시 험 성 적 서
Testing Certificate

Korea Marine Equipment Research Institute
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시험성적서 번호
Certificate No. :
KOMERI-GTA-11T129-1

■ 접수일자 : 2011. 02. 22
Date of Receipt

■ 접수번호 : 11T129
Receipt No.

■ 신 청 자 : AQUA Eng. Co., Ltd.
Applicant

■ 주 소 : #938-8, Dalsan-ri, Jeonggwan-myeon, Gijang-gun, Busan, Korea
Address

■ 시 료 명 : Ballast Water Management System
Name of Product

■ 모 델 : AquaStar™ BWMS, H-300
Model

■ 일련번호 : H-300-1002
Serial No.

■ 시험규격 : The Provisional Regulation for Type Approval of Ballast Water Management System by Ministry of Land, Transport and Maritime Affairs (PR. No. 2011-342), and Guideline 8 (IMO. Res. MEPC. 174(58), ANNEX, PART 2)
Test Standard

■ 성적서 용도 : Type Approval by the Ministry of Land, Transport and Maritime Affair (Shipboard test)
Purpose of Testing Certificate

■ 시험기간 : 2011. 03. 06 ~ 2011. 10. 29
Test Period

■ 시험환경 : 온도 (20.5 ± 5.0) ℃, 습도 (42 ± 5) % R.H
Environment *Temperature* *Humidity*

■ 시험결과 : **Conformity**
Test Result

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The test results are valid only for the test sample(s) provided by the applicant, and cannot be reproduced in full or in part without the prior written consent of the KOMERI

2012. 05. 22

시험원 *Tested by* 성명 *Name*	Hyung-Min Park (서명)	기술책임자 *Technical Manager* 성명 *Name*	Jun-Hyuk Yang (서명)

(재)한국조선해양기자재연구원장 (인)
The President of Korea Marine Equipment Research Institute

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GENERAL

■ MANUFACTURER

☑ Same as the Applicant

Company Name : AQUA Eng. Co., Ltd.

Address : #938-8, Dalsan-ri, Jeonggwan-myeon, Gijang-gun, Busan, Korea

■ ADDITIONAL TEST INFORMATION

Treatment Rated Capacity : 750 m^3/hr

■ TEST SUMMARY

No.	Test Item	Test Standard	Result
1	Ballast Water Management System (Shipboard test)	The Provisional Regulation for Type Approval of Ballast Water Management System by the Ministry of Land, Transport and Maritime Affairs (PR. No. 2011-342, Annex 5 & Annex 6) and Guideline 8 (IMO Res. MEPC.174(58), ANNEX, PART 2, 2.2, 2.4 & PART 4)	Conformity

1. SHIPBOARD TEST

1.1 TEST ENVIRONMENT

· Ambient temperature (20.5 ± 5.0) ℃

· Relative Humidity (42 ± 5) % R.H.

1.2 TEST STANDARD

· The Provisional Regulation of Type Approval of Ballast Water Management System by the Ministry of Land, Transport and Maritime Affairs (PR. No. 2011-342, Annex 5 & Annex 6) and Guideline 8 (IMO Res. MEPC.174(58), ANNEX, PART 2, 2.2, 2.4 & PART 4)

· Detailed test methods are as below;

	Item	Test standard	Remark
◆	Water temperature	Standard Method 2550:2005	Measurement with Electrode multiprobe (Hydrolab, USA)
◆	pH	Standard Method 4500 H^+ B:2005	
◆	ORP	Standard Method 2580:2005	
◆	Salinity	Standard Method 2520 B:2005	
◆	DO	ASTM Standard Method D888-09 C:2010	
◆	Turbidity	Standard Method 2130 B:2005	Measurement with Turbidity meter (Hach, 2100 P)
◆	TSS	Standard Method 2540 D:2005	-
◆	DOC/POC	ISO 8245:1999	-
◆	Viable organisms (≥ 50 μm)	Fleming & Coughlan, 1978, US EPA 600/R-10/146:2010, Standard Method 10200 C:2005	Staining with Neutral Red, Touch with the point of a fine dissecting needle, Concentration techniques
◆	Viable organisms (≥ 10 - 50 μm)	Anja et al., 2005, Standard Method 10200 C:2005	Fluorescence dyeing with 5-CFDA AM, Concentration techniques
◆	Heterotrophic bacteria	Standard Method 9215:2005	-
◆	Coliform	Standard Method 9222 B:2005	-
◆	*Escherichia coli*	US EPA 1603:2009	-
◆	Intestinal Enterococci	US EPA 1600:2009	-
◆	Toxicogenic *Vibrio cholerae* (O1, O139)	Standard Method 9260 H:2005 and/or API 20E kit (BioMerieux, Inc.)	-

1.3 TEST EQUIPMENTS

Description	Manufacturer	Model Number	Calibration Due
◆ Fluorescent microscope	Olympus	CFX41-33FL	-
◆ Sedgewick-Rafter chamber	Pyser-SGI	-	-
◆ Stereo-microscope	Olympus	SZ40	-
◆ Bogorov counting chamber	DH Sci.	-	-
◆ Multiprobe (Hydrolab)	Hach company	Hydrolab DS5	-
◆ Portable cleanbooth	DS Tech.	-	-
◆ Turbidity meter	Hach company	2100 P	-
◆ Digital imaging	BAUMER	TDI DMC3	-
◆ Digital imaging	Olympus	JUJAK 5.5	-
◆ Standard sieve	Sefar	30 μm (diagonal)	~ 2011. 12. 24
◆ Standard sieve	Sefar	10 μm (diagonal)	-
◆ Plankton net	SA Sci.	conical type (30 μm, diagonal)	-
◆ Auto pipette	Labnet International, inc.	BP-10000	~ 2011. 12. 06
◆ Micro (Pasteur) pipette	Hilgenberg	31 501 02	-
◆ Auto pipette	Labnet International, inc.	BP-1000	~ 2011. 12. 06
◆ Auto pipette	Labnet International, inc.	BP-200	~ 2011. 12. 06
◆ Filtration system	Nalgene	350 mL	-
◆ Vacuum pump	THOMAS	-	~ 2011. 12. 08
◆ Mass cylinder	Witeg	100 mL	~ 2015. 06. 04
◆ Portable incubators	CAIS	KC2500	-

1.4 TEST SET-UP

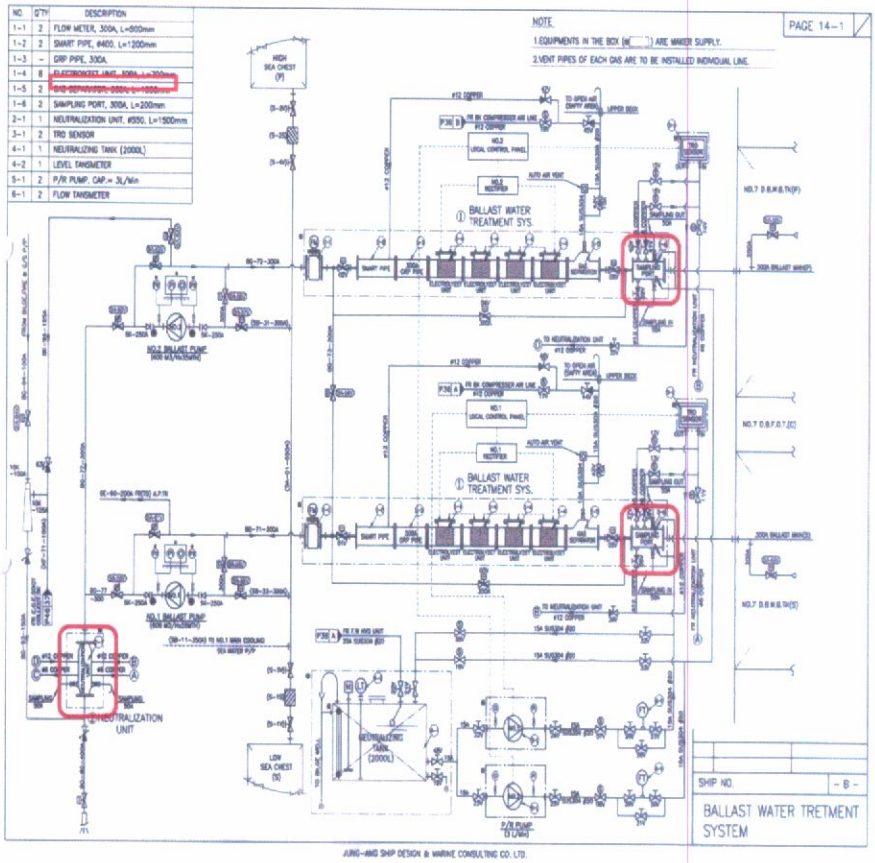


Figure 1. Diagram of the shipboard test facility of the AquaStar™ BWMS

1.5 TEST PROCEDURE

· See Appendix II. PROCEDURE ON SHIPBOARD TEST.

1.6 TEST SCHEDULE

Test period	Test mode and date	
	Ballasting	de-Ballasting
1st	2011. 03. 06 Busan newport/Korea	2011. 03. 14 Singapore port/Singapore
2nd	2011. 08. 21 Singapore port/Singapore	2011. 08. 28 Busan newport/Korea
3rd	2011. 10. 23 Hongkong port/ Hongkong	2011. 10. 28 Tongyeong bay/Korea

1.7 TEST RESULTS

1.7.1 Assessment of valid tests

(1) Viable organisms of influent water

Test period	≥ 50 μm organisms (inds./m^3)	≥ 10 - 50 μm organisms (inds./mL)	Remarks
1st	16 694	123	Conformity
2nd	28 667	147	Conformity
3rd	99 889	521	Conformity
Valid requirement	**> 100**	**> 100**	-

※ Data indicates an arithmetic mean from triplicate.

(2) Viable organisms of discharge control water

Test period	≥ 50 μm organisms (inds./m^3)	≥ 10 - 50 μm organisms (inds./mL)	Remarks
1st	7 250	26	Conformity
2nd	11 083	18	Conformity
3rd	53 500	18	Conformity
Valid requirement	**> 10**	**> 10**	-

※ Data indicates an arithmetic mean from triplicate.

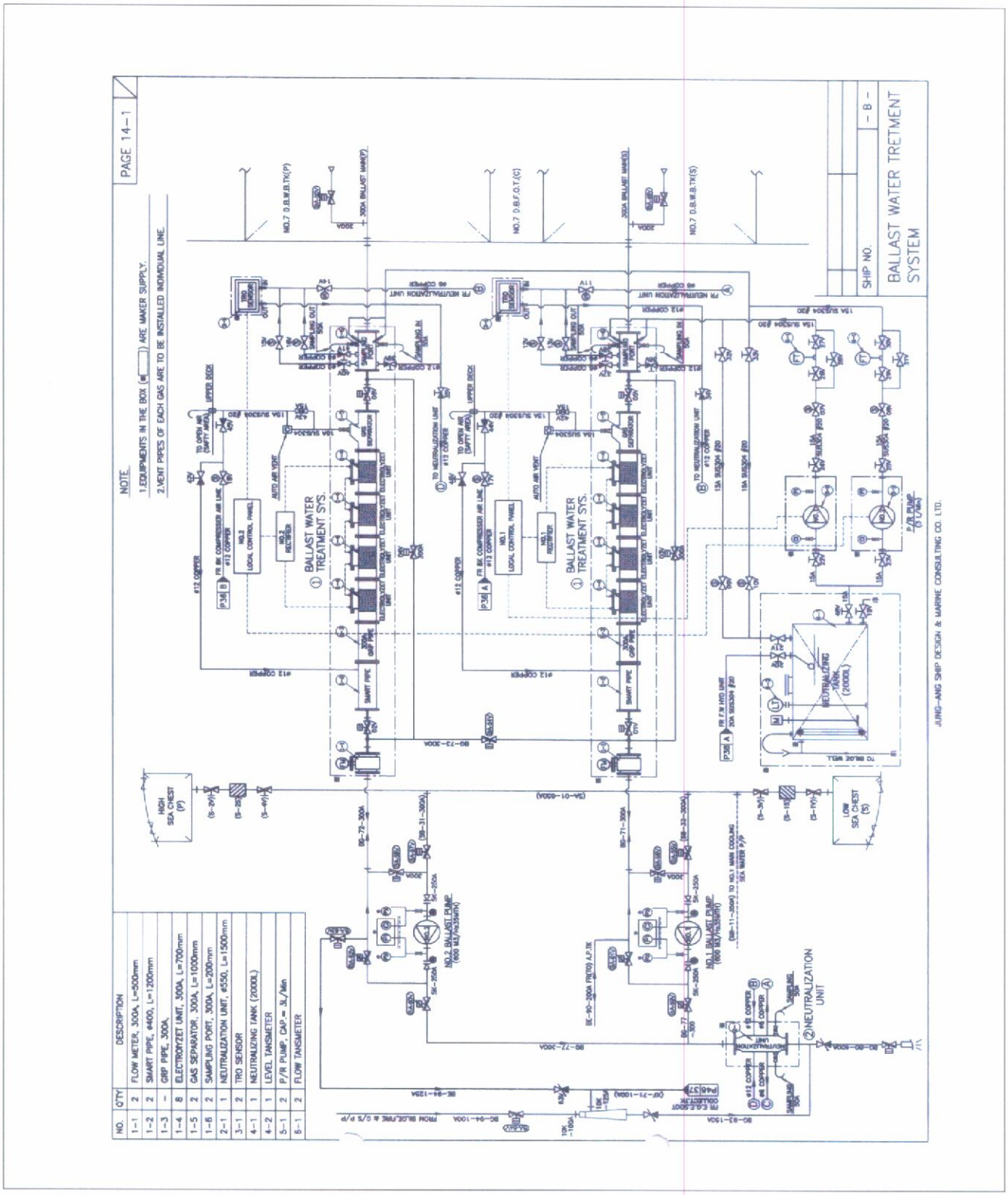
1.7.2 Assessment of discharge treated water

Test period	≥ 50 μm organisms (inds./m^3)	≥ 10 - 50 μm organisms (inds./mL)	Bacteria (cfu/100 mL)			Remarks
			Escherichia coli	Intestinal Enterococci	Toxicogenic *Vibrio cholerae* (O1, O139)	
1st	3	0	1	0	0	**Conformity**
2nd	2	0	0	0	0	**Conformity**
3rd	3	0	0	0	0	**Conformity**
Discharge standard	**< 10**	**< 10**	**< 250**	**< 100**	**< 1**	-

※ Data indicates an arithmetic mean from triplicate.

ATTACHMENT

I. DRAWING



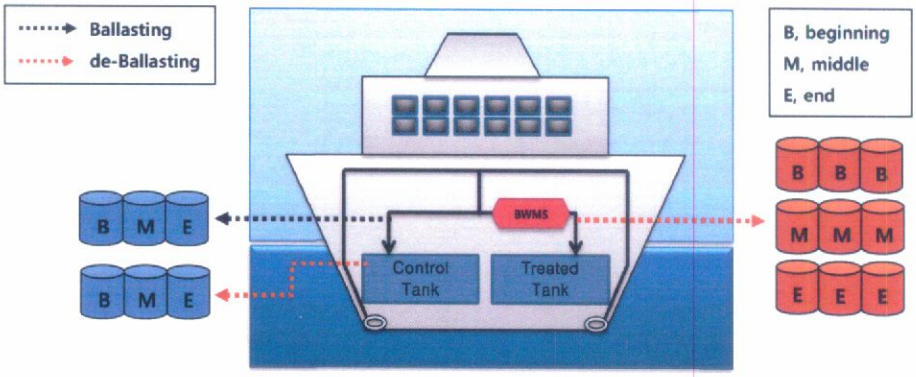
NO.	Q'TY	DESCRIPTION
1-1	2	FLOW METER, 300A, L=500mm
1-2	2	SMART PIPE, ø400, L=1200mm
1-3	-	GRP PIPE, 300A,
1-4	8	ELECTROKYZET UNIT, 300A, L=700mm
1-5	2	GAS SEPARATOR, 300A, L=1000mm
1-6	2	SAMPLING PORT, 300A, L=200mm
2-1	1	NEUTRALIZATION UNIT, ø550, L=1500mm
3-1	2	TRO SENSOR
4-1	1	NEUTRALIZING TANK (2000L)
4-2	1	LEVEL TANSMETER
5-1	2	P/R PUMP, CAP.= 3L/Min
5-1	2	FLOW TANSMETER

II. PROCEDURE ON SHIPBOARD TEST

KOMERI SOP BWMS 02
Rev. 2.0 May 2011

BWMS Test Procedure on Shipboard Test

The test cycles including invalid and unsuccessful test cycles are to span a trial period of not less than six months.

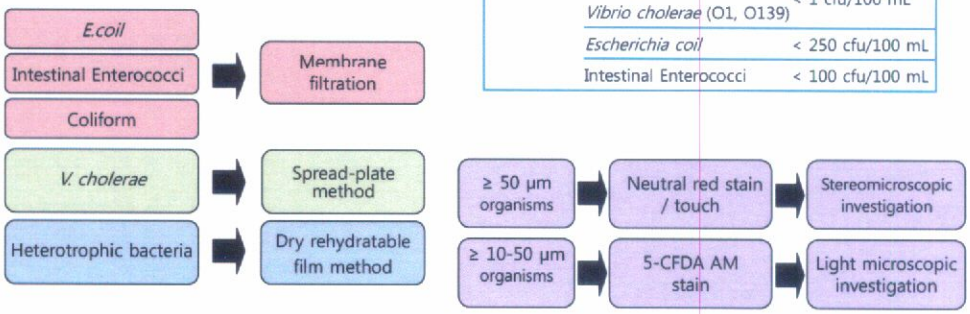


Sample volume			
Ballasting	Infleunt water	≥ 50 μm organisms	1 m³ × 3
		≥ 10-50 μm organisms	1 L × 3
		Bacteria	500 mL × 3
de-Ballasting	Discharge control water	≥ 50 μm organisms	1 m³ × 3
		≥ 10-50 μm organisms	1 L × 3
	Discharge Treated water	≥ 50 μm organisms	1 m³ × 9
		≥ 10-50 μm organisms	1 L × 9
		Bacteria	500 mL × 9

<Standard for valid test>

Ballasting		
Influent water	≥ 50 μm organisms	> 100 inds./m³
	≥ 10-50 μm organisms	> 100 inds./mL

de-Ballasting		
Discharge Control water	≥ 50 μm organisms	> 10 inds./m³
	≥ 10-50 μm organisms	> 10 inds./mL
Discharge Treated water	≥ 50 μm organisms	< 10 inds./m³
	≥ 10-50 μm organisms	< 10 inds./mL
	Toxicogenic *Vibrio cholerae* (O1, O139)	< 1 cfu/100 mL
	Escherichia coil	< 250 cfu/100 mL
	Intestinal Enterococci	< 100 cfu/100 mL



III. TEST RESULT DETAILS

· **Ballasting (1st period : 2011. 03. 06, Busan newport)**

Test Item		Ballasting			
		Source water	Influent water		
			B[1]	M[2]	E[3]
Water temperature (°C)		9.42	9.61	9.15	9.15
pH		7.35	7.37	7.65	7.63
ORP (mV)		308	311	269	262
Salinity (psu)		35.15	35.13	35.14	35.85
DO (mg/L)		8.88	8.85	9.02	9.02
Turbidity (NTU)		7.82	7.93	7.52	7.07
TSS (mg/L)		19.90	-	-	-
DOC (mg/L)		1.26	-	-	-
POC (mg/L)		0.04	-	-	-
≥ 50 μm organisms (inds./m^3)		-	13 833	20 000	16 250
> 10 - 50 μm organisms (inds./mL)		-	119	108	141
Heterotrophic bacteria (cells/mL)		-	46	20	76
Bacteria (cfu/100 mL)	Coliform	-	22	50	34
	Escherichia coli	-	5	12	7
	Intestinal Enterococci	-	5	2	7
	Toxicogenic *Vibrio cholerae* (O1, O139)	-	0	0	0

[1]Beginning, [2]Middle, [3]End.

· **de-Ballasting (1st period : 2011. 03. 14, Singapore port)**

Test Item		de-Ballasting											
		Discharge control water			Discharge treated water								
		B[1]	M[2]	E[3]	B1	B2	B3	M1	M2	M3	E1	E2	E3
Water temperature (°C)		27.51	27.59	27.62	29.27	28.46	28.03	27.71	28.05	28.11	28.09	28.01	28.00
pH		7.62	7.64	7.63	7.83	7.68	7.68	7.57	7.62	7.60	7.58	7.60	7.62
ORP (mV)		130	142	138	175	20	42	43	24	-15	-8	-30	-25
Salinity (psu)		35.51	35.40	35.47	33.69	35.44	35.44	35.50	35.50	35.44	35.41	35.44	35.51
DO (mg/L)		7.31	7.64	7.26	6.35	6.53	6.53	6.62	6.56	6.83	6.87	6.75	6.80
Turbidity (NTU)		3.61	2.32	1.83	2.11	2.90	2.90	2.70	5.89	2.89	2.45	3.77	3.69
≥ 50 μm organisms (inds./m^3)		7 083	6 583	8 083	2	0	0	1	2	3	3	7	4
≥ 10 - 50 μm organisms (inds./mL)		19	26	34	0	0	0	0	0	0	0	0	0
Heterotrophic bacteria (cells/mL)		-	-	-	TNTC[4]	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC
Bacteria (cfu/100 mL)	Coliform	-	-	-	21	0	0	0	0	0	0	0	0
	Escherichia coli	-	-	-	5	0	0	0	0	0	0	0	0
	Intestinal Enterococci	-	-	-	0	0	0	0	0	0	0	0	0
	Toxicogenic *Vibrio cholerae* (O1, O139)	-	-	-	0	0	0	0	0	0	0	0	0

[1]Beginning, [2]Middle, [3]End, [4]Too Numerous To Count.

· **Ballasting (2nd period : 2011. 08. 21, Singapore port)**

Test Item		Ballasting			
		Source water	Influent water		
			B[1]	M[2]	E[3]
Water temperature (°C)		29.90	30.00	30.09	30.20
pH		8.13	8.15	8.14	8.14
ORP (mV)		318	308	309	306
Salinity (psu)		32.34	32.35	32.40	32.25
DO (mg/L)		6.15	6.11	6.18	6.19
Turbidity (NTU)		3.89	4.32	3.36	3.87
TSS (mg/L)		15.74	-	-	-
DOC (mg/L)		1.22	-	-	-
POC (mg/L)		0.11	-	-	-
≥ 50 μm organisms (inds./m^3)		-	26 583	32 750	26 667
> 10 - 50 μm organisms (inds./mL)		-	154	145	142
Heterotrophic bacteria (cells/mL)		-	TNTC[4]	TNTC	TNTC
Bacteria (cfu/100 mL)	Coliform	-	59	70	70
	Escherichia coli	-	15	9	7
	Intestinal Enterococci	-	12	20	10
	Toxicogenic *Vibrio cholerae* (O1, O139)	-	0	0	0

[1]Beginning, [2]Middle, [3]End, [4]Too Numerous To Count.

· **de-Ballasting (2nd period : 2011. 08. 28, Busan newport)**

Test Item		de-Ballasting											
		Discharge control water			Discharge treated water								
		B[1]	M[2]	E[3]	B1	B2	B3	M1	M2	M3	E1	E2	E3
Water temperature (°C)		26.43	26.44	26.35	26.55	26.69	26.69	26.80	26.77	26.73	26.68	26.70	26.65
pH		8.16	8.20	8.20	8.05	8.07	8.03	8.03	8.06	8.06	8.07	8.07	8.05
ORP (mV)		306	285	283	82	40	39	27	19	16	31	14	10
Salinity (psu)		32.81	32.67	32.69	32.23	32.36	32.39	32.35	32.36	32.40	32.37	32.36	32.39
DO (mg/L)		6.48	6.21	6.31	6.23	6.24	6.20	6.18	6.18	6.18	6.24	6.15	6.13
Turbidity (NTU)		2.05	1.25	2.46	1.63	1.24	1.68	1.23	1.70	1.53	2.34	2.27	3.40
≥ 50 μm organisms (inds./m^3)		11 000	11 333	10 917	0	1	2	1	2	1	1	1	2
≥ 10 - 50 μm organisms (inds./mL)		21	17	17	0	0	0	0	0	0	0	0	0
Heterotrophic bacteria (cells/mL)		-	-	-	143	109	109	122	68	60	61	84	53
Bacteria (cfu/100 mL)	Coliform	-	-	-	1	0	0	0	0	1	1	0	1
	Escherichia coli	-	-	-	0	0	0	0	0	0	0	0	0
	Intestinal Enterococci	-	-	-	0	0	0	0	0	0	0	0	0
	Toxicogenic *Vibrio cholerae* (O1, O139)	-	-	-	0	0	0	0	0	0	0	0	0

[1]Beginning, [2]Middle, [3]End.

· **Ballasting (3rd period : 2011. 10. 23, Hongkong port)**

Test Item		Ballasting			
		Source water	Influent water		
			B[1]	M[2]	E[3]
Water temperature (°C)		26.73	26.59	26.51	27.29
pH		8.10	8.14	8.16	8.20
ORP (mV)		377	356	327	313
Salinity (psu)		33.58	33.56	33.65	33.08
DO (mg/L)		6.44	6.44	6.37	6.23
Turbidity (NTU)		6.69	6.63	8.41	7.93
TSS (mg/L)		20.00	-	-	-
DOC (mg/L)		1.20	-	-	-
POC (mg/L)		0.26	-	-	-
≥ 50 μm organisms (inds./m^3)		-	115 833	85 000	98 833
> 10 - 50 μm organisms (inds./mL)		-	481	521	562
Heterotrophic bacteria (cells/mL)		-	TNTC[4]	TNTC	TNTC
Bacteria (cfu/100 mL)	Coliform	-	TNTC	TNTC	TNTC
	Escherichia coli	-	105	127	104
	Intestinal Enterococci	-	9	12	10
	Toxicogenic *Vibrio cholerae* (O1, O139)	-	0	0	0

[1]Beginning, [2]Middle, [3]End, [4]Too Numerous To Count.

· **de-Ballasting (3rd period : 2011. 10. 28, Tongyeong bay)**

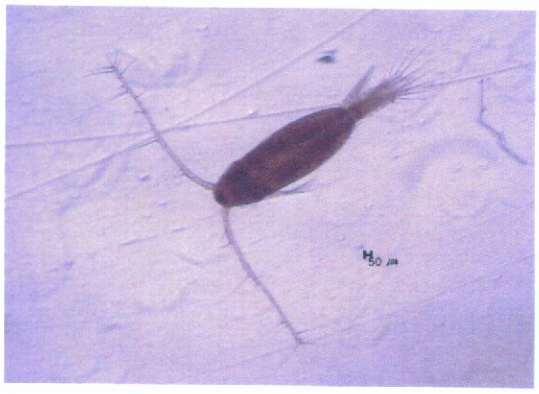
Test Item		de-Ballasting											
		Discharge control water			Discharge treated water								
		B[1]	M[2]	E[3]	B1	B2	B3	M1	M2	M3	E1	E2	E3
Water temperature (°C)		20.54	20.76	19.83	19.87	19.95	20.11	20.16	20.20	20.17	20.19	20.11	20.21
pH		8.09	8.15	8.19	8.15	8.12	8.01	8.13	8.09	8.14	8.15	8.20	8.08
ORP (mV)		363	249	225	31	4	-20	-21	-14	-34	-50	-1	-41
Salinity (psu)		34.16	33.58	33.61	33.52	33.52	33.55	33.52	33.54	33.56	33.55	33.63	33.54
DO (mg/L)		6.63	6.62	7.47	6.95	6.90	6.89	6.76	6.83	6.83	6.76	6.86	6.78
Turbidity (NTU)		2.64	1.66	18.80	1.78	1.25	0.84	0.82	1.44	1.90	2.10	4.28	5.18
≥ 50 μm organisms (inds./m^3)		34 167	60 333	66 000	6	4	2	3	1	2	1	5	2
> 10 - 50 μm organisms (inds./mL)		16	18	19	0	0	0	0	0	0	0	0	0
Heterotrophic bacteria (cells/mL)		-	-	-	0	0	0	0	0	0	0	0	0
Bacteria (cfu/100 mL)	Coliform	-	-	-	0	0	0	0	0	0	0	0	0
	Escherichia coli	-	-	-	0	0	0	0	0	0	0	0	0
	Intestinal Enterococci	-	-	-	0	0	0	0	0	0	0	0	0
	Toxicogenic *Vibrio cholerae* (O1, O139)	-	-	-	0	0	0	0	0	0	0	0	0

[1]Beginning, [2]Middle, [3]End.

IV. ANALYZED SAMPLE PICTURES

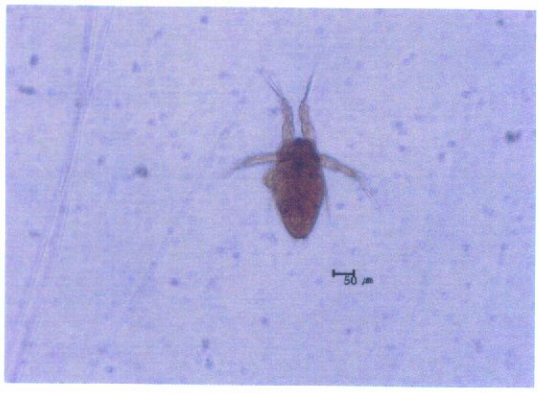
1. Minimum dimension ≥ 50 μm organisms

· **Ballasting (1st period : 2011. 03. 06, Busan newport)**

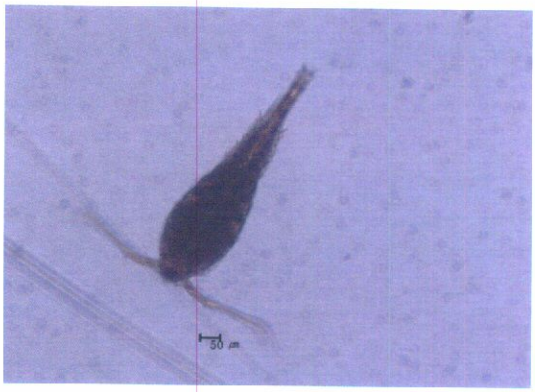


Acartia omorii (Influent water)

Copepodite (Influent water)



Copepod nauplius (Influent water)



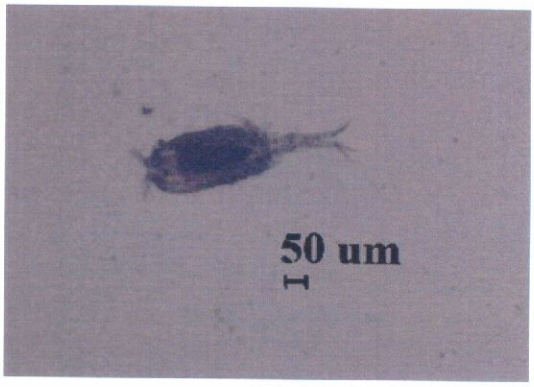
Oithona sp. (Influent water)

Harpacticoida (Influent water)

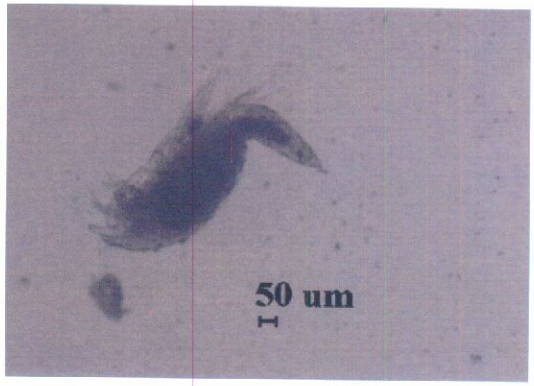
Bivalve larva (Influent water)

1. To be continued

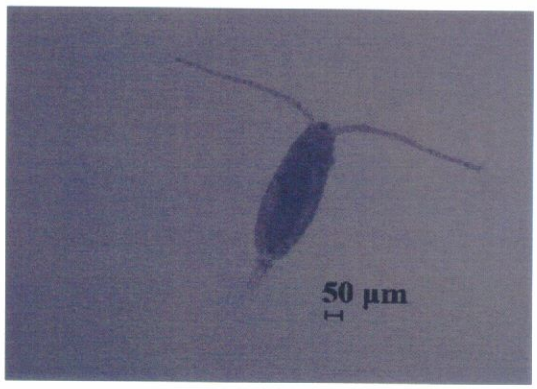
· de-Ballasting (1st period : 2011. 03. 14, Singapore port)



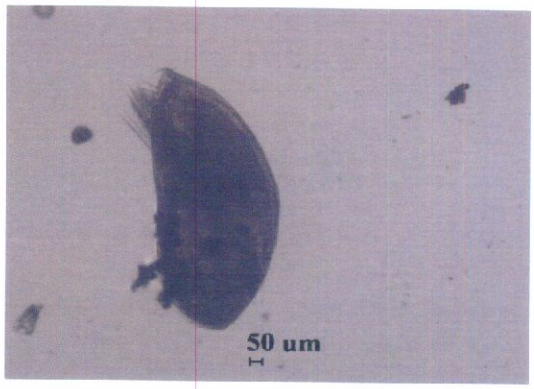
Corycaeus affinis (Control water)



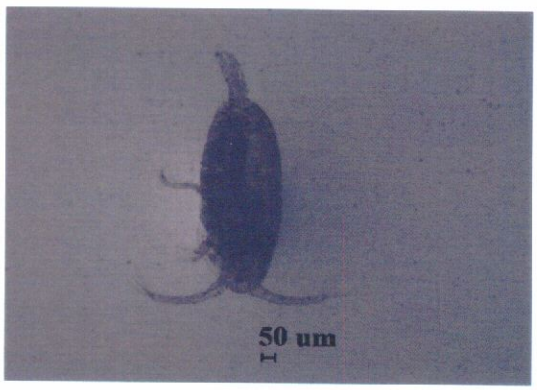
Harpacticoida (Viable, Treated water)



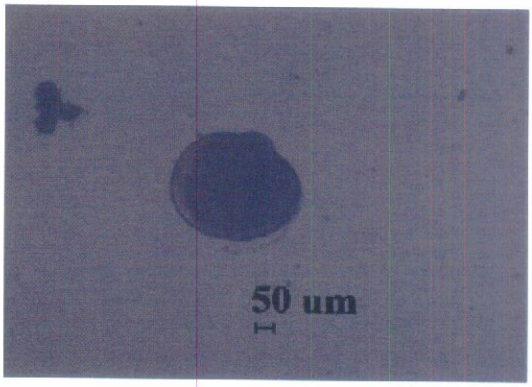
Acartia omorii (Control water)



Cyprid larva (Viable, Treated water)



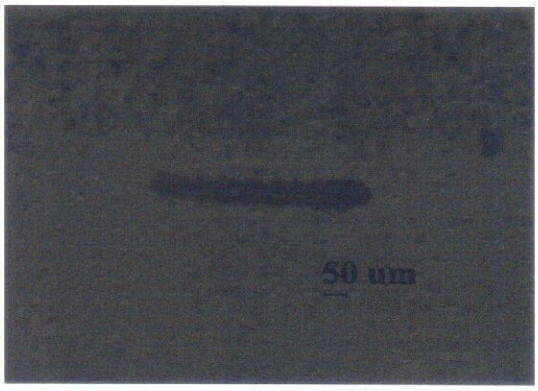
Paracalanus sp. (Control water)



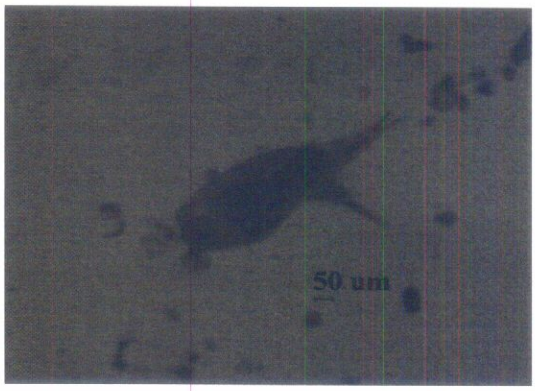
Bivalve larva (Viable, Treated water)

1. To be continued

· Ballasting (2nd period : 2011. 08. 21, Singapore port)

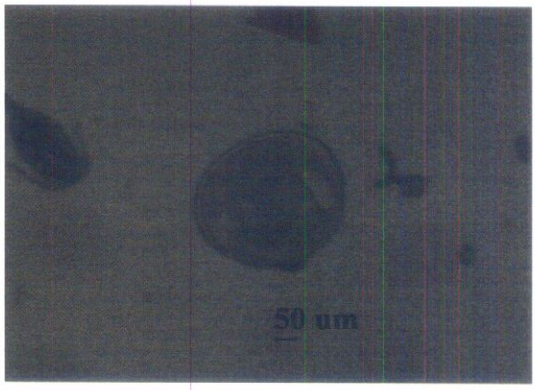


Polychaeta larva (Influent water)

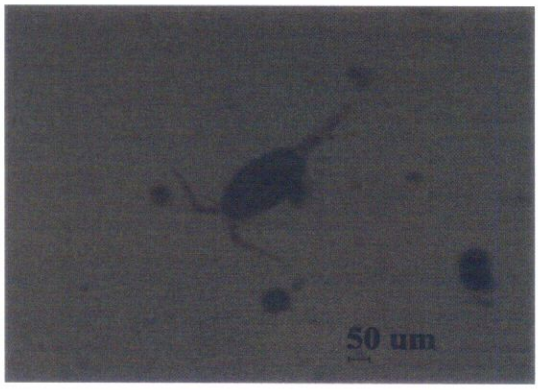


Corycaeus affinis (Influent water)

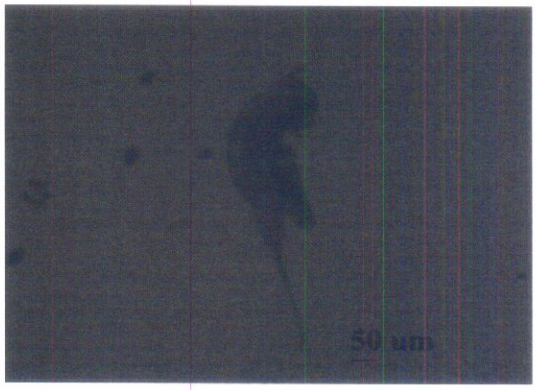
Copepod nauplius (Influent water)



Bivalve larva (Influent water)



Oithona sp. (Influent water)



Harpacticoida (Influent water)

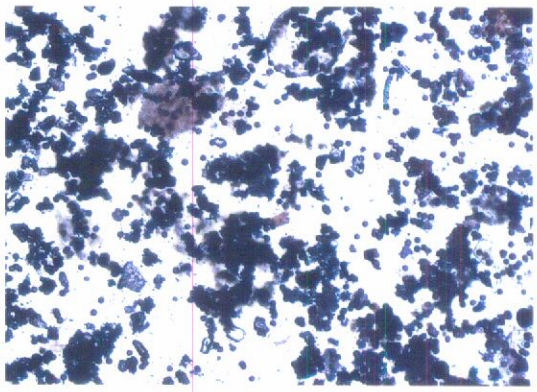
1. To be continued

· de-Ballasting (2nd period : 2011. 08. 28, Busan newport)

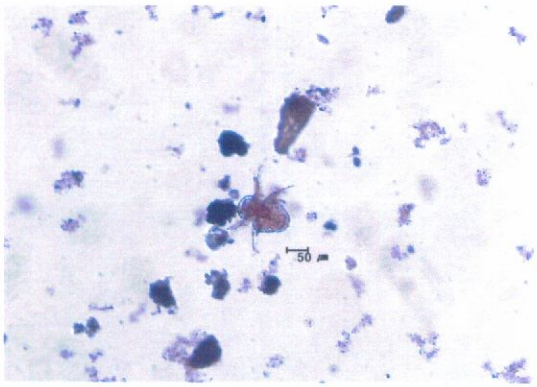
Acartia pacifica (Control water)

Copepodite (Viable, Treated water)

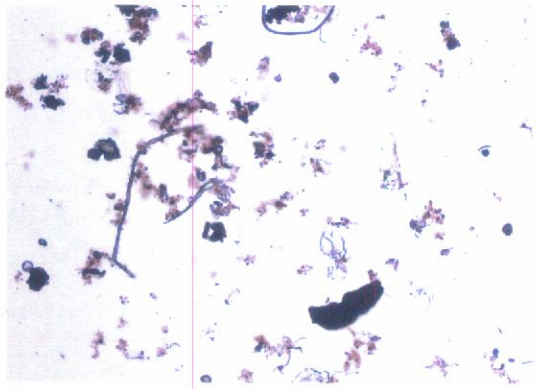
Oithona sp. (Control water)



Debris (Treated water)



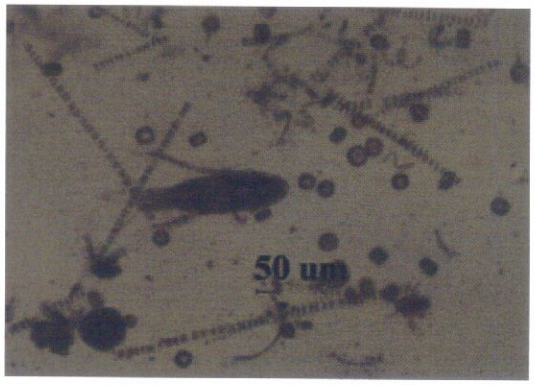
Copepod nauplius (Control water)



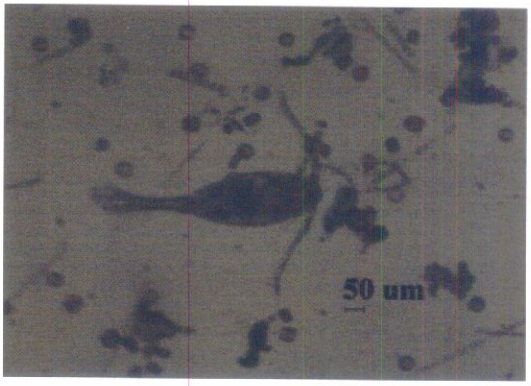
Debris (Treated water)

1. To be continued

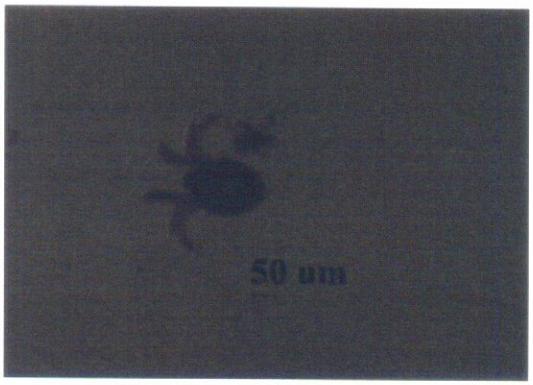
· Ballasting (3rd period : 2011. 10. 23, Hongkong port)



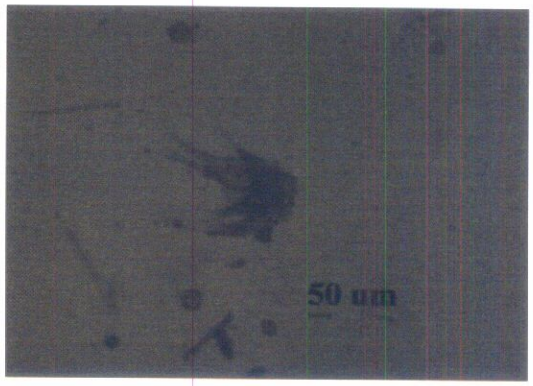
Copepodite (Influent water)



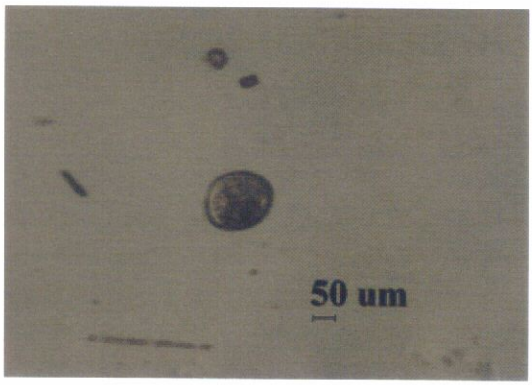
Oithona sp. (Influent water)



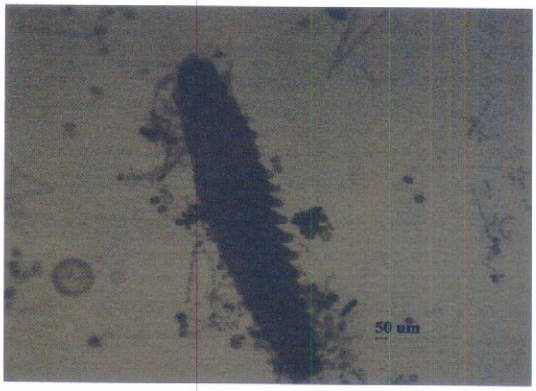
Copepod nauplius (Influent water)



Balanus larva (Influent water)



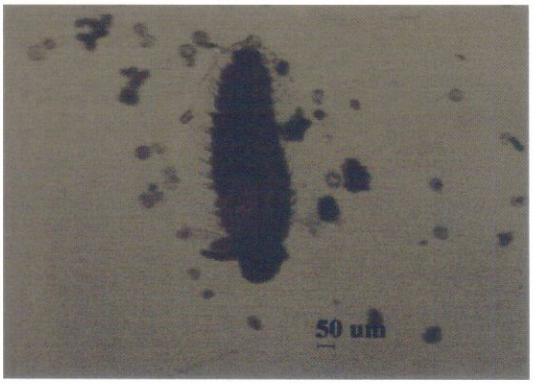
Bivalve larva (Influent water)



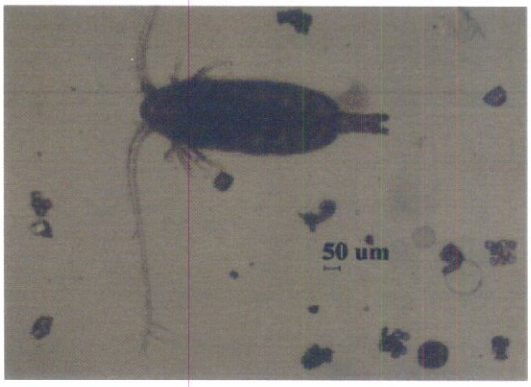
Polychaeta larva (Influent water)

1. To be continued

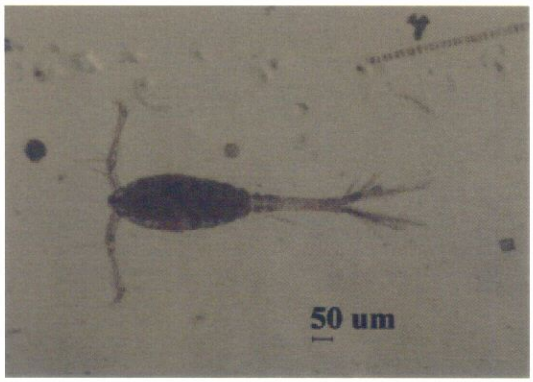
· de-Ballasting (3rd period : 2011. 10. 28, Tongyeong bay)



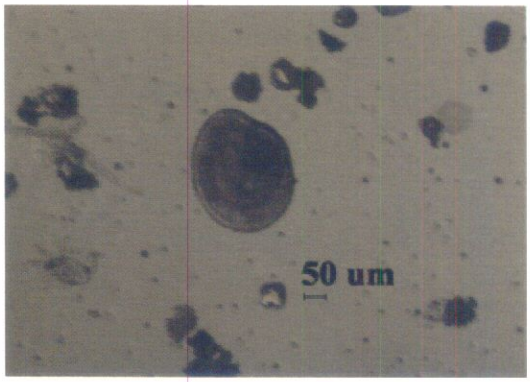
Polychaeta larva (Control water)



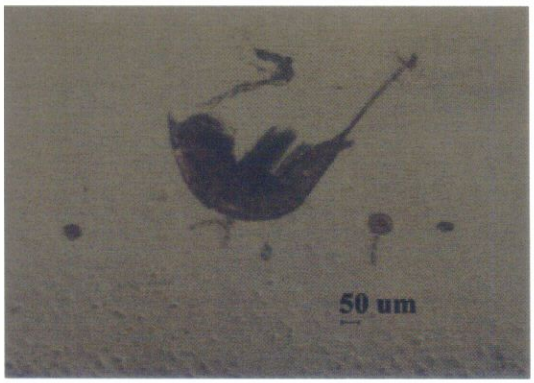
Copepodite (Viable, Treated water)



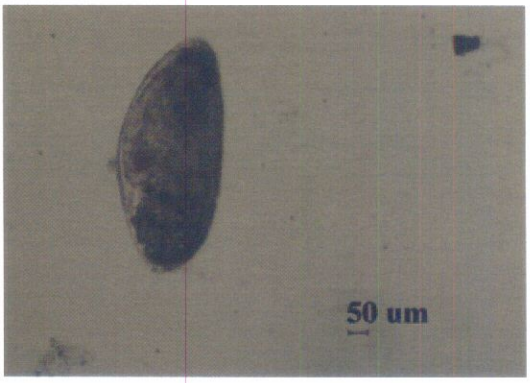
Oithona sp. (Control water)



Bivalve larva (Viable, Treated water)



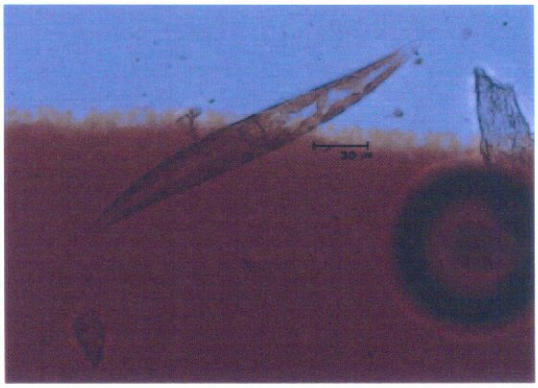
Harpacticoida (Control water)



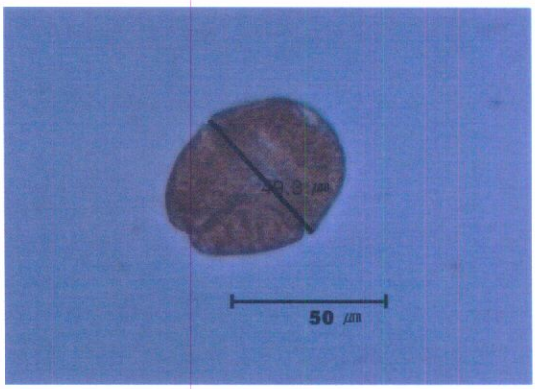
Cyprid larva (Viable, Treated water)

2. Minimum dimension ≥ 10-50 μm organisms

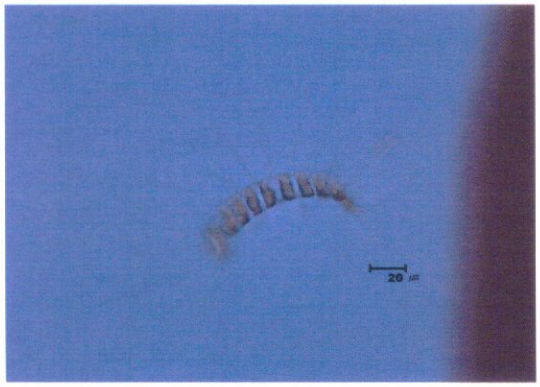
· **Ballasting (1st period : 2011. 03. 06, Busan newport)**



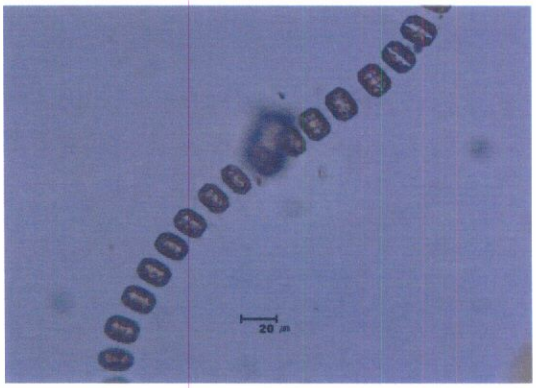
Pleurosigma sp. (Influent water)



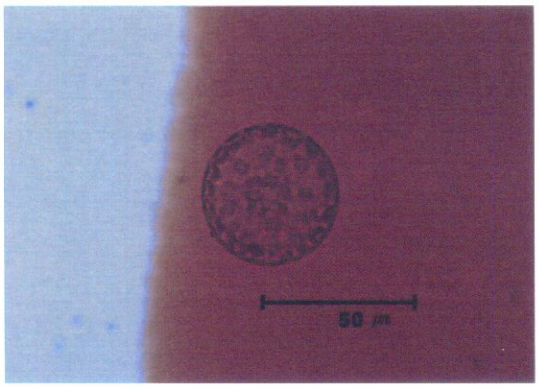
Akashiwo sanguinea (Influent water)



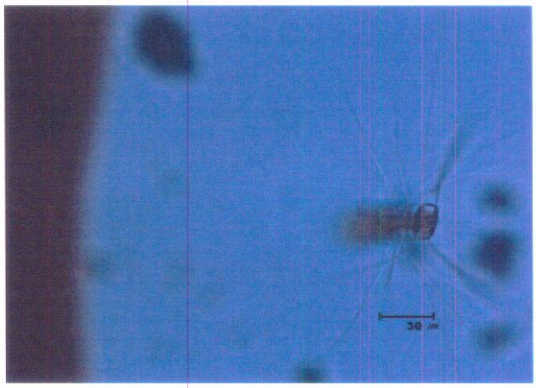
Chaetoceros sp. (Influent water)



Chaetoceros sp. (Influent water)



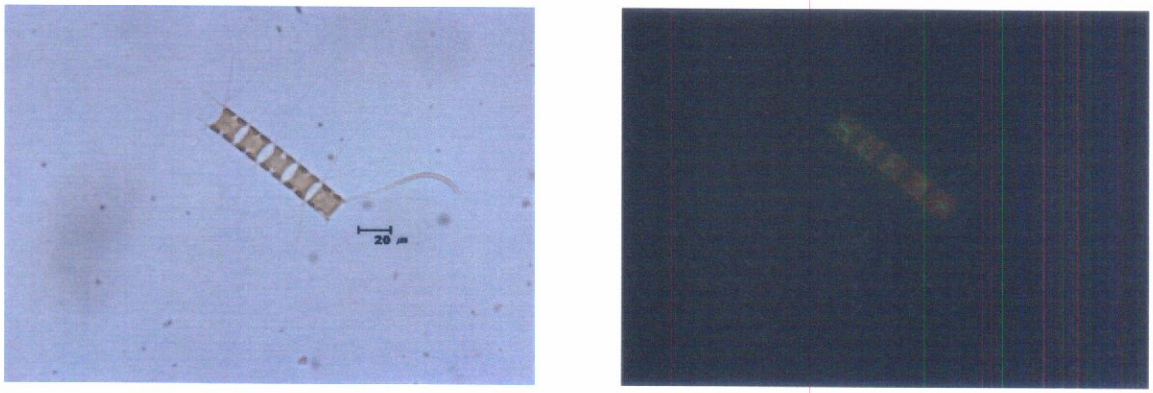
Thalassiosira sp. (Influent water)



Chaetoceros sp. (Influent water)

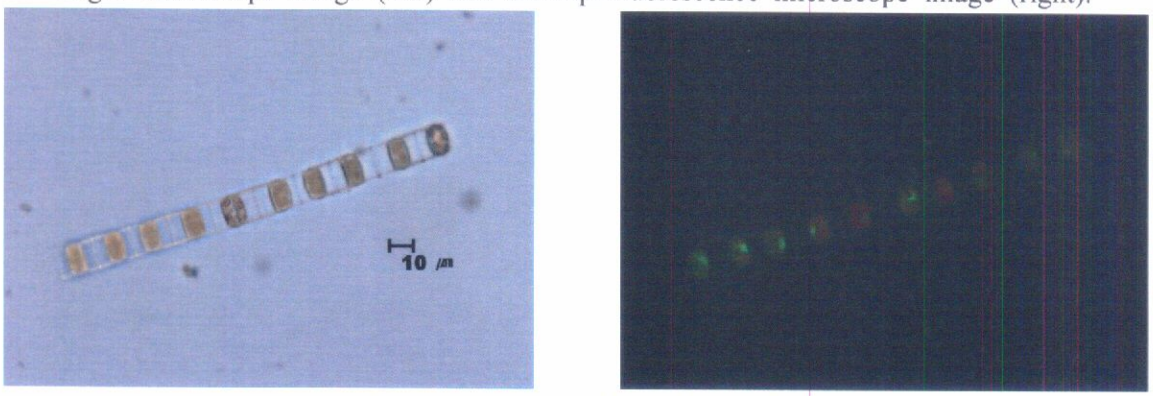
2. To be continued

· **de-Ballasting (1st period : 2011. 03. 14, Singapore port)**



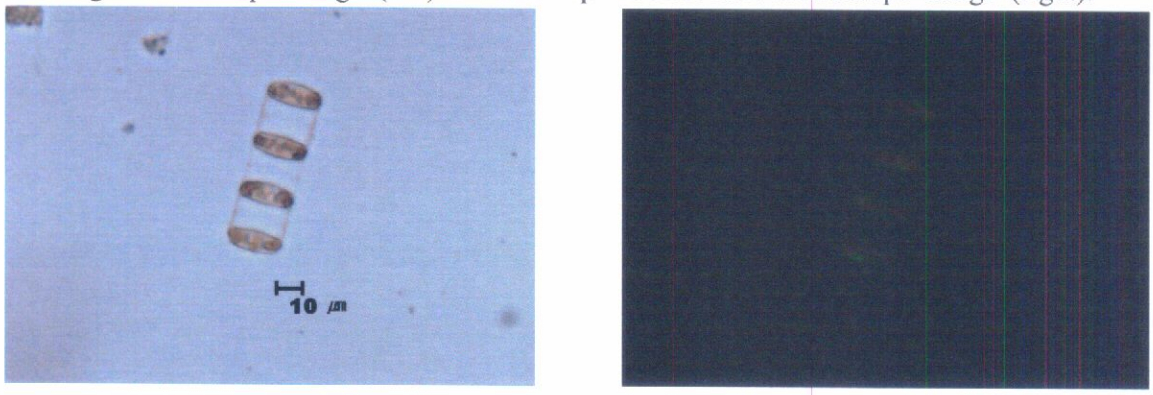
Chaetoceros sp. (Control water)

Light microscope image (left) and auto/epi-fluorescence microscope image (right).



Skeletonema sp. (Control water)

Light microscope image (left) and auto/epi-fluorescence microscope image (right).

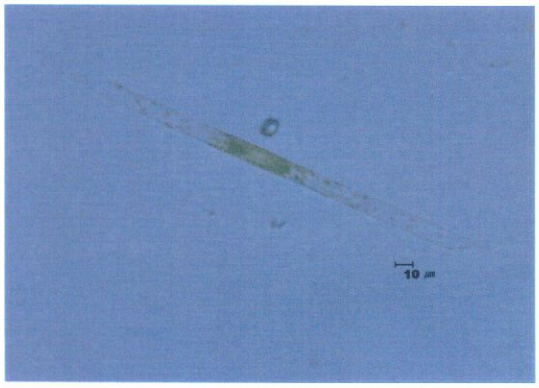


Skeletonema sp. (Control water)

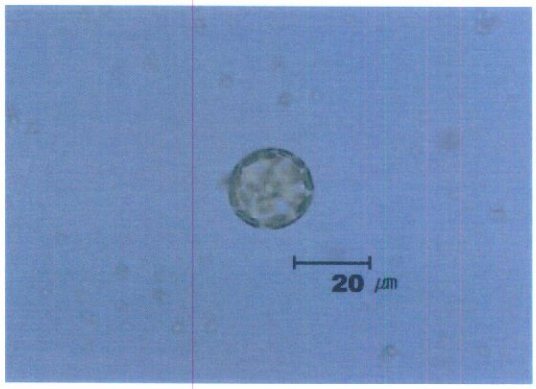
Light microscope image (left) and auto/epi-fluorescence microscope image (right).

2. To be continued

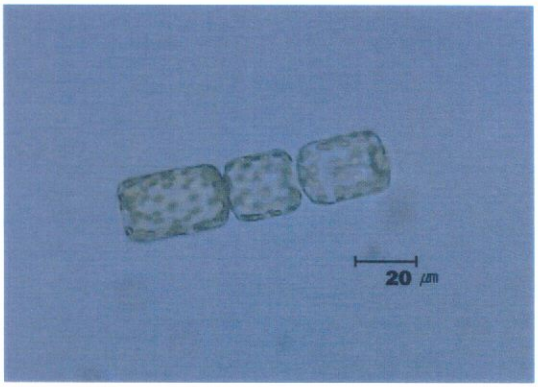
· Ballasting (2nd period : 2011. 08. 21, Singapore port)



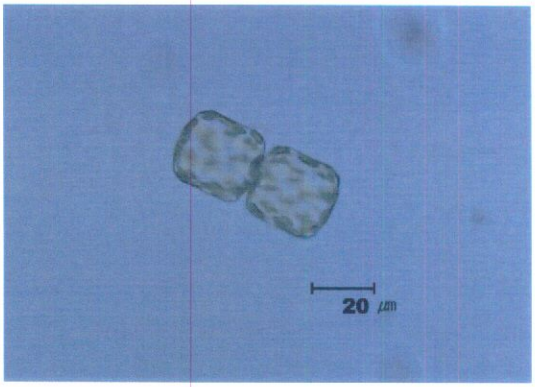
Rhizosolenia sp. (Influent water)



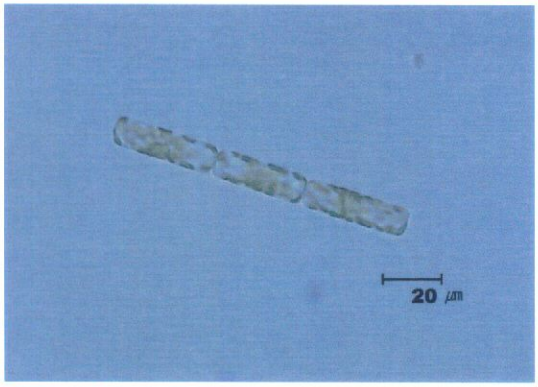
Thalassiosira sp. (Influent water)



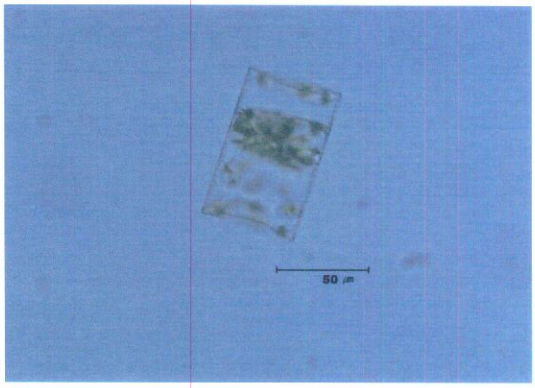
Detonula sp. (Influent water)



Detonula sp. (Influent water)



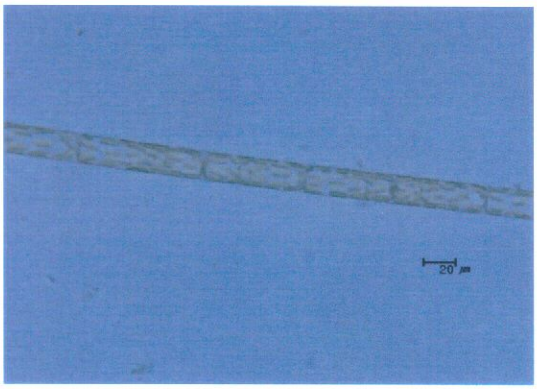
Guinardia sp. (Influent water)



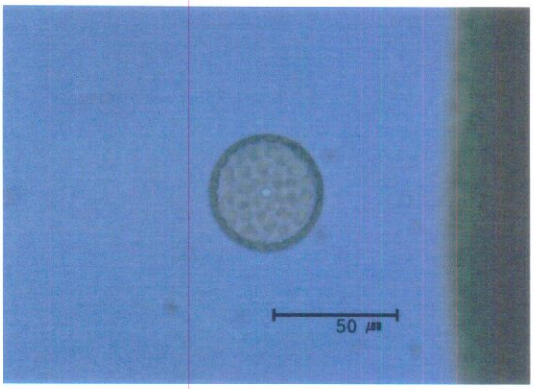
Guinardia sp. (Influent water)

2. To be continued

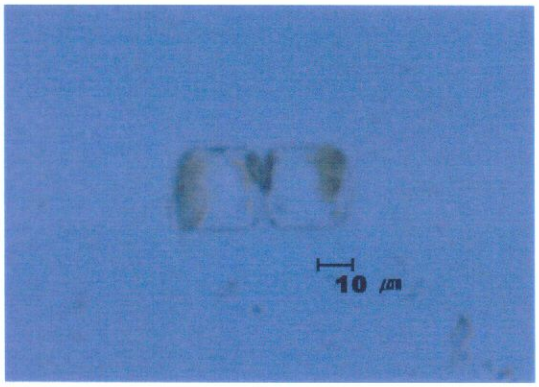
· de-Ballasting (2nd period : 2011. 08. 28, Busan newport)

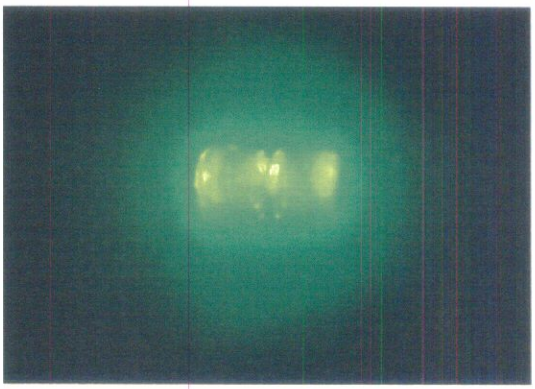


Guinardia sp. (Control water)



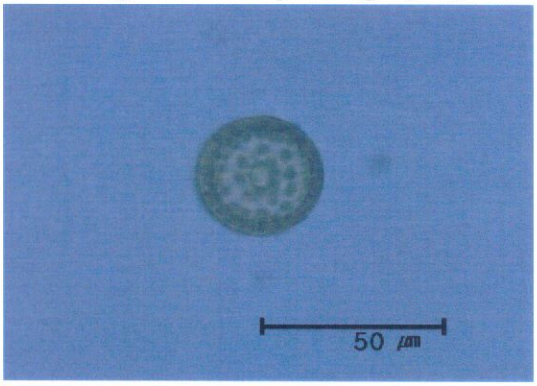
Thalassiosira sp. (Control water)



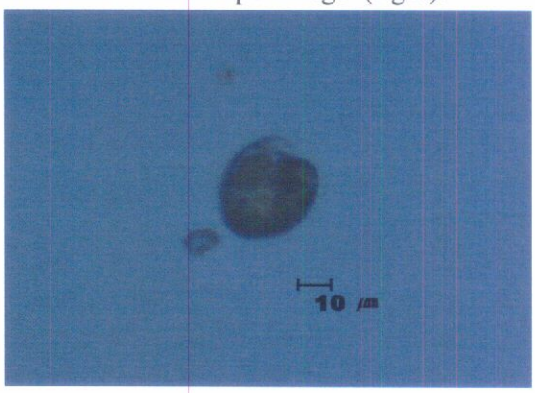


Detonula sp. (Control water)

Light microscope image (left) and epi-fluorescence microscope image (right).



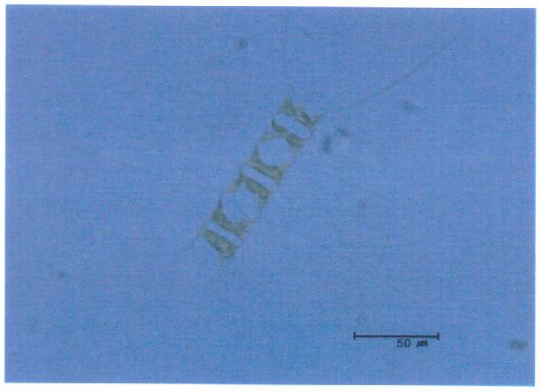
Thalassiosira sp. (Control water)



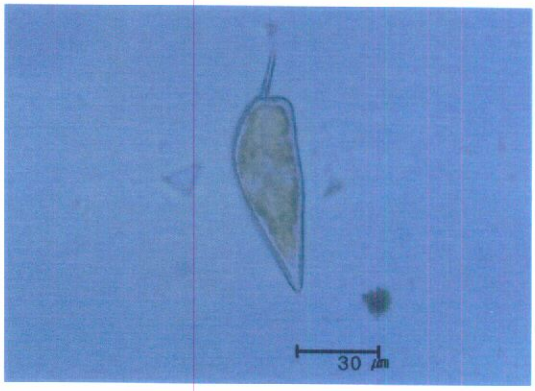
Unidentified dinoflagellate (Control water)

2. To be continued

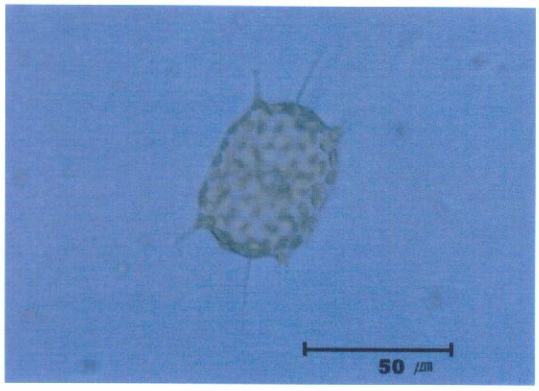
· **Ballasting (3rd period : 2011. 10. 23, Hongkong port)**

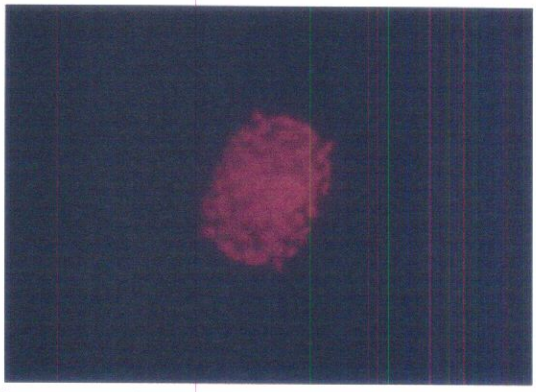


Chaetoceros sp. (Influent water)



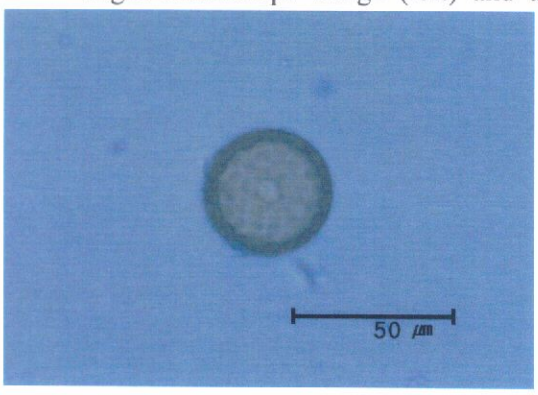
Prorocentrum sp. (Influent water)

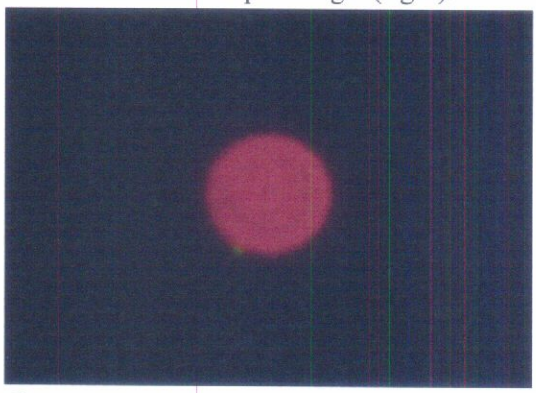




Odontella sp. (Influent water)

Light microscope image (left) and auto-fluorescence microscope image (right).



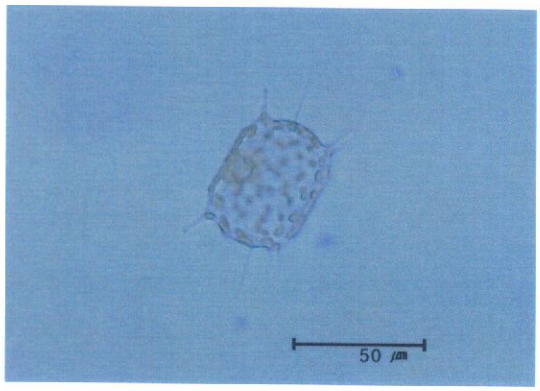


Thalassiosira sp. (Influent water)

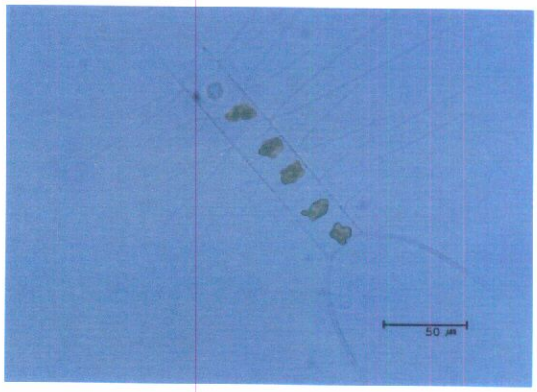
Light microscope image (left) and auto-fluorescence microscope image (right).

2. To be continued

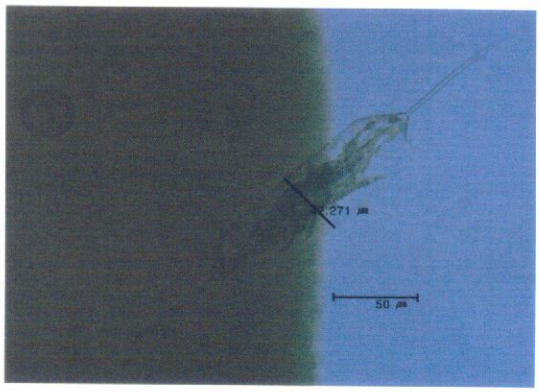
· de-Ballasting (3rd period : 2011. 10. 28, Tongyeong bay)



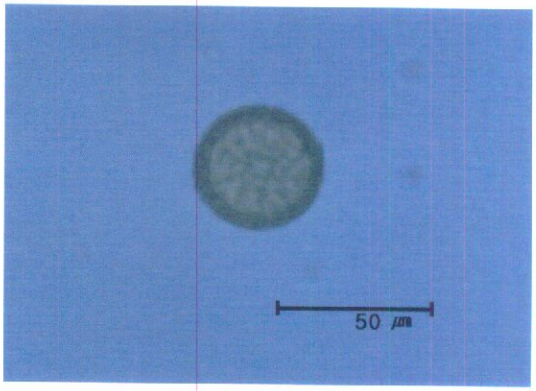
Odontella sp. (Control water)



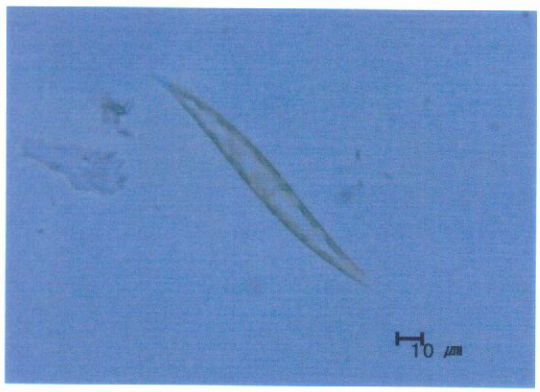
Chaetoceros sp. (Control water)



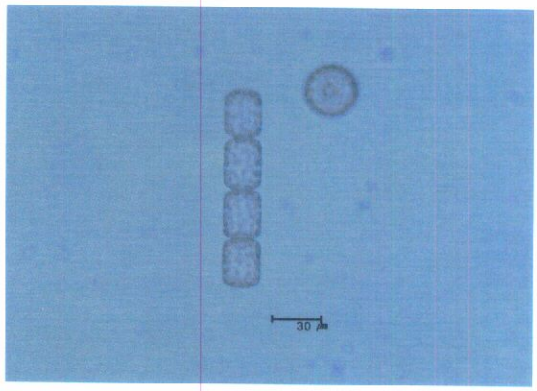
Ditylum sp. (Control water)



Thalassiosira sp. (Control water)



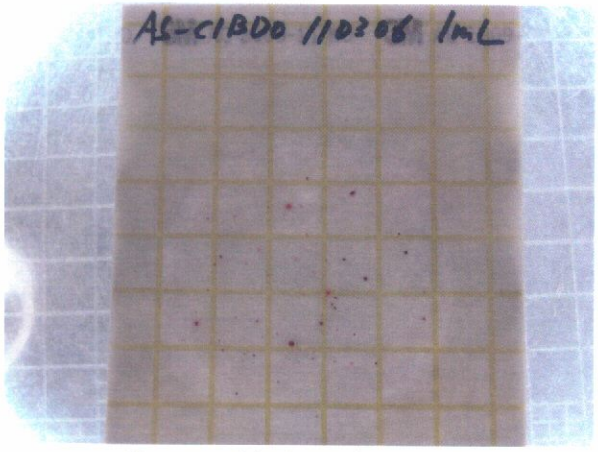
Pleurosigma sp. (Control water)



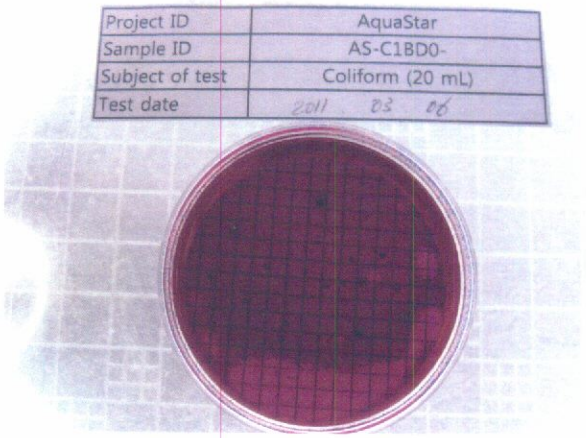
Detonula sp. (Control water)

3. Bacteria

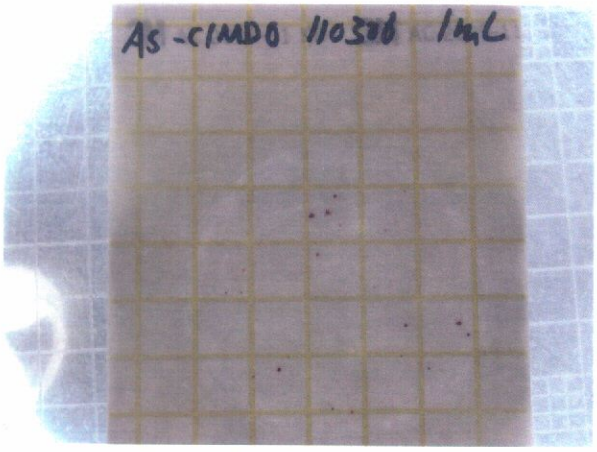
· **Ballasting (1st period : 2011. 03. 06, Busan newport)**



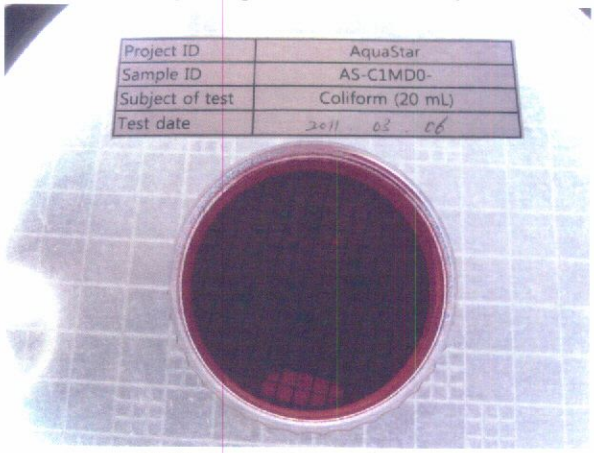
Heterotrophic bacteria - 1 mL
(Beginning of influent water)



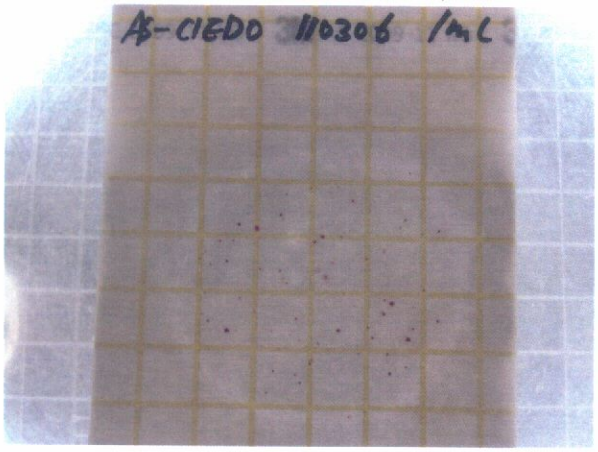
Coliform - 20 mL filtration
(Beginning of influent water)



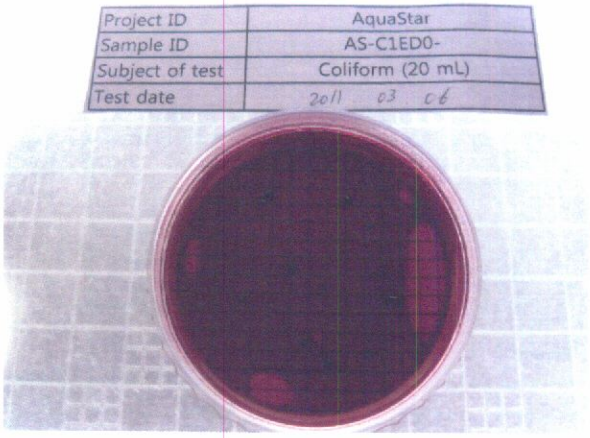
Heterotrophic bacteria - 1 mL
(Middle of influent water)



Coliform - 20 mL filtration
(Middle of influent water)



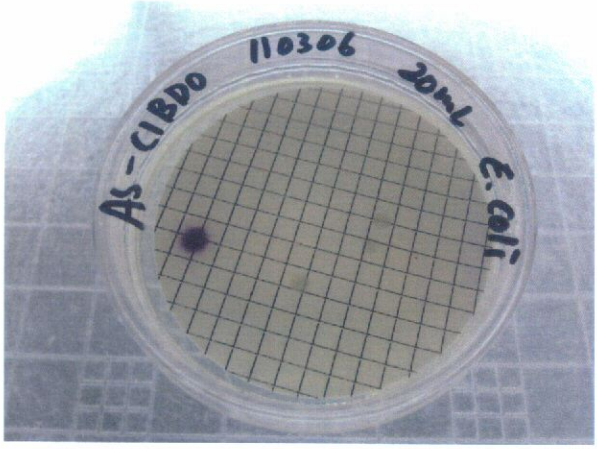
Heterotrophic bacteria - 1 mL
(End of influent water)



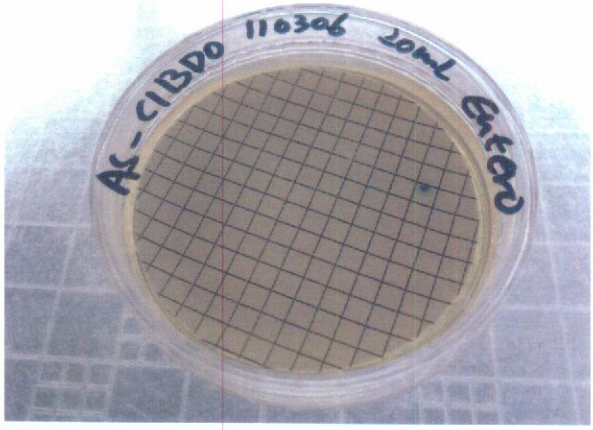
Coliform - 20 mL filtration
(End of influent water)

3. To be continued

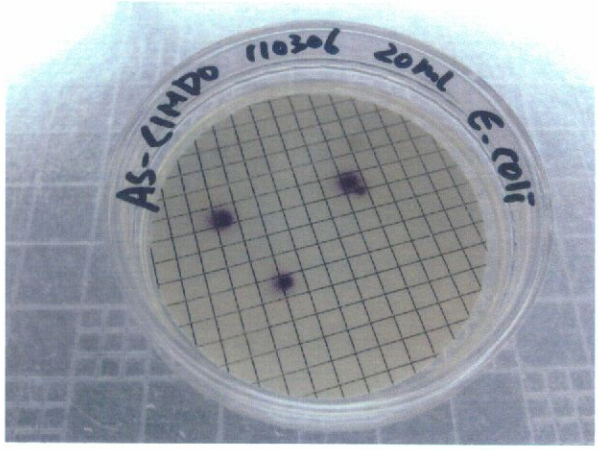
· **Ballasting (1st period : 2011. 03. 06, Busan newport)**



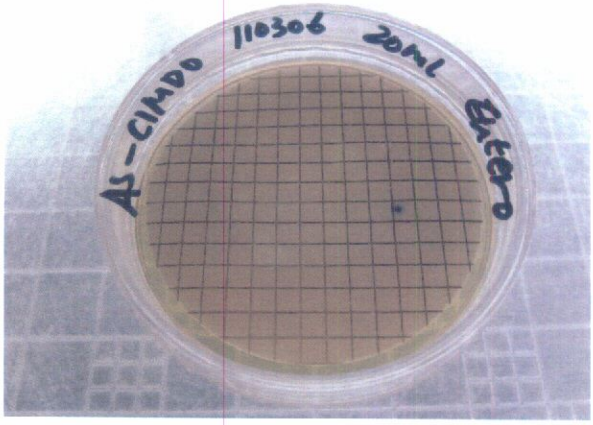
E. coli - 20 mL filtration
(Beginning of influent water)



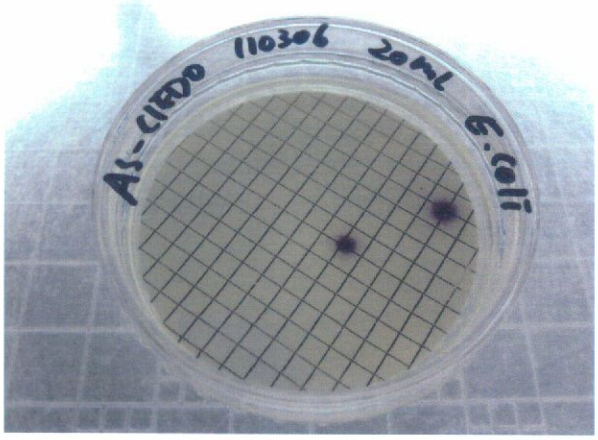
Intestinal Enterococci - 20 mL filtration
(Beginning of influent water)



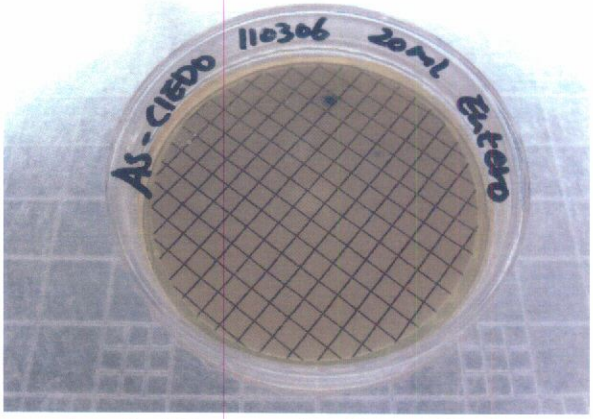
E. coli - 20 mL filtration
(Middle of influent water)



Intestinal Enterococci - 20 mL filtration
(Middle of influent water)



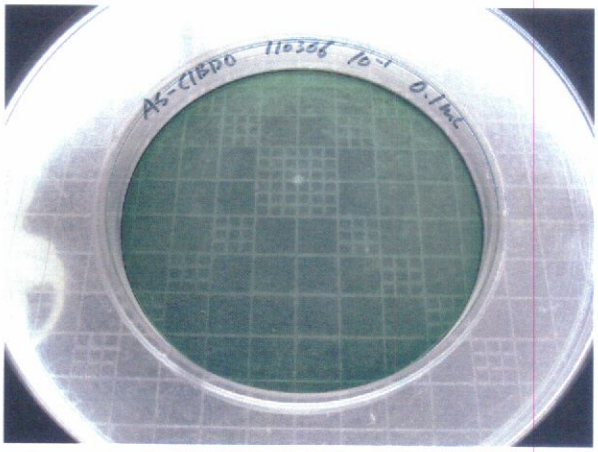
E. coli - 20 mL filtration
(End of influent water)



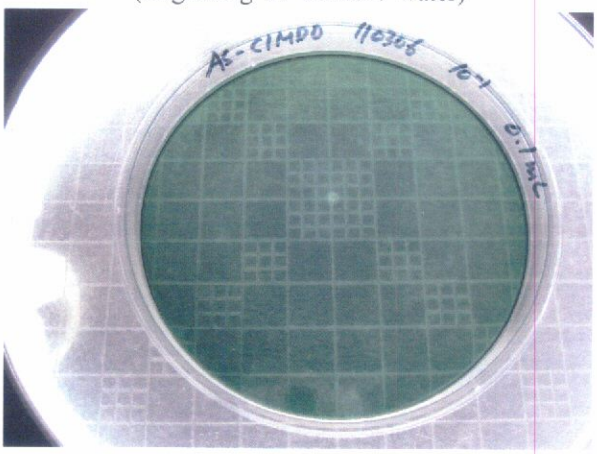
Intestinal Enterococci - 20 mL filtration
(End of influent water)

3. To be continued

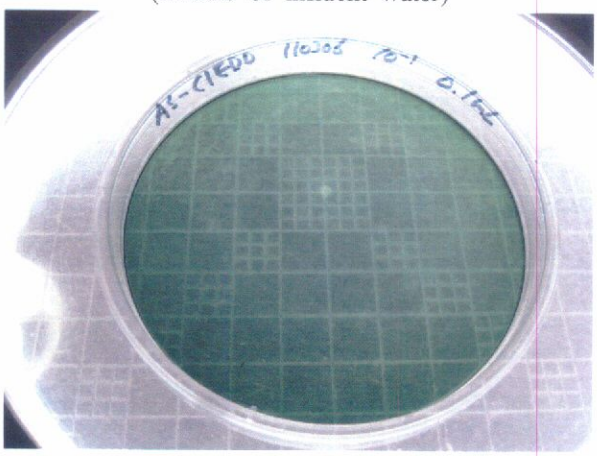
· **Ballasting (1st period : 2011. 03. 06, Busan newport)**



Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(Beginning of influent water)



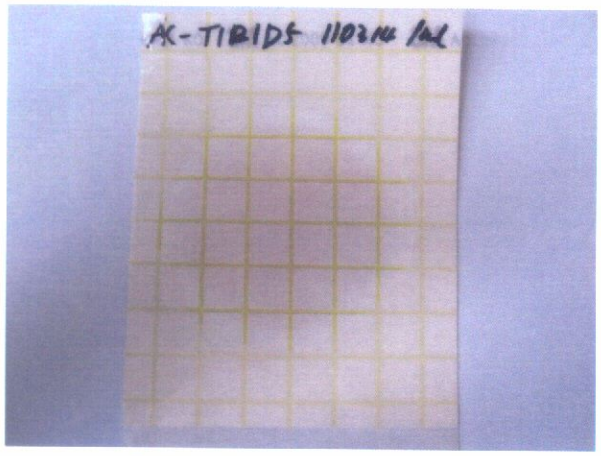
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(Middle of influent water)



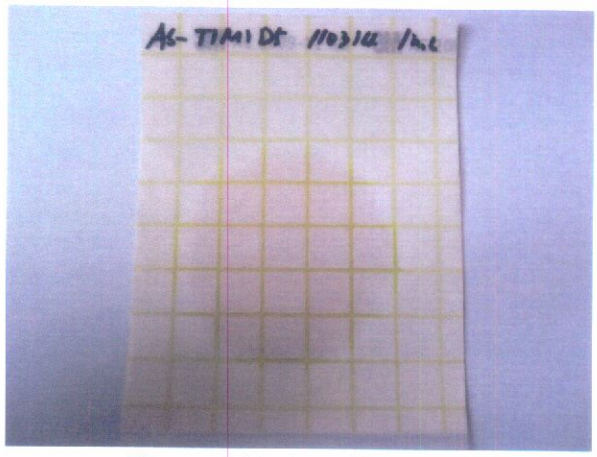
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(End of influent water)

3. To be continued

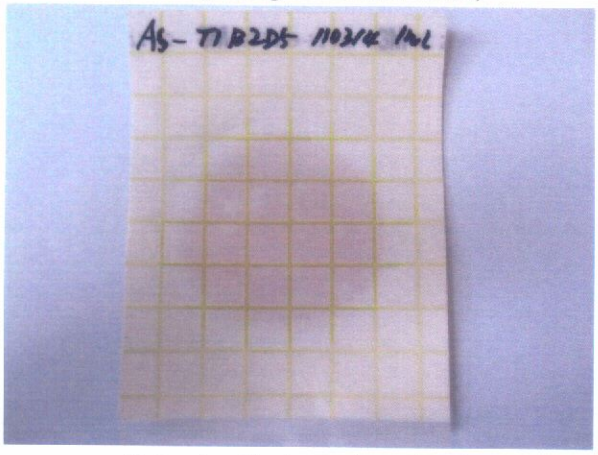
· de-Ballasting (1st period : 2011. 03. 14, Singapore port)



Heterotrophic bacteria - 1 mL
(1st Beginning of treated water)

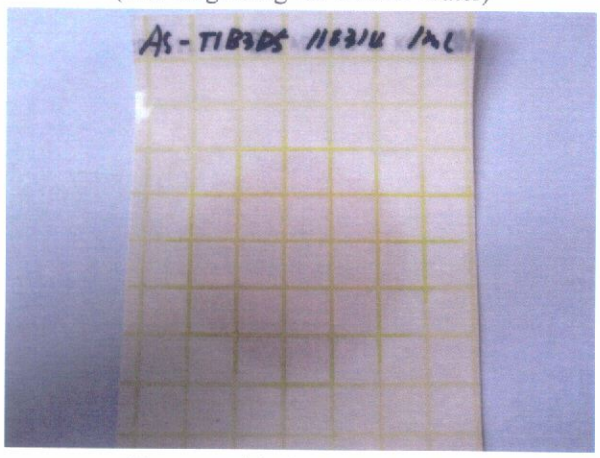


Heterotrophic bacteria - 1 mL
(1st Middle of treated water)



Heterotrophic bacteria - 1 mL
(2nd Beginning of treated water)

Heterotrophic bacteria - 1 mL
(2nd Middle of treated water)

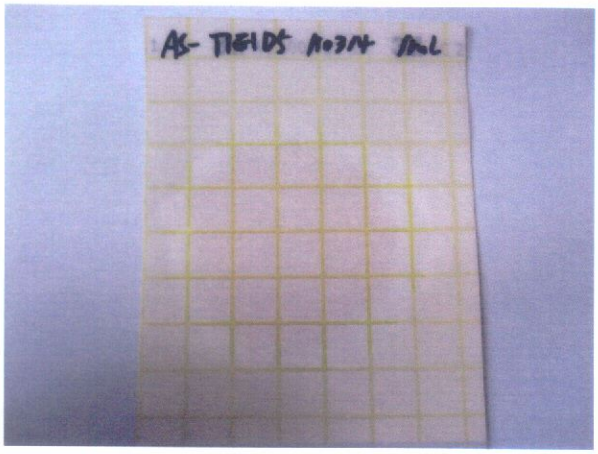


Heterotrophic bacteria - 1 mL
(3rd Beginning of treated water)

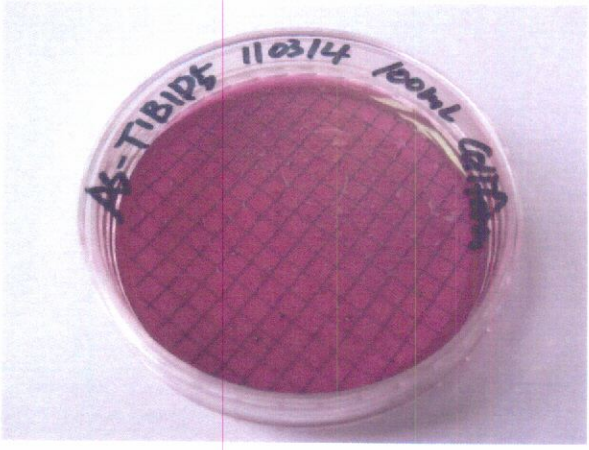
Heterotrophic bacteria - 1 mL
(3rd Middle of treated water)

3. To be continued

· de-Ballasting (1st period : 2011. 03. 14, Singapore port)

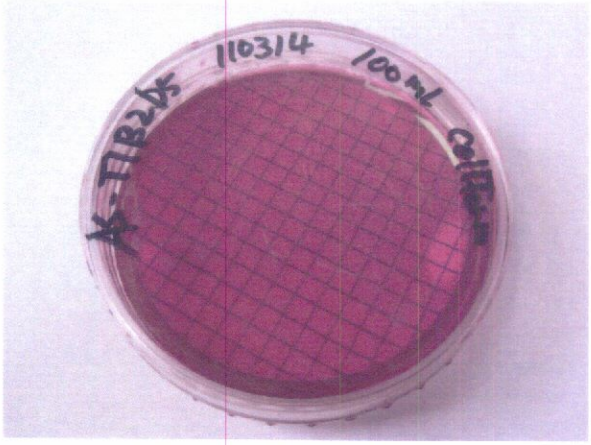


Heterotrophic bacteria - 1 mL
(1st End of treated water)

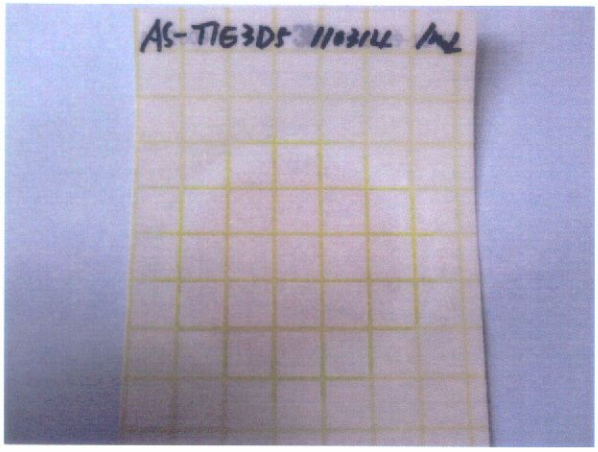


Coliform - 100 mL filtration
(1st Beginning of treated water)

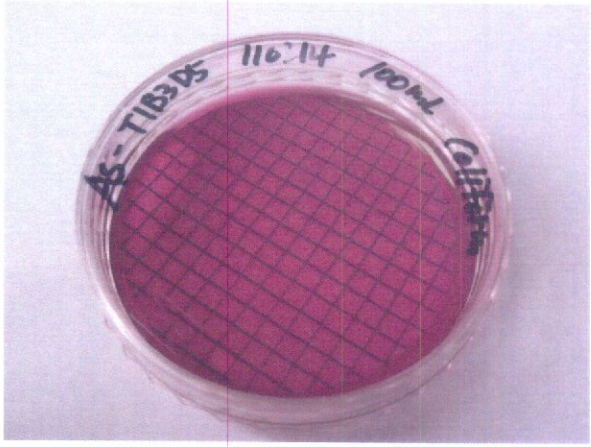
Heterotrophic bacteria - 1 mL
(2nd End of treated water)



Coliform - 100 mL filtration
(2nd Beginning of treated water)



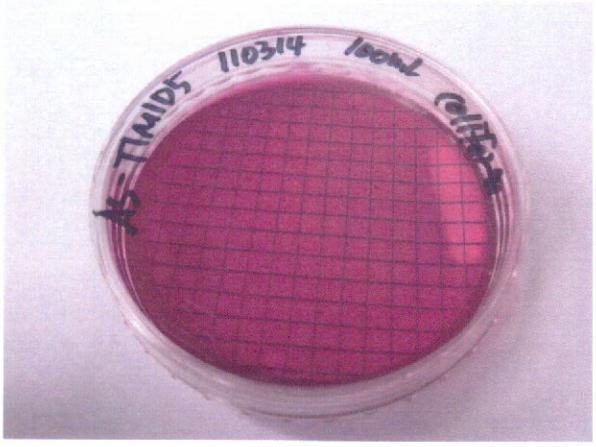
Heterotrophic bacteria - 1 mL
(3rd End of treated water)



Coliform - 100 mL filtration
(3rd Beginning of treated water)

3. To be continued

· de-Ballasting (1st period : 2011. 03. 14, Singapore port)



Coliform - 100 mL filtration
(1st Middle of treated water)

Coliform - 100 mL filtration
(1st End of treated water)

Coliform - 100 mL filtration
(2nd Middle of treated water)

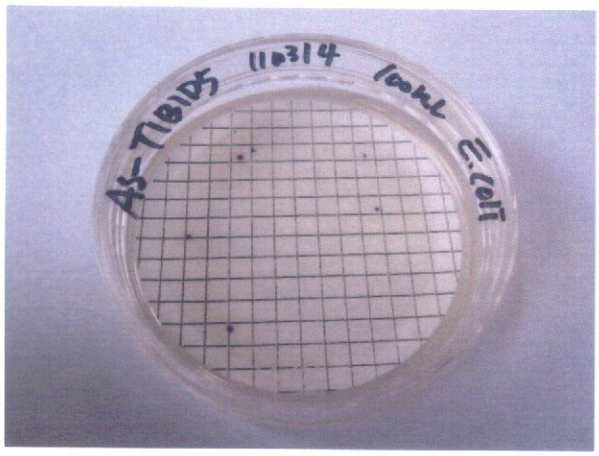
Coliform - 100 mL filtration
(2nd End of treated water)

Coliform - 100 mL filtration
(3rd Middle of treated water)

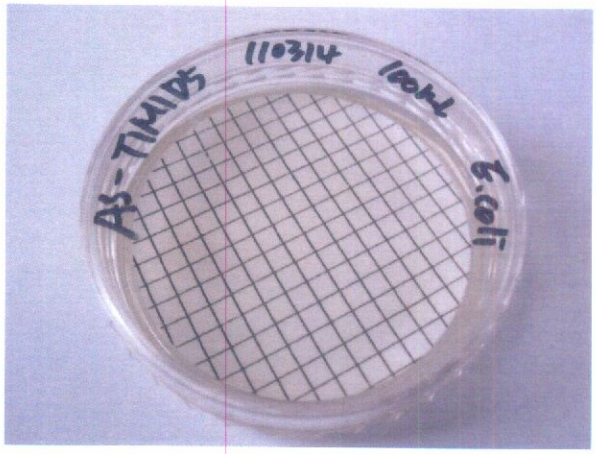
Coliform - 100 mL filtration
(3rd End of treated water)

3. To be continued

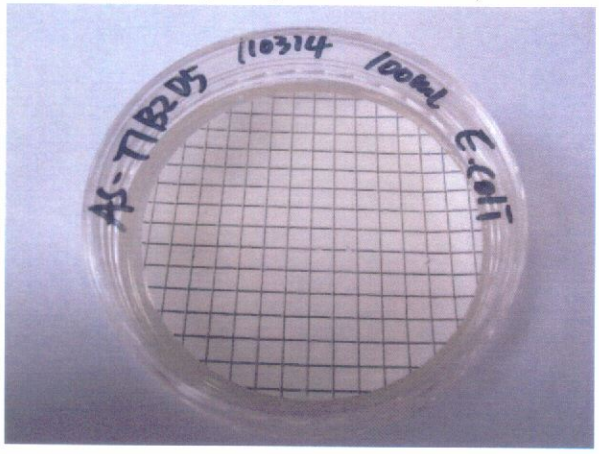
· de-Ballasting (1st period : 2011. 03. 14, Singapore port)



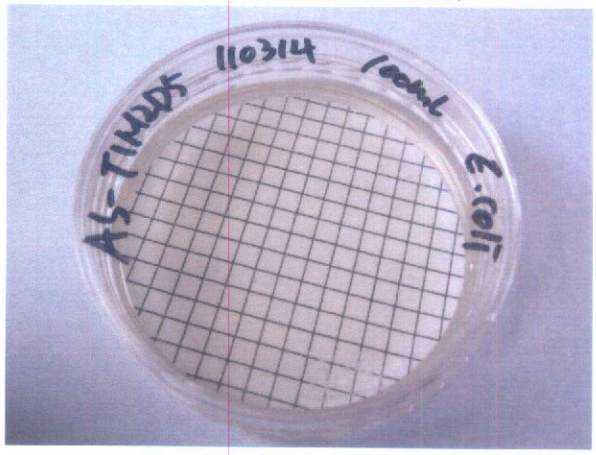
E. coli - 100 mL filtration
(1st Beginning of treated water)



E. coli - 100 mL filtration
(1st Middle of treated water)

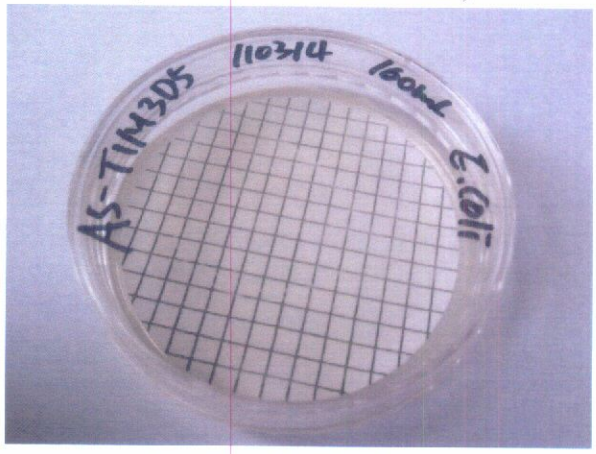


E. coli - 100 mL filtration
(2nd Beginning of treated water)



E. coli - 100 mL filtration
(2nd Middle of treated water)

E. coli - 100 mL filtration
(3rd Beginning of treated water)

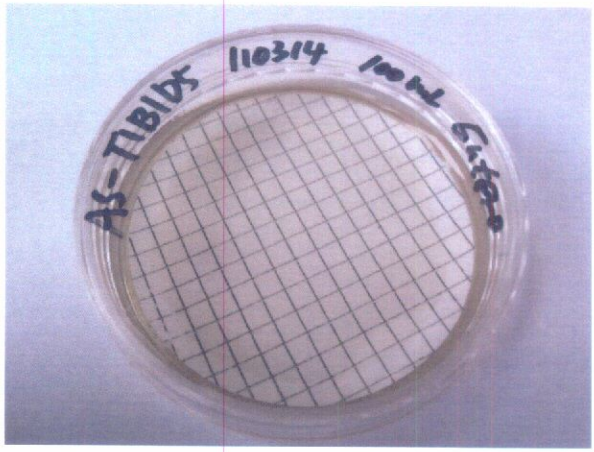


E. coli - 100 mL filtration
(3rd Middle of treated water)

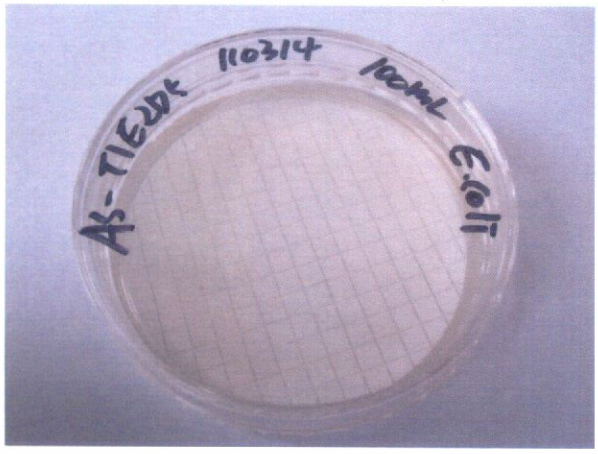
3. To be continued

· de-Ballasting (1st period : 2011. 03. 14, Singapore port)

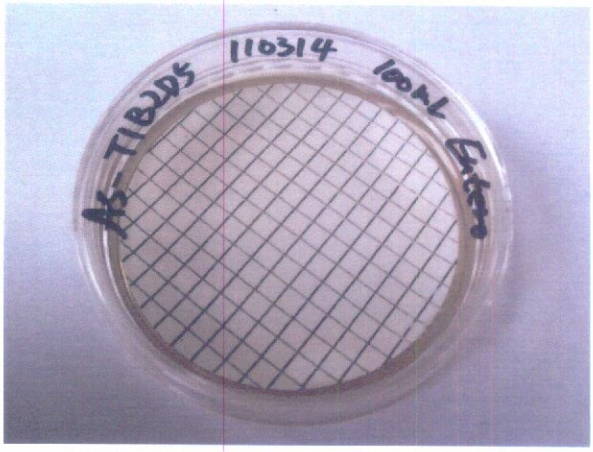
E. coli - 100 mL filtration
(1st End of treated water)



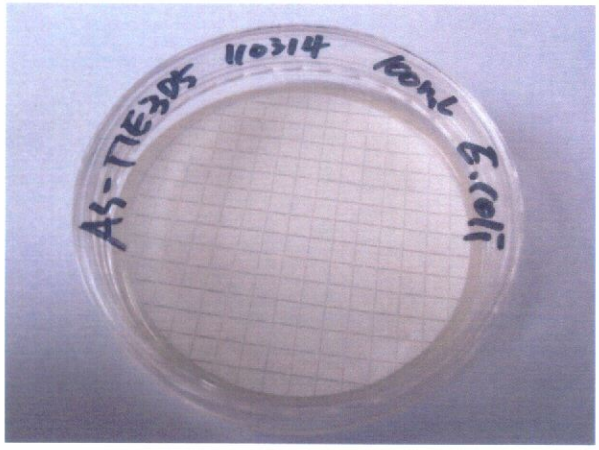
Intestinal Enterococci - 100 mL filtration
(1st Beginning of treated water)



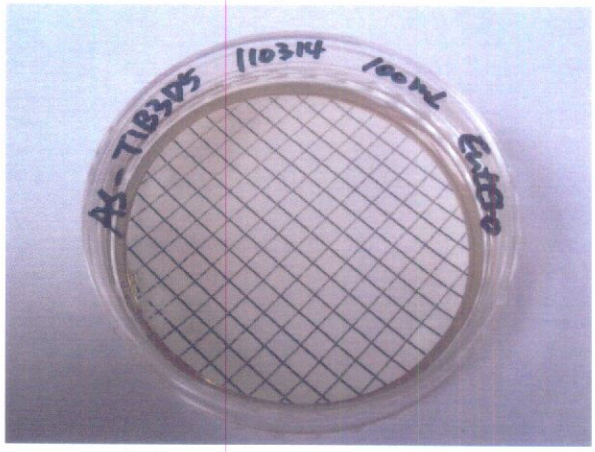
E. coli - 100 mL filtration
(2nd End of treated water)



Intestinal Enterococci - 100 mL filtration
(2nd Beginning of treated water)



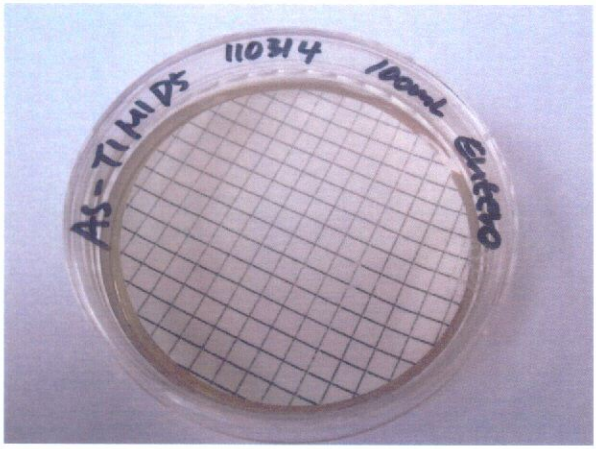
E. coli - 100 mL filtration
(3rd End of treated water)



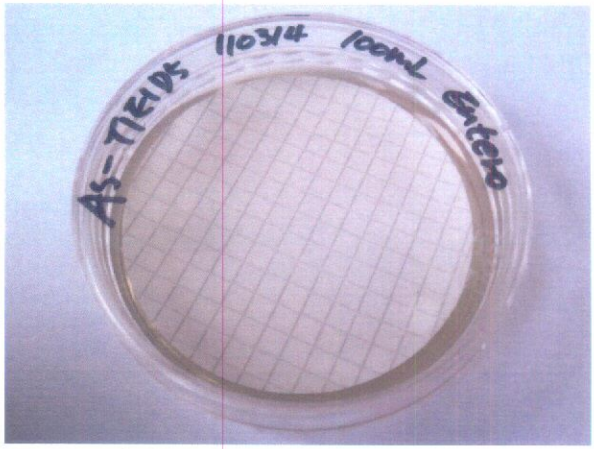
Intestinal Enterococci - 100 mL filtration
(3rd Beginning of treated water)

3. To be continued

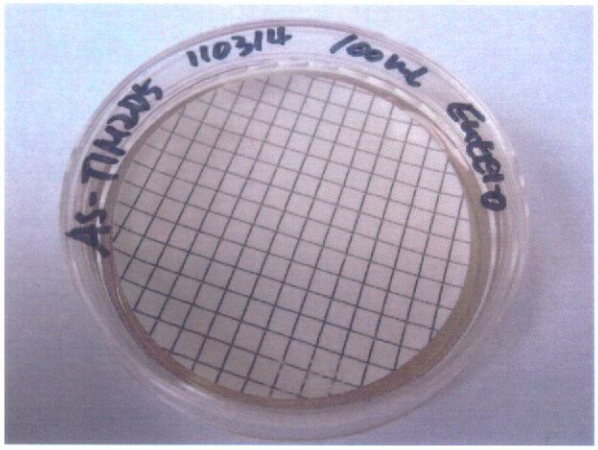
· de-Ballasting (1st period : 2011. 03. 14, Singapore port)



Intestinal Enterococci - 100 mL filtration
(1st Middle of treated water)

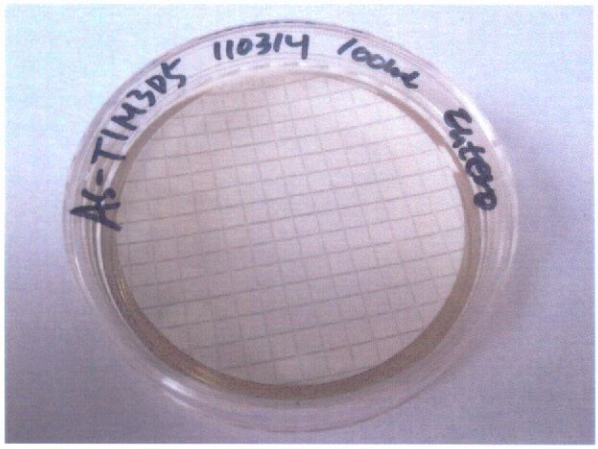


Intestinal Enterococci - 100 mL filtration
(1st End of treated water)

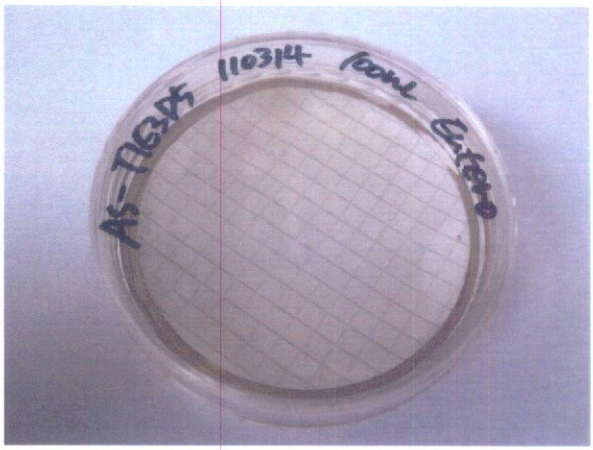


Intestinal Enterococci - 100 mL filtration
(2nd Middle of treated water)

Intestinal Enterococci - 100 mL filtration
(2nd End of treated water)



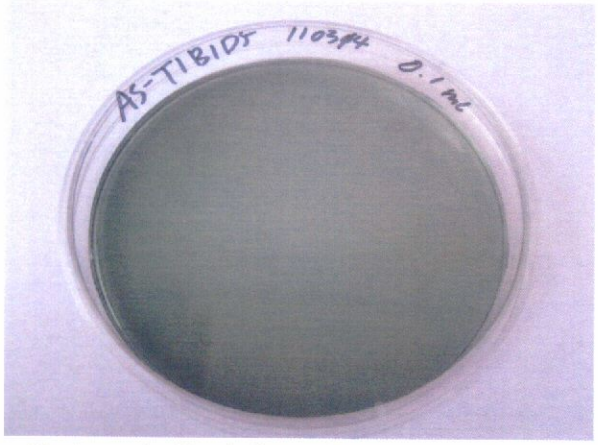
Intestinal Enterococci - 100 mL filtration
(3rd Middle of treated water)



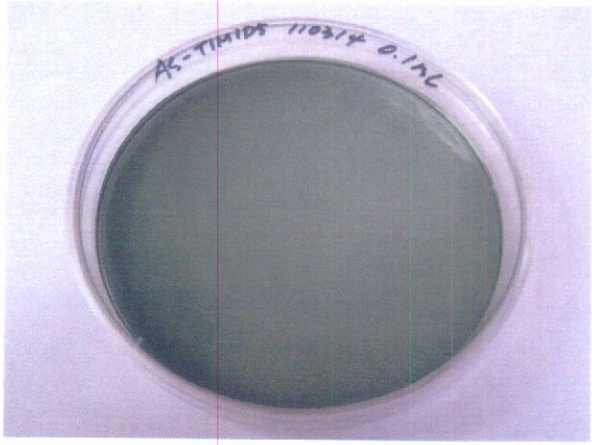
Intestinal Enterococci - 100 mL filtration
(3rd End of treated water)

3. To be continued

· **de-Ballasting (1st period : 2011. 03. 14, Singapore port)**

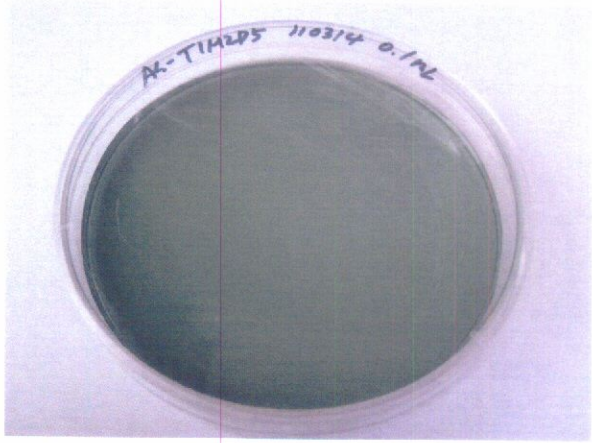


Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(1st Beginning of treated water)

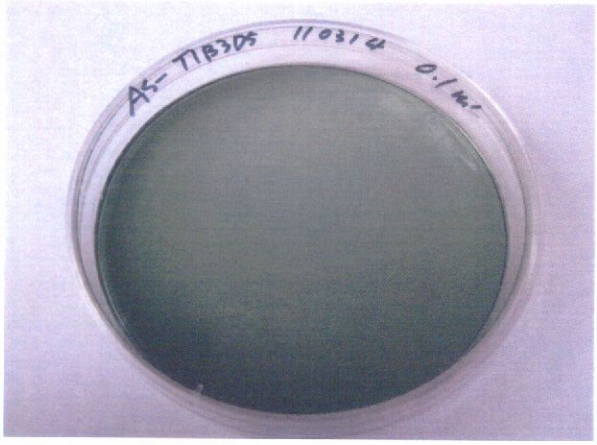


Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(1st Middle of treated water)

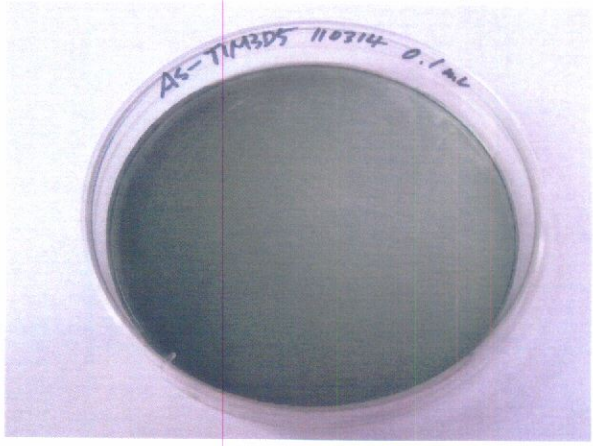
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(2nd Beginning of treated water)



Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(2nd Middle of treated water)



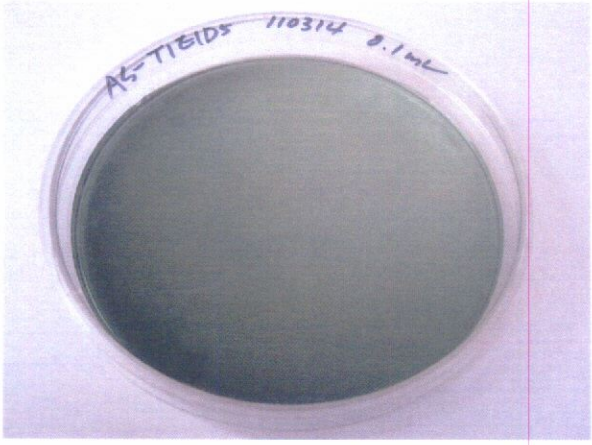
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(3rd Beginning of treated water)



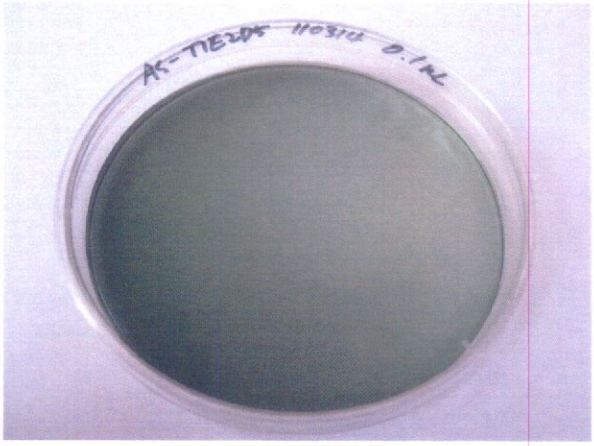
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(3rd Middle of treated water)

3. To be continued

· **de-Ballasting (1st period : 2011. 03. 14, Singapore port)**



Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(1st End of treated water)

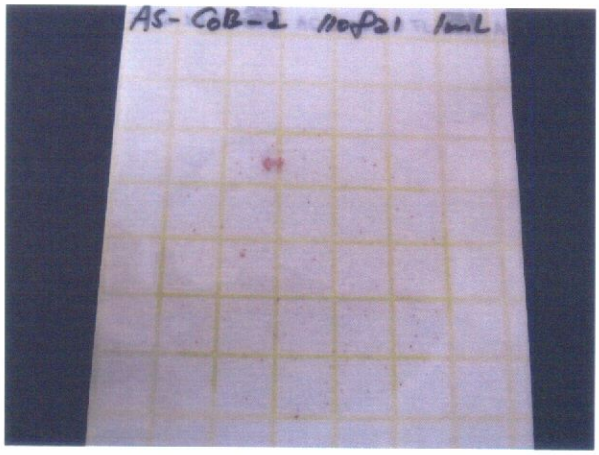


Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(2nd End of treated water)

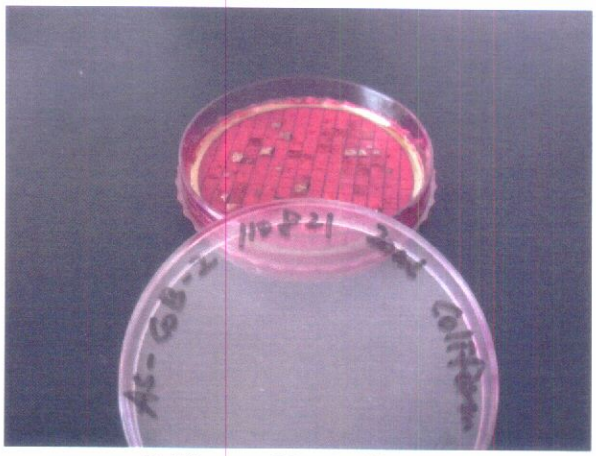
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(3rd End of treated water)

3. To be continued

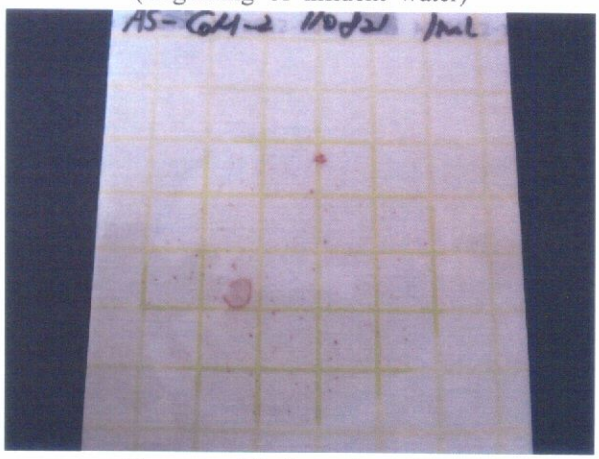
· Ballasting (2nd period : 2011. 08. 21, Singapore port)



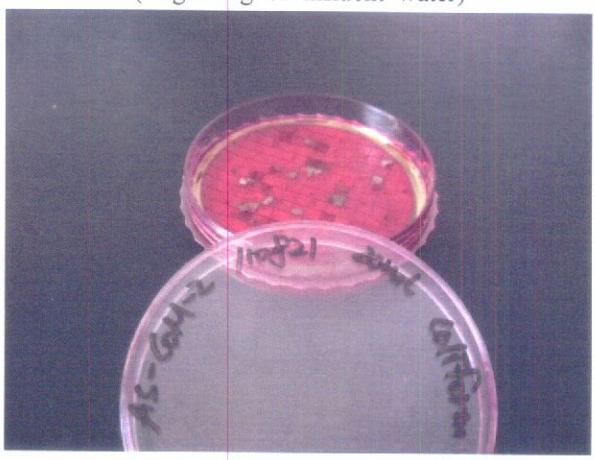
Heterotrophic bacteria - 1 mL
(Beginning of influent water)



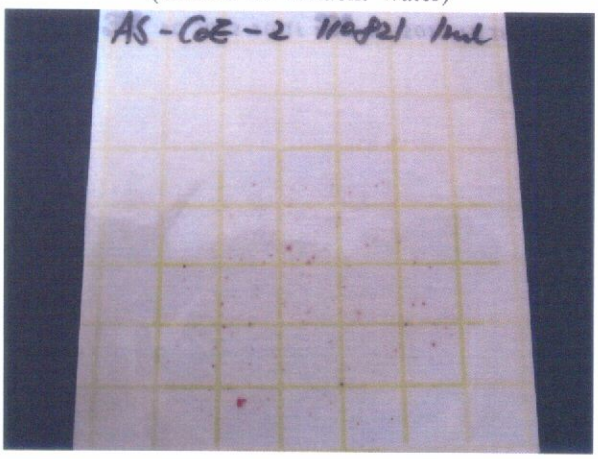
Coliform - 20 mL filtration
(Beginning of influent water)



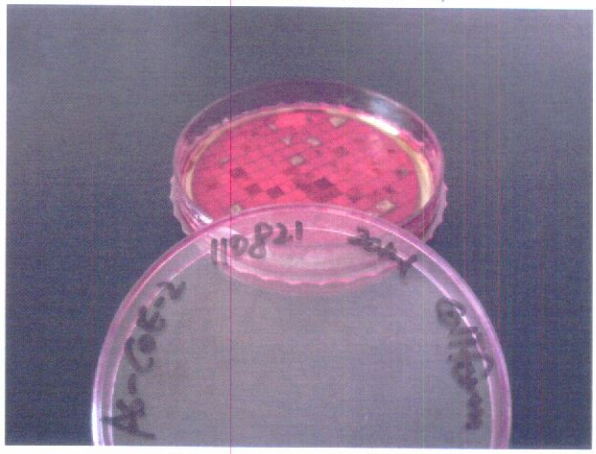
Heterotrophic bacteria - 1 mL
(Middle of influent water)



Coliform - 20 mL filtration
(Middle of influent water)



Heterotrophic bacteria - 1 mL
(End of influent water)

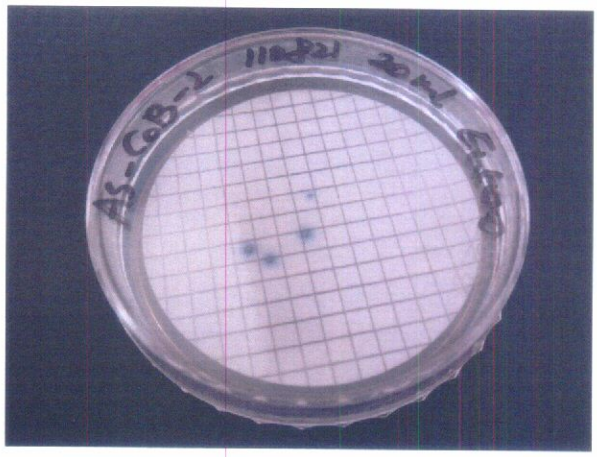


Coliform - 20 mL filtration
(End of influent water)

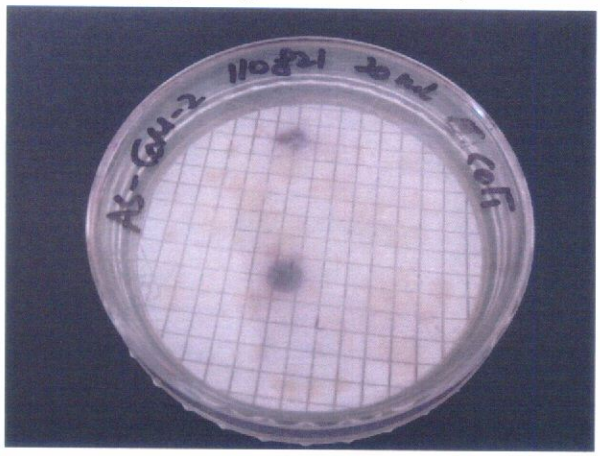
3. To be continued

· Ballasting (2nd period : 2011. 08. 21, Singapore port)

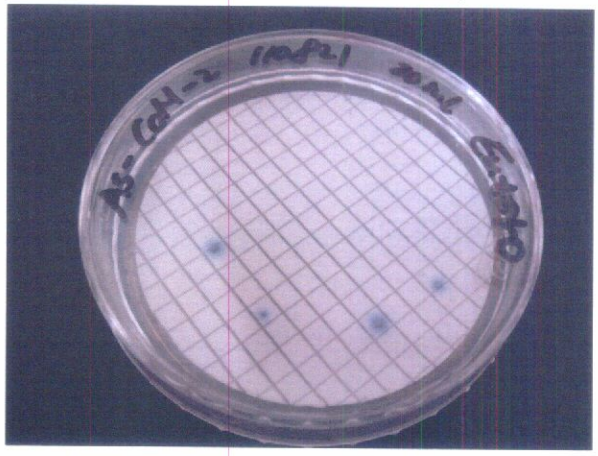
E. coli - 20 mL filtration
(Beginning of influent water)



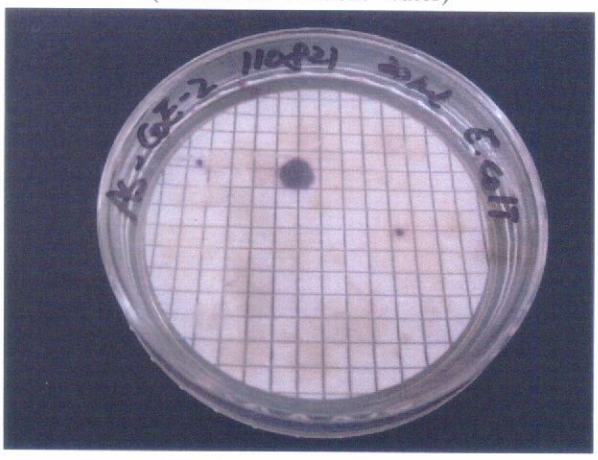
Intestinal Enterococci - 20 mL filtration
(Beginning of influent water)



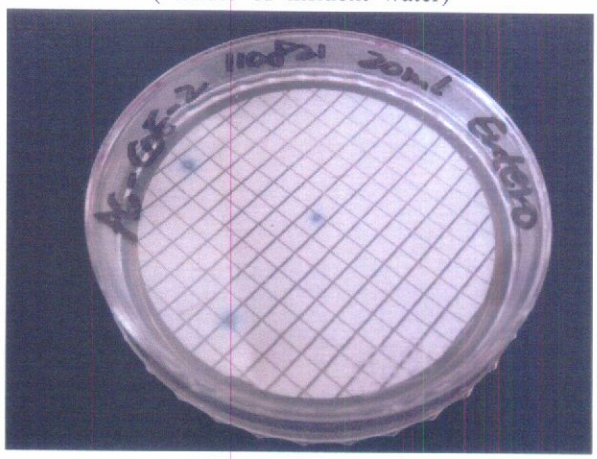
E. coli - 20 mL filtration
(Middle of influent water)



Intestinal Enterococci - 20 mL filtration
(Middle of influent water)



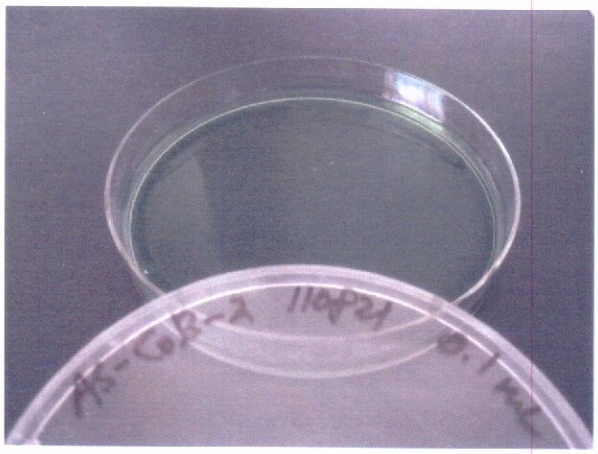
E. coli - 20 mL filtration
(End of influent water)



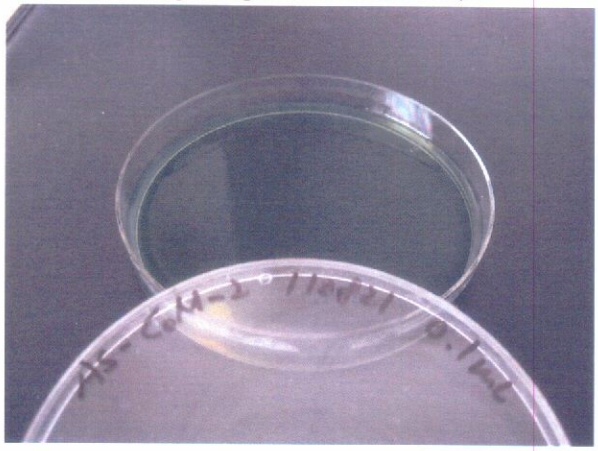
Intestinal Enterococci - 20 mL filtration
(End of influent water)

3. To be continued

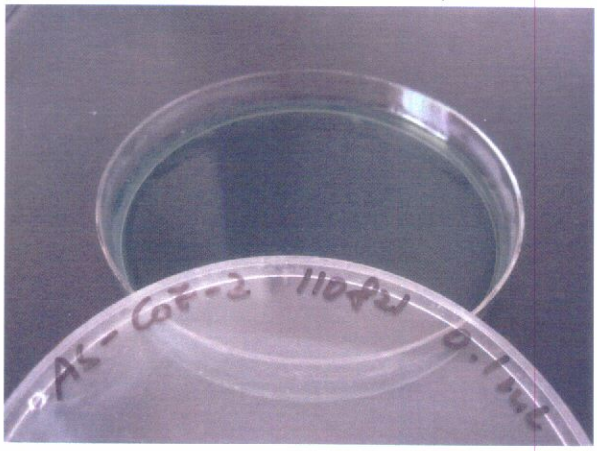
· **Ballasting (2nd period : 2011. 08. 21, Singapore port)**



Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(Beginning of influent water)



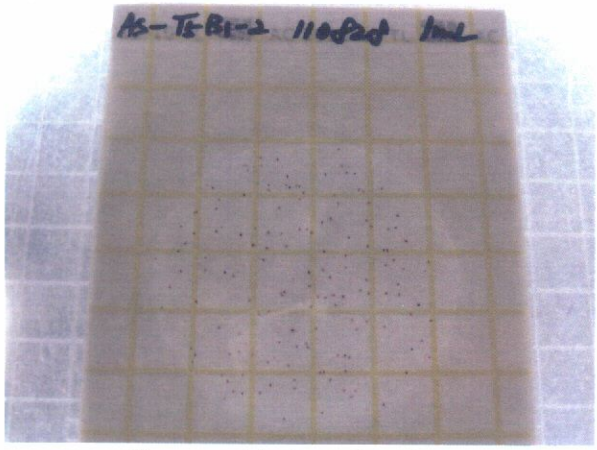
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(Middle of influent water)



Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(End of influent water)

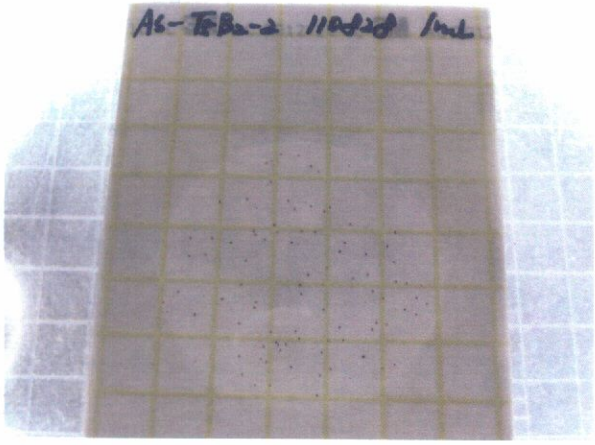
3. To be continued

· de-Ballasting (2nd period : 2011. 08. 28, Busan newport)

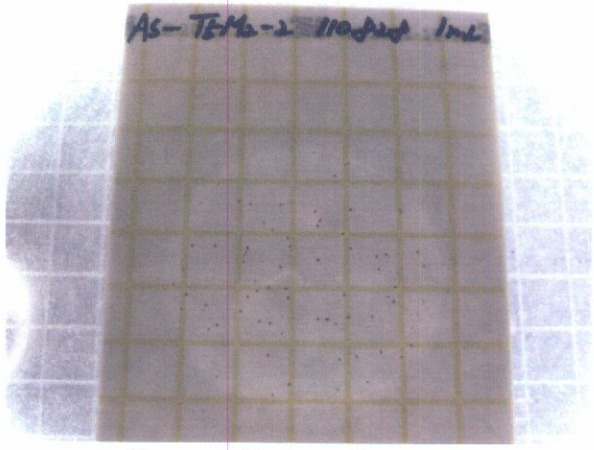


Heterotrophic bacteria - 1 mL
(1st Beginning of treated water)

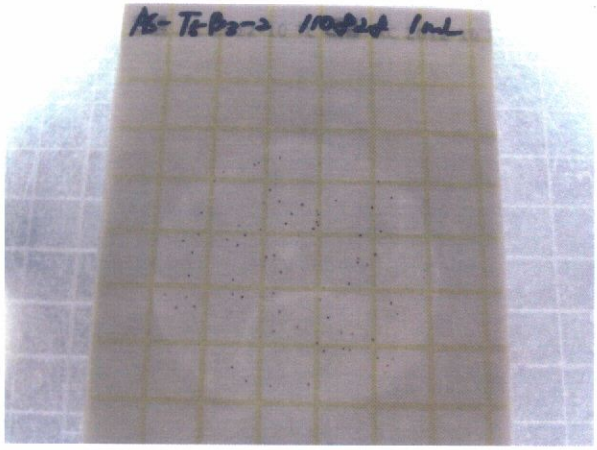
Heterotrophic bacteria - 1 mL
(1st Middle of treated water)



Heterotrophic bacteria - 1 mL
(2nd Beginning of treated water)



Heterotrophic bacteria - 1 mL
(2nd Middle of treated water)

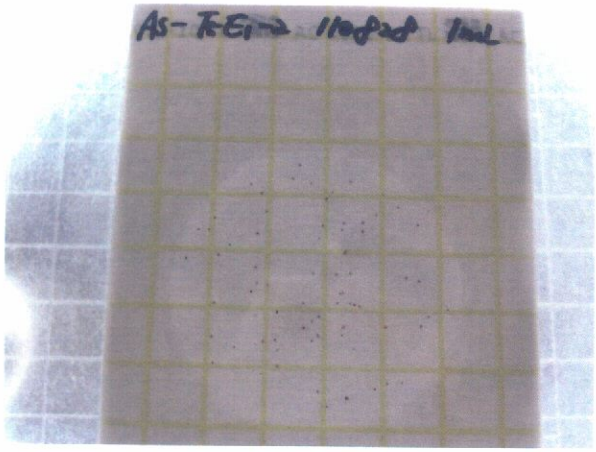


Heterotrophic bacteria - 1 mL
(3rd Beginning of treated water)

Heterotrophic bacteria - 1 mL
(3rd Middle of treated water)

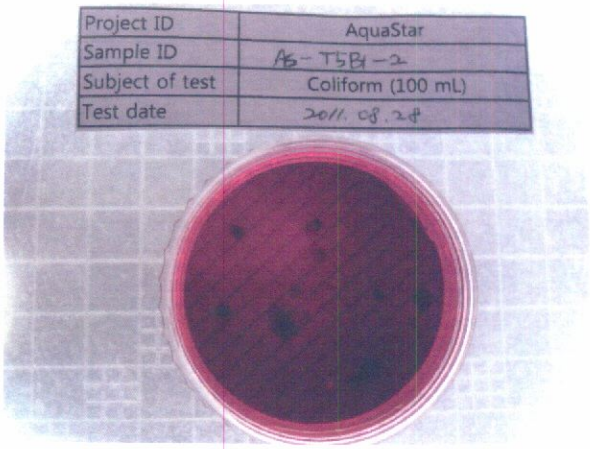
3. To be continued

· **de-Ballasting (2nd period : 2011. 08. 28, Busan newport)**



Heterotrophic bacteria - 1 mL

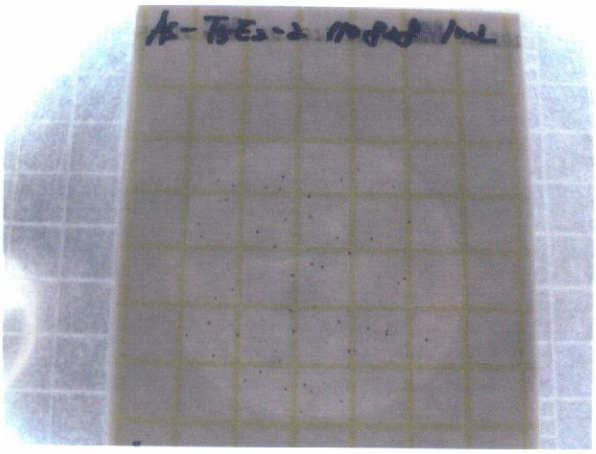
(1st End of treated water)



Project ID	AquaStar
Sample ID	AS-T5B1-2
Subject of test	Coliform (100 mL)
Test date	2011. 08. 28

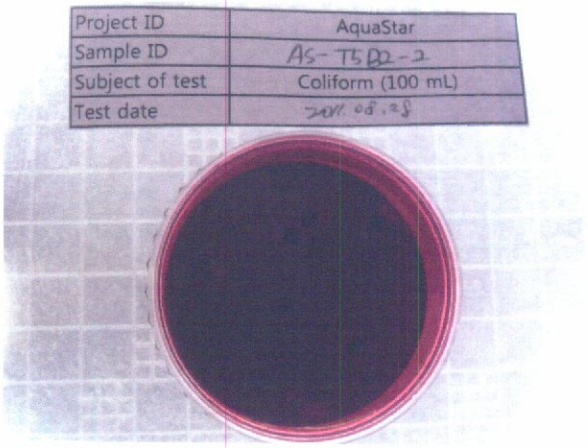
Coliform - 100 mL filtration

(1st Beginning of treated water)



Heterotrophic bacteria - 1 mL

(2nd End of treated water)



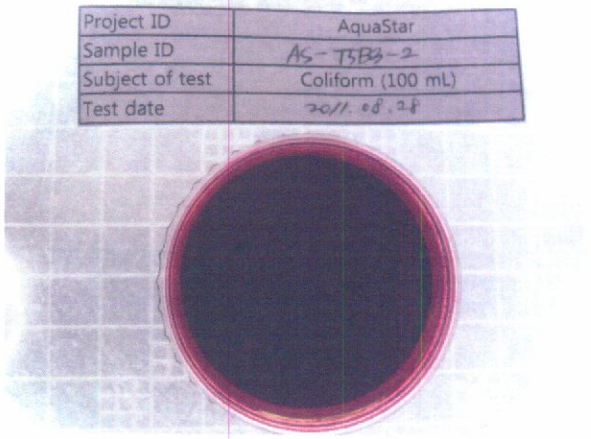
Project ID	AquaStar
Sample ID	AS-T5B2-2
Subject of test	Coliform (100 mL)
Test date	2011. 08. 28

Coliform - 100 mL filtration

(2nd Beginning of treated water)

Heterotrophic bacteria - 1 mL

(3rd End of treated water)



Project ID	AquaStar
Sample ID	AS-T5B3-2
Subject of test	Coliform (100 mL)
Test date	2011. 08. 28

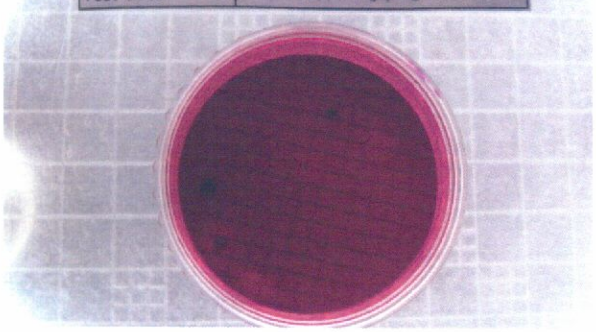
Coliform - 100 mL filtration

(3rd Beginning of treated water)

3. To be continued

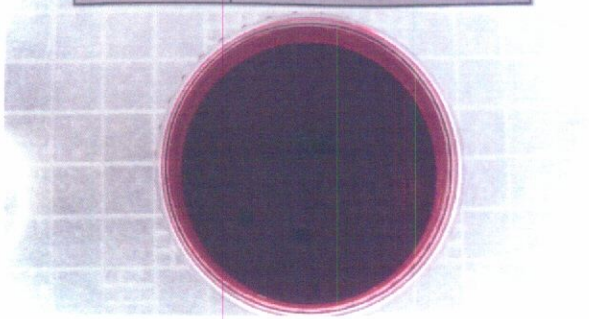
· **de-Ballasting (2nd period : 2011. 08. 28, Busan newport)**

Project ID	AquaStar
Sample ID	AS-TSM1-2
Subject of test	Coliform (100 mL)
Test date	2011. 08. 28



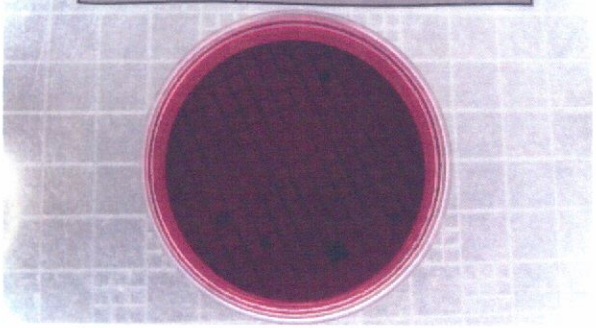
Coliform - 100 mL filtration
(1st Middle of treated water)

Project ID	AquaStar
Sample ID	AS-TSE1-2
Subject of test	Coliform (100 mL)
Test date	2011. 08. 28



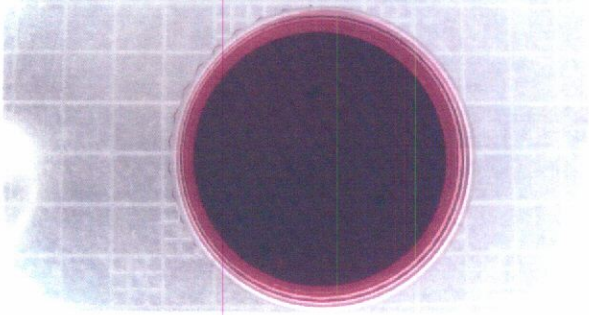
Coliform - 100 mL filtration
(1st End of treated water)

Project ID	AquaStar
Sample ID	AS-TSM2-2
Subject of test	Coliform (100 mL)
Test date	2011. 08. 28



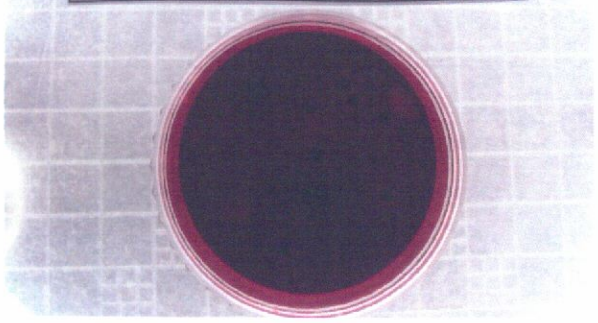
Coliform - 100 mL filtration
(2nd Middle of treated water)

Project ID	AquaStar
Sample ID	AS-TSE2-2
Subject of test	Coliform (100 mL)
Test date	2011. 08. 28



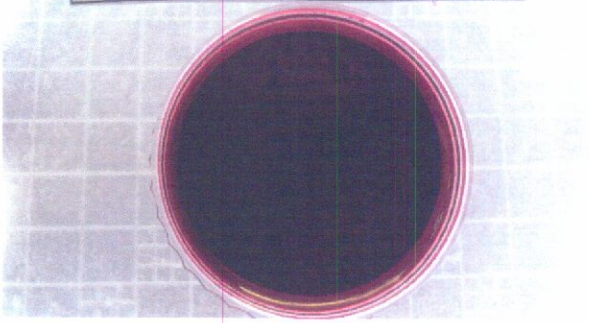
Coliform - 100 mL filtration
(2nd End of treated water)

Project ID	AquaStar
Sample ID	AS-TSM3-2
Subject of test	Coliform (100 mL)
Test date	2011. 08. 28



Coliform - 100 mL filtration
(3rd Middle of treated water)

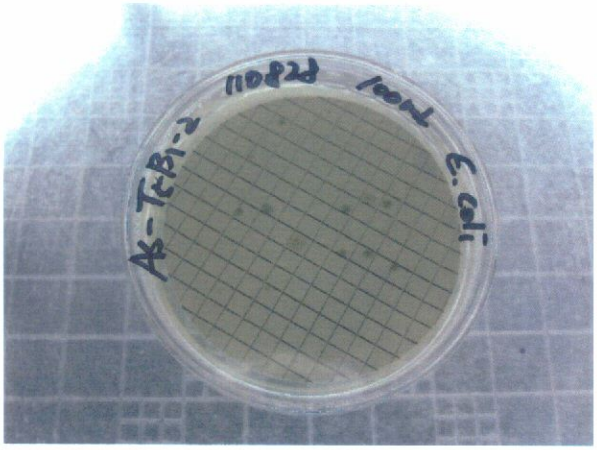
Project ID	AquaStar
Sample ID	AS-TSE3-2
Subject of test	Coliform (100 mL)
Test date	2011. 08. 28



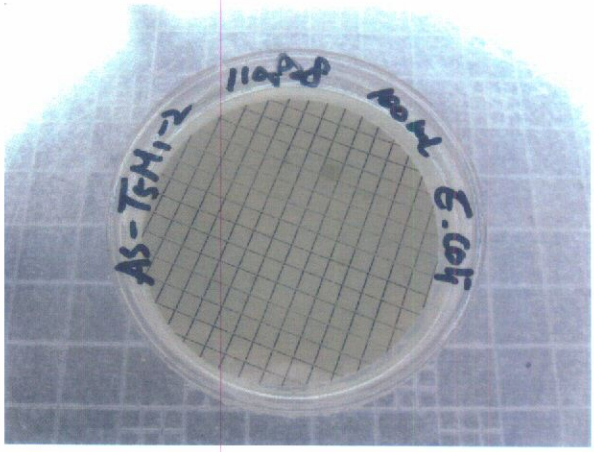
Coliform - 100 mL filtration
(3rd End of treated water)

3. To be continued

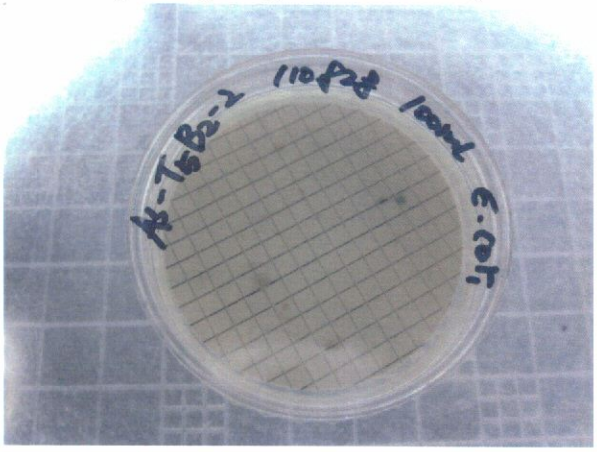
· de-Ballasting (2nd period : 2011. 08. 28, Busan newport)



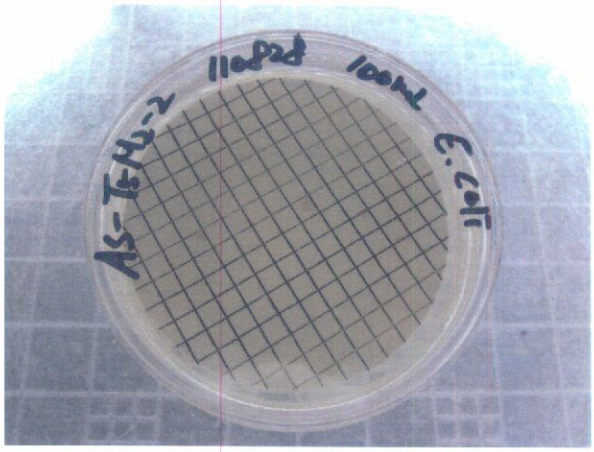
E. coli - 100 mL filtration
(1st Beginning of treated water)



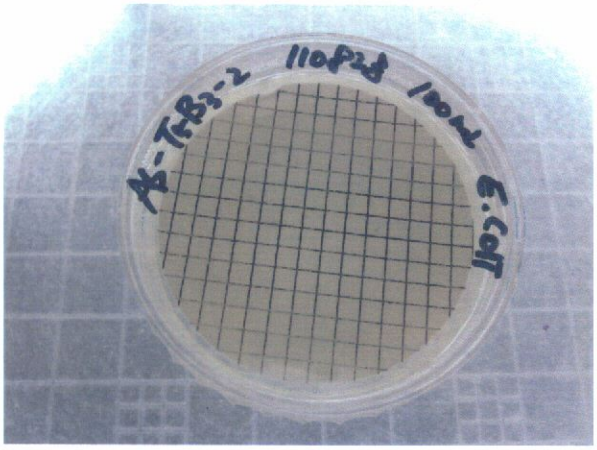
E. coli - 100 mL filtration
(1st Middle of treated water)



E. coli - 100 mL filtration
(2nd Beginning of treated water)



E. coli - 100 mL filtration
(2nd Middle of treated water)

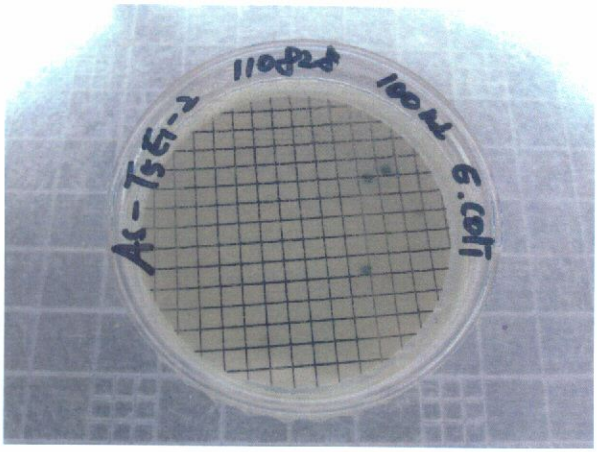


E. coli - 100 mL filtration
(3rd Beginning of treated water)

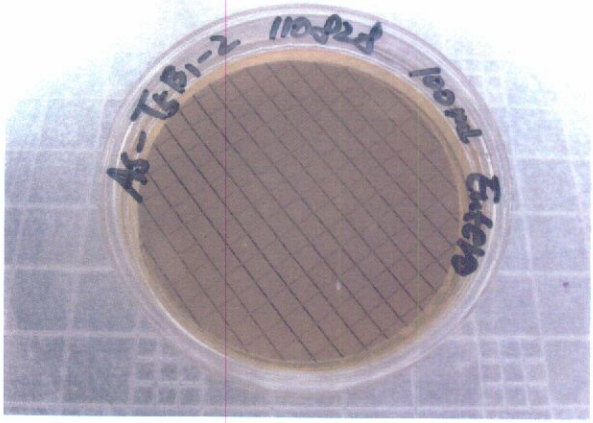
E. coli - 100 mL filtration
(3rd Middle of treated water)

3. To be continued

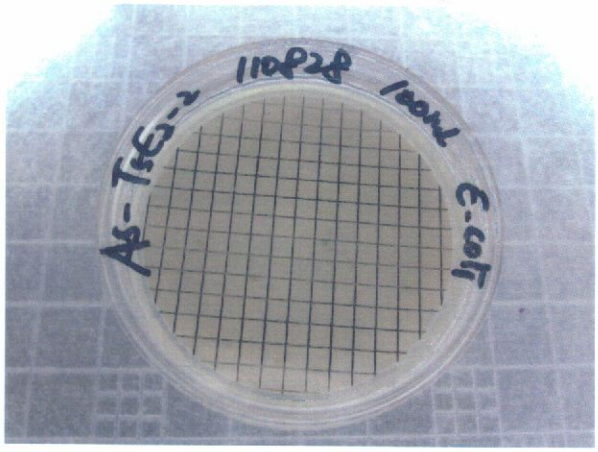
· de-Ballasting (2nd period : 2011. 08. 28, Busan newport)



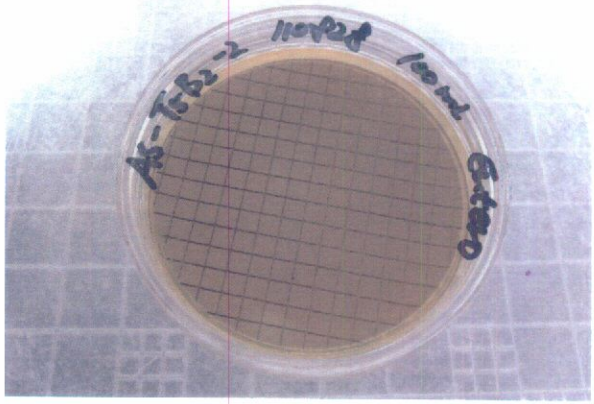
E. coli - 100 mL filtration
(1st End of treated water)



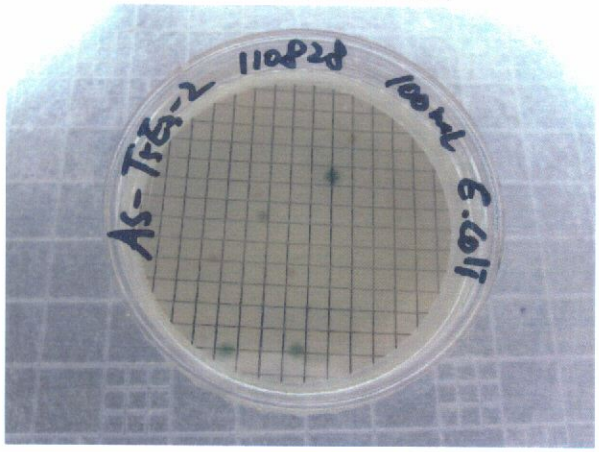
Intestinal Enterococci - 100 mL filtration
(1st Beginning of treated water)



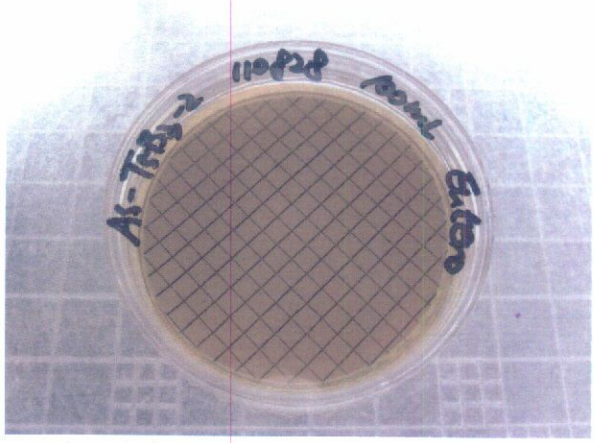
E. coli - 100 mL filtration
(2nd End of treated water)



Intestinal Enterococci - 100 mL filtration
(2nd Beginning of treated water)



E. coli - 100 mL filtration
(3rd End of treated water)

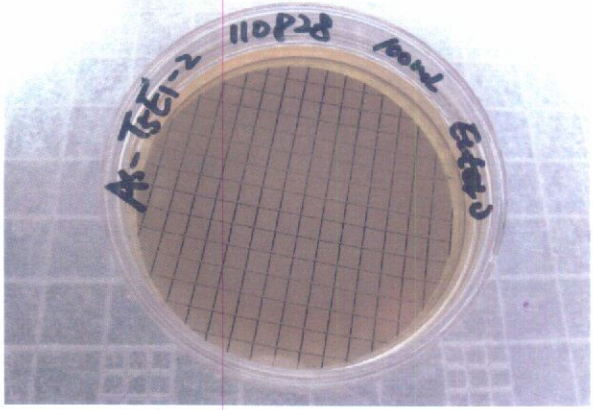


Intestinal Enterococci - 100 mL filtration
(3rd Beginning of treated water)

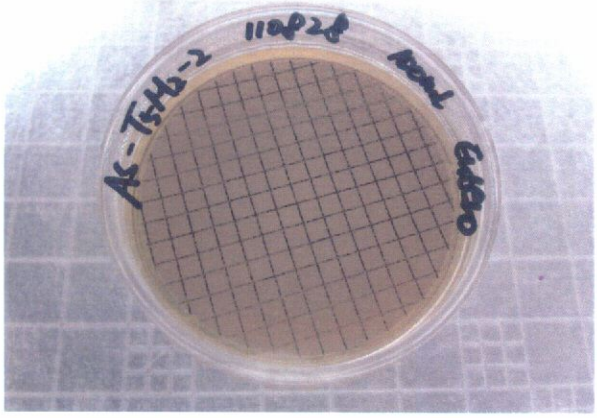
3. To be continued

· de-Ballasting (2nd period : 2011. 08. 28, Busan newport)

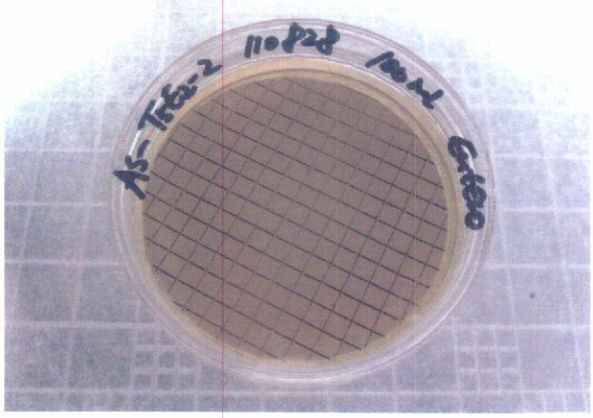
Intestinal Enterococci - 100 mL filtration
(1st Middle of treated water)



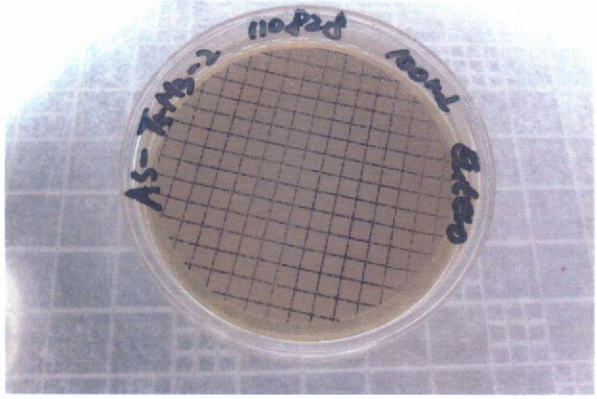
Intestinal Enterococci - 100 mL filtration
(1st End of treated water)



Intestinal Enterococci - 100 mL filtration
(2nd Middle of treated water)



Intestinal Enterococci - 100 mL filtration
(2nd End of treated water)

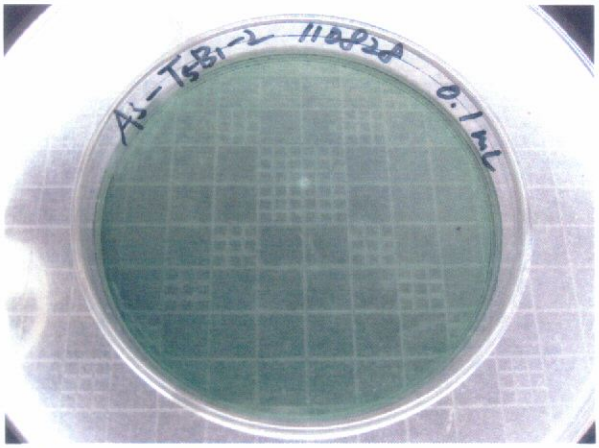


Intestinal Enterococci - 100 mL filtration
(3rd Middle of treated water)

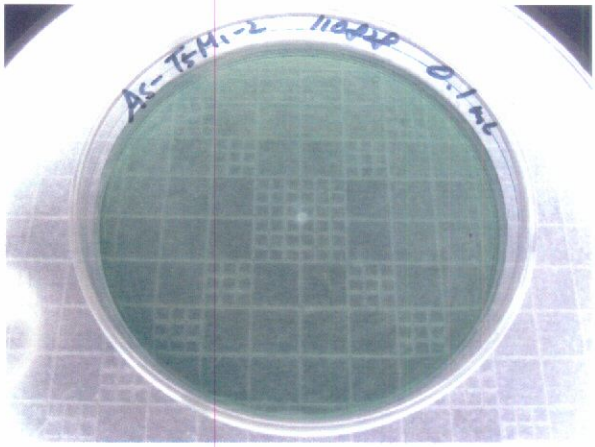
Intestinal Enterococci - 100 mL filtration
(3rd End of treated water)

3. To be continued

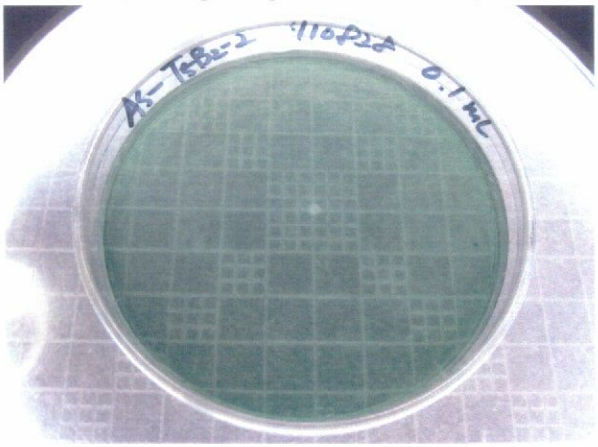
· de-Ballasting (2nd period : 2011. 08. 28, Busan newport)



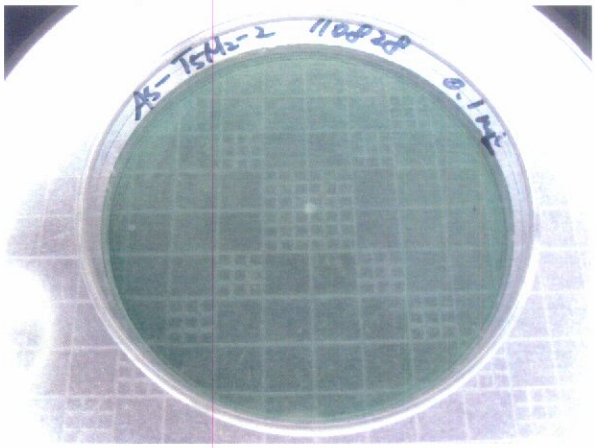
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(1st Beginning of treated water)



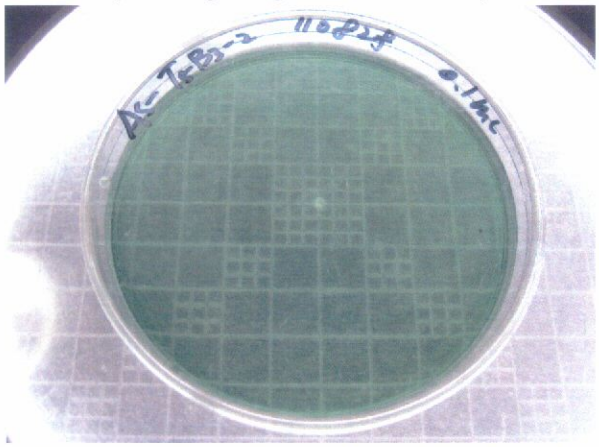
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(1st Middle of treated water)



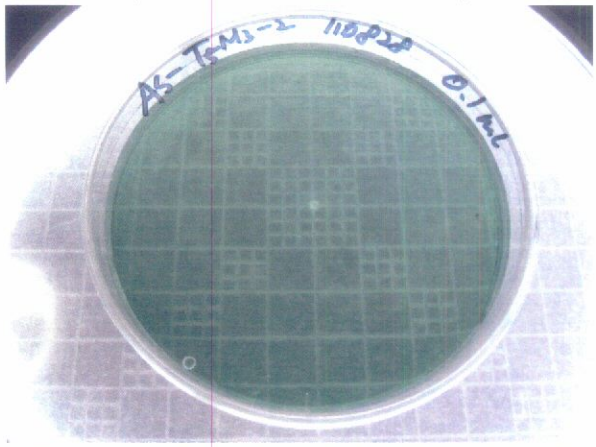
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(2nd Beginning of treated water)



Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(2nd Middle of treated water)



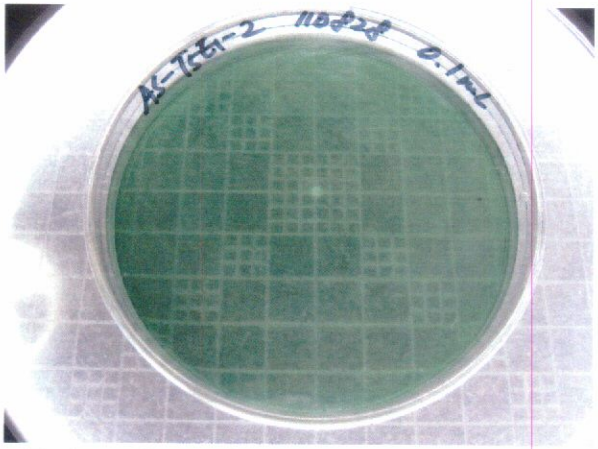
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(3rd Beginning of treated water)



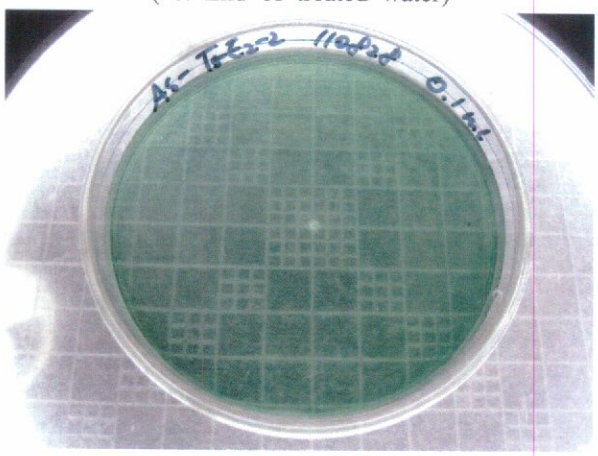
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(3rd Middle of treated water)

3. To be continued

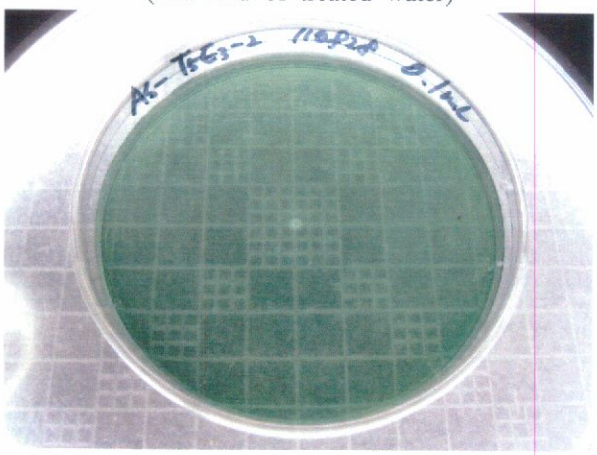
· de-Ballasting (2nd period : 2011. 08. 28, Busan newport)



Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(1st End of treated water)



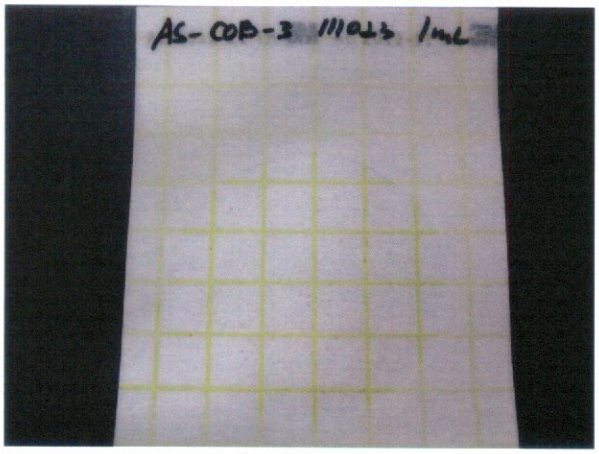
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(2nd End of treated water)



Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(3rd End of treated water)

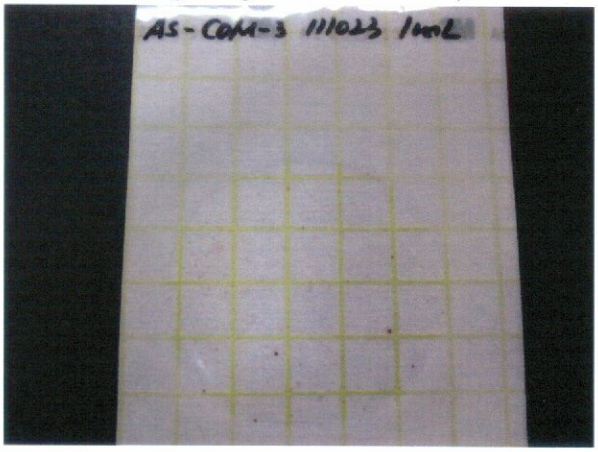
3. To be continued

· **Ballasting (3rd period : 2011. 10. 23, Hongkong port)**

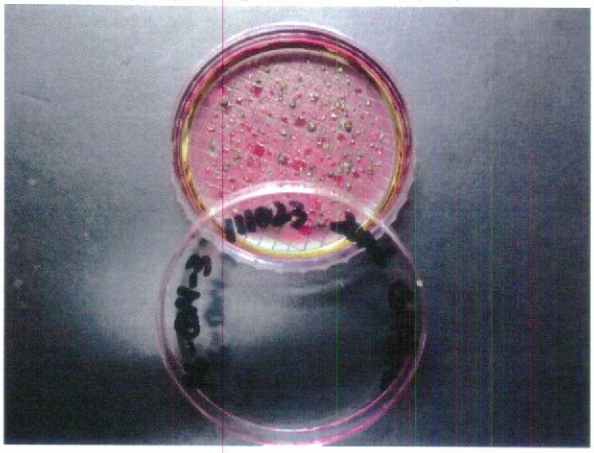


Heterotrophic bacteria - 1 mL
(Beginning of influent water)

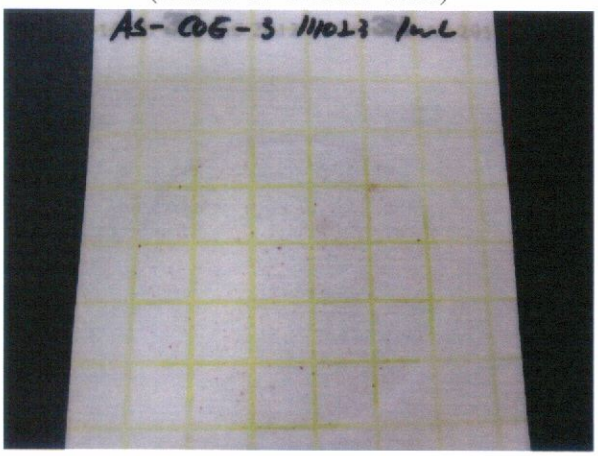
Coliform - 20 mL filtration
(Beginning of influent water)



Heterotrophic bacteria - 1 mL
(Middle of influent water)



Coliform - 20 mL filtration
(Middle of influent water)

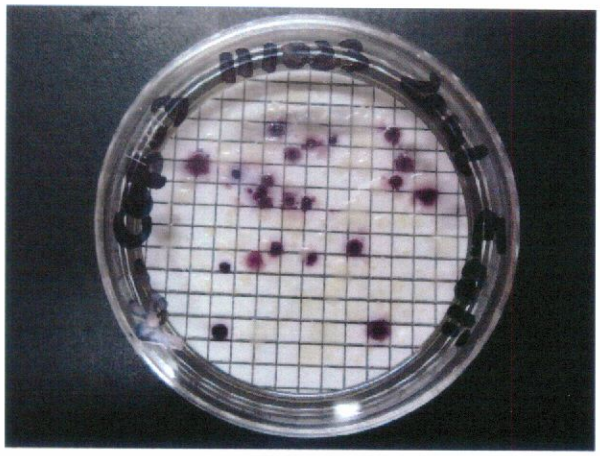


Heterotrophic bacteria - 1 mL
(End of influent water)

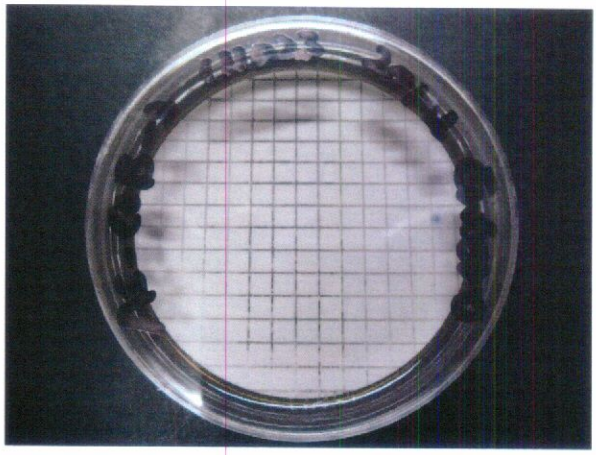
Coliform - 20 mL filtration
(End of influent water)

3. To be continued

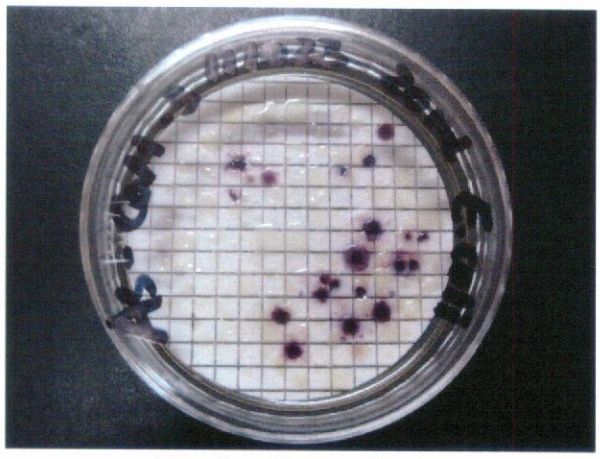
· **Ballasting (3rd period : 2011. 10. 23, Hongkong port)**



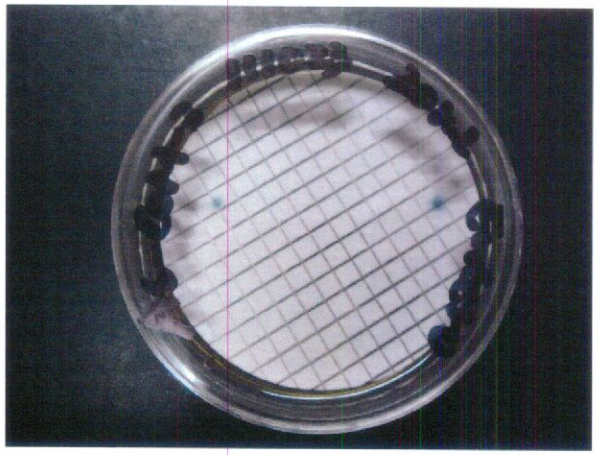
E. coli - 20 mL filtration
(Beginning of influent water)



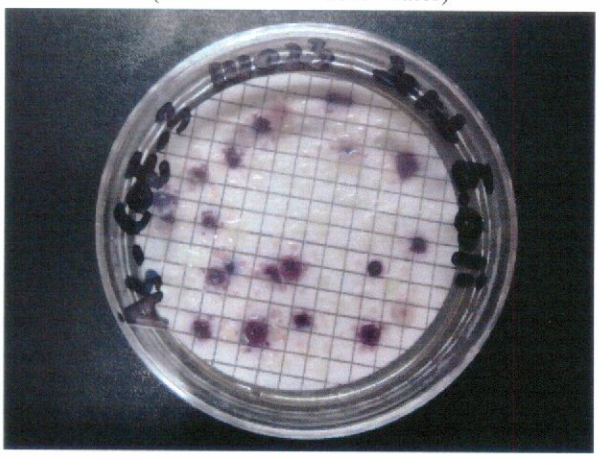
Intestinal Enterococci - 20 mL filtration
(Beginning of influent water)



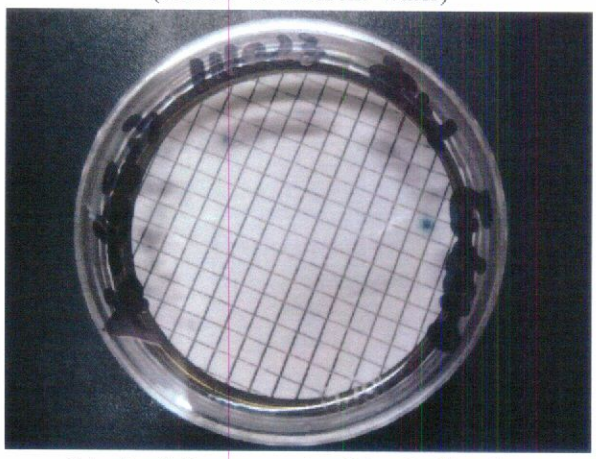
E. coli - 20 mL filtration
(Middle of influent water)



Intestinal Enterococci - 20 mL filtration
(Middle of influent water)



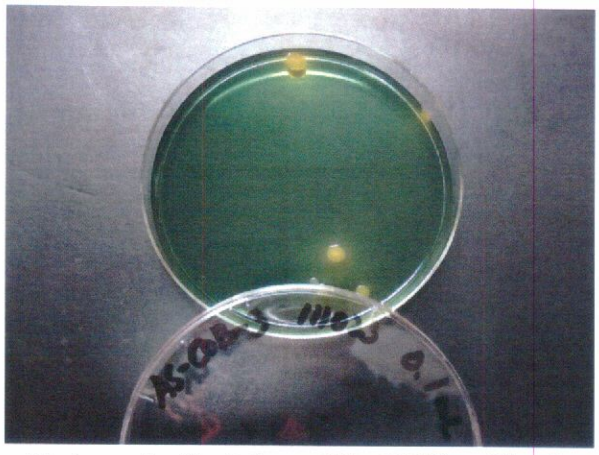
E. coli - 20 mL filtration
(End of influent water)



Intestinal Enterococci - 20 mL filtration
(End of influent water)

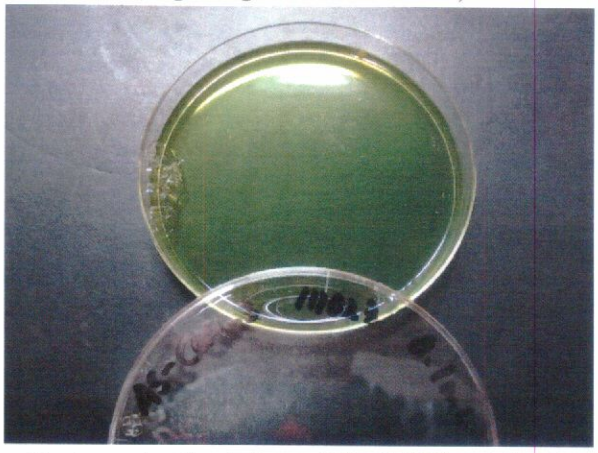
3. To be continued

· **Ballasting (3rd period : 2011. 10. 23, Hongkong port)**



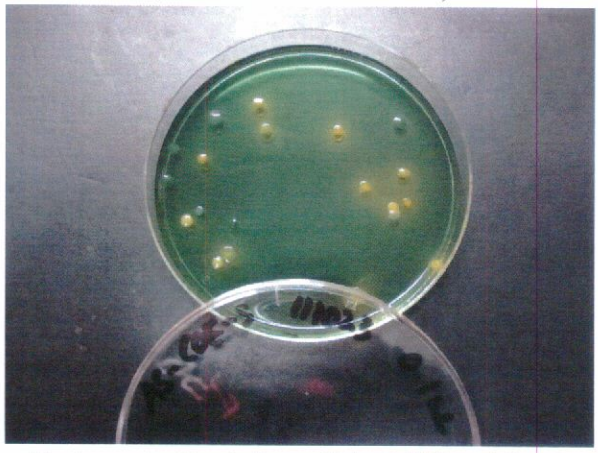
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL

(Beginning of influent water)



Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL

(Middle of influent water)

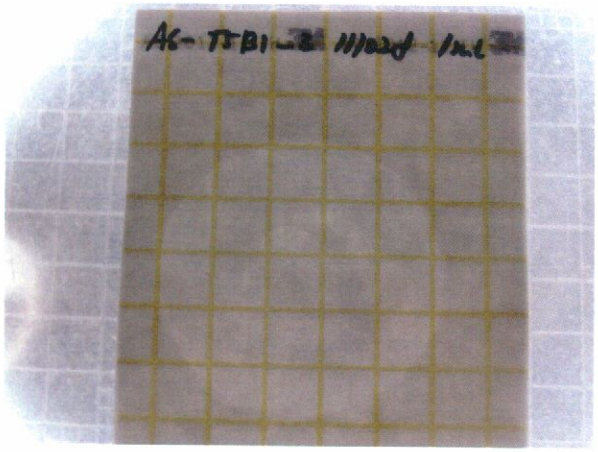


Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL

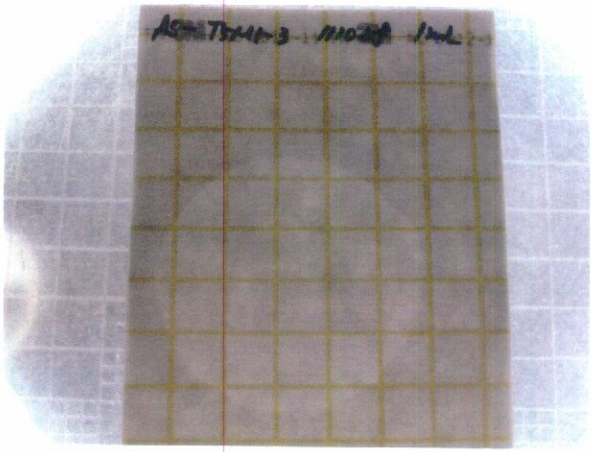
(End of influent water)

3. To be continued

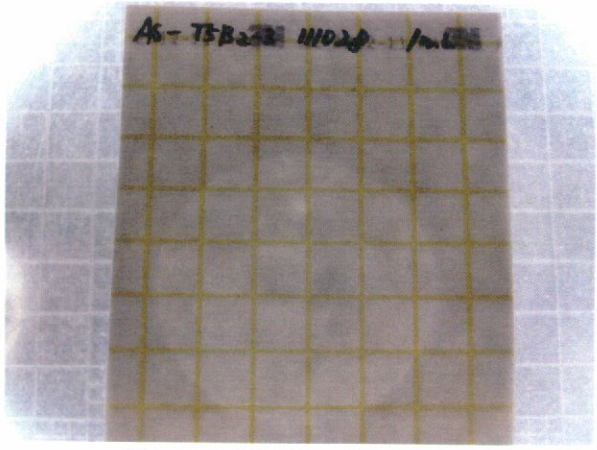
· de-Ballasting (3rd period : 2011. 10. 28, Tongyeong bay)



Heterotrophic bacteria - 1 mL
(1st Beginning of treated water)

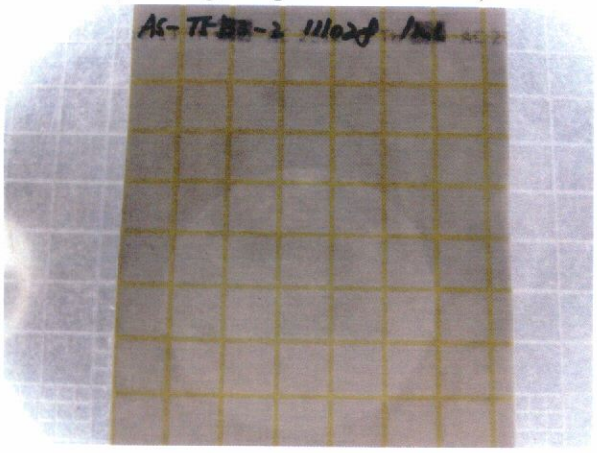


Heterotrophic bacteria - 1 mL
(1st Middle of treated water)

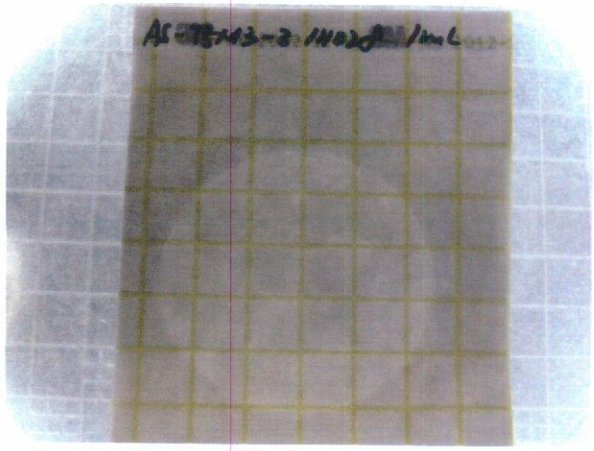


Heterotrophic bacteria - 1 mL
(2nd Beginning of treated water)

Heterotrophic bacteria - 1 mL
(2nd Middle of treated water)



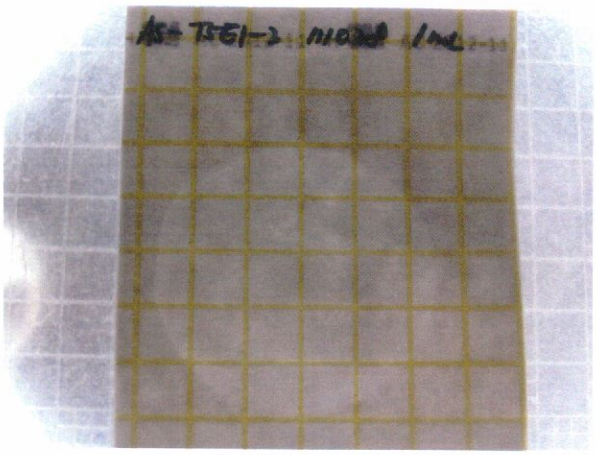
Heterotrophic bacteria - 1 mL
(3rd Beginning of treated water)



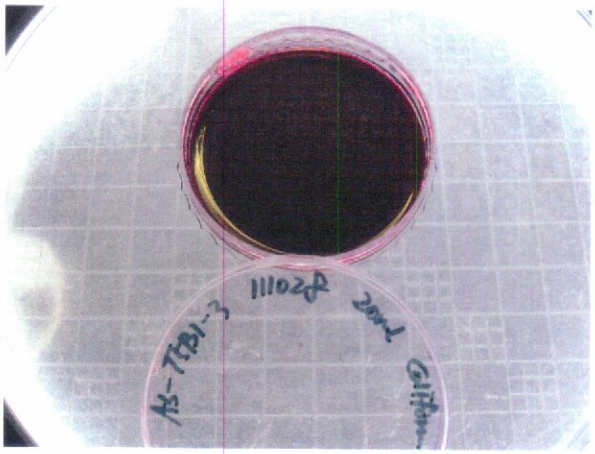
Heterotrophic bacteria - 1 mL
(3rd Middle of treated water)

3. To be continued

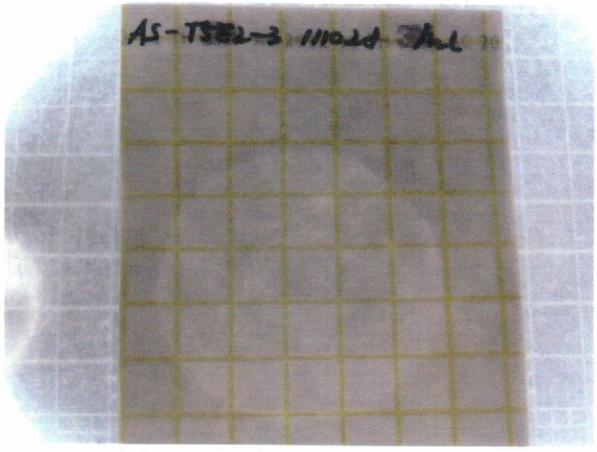
· de-Ballasting (3rd period : 2011. 10. 28, Tongyeong bay)



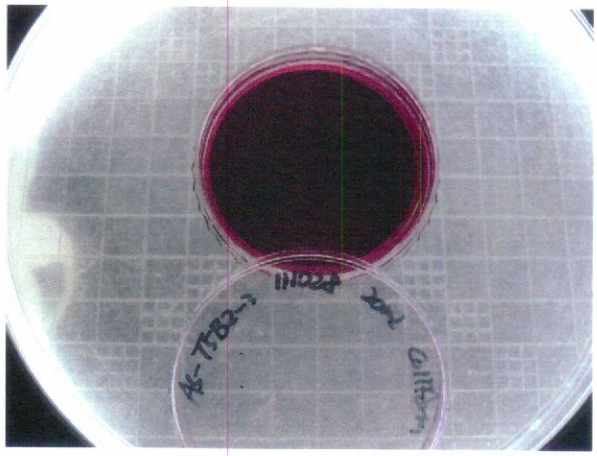
Heterotrophic bacteria - 1 mL
(1st End of treated water)



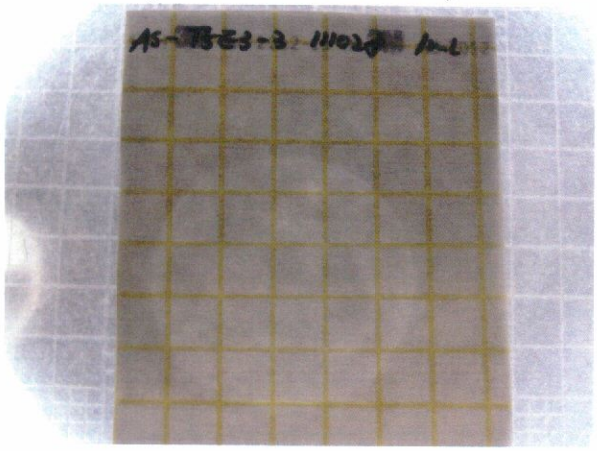
Coliform - 100 mL filtration
(1st Beginning of treated water)



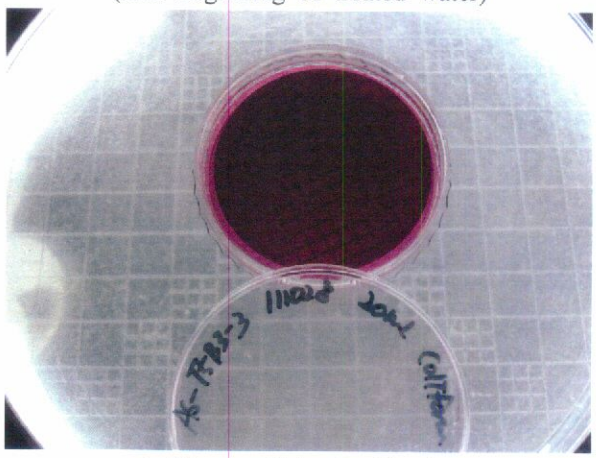
Heterotrophic bacteria - 1 mL
(2nd End of treated water)



Coliform - 100 mL filtration
(2nd Beginning of treated water)



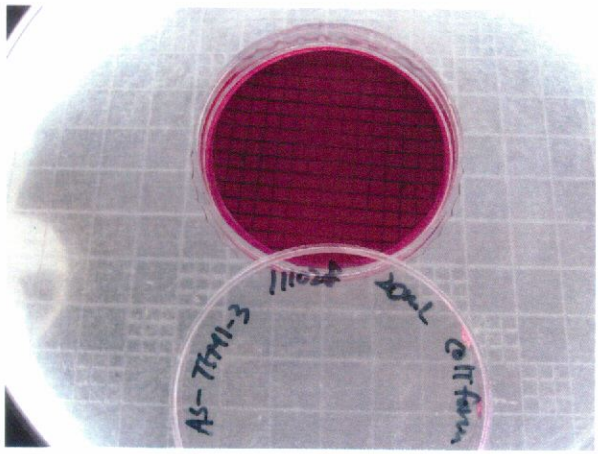
Heterotrophic bacteria - 1 mL
(3rd End of treated water)



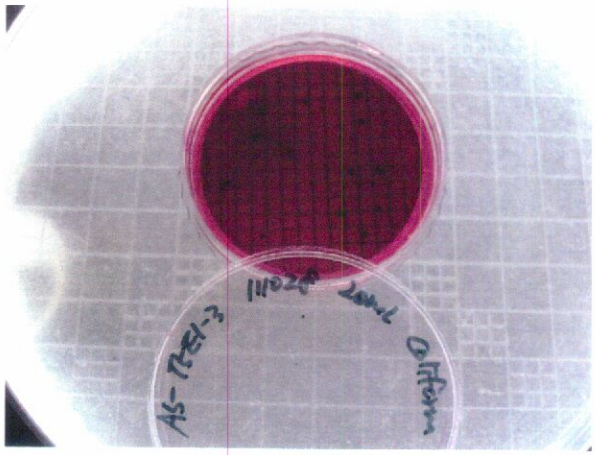
Coliform - 100 mL filtration
(3rd Beginning of treated water)

3. To be continued

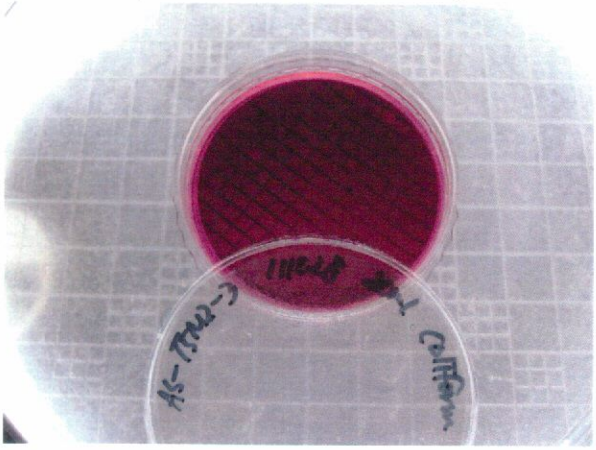
· de-Ballasting (3rd period : 2011. 10. 28, Tongyeong bay)



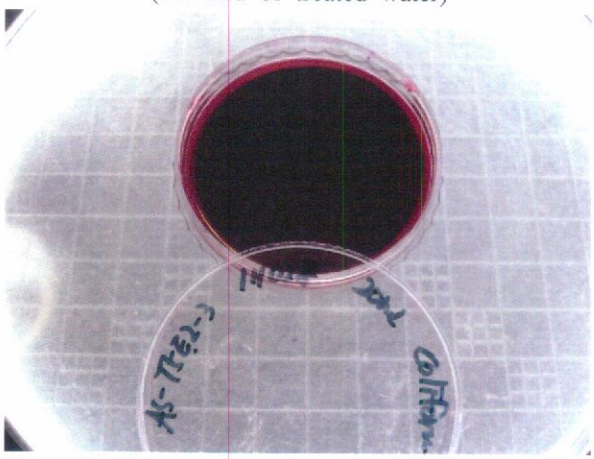
Coliform - 100 mL filtration
(1st Middle of treated water)



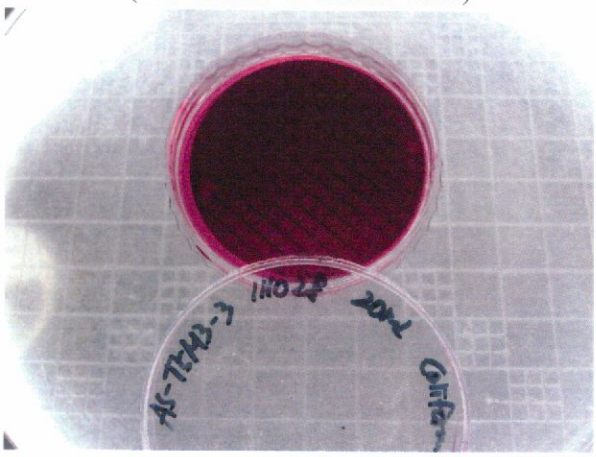
Coliform - 100 mL filtration
(1st End of treated water)



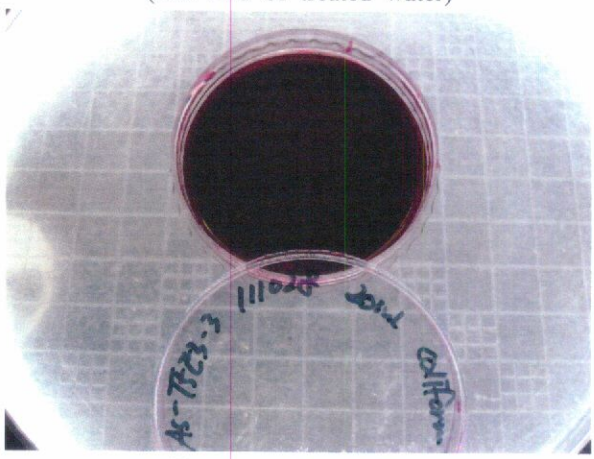
Coliform - 100 mL filtration
(2nd Middle of treated water)



Coliform - 100 mL filtration
(2nd End of treated water)



Coliform - 100 mL filtration
(3rd Middle of treated water)

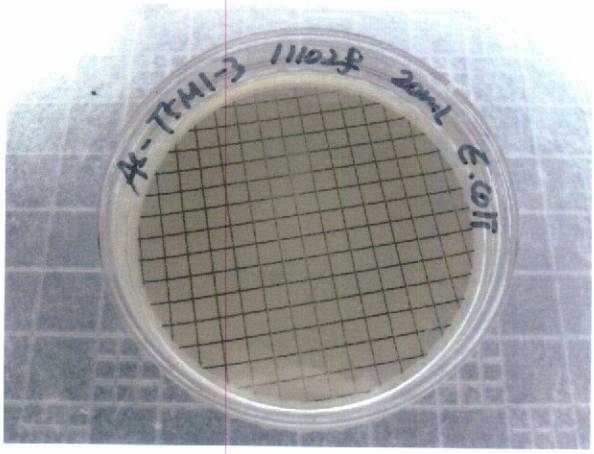


Coliform - 100 mL filtration
(3rd End of treated water)

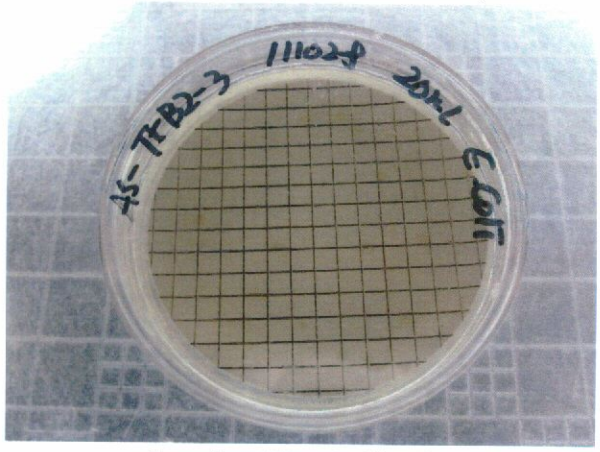
3. To be continued

· de-Ballasting (3rd period : 2011. 10. 28, Tongyeong bay)

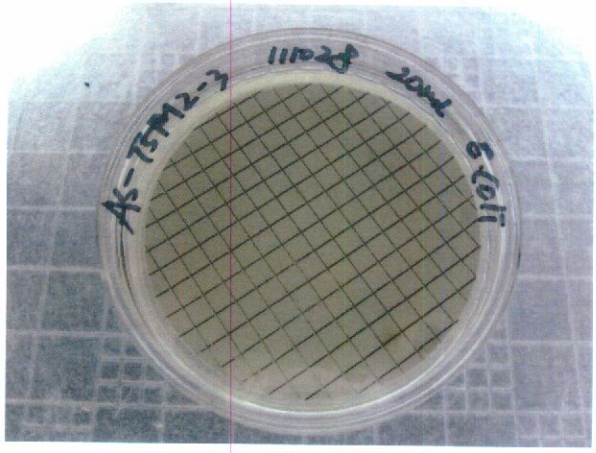
E. coli - 100 mL filtration
(1st Beginning of treated water)



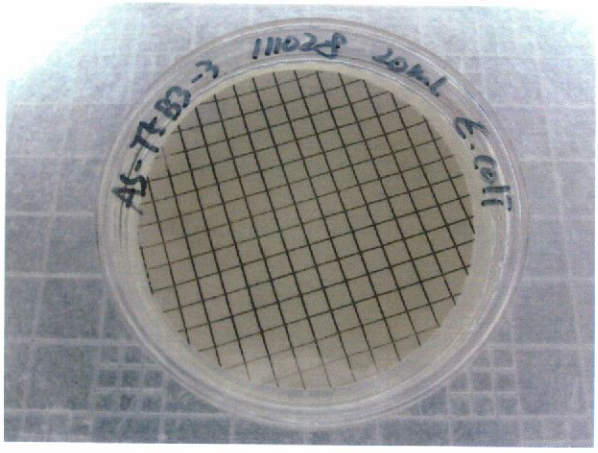
E. coli - 100 mL filtration
(1st Middle of treated water)



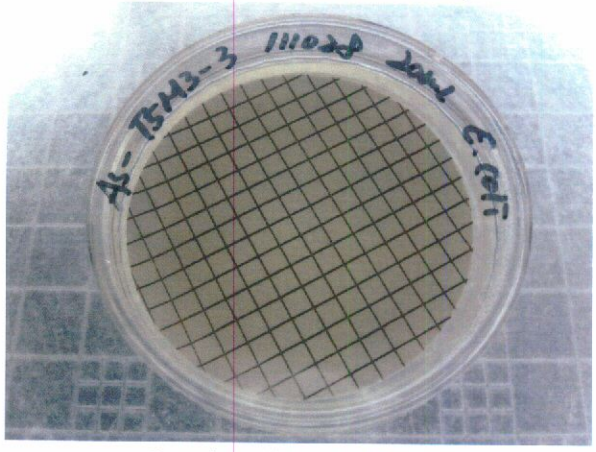
E. coli - 100 mL filtration
(2nd Beginning of treated water)



E. coli - 100 mL filtration
(2nd Middle of treated water)



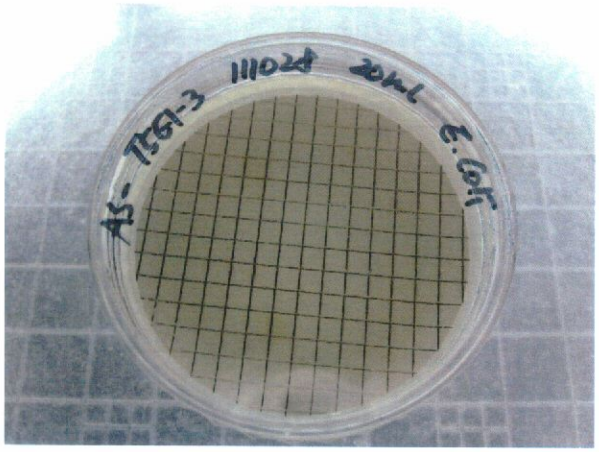
E. coli - 100 mL filtration
(3rd Beginning of treated water)



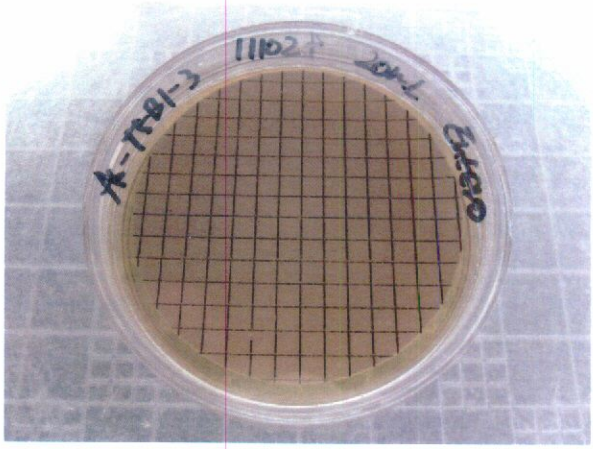
E. coli - 100 mL filtration
(3rd Middle of treated water)

3. To be continued

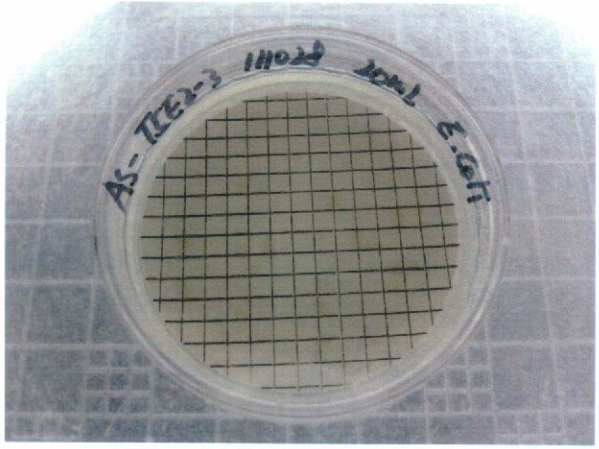
· **de-Ballasting (3rd period : 2011. 10. 28, Tongyeong bay)**



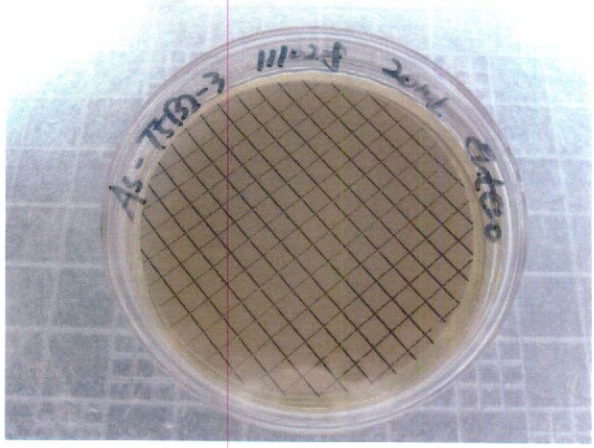
E. coli - 100 mL filtration
(1st End of treated water)



Intestinal Enterococci - 100 mL filtration
(1st Beginning of treated water)

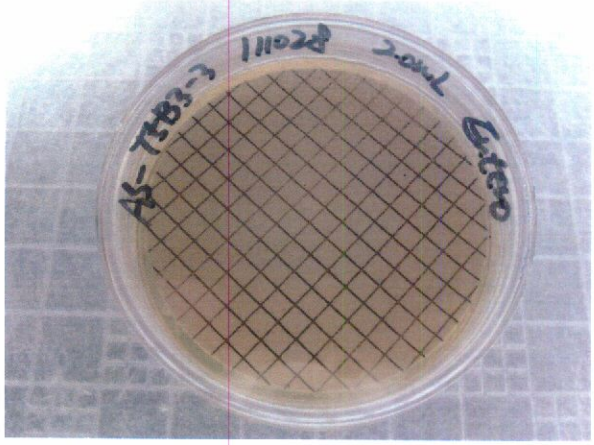


E. coli - 100 mL filtration
(2nd End of treated water)



Intestinal Enterococci - 100 mL filtration
(2nd Beginning of treated water)

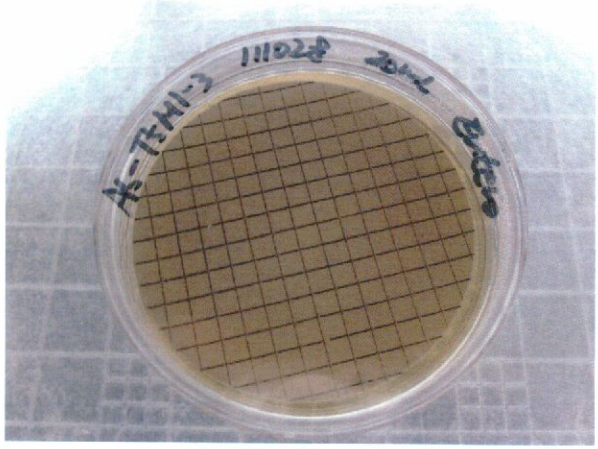
E. coli - 100 mL filtration
(3rd End of treated water)



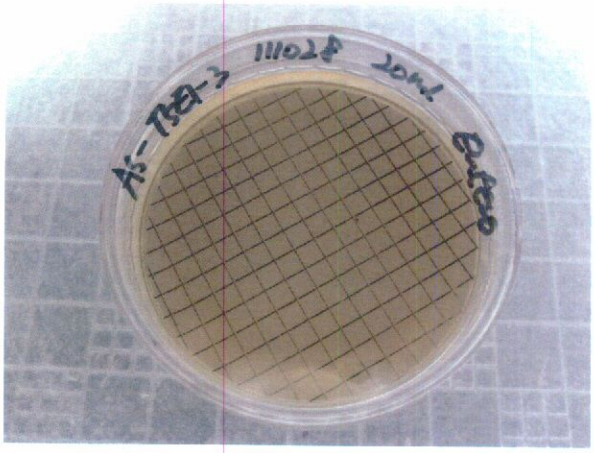
Intestinal Enterococci - 100 mL filtration
(3rd Beginning of treated water)

3. To be continued

· **de-Ballasting (3rd period : 2011. 10. 28, Tongyeong bay)**

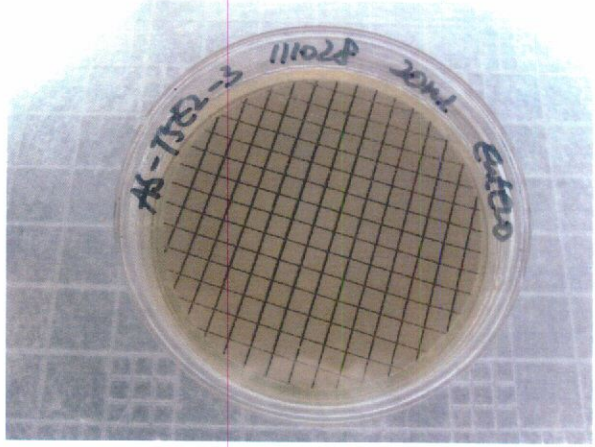


Intestinal Enterococci - 100 mL filtration
(1st Middle of treated water)

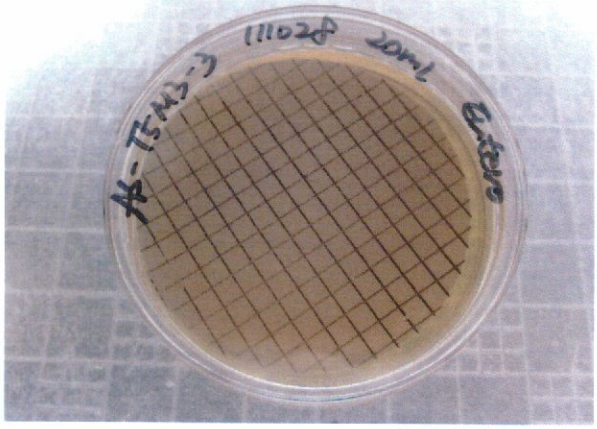


Intestinal Enterococci - 100 mL filtration
(1st End of treated water)

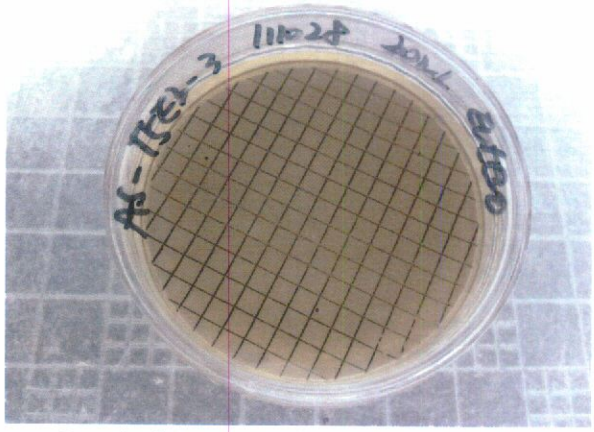
Intestinal Enterococci - 100 mL filtration
(2nd Middle of treated water)



Intestinal Enterococci - 100 mL filtration
(2nd End of treated water)



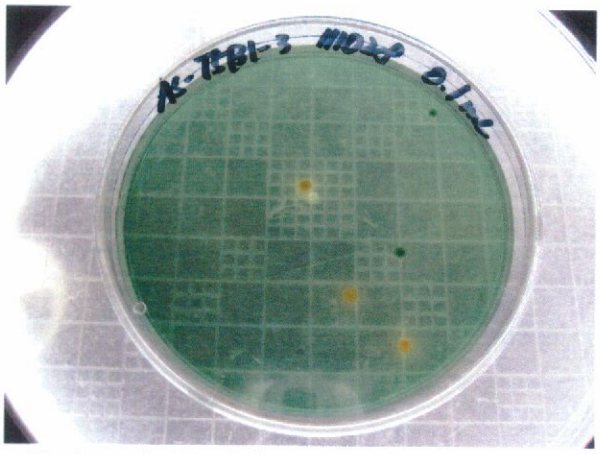
Intestinal Enterococci - 100 mL filtration
(3rd Middle of treated water)



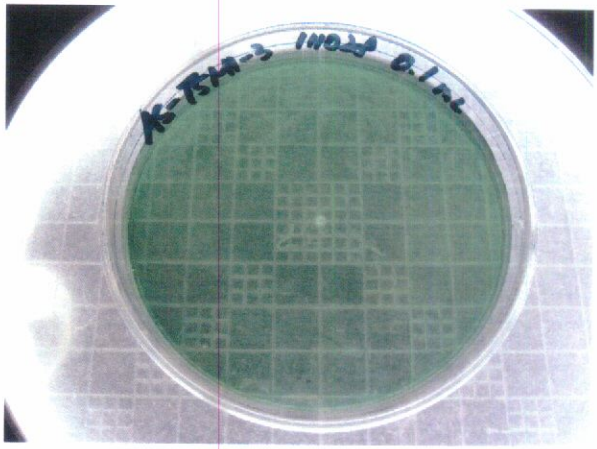
Intestinal Enterococci - 100 mL filtration
(3rd End of treated water)

3. To be continued

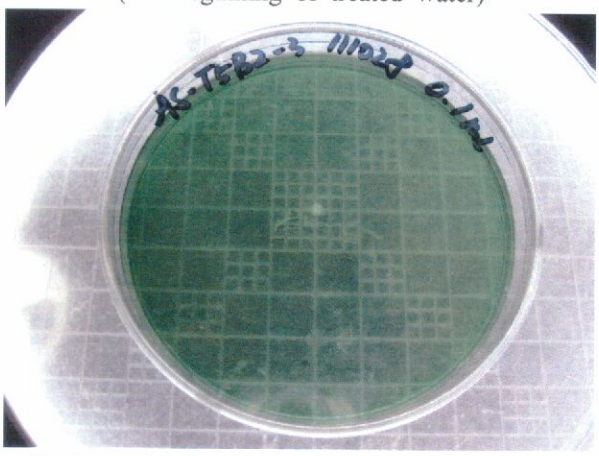
· de-Ballasting (3rd period : 2011. 10. 28, Tongyeong bay)



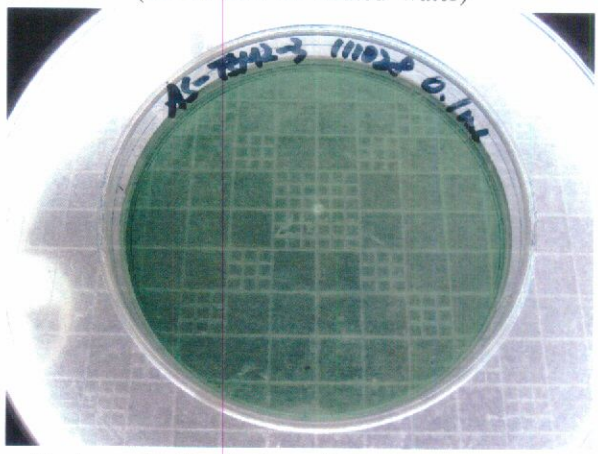
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(1st Beginning of treated water)



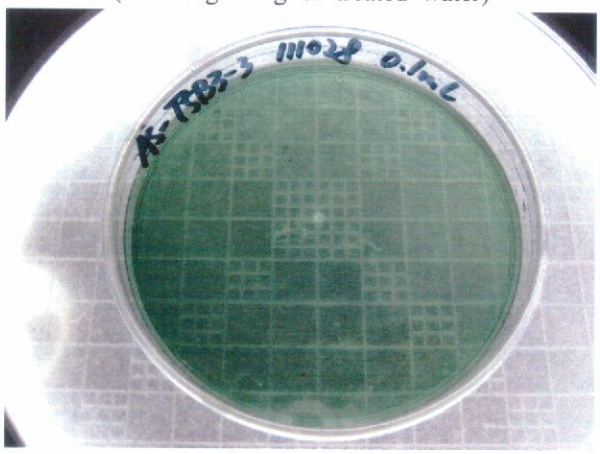
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(1st Middle of treated water)



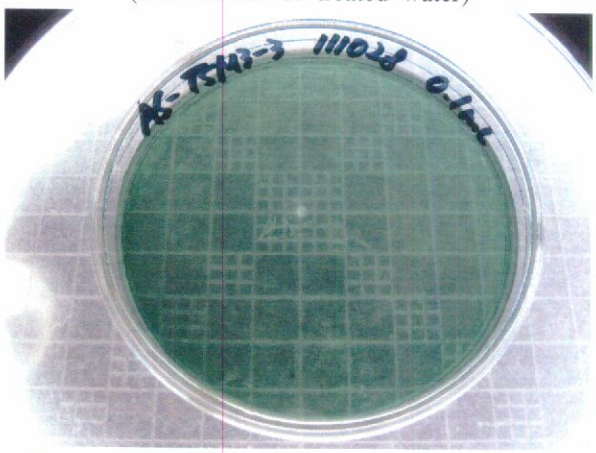
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(2nd Beginning of treated water)



Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(2nd Middle of treated water)



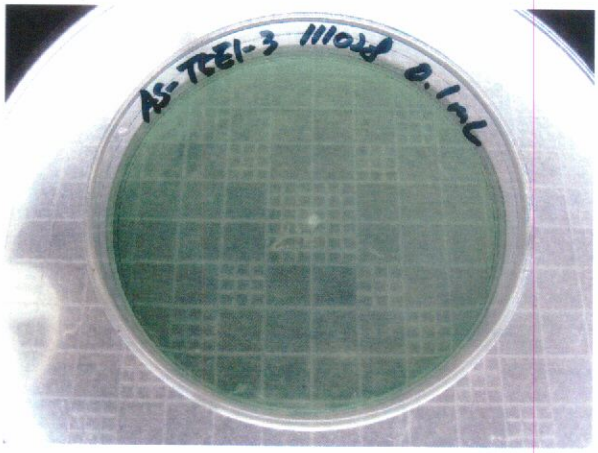
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(3rd Beginning of treated water)



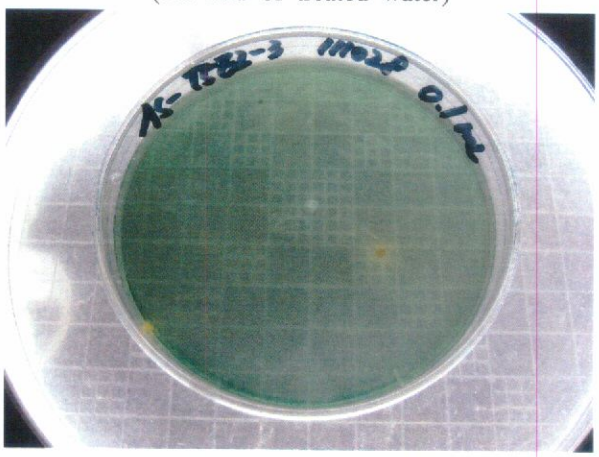
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(3rd Middle of treated water)

3. To be continued

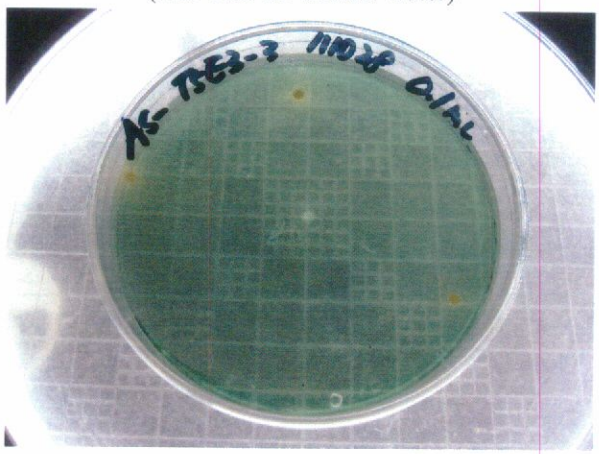
· **de-Ballasting (3rd period : 2011. 10. 28, Tongyeong bay)**



Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(1st End of treated water)



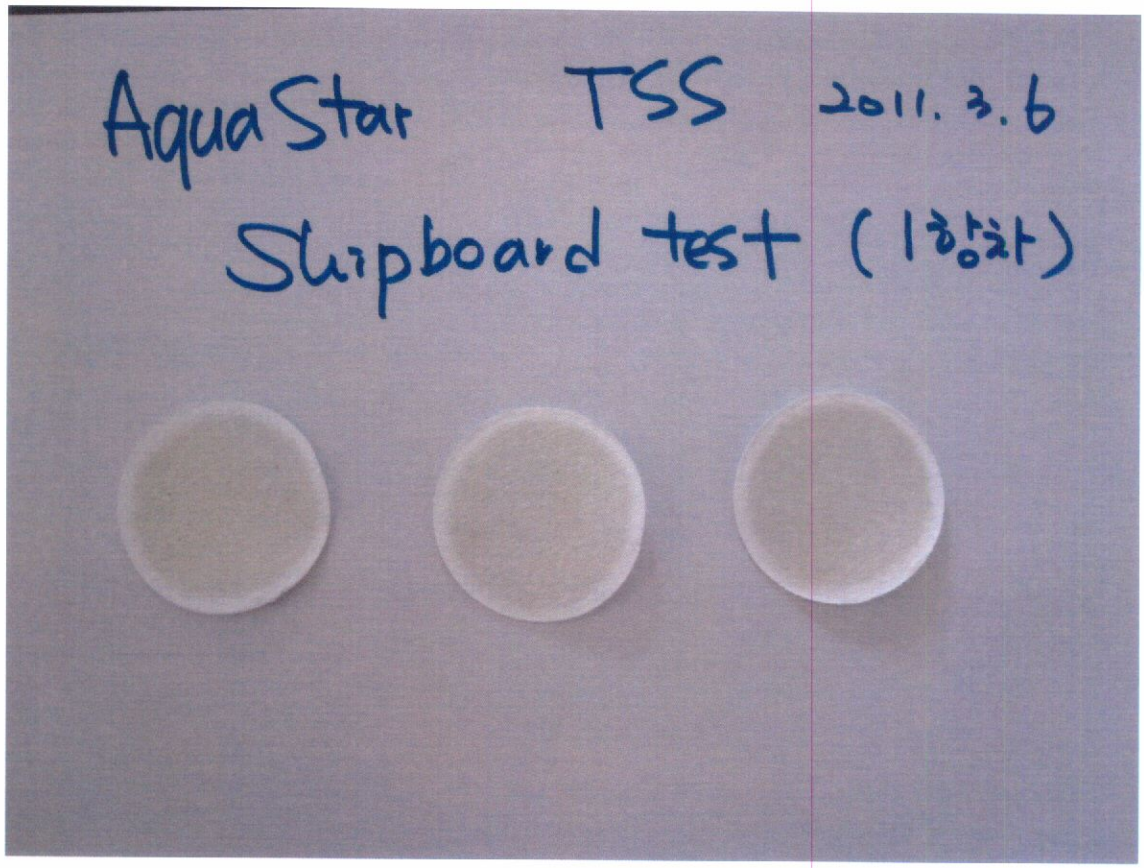
Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(2nd End of treated water)



Toxicogenic *V. cholerae* (O1, O139) - 0.1 mL
(3rd End of treated water)

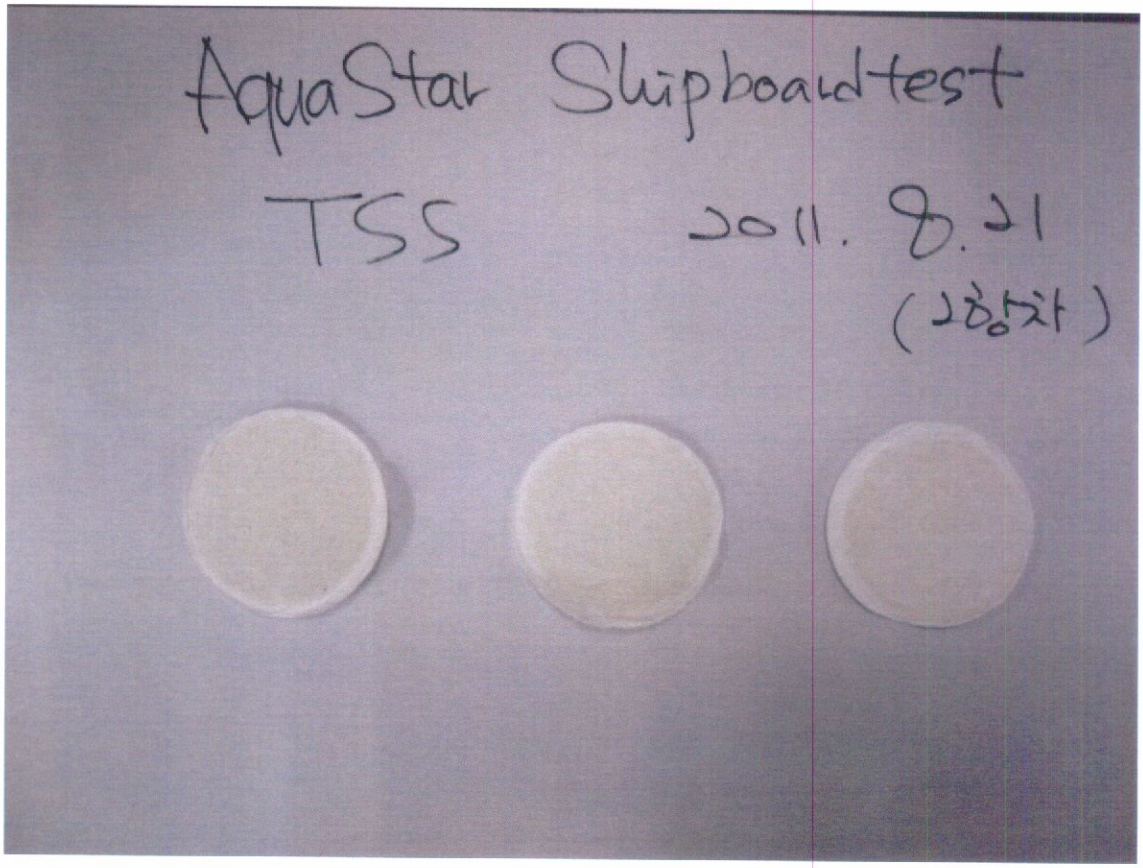
4. Total Suspended Solids (TSS)

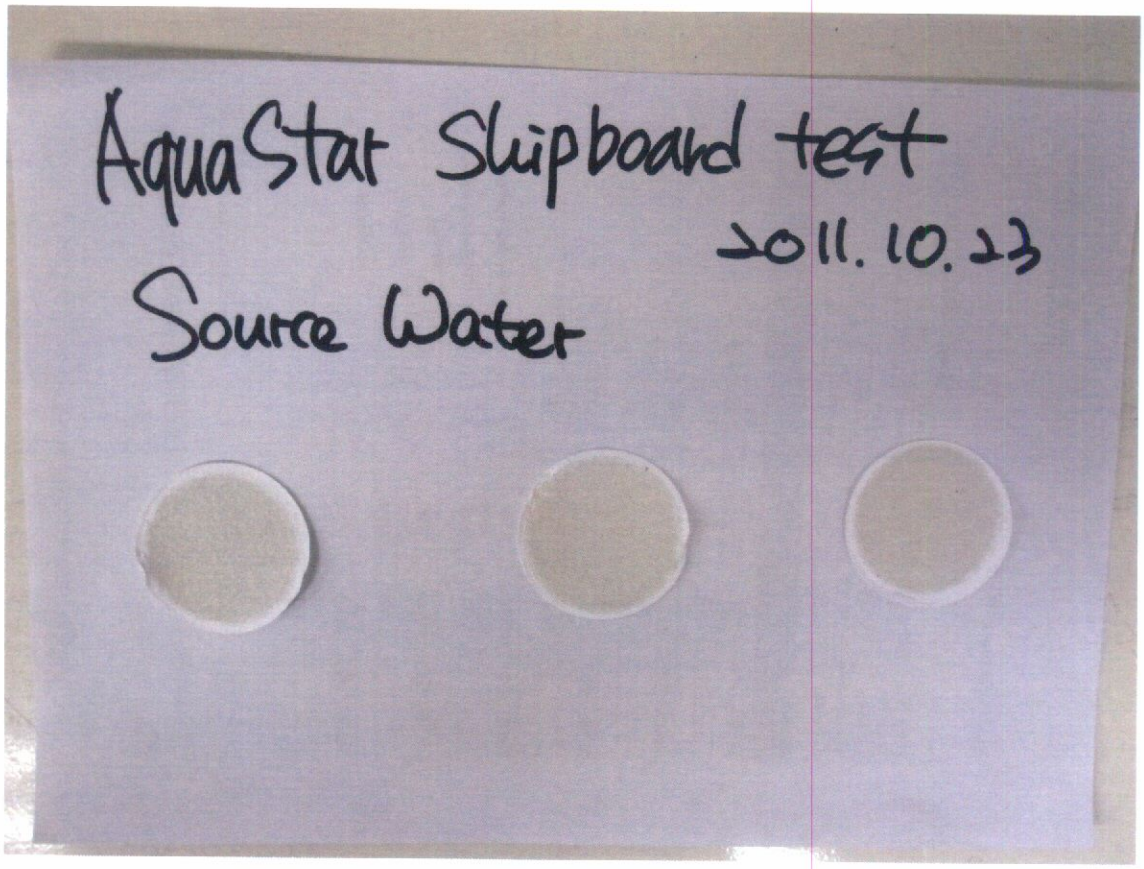
· Ballasting (1st period : 2011. 03 06, Busan newport)



4. To be continued

· Ballasting (2nd period : 2011. 08. 21, Singapore port)



4. To be continued

· Ballasting (3rd period : 2011. 10. 23, Hongkong port)