CHAPTER V

DISCUSSION

To ease the discussion of the present work, the 14 parameters reported in previous chapters will be put into 2 groups. The first one is the level of heavy metal contaminants in water, this part is the main interest of this research i.e, we would like to know the present situation of heavy metals contamination in water courses caused by the leachate from the solid waste disposal site. The second group consisted of the parameters that have tendency to influence the heavy metal mobility -transformation, adsorption, sedimentation, etc. They are pH, temperature, conductivity, alkalinity, salinity, suspended solids, dissolved and total solids. The variation of the extent of heavy metals found in aquatic environment can be well explained by these parameters. The BOD_5, COD and dissolved oxygen are also placed in group two which at the first sight they seem to be far removed from this group, nevertheless, in the evaluation of an environmental impact such parameters must be taken into consideration together with a parameter in the first group.

Since analytical methods employed and also instruments used for quantitative analyses of mercury, cadmium and manganese are all of standard ones, the reliability of the reported contents will therefore not be the topic of discussion here. On the other hand, the discussion that follows will focus on each of the heavy metals contamination namely mercury, cadmium and manganese, with an appropriate discussion and observation. The evaluation of environmental condition, by assessing from the involving parameters (group 2) will be seperately presented. Here, the term "inbound station" will be used referring to the leachate storage station and the term "outbound station" refers to the station stands outside the disposal site's boundary.

5.1 Heavy metals content in the leachate

5.1.1 Mercury

It can be observed from tables A-1 and A-2 in an appendix A page 107 and tables B-1 and B-2 in an appendix B page 112 that the mean mercury content in the leachate from solid waste disposal sites are rather low and varies considerably between months, stations (inbound and outbound) and sites (On-nuch and Nong Kham disposal sites). As for the level of mercury that seems to be unexpectedly low (0.19-39.13 ppb. at the On-nuch disposal site and 0.00-3.74 ppb. at the Nong Kham disposal site), it can be explained by comparing with the other research project conducted parallelly with this one, by Changpiyarat (1993). She measured the mercury content in the sediment whereas we measured in water (see tables 5-1 and 5-2) but both results show a similar pattern with respect to the variation in mercury content measured at different months and different spots. Changpiya-

Table 5-1 The comparison of mean mercury content in water and sediment at On-nuch disposal site.

	MONTH			
	MAY		JULY	
STATION	water (ppb)	sediment (ppb)	water (ppb)	sediment (ppb)
1	20.71	2751	3.73	2002
2	1.28	410	1.31	267
3	1.16	396	0.9	502
4	1.47	452	1.21	199
5	1.48	772	1.48	293
6	1.34	437	0.97	150
7	1.09	339	0.81	203
8	1.63	176	0.82	101
9	1.34	190	0.89	59
10	1.37	713	1.12	44

Table 5-2 The comparison of mean mercury content in water and sediment at Nong Kham disposal site.

	MONTH			
	JUNE		AUGUST	
STATION	water (ppb)	sediment (ppb)	water (ppb)	sediment (ppb)
1	0.8	547	0.85	779
2	2.05	728	2.63	1013
3	0.81	46	0.82	87
4	0.99	115	0.65	157
5	1.16	95	0.98	62
6	1.45	232	1.24	109
7	1.28	137	0.95	53

rat's results are about 10^3 times higher than what obtained in this work at every spot of observation. This is in accord with what has been mentioned in part 2.1 of chapter 2 that mercury will be accumulated in the sediment and living organisms better than in water (Laws, 1981). Moreover, in a natural condition, especially in water phase, low level of mercury was found which was caused by the binding and the adsorption of mercury on suspended materials which settled rapidly. Hence, the mercury contamination in the natural waterway was sharply declining downstreamly and this can be taken as a reason why the mercury levels in outbound stations and inbound stations were different. Not only that but also, the differences of acidity, temperature, volume of complex ions should have some influences on an adsorption process (D'Itri & D'Itri, 1977). The latter statement in couple with the observed high conductivity of a sample water should be responsible, to a certain extent, for the declining level of the mercury downstreamly.

It should be noted that the maximum acceptable level of mercury in the standard for industrial effluent is 0.005 mg/L (0.005 mg/L = 0.005 ppm. = 5 ppb.) where some of observed samples are exceeded.

The results of a significant difference test of the mercury content with the confidence limit at 95 % showed that the average mercury content in the different period of an observation had a significant difference at the On-nuch disposal site ($F_{calc.}$ = 20.831, $F_{tab.}$ = 1.90) but had insignificant difference at the Nong Kham disposal site ($F_{calc.}$ = 1.702, $F_{tab.}$ = 2.21). The significant difference in the mercury level at the On-nuch disposal site may due to the difference in the dilution effect that caused by the different amount of rainfall, being lower in May than in July. The Scheffe test showed that both observed mean mercury contents from station 1 in May and July had a significant difference to stations 2-10 at the On-nuch disposal site. At the Nong Kham disposal site, in June, the average mercury content in station 2 had a significant difference to stations 1 and 3, a significant difference was found for the content of station 2 from those of stations 1, 3, 4, 5, 6 and 7 in August at the 95 % level of confidence. In comparison to the Nong Kham's results, it can be seen that the mercury content measured at the On-nuch disposal site were higher. This may be caused by the differences in the volume of waste dumping at the site, in waste characteristics, in the disposal site's size, in the pattern of lives of canal's sides communities. All of these tend to support the findings that mercury from various sources are leached better at the On-nuch disposal site than the Nong Kham disposal site. The correlation test showed that the obtained mercury content had a positive correlation with the obtained values of alkalinity, conductivity and total solids. Although such a correlation is interesting, it must be taken with caution and should not be concluded as such. In order to be useful as an indicator, other independent factors must be thoroughly investigated.

5.1.2 Cadmium

The cadmium contamination in all water samples from both disposal sites were non-detectable since they were lower than the detection limit at 0.03 ppm.

The water samples taken for measurements exhibited pH values which vary between neutral and basic values. According to Laws (1981) this would favour the insolubility of cadmium. In other words, under this pH condition cadmium should be in an insoluble form or be adsorbed by suspended materials and, finally, settled. It was, also, noticed that the total solid of the outbound stations was not too high but relatively high at the inbound stations. This may help cadmium be better adsorbed on solid materials. If this assumption is correct, cadmium should be detected in the underwater sediment. But result of the study of Changpiyarat (1993) showed that she could detect cadmium in the sediment only once at the On-nuch disposal site -inbound station- at 0.5 ug/g (dry basis). It can therefore be concluded, here, that there is no cadmium contamination over 0.03 ppm. in water courses inside and nearby the disposal sites of the Bangkok Metropolitan Administration (BMA).

The permissible value of the cadmium content in the industrial effluent is less than 0.03 mg/L and surface water quality class 4 is 0.005 mg/L, as ruled by the NEB.

5.1.3 Manganese

The manganese content at the On-nuch disposal site ranged from 0.01-1.84 ppm. (with mean range = 0.48-0.73 ppm.) in May and ranged from 0.24-2.88 ppm. (with mean range = 0.59-0.83 ppm.) in July, for both inbound and outbound stations (see tables A-1 and A-2 in an appendix A page 107).

Manganese contamination at the Nong Kham disposal site ranged from 0.28-2.02 ppm. (with mean range = 0.41-1.01 ppm.) in June and ranged from 0.27-2.56 ppm. (with mean range = 0.73-1.28 ppm.) in August (see tables B-1 and B-2 in an appendix B page 112).

Although, it is easily to notice that some outbound stations had a higher mean manganese content than those of inbound stations, but the difference was insignificant. It is because manganese can simply be found naturally, as mentioned in part 2.3.2. of chapter 2, that about 1000 mg/kg in the earthcrust and less than 1000 ppb. in surface water in Europe and the USA. In Thailand 0.082-18 mg/L of manganese was found in a shallow well water near Mae-Hia solid waste disposal site in Chiangmai and the NEB found manganese content in lower Chao Phraya River at 10-1187 ug/L and <1.82 mg/L in Bang Pakong River (as mentioned in part 2.4.2. of chapter 2). So, the detected manganese content from the Bangkok solid waste disposal site is not surprisingly similar to the manganese content in various sources of natural waterways.

The maximum acceptable level of manganese in the standard for industrial effluent is 5.0 mg/L where all of observed samples are not exceeded that value but some of them exceed the surface water quality class 4, where the acceptable value of manganese content is 1.0 mg/L.

The results of a significant difference test showed that a different period of an observation had an insignificant effect on the average observed manganese content in water both at the On-nuch and the Nong Kham disposal site, under the level of confidence = 95 %. At the On-nuch disposal site, a significant difference of the mean manganese content in water in May and in July between each observation station was not found. At the Nong Kham disposal site, the difference of the mean manganese content between station 3 and station 7 in June and between stations 1 and 6 and stations 1 and 7 in August were found significant under the level of confidence = 95 %. The test undertaken showed no correlation between manganese content and alkalinity, conductivity, temperature and total solids.

The comparison of manganese content in water and sediment are shown in tables 5-3 to 5-4.

5.2 Environmental condition of the leachate source and the drainage receptor

The mean temperature at inbound stations are not different from outbound stations and from natural mean temperature. The variation of the observed temperature may be influenced by the different time of observation and the

Table 5-3 The comparison of mean manganese content in water and sediment at On-nuch disposal site.

	MONTH			
	MAY		JULY	
STATION	water (ppm)	sediment (ppm)	water (ppm)	sediment (ppm)
1	0.68	250.7	0.83	371.3
2	0.73	130.9	0.81	321.3
3	0.54	161.3	0.71	211.3
4	0.56	168.7	0.66	202
5	0.68	163.3	0.64	287.3
6	0.62	223.3	0.68	209
7	0.57	193.3	0.59	338
8	0.48	275.3	0.58	267.3
9	0.53	345.3	0.62	318.7
10	0.55	258.7	0.62	333.3

Table 5-4 The comparison of mean manganese content in water and sediment at Nong Kham disposal site.

	MONTH			
	JUNE		AUGUST	
STATION	water (ppm)	sediment (ppm)	water (ppm)	sediment (ppm)
1	0.72	323.3	1.279	415.9
2	0.74	965.3	0.77	726.2
3	1.01	177.3	1.082	293.5
4	0.87	183.3	0.836	212.9
5	0.51	286	0.762	410.2
6	0.62	694	0.735	180.8
7	0.41	184	0.731	191.2

sunlight radiation. The dark colour of leachate in a storage pool can help heat absorption as well as the product of the fermentation process so that the temperature in the storage pool was little raised up. The observed temperature was not too high to render any effect on heavy metals mobility.

All observed pH-values fell within a neutral range and in some cases had a tendency to be basic. The higher pH value was found in water in the leachate storage pool and this may be caused by the leaching of various kinds of elements from the dumping yard. However, the highest value of pH obtained still did not exceed the permissible pH range for surface water quality class 4, as mentioned in table 2-5.

The dissolved oxygen (DO) for all outbound stations varied between moderate to low level, while almost of inbound observations were 0.0 mg/L of oxygen dissolved in water. The NEB has ruled that the standard of DO in surface water quality class 4 not to be less than 2.0 mg/L which a few of observed DO exceed. The low water level and low water flow can lessen the oxygen perforation between water and air phase.

It was found that the conductivity values of the inbound stations were 10 times higher than those of the outbound stations. This occurrence tends to confirm the assumption that there are various kinds of element with various quantities leached from the dumping yard. The conductivity can reflect roughly on free ion content in water phase and it may influence on the adsorptability of contaminating ions on suspended particles.

The alkalinity in all inbound stations were within 3 digits range while all outbound stations were only 2 digits range. The alkalinity at the inbound stations were, approximately, 30 times higher than that of outbound stations. It was noticed that the alkalinity measured at station 3 at the Nong Kham disposal site was a little higher than other outbound stations at the same period of observation which might be caused by the fact that this station served as a secondary leachate receptor. Although, there is no alkalinity standard for water but the higher the value of alkalinity may result in a better effect on an acid-neutralizing process on those water courses. It may, also, give some complications on any wastewater treatment system.

The biochemical oxygen demand (BOD_5) at both sites at outbound stations were ranging from normal to slightly high while at the inbound station was high. It was noticed that some adjacent stations to the inbound station had a little higher BOD value than other downstream stations. The high value of BOD in this case may be caused by the drainage of high BOD leachate as well as the domestic effluent from canalsides residences onto the waterway. It was noticed, also, that at the station 1 of the Nong Kham disposal site had a lower BOD than that of other stations which was contrary to any expectation since the station 1 was inside the disposal site. In this case it was thought that the surface runoff drained onto the Klong Charoensuk at this station, and the lesser density of canalsides residences than along the canal banks outside this disposal site, may be responsible for the lower BOD-values at this station. When we determined the mean BOD with the standard for surface water quality class 4 as ruled by the NEB (< 4.0 mg/L), it was discovered that all of them exceeded that standard value. However, when we compared with the NEB's industrial effluent standard, where permissible range is 20-60 mg/L, almost all of them were accepted except the BOD of both inbound stations and stations 3 and 4 at the Nong Kham disposal site measured in June.

The chemical oxygen demand (COD) in all outbound stations were normal to moderately high while the COD in inbound stations were very high, approximately, 10-20 times higher than outbound stations. Generally, the COD value should be 3-5 times higher than the BOD_5 value. But in the work reported here the COD of inbound stations, was 10-20 times higher than BOD_5. The value of COD has a direct proportion to the number of the chemical components in the water courses. Hence, in this case it can be reasoned that the leachate from the solid waste disposal site must contain a high number of chemical components. The high difference of BOD:COD ratio will strongly govern the choice of the wastewater treatment system where the non-biotic or semi-biotic systems may be more appropriate to this wastewater character than a full biotic systems. There is no effluent standard control on COD-value at all.

The solid content in water, be it in suspended or dissolved forms were found ranging from normal to moderately high in all outbound stations and very high in inbound stations. The exact value of the solid content in water was ruled by the NEB on suspended solids, by using the term "up to dilution", and on dissolved solids, (industrial effluent standard) as less than 2000 mg/L. All inbound and adjacent stations in both sites contained dissolved solids in exceeding value of the standard. Since solid especially in the suspended form, can act as an adsorption site for any free ions or particles, therefore the high solid content means the very effective removal of some heavy metals contaminants from water which carry them in the forms of settled solids or sediment.

It can obviously be seen that the mentioned parameters above, can be used to evaluate the present environmental condition of the leachate source and the drainage receptor. The leachate had a low water quality in both physical and chemical aspects of consideration. The high content of heavy metals -mercury, cadmium and manganese- in the leachate were far from acceptable for draining onto the public waterway. If it is unavoidable and have to drain to the public waterways, it must be treated by any available methods to improve the water quality until it meets the permissible range of industrial effluent standard or natural water quality.

The aquatic environment conditions of the surrounding of both solid waste disposal sites were varied from fair to poor when compared with the standard of the surface water quality class 4, as ruled by the NEB. Some were affected by the leachate from the disposal site but other by domestic wastewater. The water quality in other public waterways is believed to be not much better than what were found in this work, although the leachate are not drained onto them. It is, fortunately, that the heavy metals contamination in the public waterway, from other sources, do not give any critical effect. Technically speaking, however, the natural water quality is so poor to be used for any domestic purposes, but due to the lack of clean fresh water sources people still have to use and take a serious risk. This is worth raising the serious interest of the authorities concerned.