

**Final Laboratory Testing Report
for
Operation Phase Whole Effluent Toxicity Test for
Advance Disinfection Facilities at Stonecutters Island
Sewage Treatment Works
(Agreement No. HATS03/2015)**

Report for the Month of January 2016

**R&D Corp
The Hong Kong University of Science and Technology**

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1. Introduction

1.1. Background

The whole effluent toxicity tests (WETT) were carried out under the requirements of Drainage Service Department (DSD).

1.2. Testing laboratory and investigator

The following tests were carried out in the Coastal Marine Laboratory (CML), Hong Kong University of Science and Technology.

Principle investigator: Prof. Wen-Xiong WANG

Phone number: (852) 2358-7346

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Address: Division of Life Science, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong

1.3. Sample

A 24-hour flow-weighted composite effluent sample was collected from Stonecutters Island Sewage Treatment Works (SCISTW) on January 20th, 2016. Effluent sample was shipped immediately to the testing laboratory on the same day of collection and stored at 4 °C until use. Toxicity testings were started on the same day after sample collection.

1.4. Test species

The following test species were included in the WETT:

- Amphipod (*Melita longidactyla*)
- Fish (*Lutjanus malabaricus*)
- Barnacle larvae (*Balanus amphitrite*)
- Diatom (*Skeletonema costatum*)
- Shrimp (*Metapenaeus ensis*)

1.5. Test protocols

The WETT testing methods and procedures follow those documented in “Consultancy Study on Fisheries and Marine Ecological Criteria for Impact Assessment-Final Report” commissioned by Agriculture, Fisheries and Conservation Department (AFCD), as indicated in tender addendum No. 1 by Drainage Services Department (DSD).

The report is certified by:

_____ (Prof. Wen-Xiong WANG) Date: _____

2. Report on Amphipod Acute Toxicity Test

Test report

2.1. Samples storage and pretreatment

Effluent sample was thoroughly mixed and passed through 2-mm mesh to remove the large debris. Effluent was added with ocean salt in order to raise the salinity to the required level (30‰) and then aerated moderately such that the dissolved oxygen (DO) reached saturation prior to use. Salinity control was set up to monitor if there was adverse effect on the test organisms.

2.2. Test organism

Species	Amphipod (<i>Melita longidactyla</i>).
Source:	Collected from local coastal waters from Sai Kung
Size/age:	0.5-0.7 cm
Acclimatization:	Acclimatized in fully aerated seawater (temperature: 22±1°C, salinity: 30‰) at least 48 hours in the laboratory prior to test. Fed with green algae <i>Ulva lactuca</i> .

2.3. Summary of test conditions

Type of test:	Static
Duration:	48 h, 24/01/2016-26/01/2016
Dilution seawater source:	Seawater collected from a pristine site in Clear Water Bay, Sai Kung, Hong Kong
Dilution seawater pretreatment:	Filtered through 0.22 µm membrane
Testing temperature:	22±1 °C
Lighting:	Continuous
Salinity:	30‰
Testing chamber:	Pre-cleaned 150 mL glass flask
Feeding:	None
Number of organisms per replicate:	10
Replicate number:	4
Volume of test medium:	100 mL
Aeration:	Moderate, around 100 bubbles/min
Reference toxicant:	CdCl ₂
Positive control:	48 h acute toxicity test
Salinity control:	Prepared with ocean salt adding into de-ionized water, salinity: 30‰

2.4. Test results

Table 1. Survival of amphipods after 48 hours.

Treatment	Effluent concentration (%)	Number of living amphipods after 48 hour (individuals)					
		Replicate 1	Replicate 2	Replicate 3	Replicate 4	Mean	SD
Negative control	0	10	10	10	10	10.0	0.0
Salinity control	0	10	10	10	10	10.0	0.0
Concentration 1	6.5	10	10	10	10	10.0	0.0
Concentration 2	12.5	10	10	10	10	10.0	0.0
Concentration 3	25	8	9	9	8	8.5	0.6
Concentration 4	50	7	5	5	6	5.8	1.0
Concentration 5	100	0	0	0	0	0.0	0.0

Table 2. Survival percentage of amphipods after 48 hours.

Treatment	Effluent concentration (%)	Percentage of living amphipods after 48 hour (%)					
		Replicate 1	Replicate 2	Replicate 3	Replicate 4	Mean	SD
Negative control	0	100.0	100.0	100.0	100.0	100.0	0.0
Salinity control	0	100.0	100.0	100.0	100.0	100.0	0.0
Concentration 1	6.5	100.0	100.0	100.0	100.0	100.0	0.0
Concentration 2	12.5	100.0	100.0	100.0	100.0	100.0	0.0
Concentration 3	25	80.0	90.0	90.0	80.0	85.0	5.8
Concentration 4	50	70.0	50.0	50.0	60.0	57.5	9.6
Concentration 5	100	0.0	0.0	0.0	0.0	0.0	0.0

2.5. Summary of water quality parameters monitoring during test.

Table 3. Summary of water quality parameters during amphipod acute toxicity test.

Water quality parameters	Effluent concentration (%)						
	Negative control	Salinity control	6.5	12.5	25	50	100
Salinity (‰)	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Dissolved oxygen (mg L ⁻¹)	6.0-7.2	6.2-6.7	6.0-7.0	6.0-6.8	6.0-6.8	6.1-7.1	6.1-7.0
Temperature (°C)	22.0	22.0	22.0	22.0	22.0	22.0	22.0
pH	8.0-8.1	7.9-8.1	7.9-8.2	7.6-8.2	8.0-8.1	7.9-8.2	7.6-8.1
Total ammonia (start/end, mg L ⁻¹)	0.06/0.31	0.05/0.15	1.21/0.46	2.25/1.98	4.78/3.91	9.52/8.23	19.8/17.1
Total sulfide (start/end, mg L ⁻¹)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total residual chlorine (start/end, mg L ⁻¹)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total suspended solid (start/end, mg L ⁻¹)	2.1/2.0	2.6/1.9	10.2/5.2	19.2/6.1	39.6/6.6	80.5/13.8	166/38.2

2.6. LC₅₀ for the amphipod *Melita longidactyla* and test acceptability

Table 4. LC₅₀ for the amphipods and test acceptability.

Parameter	Value	Control limit
Calculated LC ₅₀	(56.5±3.0)%	NA
Negative control survival	100.0%	>90%
Reference toxicant 48-h acute test	1.28 mg L ⁻¹	1.25±0.15 mg L ⁻¹
95% of confidence range of reference toxicant test	1.11-1.40 mg L ⁻¹	NA
Daily temperature variation	<0.5 °C	Average daily temperature variation: ±1 °C
Dissolved oxygen concentration	>6.0 mg L ⁻¹	>4 mg L ⁻¹

NA: Not applicable

3. Report on Fish Acute Toxicity Test

Test report

3.1. Samples storage and pretreatment

Effluent sample was thoroughly mixed and passed through 2-mm mesh to remove large debris. Effluent was added with ocean salt in order to raise the salinity to the required level (30‰) and then aerated moderately such that the dissolved oxygen (DO) reached saturation prior to use. Salinity control was set up to monitor if there was adverse effect on the test organisms.

3.2. Test organism

Species	Fish (<i>Lutjanus malabaricus</i>)
Source:	Purchased from local contracted fish farm
Size/age:	5-8 cm
Acclimatization:	Acclimatized in fully aerated seawater (temperature: 22±1°C, salinity: 30‰) at least 48 hours in laboratory prior to test. Fed with fresh shrimp purchased from local market.

3.3. Summary of test conditions

Type of test:	Static
Duration:	48 h, 20/01/2016-22/01/2016
Dilution seawater source:	Seawater collected from a pristine site in Clear Water Bay, Sai Kung, Hong Kong
Dilution seawater pretreatment:	Filtered through 5 µm filtration bag
Testing temperature:	22±1 °C
Lighting:	Continuous
Salinity:	30‰
Testing chamber:	Pre-cleaned 20 L tank
Feeding:	None
Number of organisms per replicate:	10
Replicate number:	4
Volume of test medium:	20 L
Aeration:	Moderate, with air stone
Reference toxicant:	CdCl ₂
Positive control:	48 h acute toxicity test
Salinity control:	Prepared with ocean salt adding into de-ionized water, salinity: 30‰

3.4. Test results

Table 1. Survival of fish after 48 hours.

Treatment	Effluent concentration (%)	Number of living fish after 48 hour (individuals)					
		Replicate 1	Replicate 2	Replicate 3	Replicate 4	Mean	SD
Negative control	0	10	10	9	10	9.8	0.5
Salinity control	0	10	9	10	10	9.8	0.5
Concentration 1	6.5	10	10	10	10	10.0	0.0
Concentration 2	12.5	10	10	10	10	10.0	0.0
Concentration 3	25	10	10	10	10	10.0	0.0
Concentration 4	50	10	10	10	10	10.0	0.0
Concentration 5	100	9	10	9	10	9.5	0.6

Table 2. Survival percentage of fish after 48 hours.

Treatment	Effluent concentration (%)	Percentage of living fish after 48 hour (%)					
		Replicate 1	Replicate 2	Replicate 3	Replicate 4	Mean	SD
Negative control	0	100.0	100.0	90.0	100.0	97.5	5.0
Salinity control	0	100.0	90.0	100.0	100.0	97.5	5.0
Concentration 1	6.5	100.0	100.0	100.0	100.0	100.0	0.0
Concentration 2	12.5	100.0	100.0	100.0	100.0	100.0	0.0
Concentration 3	25	100.0	100.0	100.0	100.0	100.0	0.0
Concentration 4	50	100.0	100.0	100.0	100.0	100.0	0.0
Concentration 5	100	90.0	100.0	90.0	100.0	95.0	5.8

3.5. Summary of water quality parameters monitoring during test

Table 3. Summary of water quality parameters during fish acute toxicity test.

Water quality parameters	Effluent concentration (%)						
	Negative control	Salinity control	6.5	12.5	25	50	100
Salinity (‰)	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Dissolved oxygen (mg L ⁻¹)	6.8-7.2	6.2-7.0	6.2-7.0	6.4-6.9	6.7-6.9	6.6-7.2	6.4-7.1
Temperature (°C)	22.0	22.0	22.0	22.0	22.0	22.0	22.0
pH	7.9-8.1	8.0-8.2	7.9-8.0	7.9-8.2	7.9-8.2	8.0-8.2	7.6-8.0
Total ammonia (start/end, mg L ⁻¹)	0.02/1.21	0.01/0.96	1.36/2.32	2.30/3.51	4.56/5.20	9.15/10.2	20.0/21.1
Total sulfide (start/end, mg L ⁻¹)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total residual chlorine (start/end, mg L ⁻¹)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total suspended solid (mg L ⁻¹)	4.2/5.5	5.5/4.2	11.0/6.2	18.2/6.7	40.2/6.8	91.5/20.3	158.3/33.5

3.6. LC₅₀ for the fish *Lutjanus malabaricus* and test acceptability

Table 4. LC₅₀ for the fish and test acceptability.

Parameter	Value	Control limit
Calculated LC ₅₀	Cannot be calculated ^a	NA
Negative survival	97.5%	>90%
Reference toxicant 48-h acute test	15.8 mg L ⁻¹	14.6±1.78 mg L ⁻¹
95% of confidence range of reference toxicant test	14.6-17.9 mg L ⁻¹	NA
Daily temperature variation	<0.5 °C	Average daily temperature variation: ± 1 °C
Dissolved oxygen concentration	>6.2 mg L ⁻¹	>4 mg L ⁻¹

a: The survivals in all concentration groups were >95%, and thus LC₅₀ cannot be calculated.

NA: Not applicable

4. Report on Barnacle Larvae Acute Toxicity Test

Test report

4.1. Samples storage and pretreatment

Effluent sample was thoroughly mixed and passed through 5 µm membrane filter to remove large debris. Effluent was added with ocean salt in order to raise the salinity to the required level (30‰) and then aerated moderately to dissolved oxygen (DO) saturation prior to use. Salinity control was set up to monitor if there was adverse effect on the test organisms.

4.2. Test organism

Species	Barnacle larvae (<i>Balanus amphitrite</i>).
Source:	Introduced from adult barnacles collected from Sai Kung
Size/age:	Stage II
Acclimatization:	Acclimatized in fully aerated seawater held in 500 mL glass beaker (temperature: 22±1°C, salinity: 30‰) for at least 24 hours in laboratory prior to test. Fed with diatom <i>Chaetoceros gracilis</i> .

4.3. Summary of test conditions

Type of test:	Static
Duration:	48 h, 21/01/2016-23/01/2016
Dilution seawater source:	Seawater collected from a pristine site in Clear Water Bay, Sai Kung, Hong Kong
Dilution seawater pretreatment:	Filtered through 0.22 µm membrane
Testing temperature:	22±1 °C
Lighting:	Continuous
Salinity:	30‰
Testing chamber:	Pre-cleaned 50 mL glass beaker
Feeding:	None
Number of organisms per replicate:	20
Replicate number:	4
Volume of test medium:	20 mL
Aeration:	Moderate, around 100 bubbles/min
Reference toxicant:	CdCl ₂
Positive control:	48 h acute toxicity test
Salinity control:	Prepared with ocean salt adding into de-ionized water, salinity: 30‰

4.4. Test results

Table 1. Survival of barnacle larvae after 48 hours

Treatment	Effluent concentration (%)	Number of living barnacle larvae after 48 hour (individuals)					
		Replicate 1	Replicate 2	Replicate 3	Replicate 4	Mean	SD
Negative control	0	19	19	20	18	19.0	0.8
Salinity control	0	20	19	19	20	19.5	0.6
Concentration 1	6.5	20	18	20	17	18.8	1.5
Concentration 2	12.5	19	19	18	20	19.0	0.8
Concentration 3	25	20	20	16	20	19.0	2.0
Concentration 4	50	16	17	15	20	17.0	2.2
Concentration 5	100	0	0	0	0	0.0	0.0

Table 2. Survival percentage of barnacle larvae after 48 hours.

Treatment	Effluent concentration (%)	Percentage of living barnacle larvae after 48 hour (%)					
		Replicate 1	Replicate 2	Replicate 3	Replicate 4	Mean	SD
Negative control	0	95.0	95.0	100.0	90.0	95.0	4.1
Salinity control	0	100.0	95.0	95.0	100.0	97.5	2.9
Concentration 1	6.5	100.0	90.0	100.0	85.0	93.8	7.5
Concentration 2	12.5	95.0	95.0	90.0	100.0	95.0	4.1
Concentration 3	25	100.0	100.0	80.0	100.0	95.0	10.0
Concentration 4	50	80.0	85.0	75.0	100.0	85.0	10.8
Concentration 5	100	0.0	0.0	0.0	0.0	0.0	0.0

4.5. Summary of water quality parameters monitoring during test

Table 3. Summary of water quality parameters during barnacle larvae acute toxicity test

Water quality parameters	Effluent concentration (%)						
	Negative control	Salinity control	6.5	12.5	25	50	100
Salinity (‰)	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Dissolved oxygen (mg L ⁻¹)	6.4-6.6	6.4-6.6	6.2-6.6	6.2-6.4	6.4-6.6	6.2-6.4	6.4-6.6
Temperature (°C)	22.0	22.0	22.0	22.0	22.0	22.0	22.0
pH	7.9-8.2	8.0-8.1	7.6-8.1	7.9-8.1	7.9-8.2	8.0-8.2	7.6-7.9
Total ammonia (start/end, mg L ⁻¹)	0.06/0.02	0.06/0.05	1.64/1.31	2.17/1.92	4.88/4.16	10.5/9.98	22.3/19.5
Total sulfide (start/end, mg L ⁻¹)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total residual chlorine (start/end, mg L ⁻¹)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total suspended solid (mg L ⁻¹)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2

4.6. LC₅₀ for the barnacle larvae *Balanus amphitrite* and test acceptability

Table 4. LC₅₀ for the barnacle larvae and test acceptability

Parameter	Value	Control limit
Calculated LC ₅₀	(71.8±1.7)%	NA
Negative survival	95.0%	>90%
Reference toxicant 48-h acute test	0.98 mg L ⁻¹	1.04±0.11 mg L ⁻¹
95% of confidence range of reference toxicant test:	0.89-1.18 mg L ⁻¹	NA
Daily temperature variation	<0.5 °C	Average daily temperature variation: ± 1 °C
Dissolved oxygen concentration	>6.2 mg L ⁻¹	>4 mg L ⁻¹

NA: Not applicable

5. Report on Diatom Growth Inhibition Test (Chronic toxicity test)

Test report

5.1. Samples storage and pretreatment

Effluent sample was thoroughly mixed and passed through 5 µm membrane filter to remove large debris. Effluent was added with ocean salt in order to raise the salinity to the required level (30‰) and then aerated moderately to dissolved oxygen (DO) saturation prior to use. Salinity control was set up to monitor if there was adverse effect on the test organisms.

5.2. Test organism

Species	Diatom (<i>Skeletonema costatum</i>)
Source:	Grown from laboratory culture obtained from Coastal Marine Lab, Hong Kong University of Science and Technology
Size/age:	Log growth phase
Acclimatization:	Grown in 250 mL glass flask (temperature: 22±1°C, salinity: 30‰, 3000 lux) for at least two weeks prior to test.

5.3. Summary of test conditions

Type of test:	Static
Duration:	7 days, 24/01/2016-31/01/2016
Dilution seawater source:	Seawater collected from a pristine site in Clear Water Bay, Sai Kung, Hong Kong
Dilution seawater pretreatment:	Filtered through 0.22 µm membrane
Testing temperature:	22±1 °C
Lighting:	12 h light/12 h dark cycle, 3000±500 lux
Salinity:	30‰
Testing chamber:	Pre-cleaned 100 mL glass beaker
Initial cell density:	(5.0±0.4)×10 ⁴ cell mL ⁻¹
Replicate number:	4
Volume of test medium:	25 mL
Aeration:	None
Reference toxicant:	CdCl ₂
Positive control:	7-day IC ₅₀ toxicity test
Salinity control:	Prepared with ocean salt adding into de-ionized water, salinity: 30‰

5.4. Test results

Table 1. Cell density of diatom *Skeletonema costatum* at the beginning and end of growth inhibition test. Initial cell density: $(5.0 \pm 0.4) \times 10^4$ cell mL⁻¹.

Treatment	Effluent concentration (%)	Cell density after 7-day growth ($\times 10^6$ cell mL ⁻¹)					
		Replicate 1	Replicate 2	Replicate 3	Replicate 4	Mean	SD
Negative control	0	1.18	1.35	1.26	1.21	1.25	0.07
Salinity control	0	1.35	1.46	1.25	1.30	1.34	0.09
Concentration 1	2.5	1.64	1.64	1.54	1.68	1.63	0.06
Concentration 2	5	1.76	1.78	1.84	1.73	1.78	0.05
Concentration 3	10	2.05	2.02	1.95	2.01	2.01	0.04
Concentration 4	25	0.75	0.76	0.69	0.66	0.72	0.05
Concentration 5	50	0.24	0.26	0.24	0.21	0.24	0.02
Concentration 6	100	0.00	0.00	0.00	0.00	0.00	0.00

Table 2. Growth rate of *Skeletonema costatum* within 7 days.

Treatment	Effluent concentration (%)	7-day average growth rate (d ⁻¹)					
		Replicate 1	Replicate 2	Replicate 3	Replicate 4	Mean	SD
Negative control	0	0.45	0.47	0.46	0.45	0.46	0.01
Salinity control	0	0.47	0.48	0.46	0.47	0.47	0.01
Concentration 1	2.5	0.50	0.50	0.49	0.50	0.50	0.01
Concentration 2	5	0.51	0.51	0.52	0.51	0.51	0.00
Concentration 3	10	0.53	0.53	0.52	0.53	0.53	0.00
Concentration 4	25	0.39	0.39	0.38	0.37	0.38	0.01
Concentration 5	50	0.22	0.24	0.22	0.21	0.22	0.01
Concentration 6	100	0.00	0.00	0.00	0.00	0.00	0.00

5.5. Summary of water quality parameters monitoring during test

Table 3. Summary of water quality parameters during diatom growth inhibition test

Water quality parameters	Effluent concentration (%)							
	Negative control	Salinity control	2.5	5.0	10	25	50	100
Salinity (‰)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
Dissolved oxygen (mg L ⁻¹)	6.2-9.3	6.5-10.2	6.4-9.5	6.3-8.8	6.5-10.1	6.5-9.5	6.4-8.8	6.0-7.2
Temperature (°C)	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
pH	8.2-8.8	8.4-8.8	8.5-8.7	7.9-9.0	8.4-8.8	8.1-8.7	8.0-8.7	7.6-8.1
Total ammonia (start/end, mg L ⁻¹)	0.07/0.06	0.04/0.05	0.56/0.05	1.39/0.07	2.67/0.23	5.44/0.31	10.3/7.87	19.3/18.2
Total sulfide (start/end, mg L ⁻¹)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total residual chlorine (start/end, mg L ⁻¹)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total suspended solid (mg L ⁻¹)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2

5.6. IC₅₀ for the diatom *Skeletonema costatum* and test acceptability

Table 4. IC₅₀, none observed effect concentration (NOEC) for the diatom and test acceptability

Parameter	Value	Control limit
Calculated IC ₅₀	(45.9±0.8)%	NA
None observed effect concentration (NOEC)	10%	-
Reference toxicant 7-day test:	0.13 mg L ⁻¹	0.13±0.02 mg L ⁻¹
95% of confidence range of reference toxicant test	0.10-0.18 mg L ⁻¹	NA
Temperature variation	<0.5 °C	Average daily temperature variation: ± 1 °C

NA: Not applicable

6. Report on Shrimp Acute Toxicity Test

Test report

6.1. Samples storage and pretreatment

Effluent sample was thoroughly mixed and passed through 2-mm mesh to remove the large debris. Effluent was added with ocean salt in order to raise the salinity to 25‰ and then aerated moderately such that the dissolved oxygen (DO) reached saturation prior to use. Salinity control was set up to monitor if there was adverse effect on the test organisms.

6.2. Test organism

Species	Shrimp (<i>Metapenaeus ensis</i>).
Source:	Purchased from contracted fish dealer
Size/age:	5-7 cm
Acclimatization:	Acclimatized in fully aerated seawater (temperature: 22±1°C, salinity: 25‰) at least 48 hours in the laboratory prior to test. Fed with commercial shrimp feeds.

6.3. Summary of test conditions

Type of test:	Static
Duration:	48 h, 20/01/2016-22/01/2016
Dilution seawater source:	Seawater collected from a pristine site in Clear Water Bay, Sai Kung, Hong Kong
Dilution seawater pretreatment:	Filtered through 0.22 µm membrane
Testing temperature:	22±1 °C
Lighting:	Continuous
Salinity:	25‰
Testing chamber:	Pre-cleaned 20 L tank
Feeding:	None
Number of organisms per replicate:	10
Replicate number:	4
Volume of test medium:	10 L
Aeration:	Moderate, with air stone
Reference toxicant:	CdCl ₂
Positive control:	48 h acute toxicity test
Salinity control:	Prepared with ocean salt adding into de-ionized water, salinity: 25‰

6.4. Test results

Table 1. Survival of shrimps after 48 hours.

Treatment	Effluent concentration (%)	Number of living shrimps after 48 hour (individuals)					
		Replicate 1	Replicate 2	Replicate 3	Replicate 4	Mean	SD
Negative control	0	10	9	9	9	9.3	0.5
Salinity control	0	9	10	9	10	9.5	0.6
Concentration 1	6.5	8	10	10	9	9.3	1.0
Concentration 2	12.5	10	9	9	9	9.3	0.5
Concentration 3	25	9	7	10	9	8.8	1.3
Concentration 4	50	7	8	9	8	8.0	0.8
Concentration 5	100	9	7	9	7	8.0	1.2

Table 2. Survival percentage of shrimps after 48 hours.

Treatment	Effluent concentration (%)	Percentage of living shrimps after 48 hour (%)					
		Replicate 1	Replicate 2	Replicate 3	Replicate 4	Mean	SD
Negative control	0	100	90	90	90	92.5	5.0
Salinity control	0	90	100	90	100	95.0	5.8
Concentration 1	6.5	80	100	100	90	92.5	9.6
Concentration 2	12.5	100	90	90	90	92.5	5.0
Concentration 3	25	90	70	100	90	87.5	12.6
Concentration 4	50	70	80	90	80	80.0	8.2
Concentration 5	100	90	70	90	70	80.0	11.6

6.5. Summary of water quality parameters monitoring during test.

Table 3. Summary of water quality parameters during shrimp acute toxicity test.

Water quality parameters	Effluent concentration (%)						
	Negative control	Salinity control	6.5	12.5	25	50	100
Salinity (‰)	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Dissolved oxygen (mg L ⁻¹)	6.3-7.0	6.3-7.1	6.5-7.3	6.5-7.2	6.3-7.1	6.8-7.3	6.5-7.3
Temperature (°C)	22.0	22.0	22.0	22.0	22.0	22.0	22.0
pH	7.9-8.1	7.9-8.2	7.9-8.1	7.9-8.2	7.9-8.1	7.9-8.2	7.6-8.0
Total ammonia (start/end, mg L ⁻¹)	0.04/0.13	0.03/0.10	1.55/1.78	2.54/2.98	4.78/5.41	9.23/10.3	20.3/21.2
Total sulfide (start/end, mg L ⁻¹)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total residual chlorine (start/end, mg L ⁻¹)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Total suspended solid (start/end, mg L ⁻¹)	4.2/6.3	5.5/6.2	10.1/6.3	20.3/7.1	41.2/8.6	83.5/15.3	170/44.3

6.6 LC₅₀ for the shrimp *Metapenaeus ensis* and test acceptability

Table 4. LC₅₀ for the *Metapenaeus ensis* and test acceptability.

Parameter	Value	Control limit
Calculated LC ₅₀	Cannot be calculated ^a	NA
Negative control survival	92.5%	>90%
Reference toxicant 48-h acute test	5.0 mg L ⁻¹	5.19±0.51 mg L ⁻¹
95% of confidence range of reference toxicant test	4.1-5.8 mg L ⁻¹	NA
Daily temperature variation	<0.5 °C	Average daily temperature variation: ±1 °C
Dissolved oxygen concentration	>6.3 mg L ⁻¹	>4 mg L ⁻¹

a: The survivals in all concentration groups were >80%, and thus LC₅₀ cannot be calculated.

NA: Not applicable

7. Conclusion

Table 1. Comparison of measured toxicity values with the target toxicity levels.

Test species	Measured LC ₅₀ /IC ₅₀ /NOEC	Target toxicity level
Amphipod <i>Melita longidactyla</i>	56.5%	≥7.1%
Fish <i>Lutjanus malabaricus</i>	Cannot be calculated*	≥7.1%
Barnacle larvae <i>Balanus amphitrite</i>	71.8%	≥7.1%
Diatom <i>Skeletonema costatum</i>	45.9% (IC ₅₀)	-
Diatom <i>Skeletonema costatum</i>	10% (NOEC)	≥0.51%
Shrimp <i>Metapenaeus ensis</i>	Cannot be calculated**	≥7.1%

*The survivals in all concentration groups were >95%, and thus LC₅₀ cannot be calculated.

**The survivals in all concentration groups were >80%, and thus LC₅₀ cannot be calculated.

Conclusion: all the measured values met the target toxicity levels as indicated in the EM&A Manual.

Appendix A

Monitoring Data
for
Amphipod Acute Toxicity Test

Table 1. Dissolved oxygen concentration and pH in each concentration treatment in amphipod acute toxicity test.

Concentration treatment (%)	Dissolved oxygen (mg L ⁻¹)					pH				
	0 h	12 h	24 h	36 h	48 h	0 h	12 h	24 h	36 h	48 h
Negative control	6.7	6.0	6.8	7.1	6.5	8.0	8.0	8.1	8.0	8.0
Salinity control	6.3	6.7	6.2	6.5	6.7	8.1	8.1	8.1	7.9	8.0
6.5	6.0	6.6	7.0	6.7	6.0	8.2	7.9	7.9	8.0	8.0
12.5	6.6	6.3	6.8	6.0	6.6	8.2	7.7	7.6	7.6	8.0
25	6.8	6.3	6.8	6.0	6.8	8.0	8.1	8.0	8.1	8.1
50	6.1	6.8	6.8	6.7	7.1	8.0	8.2	8.2	7.9	7.9
100	7.0	6.9	6.4	6.1	6.3	7.7	7.6	7.6	8.1	7.8

Table 2. Salinity and temperature in each concentration treatment in amphipod acute toxicity test.

Concentration treatment (%)	Salinity (‰)					Temperature (°C)				
	0 h	12 h	24 h	36 h	48 h	0 h	12 h	24 h	36 h	48 h
Negative control	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0
Salinity control	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0
6.5	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0
12.5	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0
25	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0
50	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0
100	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0

Table 3. Ammonia-N, sulphide, total suspended solids, total residual chlorine concentration at the beginning and ending of the amphipod acute toxicity test.

Concentration treatment (%)	Ammonia-N (mg L ⁻¹)		Sulphide (mg L ⁻¹)		Total suspended solids (mg L ⁻¹)		Total residual chlorine (mg L ⁻¹)	
	Initial	End	Initial	End	Initial	End	Initial	End
Negative control	0.06	0.31	<0.1	<0.1	2.1	2.0	<0.02	<0.02
Salinity control	0.05	0.15	<0.1	<0.1	2.6	1.9	<0.02	<0.02
6.5	1.21	0.46	<0.1	<0.1	10.2	5.2	<0.02	<0.02
12.5	2.25	1.98	<0.1	<0.1	19.2	6.1	<0.02	<0.02
25	4.78	3.91	<0.1	<0.1	39.6	6.6	<0.02	<0.02
50	9.52	8.23	<0.1	<0.1	80.5	13.8	<0.02	<0.02
100	19.8	17.1	<0.1	<0.1	166	38.2	<0.02	<0.02

Appendix B

**Monitoring Data
for
Fish Acute Toxicity Test**

Table 1. Dissolved oxygen concentration and pH in each concentration treatment in fish acute toxicity test.

Concentration treatment (%)	Dissolved oxygen (mg L ⁻¹)					pH				
	0 h	12 h	24 h	36 h	48 h	0 h	12 h	24 h	36 h	48 h
Negative control	6.7	6.8	6.7	6.7	7.2	8.1	7.9	8.0	7.9	8.0
Salinity control	7.0	6.7	6.2	7.0	6.8	8.1	8.1	8.1	8.2	8.0
6.5	6.5	7.0	6.2	6.4	6.8	8.1	7.9	7.9	8.0	7.9
12.5	6.9	6.4	6.6	6.8	6.8	7.9	8.2	7.9	8.2	8.2
25	6.9	6.8	6.7	6.7	7.2	7.9	7.9	8.2	8.0	8.2
50	6.6	6.7	6.9	7.2	6.4	8.0	8.1	8.2	8.0	8.0
100	7.1	6.4	6.9	6.8	7.0	7.9	8.0	8.0	7.8	7.6

Table 2. Salinity and temperature in each concentration treatment in fish acute toxicity test.

Concentration treatment (%)	Salinity (‰)					Temperature (°C)				
	0 h	12 h	24 h	36 h	48 h	0 h	12 h	24 h	36 h	48 h
Negative control	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0
Salinity control	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0
6.5	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0
12.5	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0
25	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0
50	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0
100	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0

Table 3. Ammonia-N, sulphide, total suspended solids, total residual chlorine concentration at the beginning and ending of the fish acute toxicity test.

Concentration treatment (%)	Ammonia-N (mg L ⁻¹)		Sulphide (mg L ⁻¹)		Total suspended solids (mg L ⁻¹)		Total residual chlorine (mg L ⁻¹)	
	Initial	End	Initial	End	Initial	End	Initial	End
Negative control	0.02	1.21	<0.1	<0.1	4.2	5.5	<0.02	<0.02
Salinity control	0.01	0.96	<0.1	<0.1	5.5	4.2	<0.02	<0.02
6.5	1.36	2.32	<0.1	<0.1	11.0	6.2	<0.02	<0.02
12.5	2.30	3.51	<0.1	<0.1	18.2	6.7	<0.02	<0.02
25	4.56	5.20	<0.1	<0.1	40.2	6.8	<0.02	<0.02
50	9.15	10.2	<0.1	<0.1	91.5	20.3	<0.02	<0.02
100	20.0	21.1	<0.1	<0.1	158.3	33.5	<0.02	<0.02

Appendix C

Monitoring Data
for
Barnacle Larvae Acute Toxicity Test

Table 1. Dissolved oxygen concentration and pH in each concentration treatment in barnacle larvae acute toxicity test.

Concentration treatment (%)	Dissolved oxygen (mg L ⁻¹)					pH				
	0 h	12 h	24 h	36 h	48 h	0 h	12 h	24 h	36 h	48 h
Negative control	6.4	6.5	6.6	6.6	6.5	8.2	7.9	8.2	8.1	8.1
Salinity control	6.5	6.6	6.4	6.6	6.5	8.1	8.0	8.1	8.0	8.1
6.5	6.2	6.6	6.5	6.6	6.6	7.6	7.7	8.1	8.1	8.1
12.5	6.4	6.3	6.4	6.2	6.6	7.9	8.1	7.9	7.9	8.0
25	6.4	6.6	6.5	6.5	6.4	8.2	8.1	8.2	8.2	7.9
50	6.4	6.3	6.4	6.2	6.6	8.1	8.2	8.1	8.1	8.0
100	6.4	6.6	6.5	6.5	6.4	7.7	7.9	7.8	7.6	7.7

Table 2. Salinity and temperature in each concentration treatment in barnacle larvae acute toxicity test.

Concentration treatment (%)	Salinity (‰)					Temperature (°C)				
	0 h	12 h	24 h	36 h	48 h	0 h	12 h	24 h	36 h	48 h
Negative control	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0
Salinity control	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0
6.5	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0
12.5	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0
25	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0
50	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0
100	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0

Table 3. Ammonia-N, sulphide, total suspended solids, total residual chlorine concentration at the beginning and ending of the barnacle larvae acute toxicity test.

Concentration treatment (%)	Ammonia-N (mg L ⁻¹)		Sulphide (mg L ⁻¹)		Total suspended solids (mg L ⁻¹)		Total residual chlorine (mg L ⁻¹)	
	Initial	End	Initial	End	Initial	End	Initial	End
Negative control	0.03	0.04	<0.1	<0.1	<0.2	<0.2	<0.02	<0.02
Salinity control	0.02	0.09	<0.1	<0.1	<0.2	<0.2	<0.02	<0.02
6.5	1.37	1.15	<0.1	<0.1	<0.2	<0.2	<0.02	<0.02
12.5	2.31	2.12	<0.1	<0.1	<0.2	<0.2	<0.02	<0.02
25	4.70	4.30	<0.1	<0.1	<0.2	<0.2	<0.02	<0.02
50	10.2	9.82	<0.1	<0.1	<0.2	<0.2	<0.02	<0.02
100	21.2	21.0	<0.1	<0.1	<0.2	<0.2	<0.02	<0.02

Appendix D

Monitoring Data
for
Diatom Growth Inhibition Test
(Chronic toxicity test)

Table 1. Dissolved oxygen concentration and pH in each concentration treatment in diatom growth inhibition test.

Concentration treatment (%)	Dissolved oxygen (mg L ⁻¹)								pH							
	0 h	24 h	48 h	72 h	96 h	120 h	144 h	168 h	0 h	24 h	48 h	72 h	96 h	120 h	144 h	168 h
Negative control	6.3	6.5	6.8	6.2	8.7	9.1	9.3	8.4	8.6	8.3	8.8	8.5	8.2	8.6	8.3	8.4
Salinity control	6.5	6.9	8.2	8.5	8.3	8.9	10.2	9.2	8.4	8.6	8.7	8.5	8.7	8.4	8.6	8.8
2.5	6.4	6.8	8.3	8.4	8.3	8.4	8.6	9.5	8.5	8.5	8.5	8.7	8.5	8.5	8.5	8.5
5	6.3	6.8	7.4	7.6	6.2	7.2	8.8	8.3	8.7	8.2	7.9	7.8	7.9	8.7	8.2	9.0
10	6.6	6.5	6.9	8.2	8.5	9.7	10.1	9.4	8.6	8.8	8.5	8.6	8.4	8.6	8.8	8.5
25	6.5	6.5	6.8	8.3	8.4	8.6	9.5	9.2	8.1	8.2	8.7	8.5	8.3	8.5	8.7	8.5
50	6.6	6.4	6.8	7.4	7.6	8.8	8.3	8.8	8.0	8.2	8.4	8.0	8.4	8.5	8.5	8.7
100	6.5	6.2	6.3	6.0	6.5	6.8	6.2	7.2	8.0	7.9	8.1	8.0	7.6	7.8	7.9	7.8

Table 2. Salinity and temperature in each concentration treatment in diatom growth inhibition test.

Concentration treatment (%)	Salinity (‰)								Temperature (°C)							
	0 h	24 h	48 h	72 h	96 h	120 h	144 h	168 h	0 h	24 h	48 h	72 h	96 h	120 h	144 h	168 h
Negative control	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
Salinity control	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
2.5	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
5	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
10	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
25	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
50	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
100	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0

Table 3. Ammonia-N, sulphide, total suspended solids, total residual chlorine concentration at the beginning and ending of the diatom growth inhibition toxicity test.

Concentration treatment (%)	Ammonia-N (mg L ⁻¹)		Sulphide (mg L ⁻¹)		Total suspended solids (mg L ⁻¹)		Total residual chlorine (mg L ⁻¹)	
	Initial	End	Initial	End	Initial	End	Initial	End
Negative control	0.07	0.06	<0.1	<0.1	<0.2	<0.2	<0.02	<0.02
Salinity control	0.04	0.05	<0.1	<0.1	<0.2	<0.2	<0.02	<0.02
2.5	0.56	0.05	<0.1	<0.1	<0.2	<0.2	<0.02	<0.02
5	1.39	0.07	<0.1	<0.1	<0.2	<0.2	<0.02	<0.02
10	2.67	0.23	<0.1	<0.1	<0.2	<0.2	<0.02	<0.02
25	5.44	0.31	<0.1	<0.1	<0.2	<0.2	<0.02	<0.02
50	10.3	7.87	<0.1	<0.1	<0.2	<0.2	<0.02	<0.02
100	19.3	18.2	<0.1	<0.1	<0.2	<0.2	<0.02	<0.02

Appendix E

Monitoring Data
for
Shrimp Acute Toxicity Test

Table 1. Dissolved oxygen concentration and pH in each concentration treatment in shrimp acute toxicity test.

Concentration treatment (%)	Dissolved oxygen (mg L ⁻¹)					pH				
	0 h	12 h	24 h	36 h	48 h	0 h	12 h	24 h	36 h	48 h
Negative control	6.5	7.2	6.7	7.0	6.3	7.9	7.9	8.1	7.9	8.0
Salinity control	6.3	7.1	6.5	6.9	6.6	8.2	7.9	8.1	8.0	8.0
6.5	6.5	6.7	6.7	7.3	7.0	8.1	8.0	8.1	8.0	7.9
12.5	6.5	6.7	7.1	7.2	7.2	8.2	7.9	7.9	8.0	8.2
25	7.0	6.3	6.3	7.1	6.9	8.0	8.1	7.9	8.0	8.1
50	7.3	6.9	7.3	6.9	6.8	7.9	8.1	8.1	8.0	8.2
100	7.1	6.8	7.3	7.1	6.5	7.8	7.6	7.7	8.0	7.7

Table 2. Salinity and temperature in each concentration treatment in shrimp acute toxicity test.

Concentration treatment (%)	Salinity (‰)					Temperature (°C)				
	0 h	12 h	24 h	36 h	48 h	0 h	12 h	24 h	36 h	48 h
Negative control	25.0	25.0	25.0	25.0	25.0	22.0	22.0	22.0	22.0	22.0
Salinity control	25.0	25.0	25.0	25.0	25.0	22.0	22.0	22.0	22.0	22.0
6.5	25.0	25.0	25.0	25.0	25.0	22.0	22.0	22.0	22.0	22.0
12.5	25.0	25.0	25.0	25.0	25.0	22.0	22.0	22.0	22.0	22.0
25	25.0	25.0	25.0	25.0	25.0	22.0	22.0	22.0	22.0	22.0
50	25.0	25.0	25.0	25.0	25.0	22.0	22.0	22.0	22.0	22.0
100	25.0	25.0	25.0	25.0	25.0	22.0	22.0	22.0	22.0	22.0

Table 3. Ammonia-N, sulphide, total suspended solids, total residual chlorine concentration at the beginning and ending of the shrimp acute toxicity test.

Concentration treatment (%)	Ammonia-N (mg L ⁻¹)		Sulphide (mg L ⁻¹)		Total suspended solids (mg L ⁻¹)		Total residual chlorine (mg L ⁻¹)	
	Initial	End	Initial	End	Initial	End	Initial	End
Negative control	0.04	0.13	<0.1	<0.1	4.2	6.3	<0.02	<0.02
Salinity control	0.03	0.10	<0.1	<0.1	5.5	6.2	<0.02	<0.02
6.5	1.55	1.78	<0.1	<0.1	10.1	6.3	<0.02	<0.02
12.5	2.54	2.98	<0.1	<0.1	20.3	7.1	<0.02	<0.02
25	4.78	5.41	<0.1	<0.1	41.2	8.6	<0.02	<0.02
50	9.23	10.3	<0.1	<0.1	83.5	15.3	<0.02	<0.02
100	20.3	21.2	<0.1	<0.1	170	44.3	<0.02	<0.02