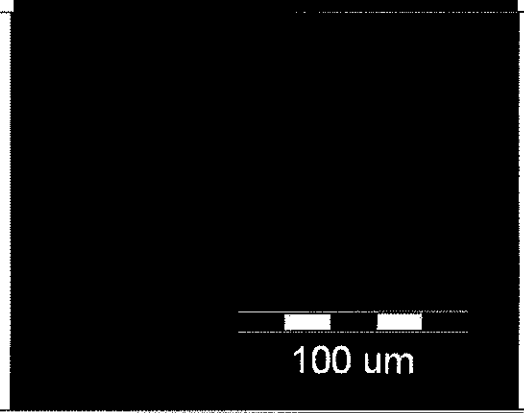
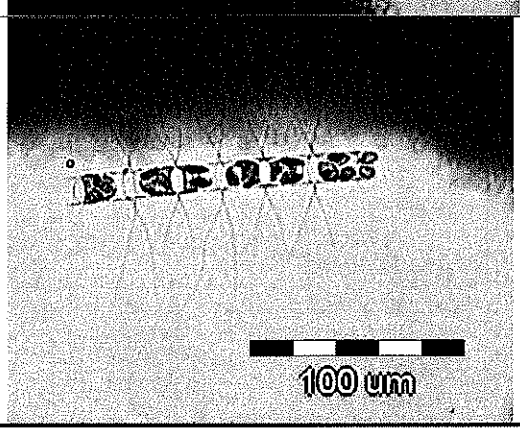
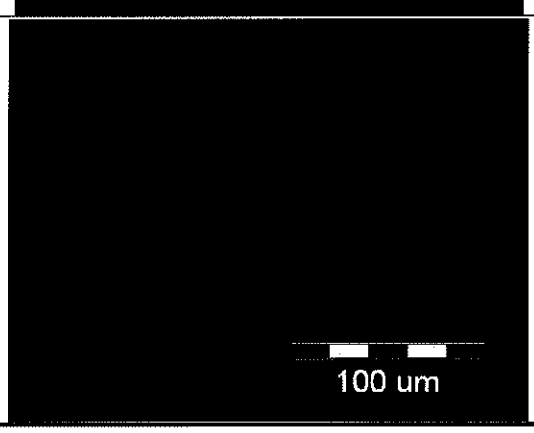
Appendix 20. The microscope image of 10㎛−50㎛ in control (untreated) brackish water by treatment of Purimar™ BWMS (Day0)

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

***Ebria* sp.**		

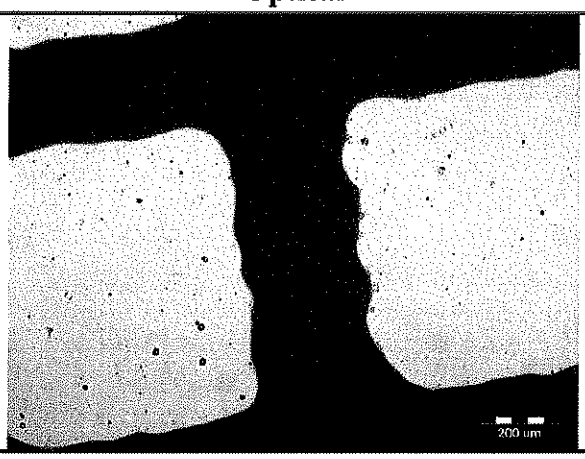
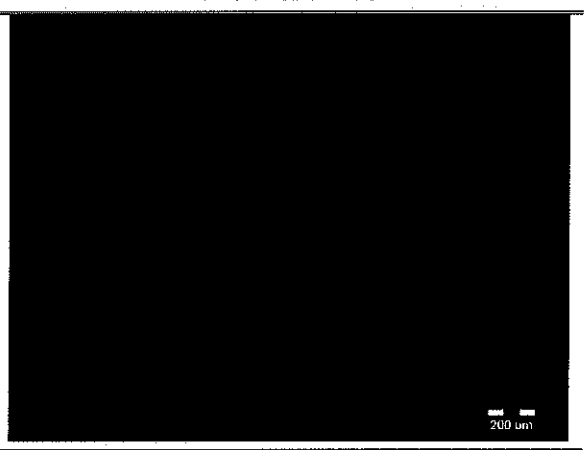
Magnification : 200

Appendix 21. 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		
Ebria sp.		
Cheatoceros sp.		

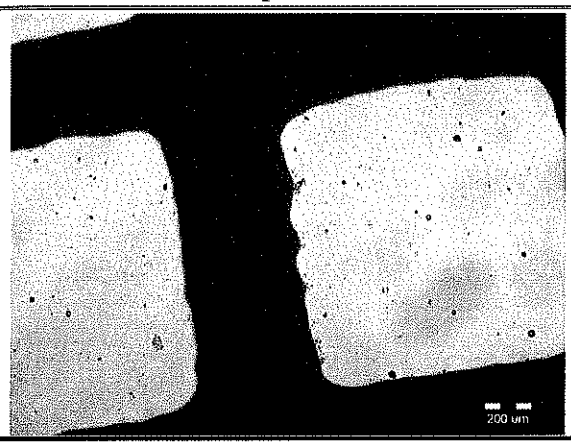
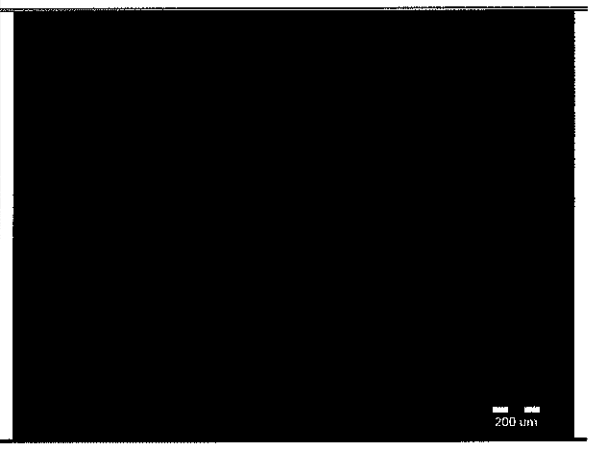
Magnification : 200

Appendix 22. 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

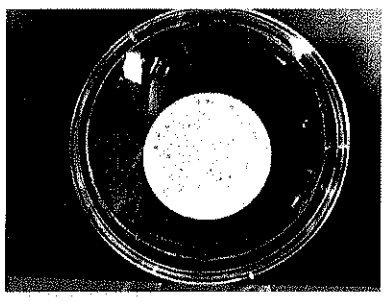
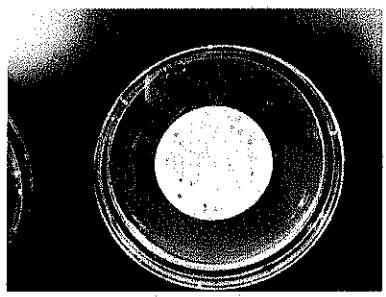
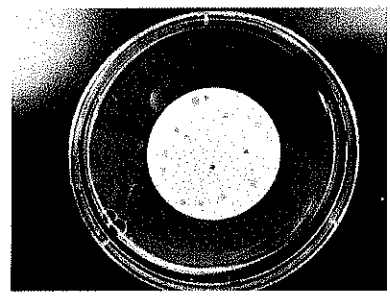
Appendix 23. The microscope image of 10 ㎛–50 ㎛ in neutralized water by treatment of Purimar™ BWMS (Day5)

Specific Name	Neutralized water	
	Optical	Fluorescence
-		

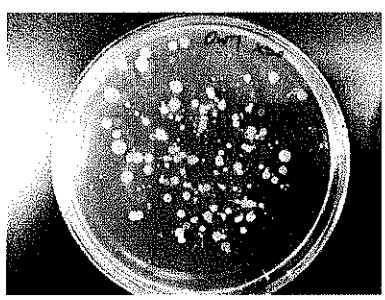
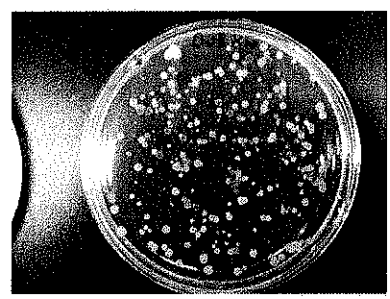
Magnification : 200

Appendix 24. The image of heterotrophic bacteria: Day 0

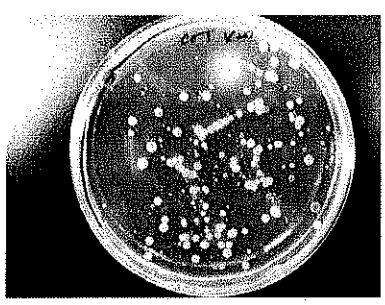
Treated ballast brackish water

Top	Middle	Bottom
		

Original water

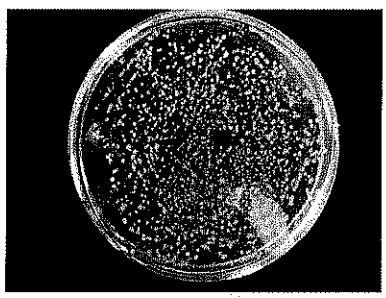
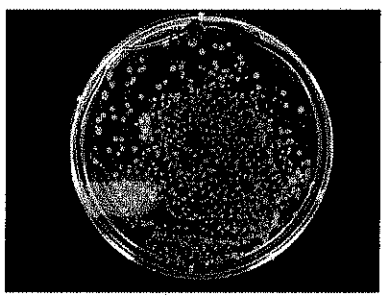
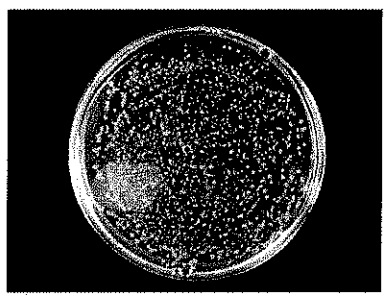
Top	Middle	Bottom
		

Control (untreated) brackish water

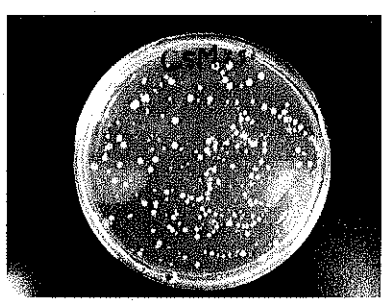
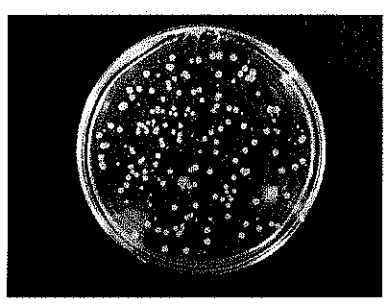
Top	Middle	Bottom
		

Appendix 25. The image of heterotrophic bacteria: Day 5

Treated ballast brackish water

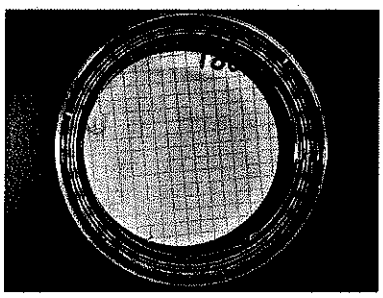
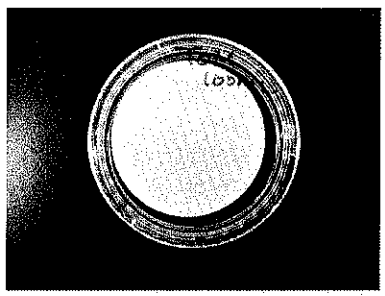
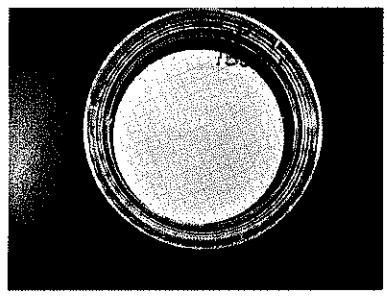
Top	Middle	Bottom
		

Control (untreated) brackish water

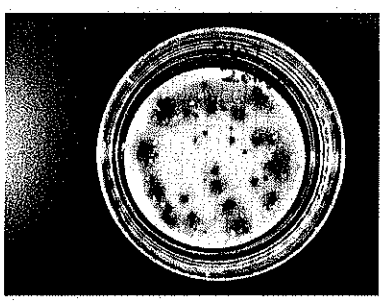
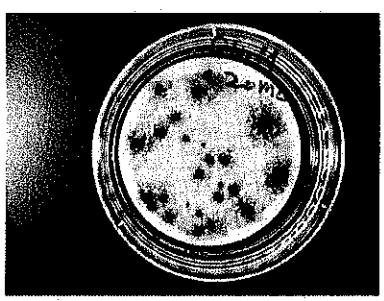
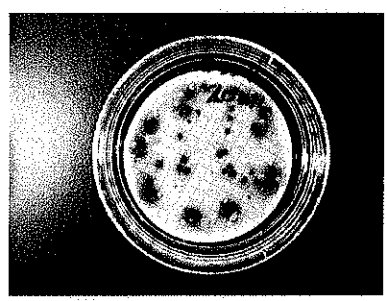
Top	Middle	Bottom
		

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

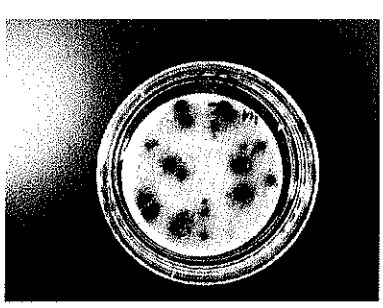
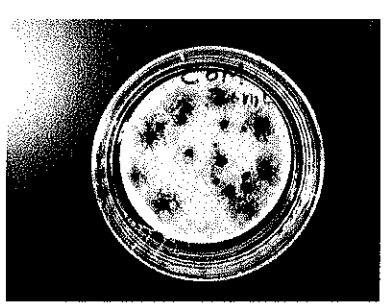
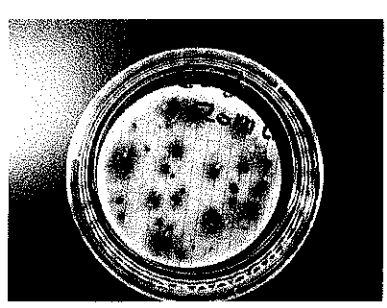
Treated ballast brackish water

Top	Middle	Bottom
		

Original water

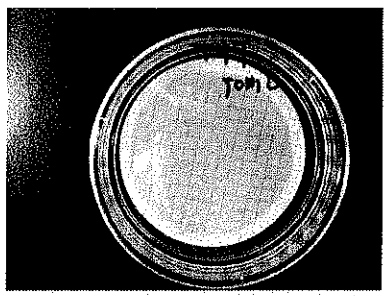
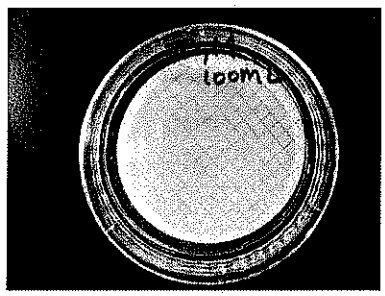
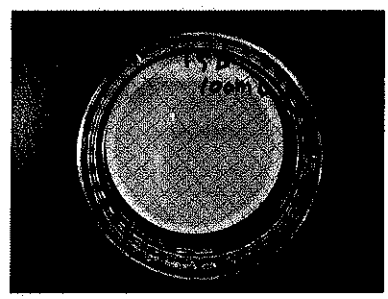
Top	Middle	Bottom
		

Control (untreated) brackish water

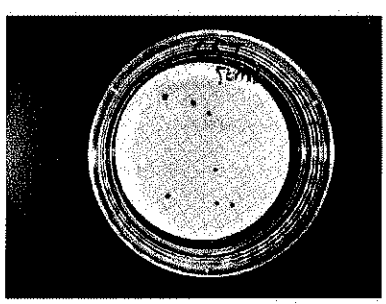
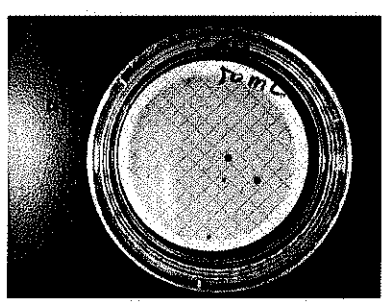
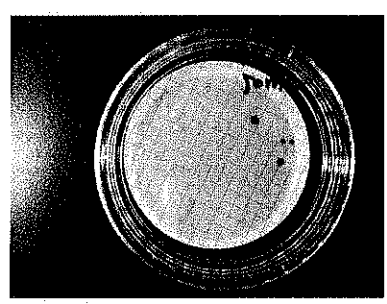
Top	Middle	Bottom
		

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

Treated ballast brackish water

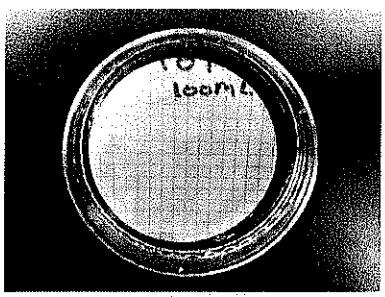
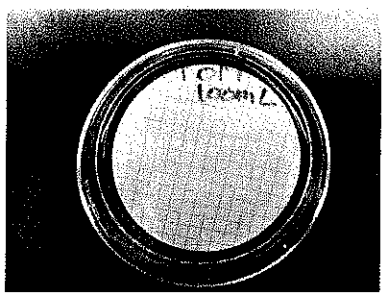
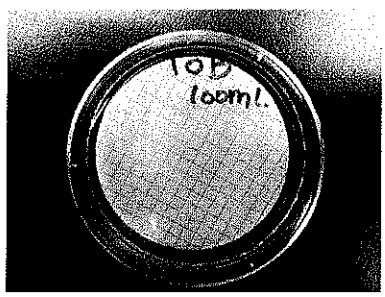
Top	Middle	Bottom
		

Control (untreated) brackish water

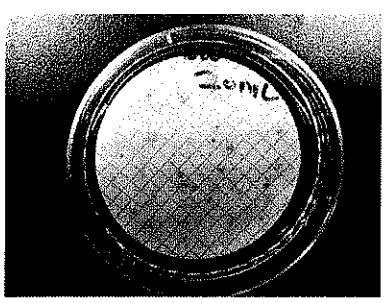
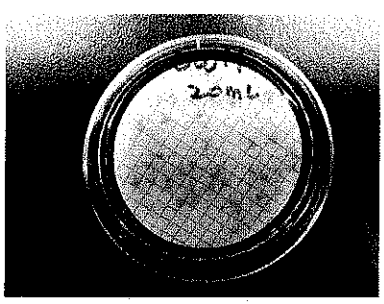
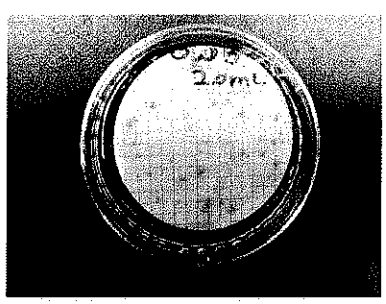
Top	Middle	Bottom
		

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

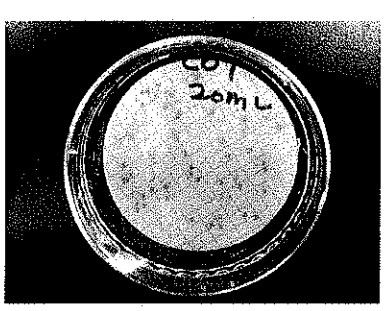
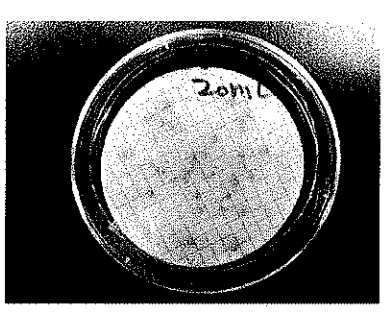
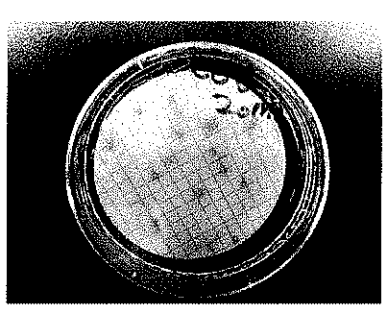
Treated ballast brackish water

Top	Middle	Bottom
		

Original water

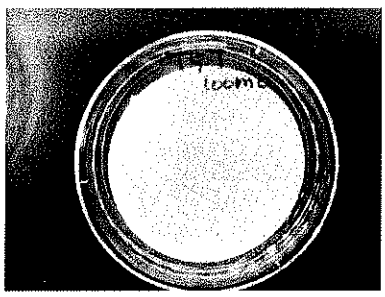
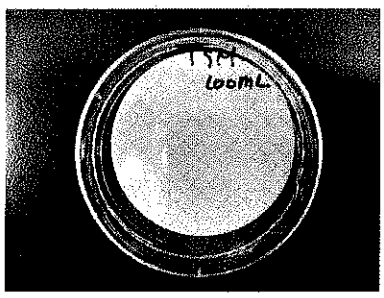
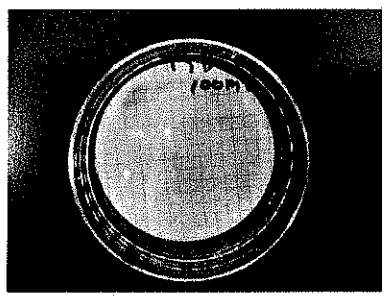
Top	Middle	Bottom
		

Control (untreated) brackish water

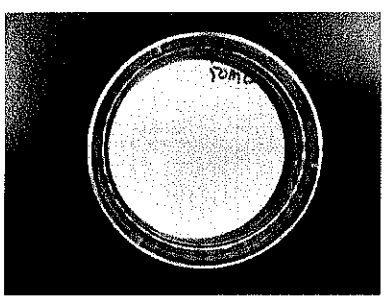
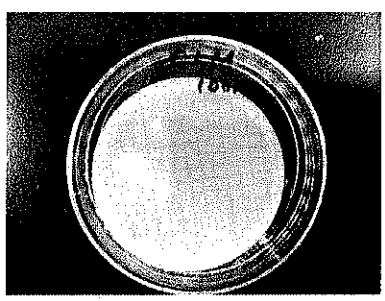
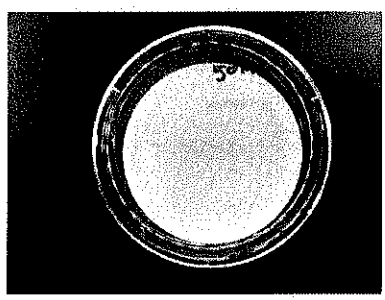
Top	Middle	Bottom
		

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

Treated ballast brackish water

Top	Middle	Bottom
		

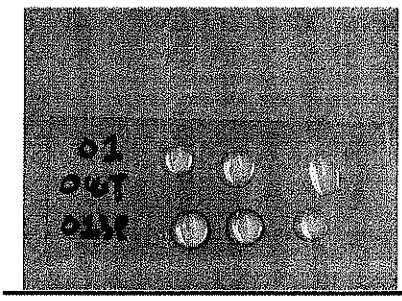
Control (untreated) brackish water

Top	Middle	Bottom
		

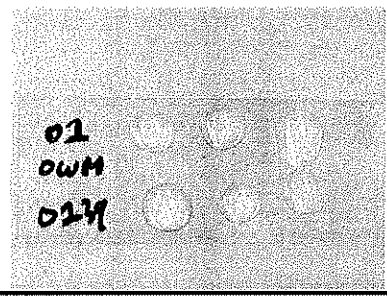
Appendix 30. The image of *Vibrio cholera* O1, O139: Day 0

Original water

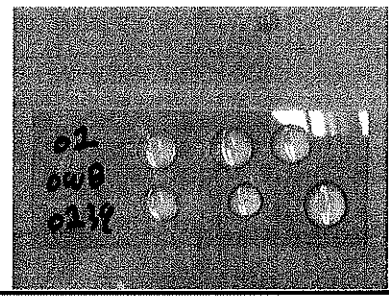
Top



Middle

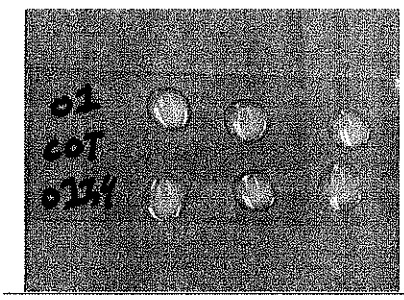


Bottom

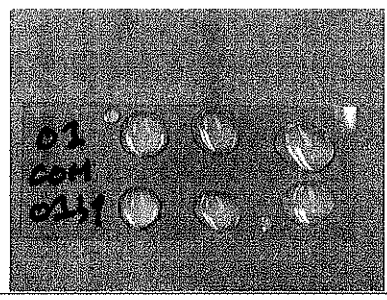


Control (untreated) brackish water

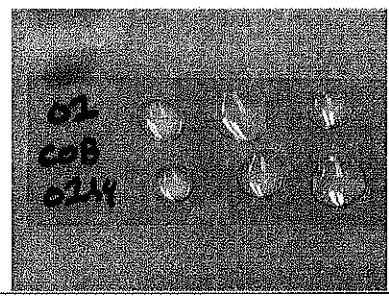
Top



Middle

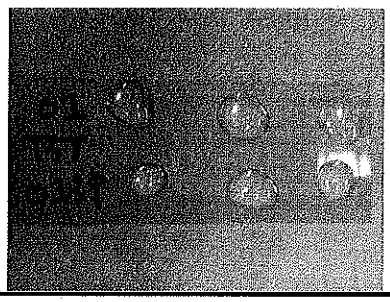
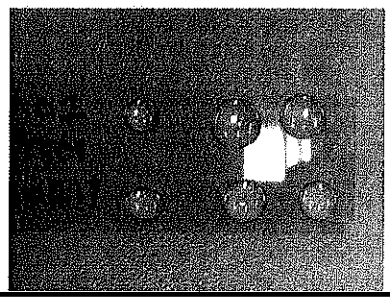
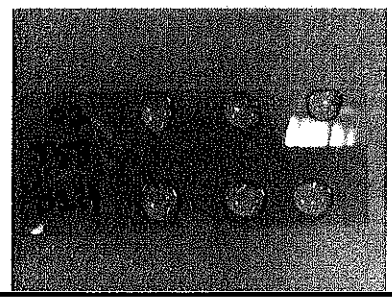


Bottom

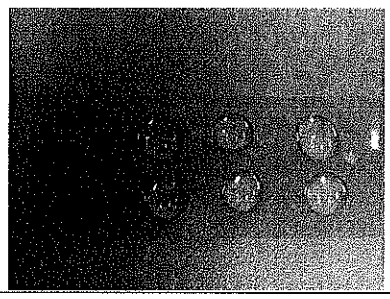
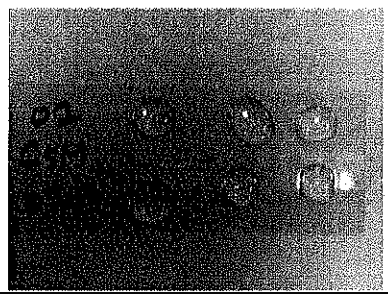


Appendix 31. The image of *Vibrio cholera* O1, O139: Day 5

Treated ballast brackish water

Top	Middle	Bottom
		

Control (untreated) brackish water

Top	Middle	Bottom
		

5. Attachment

5.1 Filtered natural 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