Appendix A

Table A- 1 Concentration of Cd, Cu, Pb, Fe and Mn in pore water from different sites.

Location	Concentration (μg L^{-1})					References
	Cd	Cu	Pb	Fe	Mn	
Ansedonia BayMiddle Tyrrhenian Sea (1986, Italy)	-	-	0.50- 1.5	0.05 - 3.0	0.75 - 6.25	Ciceri e*t al.* 1992
Ansedonia BayMiddle Tyrrhenian Sea (1988, Italy)	0.3 – 2.5	0.5 - 3.3	0.1 – 2.4	0.2 - 0.7	0.8 - 9.5	Ciceri e*t al.,* 1992
Bang Pakong River Estuary (Thailand)	0.12 - 0.16	22 – 100	8.9 – 26.5	0.08 - 0.27	0.16 - 6.24	Cheevaporn, *et al.,* 1995
Gulf of Papua(Papua New Guinea)	-	1.9 – 19	-	0 – 6.98	0 – 13.74	Alongi *et al.,* 1996
North-Eastern Irish Sea (UK)	-	22	42	9	13	William *et al*., 1998
Galveston Bay, Texas(USA)	-	-	-	0.2 - 6.8	0.6 - 15.5	Warnken *et al*.,2001
Coastal wetland (Hong Kong)	-	40 – 50	-	-	-	Lou and Chu, 1999

Table A- 2 Diffusive flux of metals from different sites

Location	**Diffusive fluxes (μg cm^{-2} yr^{-1})**					**Reference**
	Cd	**Cu**	**Pb**	**Fe**	**Mn**	
Ansedonia Bay in 1986 (Italy)	-	-	-0.77	9.6	683	Ciceri *et al.*, 1992
Ansedonia Bay in 1988 (Italy)	0.02	-0.05	-0.86	12	1401	Ciceri *et al.*, 1992
Bang Pakong River Estuary (Thailand)	0.01-0.03	2.10-4.80	1.50-2.50	-	-	Jancinto *et al*, 1995
Gulf of Papua (Papua New Guinea)	-	-	-	(-83) – 1192	46 – 1215	Alongi *et al.*, 1996
Los Angeles/Long Beach Harbours (USA)	-	0.53 – 4.20	0.73 – 2.50	-	200 – 730	William *et al.*, 1998
The Mouth of U-Tapao Canal, Changwat Songkhla (Thai)	-	(-0.64)-0.65	(-2.30)-0.63	72.86-377.69	(-17.35)-19.48	Chaichana, 2001
Trinity Bay region Galveston Bay (Texas)	-	-	-	(-71) – (-124)	(-334) – (-421)	Warnken *et al.*, 2001
Morlaix river estuary (Brittany, France)	-	(-0.02) – 0.61	-	-	-	Monbet, 2004

Table A-3 Benthic fluxes of metals from different sites

Location	Benthic fluxes (nmol cm^{-2} yr^{-1})					References
	Cd	Cu	Pb	Fe	Mn	
Ansedonia Bay, middleTyrrhenian Sea (1986)	-	-	(-2698) - (-105)	(-1568) - (-481)	4143 – 4940	Ciceri *et al.*, 1992
Ansedonia Bay, middle Tyrrhenian Sea (1988)	1.84-7.18	(-86) – (105)	(-63) – (-35)	(-12) – 10	7489 - 9636	Ciceri *et al.*, 1992
River Po outflow,(Italy)	5.96	60	-	-	-	Zago *et al.*, 2000
Los Angeles/Long Beach Harbours (USA)	(-7.7) -(4.3)	-	-	-	-	Colbert *et al.*, 2001
Trinity Bay region Galveston Bay, TX (USA)	-	-	-	227 - 1235	16,425 – 84,674	Warnken *et al.*, 2001
Tresse, Lagoon of Venice,(Italy)	1.84	2.54	-	-30	166	Tureeta *et al.*,2005
Campalto, Lagoon of Venice,(Italy)	1.58	4.38	-	-55	105	Tureeta *et al.*,2005

Table A-4 Different design of benthic chamber

Material	Shape	Surface area (cm^2)	Height of overlying water (cm.)	Bottom deployment time	Reference
Acrylic	cylindrical	730	10	5 day	Smith *et al.*, 1976
Titanium	square	900	22	7 day	Weiss *et al.*, 1977
Teflon coated aluminium	cylindrical	443	8	7 day	Hinga *et al.*, 1979
Stainless steel	square	413	30	5 day	Smith *et al.*, 1979
Plexiglass	cylindrical	3,850	32	4 day	Ciceri *et al.*, 1992
Plexiglass	cylindrical	3,850	45	40 hour	Wehrli *et al.*, 1994
Stainless steel	square	400	15	7 day	Tengberg *et al.*, 1995
Polycarbonate	cylindrical	177	10 - 35	1 day	Warnken *et al.*, 2000
Polycarbonate	cylindrical	962	30	4 day	Zago *et al.*, 2000

Table A-5 Water qualities in the Outer Songkhla Lake

Parameter	October, 2000 (Wet season)	April, 2001 (Dry season)
Depth (m)	0.8-4.0	0.9-4.3
Turbidity (m)	0.4-1.6	0.6-1.9
Temperature (°C)	29-30	30.2-32.6
pH	6.7-9.5	7.6-8.2
Salinity (psu)	0-25.0	30.5-38.7
Dissolve oxygen (mg L^{-1})	5.44-11.84	6.04-8.05
Total dissolve solid (mg L^{-1})	10-83.5	11.5-120

Table A-6 Concentrations of dissolved Cd, Cu, Pb, Fe and Mn in the Outer Lake.

Concentration (nmol L^{-1})					Reference
Cd	**Cu**	**Pb**	**Fe**	**Mn**	
0.009 - 0.34	0.66 - 8.83	0.019 - 0.123	0.002 - 0.835	0.004- 0.548	Sirinawin *et al* 1998
0.006-2.67	1.42-47.2	0.097-81.1	3.58-13478	0.546-2156	Kongthong, 2006

Table A-7 Total concentrations of Cu, Pb, Fe and Mn in sediment from the Outer Lake.

Concentration (g kg^{-1})				Reference
Cu	**Pb**	**Fe**	**Mn**	
0.004 – 0.015	-	8.26 -28.02	0.09 - 0.52	Maneepong, 1996
0.008-0.028	0.012-0.044	16.72-41.97	0.20-0.59	Jungsriruntanakun, 2001
0.00003-0.0042	0.00045-0.0059	0.50-13.54	0.038-0.362	Chaichana, 2001
<0.00067-0.015	-	8.47-45.55	0.139-0.776	Nakinchart and Sompongchaiyakul, 2006

Appendix B

B-1 Chemicals and materials

Table B-1 The list of chemical reagents

Order	Chemical reagent name
1	Acetic acid (CH_3COOH) (Lab-Scan, Thailand)
2	Ammonium Hydroxy (NH_4OH) ((J.T. Baker, USA.)
3	Ammonium tetramethylene dithiocarbamate (Fluka, Switzerland)
4	Boric acid (H_3BO_3) (Merck, Germany)
5	Chloroform ($CHCl_3$) (Lab-Scan, Ireland)
6	Diethylammonium diethyldithiocarbamate (Merck, Dermstadt)
7	Hydrochloric acid (HCl) (Lab-Scan, Ireland)
8	Nitric acid (HNO_3) (Lab-Scan, Ireland)
9	Sulfuric acid (H_2SO_4) (J.T. Baker, USA.)
10	Potassium iodate (KI)
11	Potassium hydroxyl (KOH)
12	Sodium thiosulphate ($Na_2S_2O_3.5H_2O$)

Table B-2 The lists of materials

Order	materials name and
1	Filter holder (Sartorius Gottingen, Germany)
2	Low density polyethylene NALGENE® , 60 ml and 125 ml
3	Pure nitrogen gas (purity 99.995%: TIG, Thailand)
4	Acetylene gas (purity 99.99%: TIG, Thailand)
5	Pure argon gas (purity 99.995%: TIG, Thailand)
6	Polypropylene centrifuge tube Corning®
7	Teflon vessel (Lorran International, Canada)
8	Automatic refrigeration (SORVALL, USA)
9	Freeze dryer (Dura-Stop™, USA)
10	Hydraulic pressure
11	Multi-parametric probe (Mettler-Toledo, Gmbh, Model 681, Switzerland)
12	Automatic refrigeration (SORVALL, USA, Model T21)

B-2 Chemical reagent preparations

1. Extraction reagent solution (1% w/v APDC and DDDC)

Dissolved 0.5 mg APDC and 0.5 mg DDDC in nanopure water and make up to 50 mL.

2. Acetate buffer 2 M

Mixed NH_4OH 7M 29.5 mL and 96% (W/V) CH_3COOH 28.3 mL and make the final volume to 250 mL.

3. Mixed standard solution for calibration curve

- Cd standard solution: 1, 2 and 4 $\mu g\ L^{-1}$
- Cu standard solution: 20, 40 and 80 $\mu g\ L^{-1}$
- Pb standard solution: 25, 50 and 100 $\mu g\ L^{-1}$
- Fe standard solution: 20, 40 and 80 $\mu g\ L^{-1}$
- Mn standard solution: 5, 10 and 20 $\mu g\ L^{-1}$

4. Strontium standard solution

A series of strontium standard solution was prepared from 1000 mg L^{-1} stock solution and Khao-Daeng estuarine water was used as a blank.

Table B-3 Operating conditions used for GFAAS

Lamp settings	**Cd**	**Cu**	**Pb**	**Fe**	**Mn**
Wavelength (nm)	228.8	324.8	283.3	248.3	279.5
Spectral band width (nm)	0.7	0.7	0.7	0.2	0.7
Furnace temperature (°C)					
Drying 1 (ramp 1 s, hold 20 s)	110	110	110	110	110
Drying 2 (ramp 15 s, hold 30 s)	130	130	130	130	130
Ashing (ramp 10 s, hold 20 s)	500	900	750	1000	1100
Atomizing (ramp 0 s, hold 5 s)	1400	2000	1500	2100	1700
Clean-up (ramp 1 s, hold 3 s)	2250	2250	2250	2250	2250

Table B-4 Operating conditions used for FAAS.

Parameter	**Cd**	**Cu**	**Pb**	**Mn**	**Fe**	**Sr**
Wavelength (nm)	228.8	324.8	283.3	279.5	248.3	460.7
HC-Lamp current (mA)	8	8	8	5	8	8
Slit width (nm)	0.3	0.5	0.3	0.4	0.2	0.5
Type of flame	AIR-C_2H_2	AIR-C_2H_2	AIR-C_2H_2	AIR-C_2H_2	AIR-C_2H_2	AIR-C_2H_2
Fuel gas flow rate	1.8	1.8	1.8	1.9	2.0	1.4

Appendix C

Table C-1 The changes of metal concentration in aerobic and anaerobic condition

Time (hour)	**Metal concentration (mg L^{-1})**					
	Cd aerate	**Cd non-aerate**	**Cu aerate**	**Cu non-aerate**	**Pb aerate**	**Pb non-aerate**
0	1.010	1.010	2.005	2.039	2.049	2.189
0.5	0.954	1.012	1.835	1.985	1.944	1.979
1	0.927	1.012	1.781	1.985	1.944	1.979
1.5	0.879	0.996	1.665	1.985	1.874	1.979
2	0.868	1.004	1.638	1.985	1.804	1.979
2.5	0.863	1.004	1.584	1.950	1.768	1.944
3	0.855	1.012	1.522	1.977	1.804	1.944
3.5	0.843	1.012	1.450	1.968	1.663	1.874
4	0.807	1.007	1.351	1.941	1.663	1.874
4.5	0.788	1.004	1.217	1.932	1.488	1.909
5	0.741	1.007	1.181	1.932	1.558	1.839
5.5	0.733	1.004	1.136	1.923	1.558	1.839
6	0.722	1.007	1.145	1.914	1.453	1.839
6.5	0.724	1.007	1.082	1.878	1.523	1.874
7	0.705	0.999	1.065	1.878	1.488	1.839
7.5	0.697	0.993	1.002	1.869	1.453	1.804
8	0.688	0.982	0.805	1.842	1.347	1.839
10	0.630	0.979	0.733	1.851	1.312	1.804
13	0.580	0.965	0.697	1.878	1.277	1.768
15	0.561	0.952	0.670	1.367	1.242	1.698
18	0.558	0.766	0.581	1.287	1.242	1.698
21	0.528	0.719	0.563	1.170	1.242	1.523
23	0.508	0.708	0.491	1.080	1.242	1.382
26	0.444	0.674	0.446	0.964	1.172	1.277
28	0.383	0.661	0.375	0.749	1.137	1.207
30	0.342	0.420	0.276	0.749	1.067	1.207

Table C-2 The changes of metal concentration in control condition

Time (hour)	Metals concentration (mg L^{-1})		
	Cd	Cu	Pb
In aerobic condition			
0	1.004	1.976	2.061
1	0.998	1.960	2.061
2	0.990	1.943	2.027
4	0.987	1.918	2.027
6	0.990	1.926	2.027
8	0.984	1.901	2.027
10	0.987	1.901	1.993
13	0.982	1.909	1.960
15	0.982	1.909	1.960
18	0.973	1.859	1.960
23	0.965	1.859	1.960
26	0.962	1.851	1.960
28	0.962	1.809	1.926
30	0.965	1.792	1.960
In anaerobic condition			
0	0.984	1.960	2.061
1	0.979	1.951	2.027
2	0.990	1.951	2.027
4	0.987	1.918	2.027
6	0.990	1.926	2.027
8	0.984	1.842	2.061
10	0.987	1.851	1.993
13	0.968	1.851	1.960
15	0.962	1.851	1.960
18	0.960	1.851	1.960
23	0.957	1.851	1.960
26	0.960	1.842	1.960
28	0.957	1.809	1.926
30	0.960	1.792	1.960

Table C-3 The changes of Cd concentration in different salinity

Time(hour)	Cd concentration (mg L^{-1})			
	0 psu	**10 psu**	**20 psu**	**30 psu**
0	0.986	1.016	1.005	1.065
0.5	0.953	0.998	0.986	0.948
1	0.944	0.855	0.980	0.832
1.5	0.894	0.733	0.974	0.734
2	0.879	0.629	0.946	0.676
3	0.865	0.590	0.940	0.578
4	0.826	0.587	0.949	0.559
5	0.809	0.587	0.906	0.543
6	0.738	0.416	0.896	0.500
9	0.634	0.358	0.875	0.494
12	0.605	0.267	0.856	0.462
15	0.569	0.258	0.834	0.455
17	0.507	0.255	0.776	0.442
19	0.463	0.230	0.745	0.325
22	0.404	0.221	0.680	0.384
24	0.330	0.188	0.652	0.387
26	0.297	0.185	0.726	0.345
28	0.274	0.166	0.711	0.374
30	0.250	0.160	0.708	0.335
32	0.226	0.154	0.735	0.257
34	0.182	0.148	0.670	0.238
36	0.126	0.145	0.636	0.228
38	0.120	0.136	0.568	0.218
40	0.114	0.142	0.550	0.212
42	0.108	0.130	0.537	0.179
44	0.105	0.127	0.466	0.088
46	0.093	0.102	0.448	0.072
48	0.087	0.093	0.531	0.072
50	0.085	0.084	0.485	0.053

Table C-4 The changes of Cu concentration in different salinity

Time(hour)	Cu concentration (mg L^{-1})			
	0 psu	**10 psu**	**20 psu**	**30 psu**
0	2.002	2.058	2.028	2.066
0.5	1.926	1.961	2.019	1.927
1	1.683	1.786	1.994	1.659
1.5	1.548	1.628	1.884	1.139
2	1.515	1.295	1.842	1.113
3	1.506	1.207	1.833	1.087
4	1.355	1.119	1.825	1.105
5	1.296	0.900	1.690	1.087
6	0.902	0.505	1.681	1.070
9	0.877	0.382	1.495	0.905
12	0.625	0.330	1.393	0.879
15	0.549	0.286	1.190	0.698
17	0.499	0.251	1.173	0.672
19	0.373	0.181	1.063	0.594
22	0.331	0.137	0.835	0.542
24	0.297	0.102	0.742	0.516
26	0.272	0.067	0.624	0.490
28	0.222	0.049	0.497	0.438
30	0.146	0.032	0.429	0.386
32	0.104	0.032	0.302	0.334
34	0.071	0.032	0.277	0.256
36	0.045	0.023	0.226	0.230
38	0.045	0.023	0.150	0.178
40	0.045	0.023	0.124	0.152
42	0.045	0.023	0.107	0.109
44	0.037	0.023	0.099	0.092
46	0.037	0.023	0.074	0.057
48	0.037	0.023	0.031	0.040
50	0.029	0.014	0.023	0.022

Table C-5 The changes of Pb concentration in different salinity

Time (hour)	**Pb concentration (mg L^{-1})**			
	0 psu	**10 psu**	**20 psu**	**30 psu**
0	2.094	1.984	2.306	1.804
0.5	2.022	1.780	2.213	1.559
1	1.949	1.780	2.074	1.461
1.5	1.732	1.699	1.889	1.216
2	1.696	1.577	1.796	1.118
3	1.732	1.293	1.380	1.069
4	1.623	1.171	1.241	0.824
5	1.514	1.130	1.009	0.627
6	1.152	0.846	1.009	0.529
9	1.043	0.561	1.056	0.382
12	0.971	0.561	1.102	0.529
15	0.826	0.480	1.056	0.529
17	0.681	0.439	1.009	0.480
19	0.609	0.439	0.685	0.382
22	0.536	0.317	0.500	0.284
24	0.500	0.317	0.454	0.333
26	0.464	0.317	0.454	0.284
28	0.391	0.317	0.361	0.235
30	0.391	0.276	0.269	0.235
32	0.355	0.236	0.269	0.235
34	0.283	0.317	0.269	0.235
36	0.283	0.317	0.269	0.235
38	0.246	0.317	0.269	0.284
40	0.210	0.236	0.269	0.333
42	0.283	0.317	0.269	0.137
44	0.246	0.358	0.269	0.137
46	0.210	0.195	0.222	0.137
48	0.210	0.114	0.176	0.088
50	0.210	0.154	0.130	0.088

Table C-6 D.O. changes of the water inside and outside benthic chambers at Kor-Yor (22- 23 January, 2005)

Time (hour)	Dissolved oxygen (mgL^{-1})								Outside Chamber (Probe)
	Titrate		Probe		chamber		Probe		
	Light-1	Light-2	Light-1	Light-2	Dark-1	Dark-2	Dark-1	Dark-2	
0	5.10	5.20	-	-	4.80	3.50	-	-	6.96
2	4.50	5.00	3.95	3.82	2.50	3.00	2.17	2.45	6.76
4	5.20	5.20	3.83	3.79	2.20	2.30	2.01	2.13	6.83
6	5.00	4.80	3.83	3.78	1.60	1.90	1.38	1.25	-
9	2.10	3.60	3.22	3.22	1.50	1.80	1.31	1.65	-
21	3.80	3.40	3.38	2.55	1.10	0.90	0.95	1.02	4.81
24	4.70	3.80	3.79	3.05	0.80	1.10	1.01	0.82	6.28
27	5.10	4.90	4.32	3.81	1.50	1.30	1.10	0.88	7.20
30	5.00	4.40	4.49	3.76	1.10	1.00	1.10	1.18	7.13

Table C-7 D.O. changes of the water inside and outside benthic chambers at Khao-Deang (11-12 April, 2005)

Time (hour)	Dissolved oxygen (mgL^{-1})								Outside Chamber (Probe)
	Titrate		Probe		chamber		Probe		
	Light-1	Light-2	Light-1	Light-2	Dark-1	Dark-2	Dark-1	Dark-2	
0	3.74	4.23	6.00	6.20	4.88	4.88	5.80	6.00	8.20
2	3.25	4.56	6.30	6.10	4.52	5.21	5.80	6.00	8.10
4	6.02	4.23	6.20	6.10	3.91	2.60	5.70	6.10	7.50
6	2.28	1.63	2.11	2.34	3.25	3.91	4.54	3.14	5.55
9	2.77	3.64	2.65	2.46	2.21	2.44	1.86	1.65	4.85
12	2.21	3.91	1.56	1.33	1.40	2.44	1.65	2.10	4.00
18	1.43	2.15	1.22	1.92	1.63	1.30	1.27	1.26	4.50
21	1.79	2.60	1.39	0.88	1.46	1.79	1.04	0.87	5.60
24	1.95	3.09	2.28	3.26	1.30	1.85	0.84	1.06	6.28
27	2.18	3.06	2.57	3.46	0.94	1.50	1.43	1.34	5.70
30	2.28	3.74	2.16	3.27	1.14	1.46	1.14	1.18	4.00

Table C-8 D.O. changes of water inside and outside benthic chambers at Khao-Deang (25-27 April, 2006)

Time (hour)	Dissolved oxygen (mgL^{-1})								Outside Chamber (Probe)
	Titrate		Probe		Titrate		Probe		
	Light-1	Light-2	Light-1	Light-2	Dark-1	Dark-2	Dark-1	Dark-2	
0	5.53	6.18	8.00	7.60	6.02	6.18	7.80	7.90	7.9
2	6.51	5.86	7.70	6.90	5.86	5.86	7.00	7.20	7.80
4	6.18	5.53	6.80	7.00	5.21	5.53	7.00	7.10	8.20
6	5.53	5.86	6.60	6.90	4.88	5.86	7.20	7.20	8.00
8	4.88	5.53	6.40	6.80	4.88	5.53	6.80	6.70	7.80
11	4.23	4.88	5.90	5.50	4.56	4.88	6.20	6.50	7.60
14	3.91	3.91	5.20	4.80	3.58	3.91	4.90	5.70	6.60
17	2.93	3.91	4.80	4.70	3.25	3.91	4.70	5.10	6.70
20	2.93	3.25	3.80	4.20	2.93	3.25	3.50	3.80	6.80
23	2.93	2.93	3.90	4.00	2.60	2.93	2.80	3.50	7.20
26	2.77	2.77	3.50	3.80	2.44	2.77	2.60	2.90	7.50
29	2.93	2.44	3.20	3.65	1.95	2.44	2.20	2.75	7.60
32	2.60	2.60	3.85	3.40	2.12	2.60	2.15	2.40	7.80
35	7.48	2.28	4.50	2.60	2.60	2.28	2.30	2.10	7.40
38	3.58	2.60	4.20	2.65	2.93	2.60	2.50	1.85	7.10
41	8.46	1.79	5.80	2.20	2.93	1.79	2.55	1.60	6.90
45	4.72	1.63	4.90	1.80	2.77	1.63	2.50	1.55	7.20
49.5	4.88	1.63	4.85	1.65	2.93	1.63	2.60	1.40	8.50
52.0		1.63		1.57	3.42	1.63	3.00	1.50	8.00
55.5		1.63		1.50	3.58		1.63		7.50

Table C-9 The pH changes of water inside light and dark benthic chamber at Khao-Deang (11-12 April, 2005)

Time (hour)	pH			
	Light 1	Light 2	Dark 1	Dark 2
2	7.94	7.98	8.12	8.19
4	8.16	7.76	8.07	7.78
6	7.74	8.11	8.51	7.96
9	7.94	7.82	8.03	7.71
12	7.88	7.79	8.03	7.72
18	7.64	7.58	7.79	7.56
21	7.07	7.49	7.83	7.56
24	7.42	7.98	7.54	7.78
27	7.83	7.55	8.02	7.53
30	7.78	7.61	8.12	7.67
ΔpH	1.10	0.6	1.0	0.7
Average ΔpH	0.8		0.8	

Table C-10 The pH changes of water inside light and dark benthic chamber at Khao-Deang (25-27January, 2005)

Time (hour)	pH				
	Light-1	Light-2	Dark 1	Dark 2	Outside chamber
0	7.79	7.84	7.77	7.76	7.85
2	7.78	7.75	7.76	7.84	7.87
4	7.87	7.80	7.80	7.82	7.80
6	7.80	7.78	7.77	7.82	7.84
8	7.77	7.67	7.65	7.76	7.84
11	7.76	7.67	7.67	7.75	7.83
14	7.73	7.63	7.59	7.79	7.84
17	7.40	7.56	7.56	7.63	7.80
20	7.67	7.56	7.54	7.67	7.80
23	7.61	7.49	7.50	7.59	7.71
26	7.65	7.50	7.50	7.63	7.70
29	7.67	7.47	7.39	7.34	7.96
32	7.54	7.14	7.24	7.07	8.08
35	7.87	7.16	7.24	7.24	7.88
38	7.50	7.09	7.20	7.16	7.66
41	7.80	7.02	7.20	7.12	7.65
45	7.50	7.07	7.21	7.22	7.66
49.5	7.42	6.99	7.18	7.23	7.91
52.0		6.94	7.14	7.16	7.93
55.5		6.88	7.03	7.07	7.67
ΔpH	0.33	0.75	0.6	0.77	0.87
Average ΔpH	0.53		0.67		0.87

Table C-11 Conductivity and total dissolved solid changes of water inside and outside benthic chambers at Khao-Deang (25-27 April, 2006)

Time (hour)	**Conductivity (ms cm^{-1})**					**TDS (g L^{-1})**				
	Light 1	Light 2	Dark 1	Dark 2	Outside	Light 1	Light 2	Dark 1	Dark 2	Outside
0	44.8	44.7	44.7	44.8	44.5	22.4	22.4	22.4	22.4	22.2
2	44.6	44.7	44.7	44.7	44.6	22.3	22.4	22.3	22.3	22.3
4	44.8	44.6	44.6	44.4	45.0	22.4	22.3	22.2	22.2	22.5
6	44.7	44.5	44.5	44.4	44.8	22.3	22.2	22.2	22.2	22.3
8	44.4	44.3	44.3	44.2	44.8	22.1	22.2	22.1	22.1	22.4
11	44.4	44.0	44.2	44.2	44.3	22.1	22.0	22.1	22.1	22.1
14	44.2	44.1	44.0	44.1	43.6	22.0	22.0	22.0	22.0	21.7
17	44.0	44.0	44.0	44.2	43.6	21.9	22.0	21.9	22.0	21.8
20	43.4	43.9	43.9	44.0	43.0	21.7	21.9	21.9	22.0	21.5
23	42.8	43.7	43.5	43.7	42.5	21.5	21.9	21.7	21.8	21.3
26	43.2	43.7	43.5	43.5	42.3	21.7	21.9	21.8	21.8	22.1
29	43.5	43.6	43.6	43.5	43.0	21.6	21.8	21.8	21.8	21.5
32	43.3	43.5	43.2	43.4	40.8	21.6	21.7	21.6	21.7	20.4
35	41.7	43.5	43.4	43.3	40.9	20.9	21.7	21.7	21.7	20.4
38	42.9	43.4	43.0	43.3	41.4	21.3	21.7	21.5	21.6	20.6
41	30.5	43.2	41.8	43.0	28.7	15.3	21.6	20.9	21.5	14.3
45	35.8	43.3	40.4	43.2	37.9	17.9	21.6	20.2	21.6	18.9
49.5	38.8	43.6	40.7	43.1	42.8	19.4	21.8	20.4	21.6	21.4
52.0		43.3	40.9	43.1	42.7		21.6	20.5	21.6	21.3
55.5		43.2	41.6	43.1	43.5		21.6	20.8	21.5	21.7

L1 = Light chamber 1	L2 = Dark chamber 2
D1 = Light chamber 1	D2 = Dark chamber 2

Table C-12 Salinity and Temperature changes of water inside and outside benthic chambers at Khao-Deang (25-27 April, 2006)

Time (hour)	Salinity (psu)					Temperature (° C)				
	Light1	Light2	Dark1	Dark2	Outside	Light1	Light2	Dark1	Dark2	Outside
0	28.9	28.9	28.8	29.0	28.7	29.4	29.2	29.2	29.2	29.7
2	28.8	28.9	28.9	28.8	28.7	29.3	29.2	29.2	28.9	28.6
4	28.9	28.7	28.6	28.7	29.0	28.0	28.5	28.5	28.3	28.3
6	28.8	28.6	28.6	28.6	28.8	28.1	27.9	28.0	27.7	28.4
8	28.5	28.6	28.5	28.5	28.9	27.6	27.6	27.6	27.5	27.9
11	28.5	28.4	28.5	28.5	28.4	27.7	27.7	27.8	27.8	27.8
14	28.3	28.4	28.3	28.4	28.0	27.5	27.5	27.5	27.6	27.7
17	28.3	28.4	28.3	28.4	28.1	27.0	26.9	26.9	27.0	25.8
20	27.9	28.3	28.2	28.3	27.6	26.9	26.8	26.9	26.8	27.1
23	27.7	28.2	28.0	28.1	27.4	28.7	28.5	28.4	28.3	27.6
26	27.9	28.1	28.0	28.0	27.1	28.9	28.8	28.8	28.7	29.2
29	27.8	28.1	28.0	28.0	27.4	28.8	28.7	28.8	28.6	29.2
32	27.8	27.9	27.8	27.9	26.0	27.5	27.5	27.4	27.5	28.2
35	26.7	28.0	27.9	27.9	26.0	27.5	27.7	27.7	27.8	27.9
38	27.3	28.0	27.6	27.8	26.3	27.9	27.3	27.4	27.5	28.0
41	18.9	27.8	26.8	27.6	17.7	27.5	27.8	27.6	27.5	27.7
45	22.6	27.8	25.8	27.7	23.9	27.6	27.5	27.5	27.5	27.7
49.5	24.7	28.0	26.0	27.7	27.5	29.0	29.1	29.0	28.9	29.5
52.0		27.9	26.3	27.7	27.3		29.2	29.3	29.1	29.7
55.5		27.8	26.6	27.7	27.9		27.4	27.6	27.5	29.1

L1 = Light chamber 1

L2 = Dark chamber 2

D1 = Light chamber 1

D2 = Dark chamber 2

Table C-13 Average concentrations of Cd, Cu, Pb, Fe and Mn (nmol L^{-1}) in water samples at Kor-Yor collected on 22-23 January, 2005.

Time (hour)	**Cd (nmol L^{-1})**		**Cu (nmol L^{-1})**		**Pb (nmol L^{-1})**		**Fe (nmol L^{-1})**		**Mn (nmol L^{-1})**	
	Light	**Dark**	**Light**	**Dark**	**Light**	**Dark**	**Light**	**Dark**	**Light**	**Dark**
0	0.171	0.444	5.63	4.85	0.841	0.265	45	58	1.62	0.19
2	0.958	0.201	6.37	3.85	0.215	0.654	275	296	1.93	1.04
4	0.464	0.117	8.68	2.70	1.400	0.138	127	113	0.84	0.72
6	0.084	0.188	6.32	4.98	0.588	0.943	213	432	0.91	2.71
9	0.230	0.351	7.48	3.08	0.511	0.413	96	129	0.10	1.23
21	0.639	0.132	12.89	5.38	0.550	0.702	75	84	6.88	0.55
24	0.559	0.066	8.87	1.36	0.380	0.352	140	166	3.32	4.00
27	0.194	0.122	6.87	2.64	0.736	0.168	167	169	2.70	5.89
30	0.279	0.727	9.63	3.42	0.742	1.159	179	200	1.93	5.09

Table C-14 Average concentrations of Cd, Cu, Pb, Fe and Mn (nmol L^{-1}) in water samples at Khao - Deang collected on 11-12 April, 2005.

Time (hour)	**Cd (nmol L^{-1})**		**Cu (nmol L^{-1})**		**Pb (nmol L^{-1})**		**Fe (nmol L^{-1})**		**Mn (nmol L^{-1})**	
	Light	**Dark**	**Light**	**Dark**	**Light**	**Dark**	**Light**	**Dark**	**Light**	**Dark**
0	0.629	0.748	4.00	4.84	0.428	0.374	618	291	4.06	10.77
2	0.192	0.629	4.53	5.15	0.206	0.930	782	271	2.48	9.43
4	0.511	0.820	3.52	4.24	0.345	0.326	445	369	5.89	21.59
6	0.780	0.703	4.97	9.03	0.803	0.180	374	261	6.84	28.61
9	0.215	0.407	6.57	3.77	0.866	0.149	341	504	1.83	23.34
12	0.392	0.305	3.56	8.06	0.796	1.146	947	327	3.07	38.85
18	0.179	0.410	2.69	2.13	0.206	0.117	789	938	0.54	45.82
21	0.362	0.302	4.18	3.16	0.428	0.345	356	573	8.22	28.47
24	0.086	0.424	7.89	2.64	0.568	0.631	343	544	2.41	20.24
27	0.464	0.176	7.62	2.38	1.431	0.631	573	799	7.34	34.38
30	0.232	0.381	8.44	3.58	0.758	0.314	676	386	4.97	27.03

Table C-15 Average concentrations of Cd, Cu, Pb, Fe and Mn (nmol L^{-1}) in water samples at Khao-Deang collected on 25-27 January, 2006.

Time (hour)	**Cd (nmol L^{-1})**		**Cu (nmol L^{-1})**		**Pb (nmol L^{-1})**		**Fe (nmol L^{-1})**		**Mn (nmol L^{-1})**	
	Light	**Dark**	**Light**	**Dark**	**Light**	**Dark**	**Light**	**Dark**	**Light**	**Dark**
0	1.83	0.61	12.01	30.52	1.67	10.53	191.89	186.19	8355	10145
2	4.11	0.80	24.41	5.75	0.86	5.70	78.60	239.87	18314	4289
4	4.12	0.38	9.50	10.46	1.26	0.89	175.79	168.94	18705	3860
6	0.64	0.83	10.22	10.29	1.15	0.88	282.68	75.52	8728	6192
8	3.09	1.35	6.48	5.79	8.29	6.84	147.22	226.08	17288	4737
11	2.05	0.70	8.59	7.21	7.58	0.90	215.19	202.28	8159	2555
14	3.09	0.35	8.47	13.12	0.90	5.25	203.29	355.00	9735	4215
17	1.84	3.18	12.77	13.44	19.44	30.59	134.28	135.90	7963	3170
20	2.73	1.27	12.10	12.01	12.15	9.74	172.17	392.12	11227	5296
23	2.13	0.24	11.02	15.71	3.49	1.09	104.79	206.44	11936	5347
26	1.34	0.26	7.71	10.31	0.87	0.90	145.72	126.74	7973	12678
29	1.55	0.23	6.80	6.18	0.52	0.87	373.79	88.46	9269	7553
32	0.32	0.26	8.45	6.68	0.95	0.41	281.61	86.69	12215	9138
35	3.08	0.20	8.11	6.73	0.97	0.58	172.10	122.65	18463	3823
38	0.26	0.20	8.23	8.89	0.53	0.82	162.32	279.83	22006	6453
41	0.76	0.20	10.35	8.95	0.72	0.39	234.94	116.42	37858	11413
45	0.41	0.27	8.65	8.58	0.51	0.65	327.81	133.21	3543	7907
49.5	3.54	0.25	7.74	9.27	0.34	2.47	556.61	130.05	895	6919
52.0	6.75	0.18	5.39	12.27	0.32	0.89	753.53	226.85	56060	3376
55.5	1.29	0.16	4.94	8.55	0.19	0.97	565.31	177.37	48115	1399

Table C-16 The absorbance of 2 μg L^{-1} of Cd at the difference ashing and atomizing temperatures.

Temperature (°C)	Absorbance	
	Ashing	Atomizing
300	0.4400	
400	0.4260	
500	0.4280	
600	0.2987	
700	0.0121	
1000		0.2807
1100		0.2963
1200		0.3205
1300		0.3743
1400		0.4448
1500		0.4373
1600		0.4299

Table C-17 The absorbance of 25 μg.$L^{-1}$of Cu at the difference ashing and atomizing temperatures

Temperature (°C)	Absorbance	
	Ashing	Atomizing
700	0.3527	
800	0.4139	
900	0.4172	
1000	0.4001	
1100	0.2948	
1200	0.2070	
1300	0.1050	
1400	0.0544	
1500		0.1452
1600		0.1855
1700		0.1963
1800		0.2424
1900		0.2784
2000		0.3099
2100		0.3160
2200		0.3118

Table C-18 The absorbance of 50 µg. L^{-1} of Pb metal at the difference ashing and atomizing temperatures

Temperature (°C)	**Absorbance**	
	Pyrolysis	**Atomized**
450	0.3166	
550	0.3530	
650	0.3751	
750	0.3835	
850	0.3643	
950	0.3197	
1050	0.0170	
1000		0.1109
1100		0.1684
1200		0.2283
1300		0.2969
1400		0.3332
1500		0.3503
1600		0.3395
1700		0.3479
1800		0.3449

Table C-19 The absorbance of 20 µg. L^{-1} of iron metal at difference ashing and atomizing temperatures

Temperature (°C)	**Absorbance**	
	Pyrolysis	**Atomized**
700	0.1330	
800	0.1313	
900	0.1314	
1000	0.1389	
1100	0.0975	
1900		0.0953
2000		0.1246
2100		0.1353
2200		0.1389
2300		0.1272

Table C-20 The absorbance of 25 µg.L^{-1}of Mn metal at difference ashing and atomizing temperatures

Temperature (°C)	Absorbance	
	Pyrolysis	**Atomized**
700	0.4603	
800	0.4677	
900	0.4688	
1000	0.4876	
1100	0.4980	
1200	0.4864	
1300	0.4293	
1400	0.2062	
1500		0.2777
1600		0.3513
1700		0.3768
1800		0.3757
1900		0.3734
2000		0.3879
2100		0.3956

Table C-21 The Cd result of the standard addition in estuarine water sample

Cd concentration (µg L^{-1})	STD curve (Mean ± SD)	STD addition (Mean ± SD)
0	0± 0.0014	0.0219 ± 0.0027
0.5		0.0392± 0.0017
1	0.0384 ± 0.0018	0.0581 ± 0.0016
2	0.0732 ± 0.0011	0.0946 ± 0.031
4	0.1402 ± 0.0004	0.1589 ± 0.0043

3 Replications, RSD < 4%

Table C-22 The Cu result of the standard addition in estuarine water sample

Cu concentration (µg L^{-1})	STD curve (Mean ± SD)	STD addition (Mean ± SD)
0	0± 0.0001	0.0683 ± 0.0030
5		0.0861 ± 0.0047
10		0.1118 ± 0.0068
20		0.1420 ± 0.0027
25	0.0858 ± 0.0001	
40		0.2127 ± 0.0033
50	0.1788 ± 0.0002	
100	0.3389 ± 0.0001	

3 Replications, RSD < 7%

Table C-23 The Pb result of the standard addition in estuarine water sample

Pb concentration (µg L^{-1})	STD curve (Mean ± SD)	STD addition (Mean ± SD)
0	0± 0.0001	0.0334 ± 0.0029
12.5		0.0471 ± 0.0016
25	0.0462 ± 0.002	0.0641 ± 0.0025
50	0.0819 ± 0.0002	0.0981 ± 0.0008
100	0.1632 ± 0.0001	0.1617 ± 0.0016

3 Replications, RSD < 4%

Table C-24 The Fe result of the standard addition in estuarine water sample

Fe concentration (µg L^{-1})	STD curve (Mean ± SD)	STD addition (Mean ± SD)
0	0± 0.0015	0.1244 ± 0.0024
10		0.1839± 0.0007
20	0.1932 ± 0.0001	0.2445 ± 0.0023
40	0.3632 ± 0.0013	0.3451 ± 0.0096
80	0.6604 ± 0.0018	0.5586 ± 0.0103

3 Replications, RSD < 7%

Table C-25 The Mn result of the standard addition in estuarine water sample

Mn concentration (μg L^{-1})	**STD curve (Mean ± SD)**	**STD addition (Mean ± SD)**
0	0±0.0001	0.0277± 0.002
2		0.0559 ± 0.001
4		0.0869 ± 0.002
5	0.0892±0.0005	
8		0.1452 ± 0.001
10	0.1615±0.0005	
16		0.2600 ± 0.002
20	0.3141±0.0005	

3 Replications, RSD < 3%

Table C- 26 Detection limit (μg L^{-1})

Number	**Metal concentrations (μg L^{-1})**				
	Cd	**Cu**	**Pb**	**Fe**	**Mn**
1	0.0128	0.1567	0.0531	0.2404	0.0259
2	0.0142	0.1533	0.0625	0.2456	0.0221
3	0.0142	0.1467	0.0594	0.2412	0.0262
4	0.0140	0.1450	0.0594	0.2412	0.0259
5	0.0142	0.1450	0.0563	0.2397	0.0248
6	0.0148	0.1450	0.0625	0.2412	0.0228
7	0.0139	0.1533	0.0563	0.2390	0.0217
8	0.0142	0.1533	0.0594	0.2412	0.0259
9	0.0137	0.1550	0.0625	0.2390	0.0241
10	0.0144	0.1533	0.0625	0.2412	0.0234
Average	0.0140	0.1507	0.0594	0.3034	0.0243
SD	0.0005	0.0044	0.0031	0.0022	0.0016
3 SD	0.0014	0.0133	0.0094	0.0067	0.0048

Calculation

The detection limit (DL) = (3 x SD) μg L^{-1}

Hence, the limit of detection for dissolved Cd, Cu, Pb, Mn and Fe for GFAAS was 0.0014, 0.0133, 0.0094, 0.0067 and 0.0048 μg L^{-1}, respectively.

Table C-27 The % RSD calculation from sediment sample

Order	Cd concentration (μg L^{-1})	Cu concentration (μg L^{-1})	Pb concentration (μg L^{-1})	Fe concentration (mg L^{-1})	Mn concentration (mg L^{-1})
1	0.7549	35.9	5.9	28.3	1.04
2	0.8538	36.8	6.0	28.8	1.00
3	0.8024	36.0	5.7	30.0	1.00
4	0.8103	37.4	5.5	29.8	0.97
5	0.8024	35.9	5.9	27.9	0.98
6	0.7846	36.3	5.0	28.7	0.97
7	0.7905	37.6	5.7	29.5	1.00
8	0.7431	36.3	5.4	29.6	0.98
9	0.8202	36.3	5.6	29.6	0.95
10	0.8478	36.0	5.7	29.7	0.98
Average (μg g^{-1})	0.8010	36.5	5.6	29.2	0.988
Stand Deviation	0.0336	0.579	0.260	0.68	0.022
%RSD	4.2	1.6	4.6	2.3	2.2

Table C- 28 The changes of Cd, Cu, Pb, Fe and Mn absorbance in nanopure-water

Time	**Peak area of metals**				
(day)	Cd	Cu	Pb	Fe	Mn
0	0.0009	0.0016	0.0019	0.0078	0.0021
3	0.0005	0.0016	0.0019	0.0079	0.0025
7	0.0006	0.0018	0.0021	0.0081	0.0024

Appendix D

Table D-1 The changes of Sr concentration (mg L^{-1}) of the water inside benthic chambers at Kor-Yor (22- 23 January, 2005)

Time (hours)	**Sr (mg L^{-1})**			
	Light chamber 1	Light chamber 2	Dark chamber 1	Dark chamber 2
0	0.781	0.828	0.749	0.864
6	0.709	0.748	0.629	0.707
24	0.639	0.614	0.592	0.724
30	0.580	0.578	0.577	0.714

Table D-2 The changes of Sr concentration (mg L^{-1}) of the water inside benthic chambers at Khao-Deang (11-12 April, 2005)

Time (hours)	**Sr (mg L^{-1})**			
	Light chamber 1	Light chamber 2	Dark chamber 1	Dark chamber 2
0	4.01	3.74	4.02	3.82
6	3.42	3.55	3.77	3.77
24	3.58	3.59	3.95	3.94
30	3.56	3.60	3.91	3.90

Table D-3 The changes of Sr concentration (mg L^{-1}) of the water inside benthic chambers at Khao-Deang (25-27 January, 2006)

Time (hours)	**Sr (mg L^{-1})**			
	Light chamber 1	Light chamber 2	Dark chamber 1	Dark chamber 2
0	-	1.23	1.42	1.36
2	1.23	1.34	1.34	1.41
4	1.29	1.38	1.40	1.47
6	1.30	1.42	1.43	1.47
8	1.30	1.40	1.39	1.44
14	1.36	1.44	1.45	1.48
17	1.31	1.48	1.41	1.56
20	1.37	1.41	1.49	1.47
23	1.33	1.46	1.43	1.45
29	1.33	1.46	1.38	1.47
32	1.36	1.42	1.39	1.45
35	1.27	1.42	1.42	1.47
38	1.32	1.45	1.37	0.00
41	0.93	1.38	1.25	1.40
45	1.08	1.43	1.30	1.40
49.5	1.22	1.45	1.32	1.42
52.0	0	1.43	1.31	1.41
55.5	0	1.43	1.32	1.42

Appendix E

E-1 Calculation the Sediment surface of light and dark benthic chamber

The Sediment surface of light and dark benthic chamber was calculated by using equation below

$$S = ¶x\ r^2$$

Where

s is sediment surface of light and dark benthic chamber

r is the radius of light and dark benthic chamber

$$S = 3.14\ X\ (16X16)$$

$$S = 803.84\ cm^2$$

E-2 Calculation of Diffusive fluxes

The diffusive fluxes are a term to measure the transportation of dissolved metals from pore water in the sediment to the overlying water. The magnitude of diffusive release was estimated using a modification of Fick’s first law of diffusion appropriate for sediments (Berner, 1980)

$$Ji = -\ \phi D_s \frac{dC}{dz}\ \mathrm{z{=}o} \qquad \text{(D-1)}$$

$$Ds = \mathrm{Do}/\mathrm{F}\phi \qquad \text{(D-2)}$$

$$\mathrm{F} = 1/\phi^{\mathrm{m}} \qquad \text{(D-3)}$$

Thus $$Ji = -\ \phi^{\mathrm{m}}\ Do \frac{dC}{dz}\ \mathrm{z{=}o}$$

Where

J is the diffusive flux (mol $m^{-2}\ d^{-1}$)

ϕ is the porosity of the surface sediments, $\phi = \dfrac{V_{water}}{[\ V_{water} + V_{solid}\ ]}$

$\frac{dC}{dz}$ z=0 is the concentration gradient evaluated at the sediment-water interface, with dC as the difference between bottom water concentration and pore water concentration in the top-most section of sediment, and dz is the thickness of sediments across which diffusion takes place.

m is approximately equal to 2 when $\phi < 0.5$ (Ullman and Aller, 1982)

D_0 is the diffusion coefficient at 10 °C (Li and Gregory, 1974)

D_0 is the temperature dependent, free-solution diffusion coefficient of a solute. The diffusion coefficients used in this study were taken from Ditoro (2001) and corrected for in-situ temperature. The diffusion coefficients (D_0) were corrected for temperature effects by applying the Stokes-Einstein equation (Warnken, 2000)

$$\frac{D_1\eta_1}{T_1} = \frac{D_2\eta_2}{T_2}$$

$T1 = 10°C \qquad \eta_1 = 1.307$

$T1 = 28°C \qquad \eta_2 = 0.8327$

D_1 is D_0 at T= 10°C = $1.41X10^{-5}$ cm ^{2} s^{-1}

D_2 is D0 at T= 28 °C

Thus

$D_2 = 6.94x10^{-6}$ cm^2 s^{-1} (Ditoro, 2001)

The diffusion coefficient of Cd^{2+}, Fe^{2+}, Mn^{2+} are the same value (Ditoro, 2001). Thus, in this study it is assumed that diffusion coefficient of all metals are the parallel

Example. Calculation of difussive fluxes of Mn in wet season

$$Ji = -\phi^m Do \frac{dC}{dz} z=o$$

$$Ji = \frac{-(0.35)^2 X (6.94X10^{-6} cm^2 s^{-1})(246-51636 nmol L^{-1})}{1 cm}$$

Ji = 157.28 pmol cm^{-2} h^{-1}

E-3 Calculation

The concentration that was measured ($C_{measured}$) from the GFAAS was converted to the mass of metals in unit mass of soil, i.e,

$$Csoil = \frac{C_{measured} \text{ X Volume}_{(liquid)}}{m_{soil}}$$

Where

C_{soil} = concentration of the metals of the soil

Volume (liquid) = dilution volume which is 100 mL for all cases

m_{soil} = the sum of the mass of the measured dry soil

m_{solid} is approximately 150 mg for all cases and the mass of water which was contained in dry soil mass (m_{liquid} = wmsolid).

Example, [Cd] measured = 0.1235 µg L^{-1}

$$C_{soil} = \frac{(0.1235\ \mu g\ L^{-1})X(100\ mL)}{150\ mg}$$

C_{soil} = 82.00 µg kg^{-1}

Appendix F

F-1 Extraction procedures

In the filtered solutions (dissolved phase), trace metals were preconcentrated 20 folds by using ammonium pyrolidindithiocarbamate (APDC) and diethylammoniumdithiocarbamate (DDDC) based on the procedure of Magnusson and Westerlund (1981).

The method includes the following steps: transfer 10 ml of chloroform to a teflon separatory funnel. Add 30 ml of acidified estuarine water, 600 µl of mixed substance from 2 M acetate buffer and complexing agent (APDC and DDDC). Immediately, shake the funnel vigorously for 2 minute. Allow the phases to separate and collect the lower organic phase. Add another 10 ml of chloroform and shake the funnel for 2 minute. Combine the organic phases. After that the trace metals back extracted by adding 30 µl concentrated HNO_3 to the combined organic phases, shake vigorously for 2 minute and stand for overnight. Add 1,470 µl of nanopure water, mix vigorously and after a reaction time of 1 h. The aqueous solution was then analysed undertaken using either a Graphite-Furnace Atomic Absorption Spectrometer (GFAAS) for Cd, Cu, Pb, Mn and Fe or Flame Atomic Absorption Spectrometer (FAAS) for Mn metal in wet season. Blank was prepared in the same method as the samples