CHAPTER 4 : RESULTS AND DISCUSSION

4.1 Introduction

The landfill leachate and water samples obtained from the Michu and Sungai Langat were analysed and is presented in three sections. Firstly, the studies on the physical and chemical aspects of the leachate, followed by physical, chemical and microbiological analysis of the water samples and lastly by the heavy metal analysis.

4.2 Leachate Studies

A landfill can be regarded as a bioreactor where organic matter which has been disposed and resulting in biological and chemical reactions will produce leachate and gases. The chemical composition of leachate may depend on many factors such as the fill material, geological conditions, dump depth, age of residues age of the landfill, method of disposal, degree of wetness and the composition of solid waste disposed.

Since the actual composition of the solid waste in the Ampang non-sanitary landfill during its active life was not available, published data on the composition of solid waste in Kuala Lumpur city was taken as a reference since Ampang non-sanitary landfill was also used for the city waste disposal too. Characteristics and composition of solid waste generated in Kuala Lumpur is given in Table 4.1. The nature of waste generated in Kuala Lumpur is mainly organic waste followed by paper and similar trend was observed for waste from other councils and municipalities in other major towns in the country (Agamuthu, 1997).

Table 4-1 : Composition Of Solid Waste In Kuala Lumpur.

Item	(% weight)
Organic waste	45.70
Paper	20.00
Plastics	9.00
Glass	3.90
Ferrous metal	5.10
Non-ferrous metal	-
Textiles / leather	2.10
Woods	-
Others	4.3

Sources : Hassan *et. al.* (1998)

Bulk of waste generated in the city of Kuala Lumpur is organic waste which constitutes 45.70% of total weight. This is followed by paper, 20%; plastics, 9.0%; and ferrous metal, 5.10%. In Malaysia only 3% of the glass materials and paper are recycled.

The high moisture content in the Malaysian waste and the high tropical temperature require waste to be collected and disposed off in the landfill as soon as possible. The bulk of waste disposed of via landfill remains relatively inert after burial. However, most of the organic material in the waste biodegrades gradually over time giving rise to variety of products. The rate of decomposition is dictated by the nature of the waste, its pH, temperature and moisture content, the availability of oxygen and the bacteriological conditions. As a result of various chemical reactions that occur as time passes, an aqeous layer called leachate is produced. This leachate is organic in nature, containing not only fatty acids, aldehydes and ketones but it also contains some inorganic chemicals such as chlorides and sulphates.

Landfill leachates are in many cases, highly contaminating and can degrade surface and ground water resources. In Malaysia, the traditional source of drinking water had been surface water. It is therefore very important that municipal landfill is properly sited, designed, managed and maintained so that the sources of water (surface or groundwater) is protected from the leachate emanating from the landfill.

Generally the organic and inorganic constituents of the leachate collected before the landfill was closed are higher. The composition of leachate differ in terms of chemical and biological constituents as the age of the fill increases. The concentration of leachate tend to decrease as the age of the fill increases and this enhances the leachate quality.

The presence of heavy metal is of a major concern from an ecological point of view. It can be observed from the results obtained that a significant concentration of heavy metals like iron, magnesium, nickel, kalium, natrium are found in the leachate samples which could be attributed to the waste from industrial and domestic.

The characteristics of leachate samples which are collected before and after closure of the Ampang non-sanitary landfill are listed in Table 4.2.

Table 4-2 : Composition Of Landfill Leachate From Ampang Landfill Site (C1)

PARAMETER	Ampang landfill (mean)		EQA 1974	
	Before closure	After closure	Standard A	Standard B
BOD (mg/l)	1026 ± 52	88 ± 5	20	50
COD (mg/l)	3087 ± 45	1071 ± 52	50	100
pH	7.85 ± 0.03	7.7 ± 0.07	6.0-9.0	5.5-9.0
Turbidity (NTU)		125.5		
TSS (mg/l)	618 ± 8	194 ± 7	50	100
Ammonia - N(ppm)	-	690	-	-
TS (mg/l)	7057 ± 34	2029 ± 20	-	-
Total Alkalinity (ppm)	3600 ± 37.7	2850 ± 35.3	-	-
Hardness ($CaCO_3$) (ppm)	680 ± 8.5	510 ± 7.7	-	-
Chloride (ppm)	2500 ± 70.7	1200 ± 49.5	-	-
Sulfite (ppm)	60 ± 5.0	43 ± 2.1	-	-
Chromium (ppm)	0.135 ± 0.003	0.115 ± 0.002	-	-
Manganese (ppm)	0.187 ± 0.008	0.041 ± 0.004	-	-
Ferum (ppm)	45 ± 3.5	22 ± 2.1	1.00	5.00
Nickel (ppm)	0.044 ± 0.003	0.026 ± 0.002	-	-
Cuprum (ppm)	0.073 ± 0.002	0.071 ± 0.004	0.2	1.00
Zinc (ppm)	0.271 ± 0.008	0.095 ± 0.003	0.2	1.00
Cadmium (ppm)	0.035 ± 0.004	0.034 ± 0.003	0.01	0.02
Plumbum (ppm)	0.030 ± 0.003	0.027 ± 0.005	0.01	0.50
Magnesium (ppm)	35 ± 2.8	9.1 ± 1.4	0.2	1.00
Barium (ppm)	0.074 ± 0.006	0.031 ± 0.004	-	-
Kalium (ppm)	785 ± 12.6	350 ± 11.6	-	-
Sodium (ppm)	687 ± 22.2	315 ± 24.7	-	-

The average pH value of the leachate samples before and after closure is 7.75 and 7.85 respectively and this indicates a methanogenic phase. In this stage the organic acids produced in the nonmenthanogenic phase are consumed by the bacteria and this raises the pH of leachate to the range of 7 to 8. During this phase, leachate characteristically has a near neutral pH, low volatile fatty acids and low total dissolved solids (Mc Bean *et. al.*, 1995). The decomposition process produces various chemicals and substances which are clearly reflected in the organic indicators like COD and BOD of leachate samples. In this study, the average value of BOD after closure is 88 mg/l and this low BOD value indicates that the organic matter is no more easily biodegradable. The ratio of BOD to COD value is approximately 0.08 and this shows that the leachate is produced during methanogenic phase. The COD value of leachate samples before closure are generally high with an average concentration of 3087 mg/l.

The average TSS values of the leachate samples before and after closure were 618 mg/l and 194 mg/l whereas the average TS values were 7057.0 mg/l and 2029.0 mg/l, respectively. Leachate samples obtained before the closure shows a very high TS and TSS contents and this is due to the presence of high organic and inorganic particles. The presence of this particles provides an adsorption sites for chemical and biological agents. The turbidity recorded in the leachate sample was 125.5 NTU. Soaps, detergents and emulsifying agents produce stable colloids that results in turbidity.

The average alkalinity of the leachate samples are 3600 ppm before closure and 2850 ppm after closure. The constituents of alkalinity are bicarbonate, carbonate, hydroxide, ammonia and hydrogen sulphide. These compounds result from dissolution of minerals from the soil. Hydrogen sulfide and ammonia may be the products of microbial decomposition of organic material in the landfill (Peavy *et. al.*, 1988). Since Ampang non-sanitary landfill received organic waste mainly, the decomposition of these materials produced chemicals which increases the alkalinity. The carbonate hardness found in both the leachate samples before and after closure were 680 ppm and 510 ppm respectively.

The concentration of ammoniacal nitrogen found in the leachate samples collected after closure was 690 ppm. This concentration is relatively high compared to ammoniacal nitrogen present in leachates from other landfills for example the Sabak Bernam Landfill which only recorded an average concentration of 8.0 ppm. The high concentration could be attributed to the high percentage of organic waste received by the landfill, for example food waste, plastics, fertilizers etc. Ammoniacal nitrogen present in these wastes undergo initial acetogenic decomposition and once released into the anaerobic environment of the landfill, there is no significant biochemical pathways whereby ammonia can leave the wastes other than as ammonia in the leachate (Robinson, 1989).

The mean concentration of chloride of the leachate samples before closure was 2500 ppm and 1200 ppm in leachate samples collected after closure. Chloride is present in abundance from both municipal and industrial refuse and is essentially unretained by soil mechanisms because it is non reactive both physically and biologically and diffuses quickly. Therefore it is normally present in high concentration in the leachate. The chloride content found in this leachate is much higher compared to the chloride content in the leachate from Sabak Bèrnam and Kelana Jaya landfill which was recorded at 420 mg/l and 23-30 mg/l respectively (refer to page 2-22)

Sulfate is the most common form of sulfur in landfills. It is quite mobile and is helpful in monitoring the leachate movement. Sulfate is easily reduced to sulfide, which complex readily with metals. The average the concentration of sulfide which was detected in the leachate samples before closure was 60 ppm and 43 ppm in the leachate samples collected after closure.

The leachate contains high amounts of ferum, zinc, cadmium and magnesium which exceeded the effluent standards stipulated in the EQA, 1974. For example, the magnesium concentration in the leachate samples were 35 ppm (before closure) and 9.1 ppm (after closure), while the EQA limit is below 0.2 ppm for standard A. Sources of magnesium in the landfills are cosmetics, cement and textiles. Similarly the concentration of ferum in the leachate samples before and after closure were 45 ppm and 22 ppm respectively, while the EQA limit was only 5ppm.

The potassium and sodium concentration of the landfill leachate were 785 ppm and 687 ppm before closure and 350 and 315 ppm after closure. Sodium is the principal alkali metal and tends to remain in solution and do not subject to attenuation. Its presence in leachate may stem from the extensive use of sodium salts in industry and domestic activities (paper, soap, baking, borax etc.). Whereas potassium is released during refuse decomposition and its major sources are plants and discarded food.

Some general observations can be made when comparing Ampang non-sanitary landfill with other published Malaysian data. The BOD:COD ratio of the leachate from

Ampang non-sanitary landfill is similar to the ratio recorded in the leachate from Taman Beringin landfill. Taman Beringin landfill leachate has a BOD:COD ratio of 0.05. One of the common features between these two landfills are the kind of waste they receive. Taman Beringin landfill also received mainly domestic refuse, construction refuse and garden refuse from residentials in Selayang, Kepong and Sungai Besi. However, the concentration of lead and ammoniacal nitrogen in the leachate from Taman Beringin landfill was relatively high compared to other Malaysian landfills which were about 100.439 ppm and 22585.0 ppm respectively. The values recorded in the Ampang non sanitary landfill leachate collected after the landfill was closed were only 0.03 ppm for lead and 690 ppm for ammoniacal nitrogen.

Sabak Bernam landfill leachate (refer to page 2-22) contained higher cations for example magnesium (55.3 ppm) and sodium (1289 ppm) but lower in ammoniacal nitrogen (8.0ppm) compared to Ampang non-sanitary landfill. This is probably because Sabak Bernam landfill receives agrowaste mainly and it is an active landfill (7 years old), whereas Ampang non-sanitary landfill is closed and over 10 years old. The COD concentration recorded in the landfill leachate during its active life was found to be much higher than the leachate from Sabak Bernam landfill (1250– 2570 ppm). The lower COD concentration observed in the Sabak Bernam landfill leachate is due to the lower amount of putrescible waste disposed in the Sabak Bernam landfill.

Ampang non-sanitary landfill leachate was observed to contain higher concentration of ferum (45 ppm) compared to the Taman Beringin landfill leachate (3.2 – 17.4 ppm) and Air Hitam landfill leachate (3.6 – 15.7 ppm). The disposal of scrap metals in the Ampang non-sanitary landfill may explain the higher strength of ferum found in the leachate.

Comparison of the Ampang non-sanitary landfill leachate to other published data shows that the concentration of total nitrogen in the leachate is very much higher in our country. The concentration of ammoniacal nitrogen in the leachate samples collected after landfill closure from Ampang non-sanitary landfill was 690 ppm whereas leachate from a closed landfill in Vancouver was only 202 ppm (refer to page 2-21). This indicates the presence of a higher organic waste in our landfill. The turbidity found in the Vancouver landfill leachate was only 67 NTU compared to 125.5 NTU in the leachate from Ampang non-sanitary landfill.

In general and as expected, a higher level of pollution was observed in the leachate samples collected before landfill closure compared to the samples collected after the landfill was closed. Most of the chemical and physical parameters analysed do not comply with the standard set in Standard A of EQA 1974 except for cuprum and zinc concentration.

4.3 Chemical Analysis Of The River Water Samples

In the previous section, the physical and chemical parameters of the Ampang non-sanitary landfill leachate has been presented and analysed. In this section, the results of the water samples collected from the Michu and Langat rivers will be analysed to investigate the extend of leachate contamination in these rivers. Besides the leachate, the other sources of contamination of these rivers are industrial discharge, domestic refuse and sewage contamination.

4.3.1 COD

COD concentrations in the water samples collected after the landfill closure generally fall in the range between 0 to 293.12 mg/l. The highest COD concentration was found to be at C2 station with an average value of 193.416 ± 65.4 mg/l (Figure 4-1).

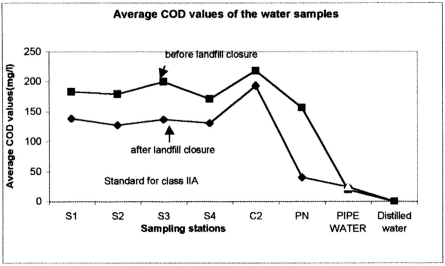

Figure 4.1 : Average COD concentrations in the water samples collected before and after landfill closure

Illegal factories which are operating along the Langat River were found to be the main cause of the high COD value here. These factories dispose untreated effluents into the river causing severe river pollution.

S1 station was found to record the second highest COD concentration. This is due to the presence of leachate which seeps through the soil and contaminates the river. This was followed by the S3 station with an average COD concentration of 137.39 ± 38.1 mg/l. This suggests that the residents are probably disposing toxic waste, for example, batteries, electrical appliances, metal containers, paints etc into the river. COD comparison with the leachate samples collected before the landfill closure shows, as expected higher COD values during the active life of the landfill. Figure 4-2 shows the overall changes in the COD concentrations at all the stations over time.

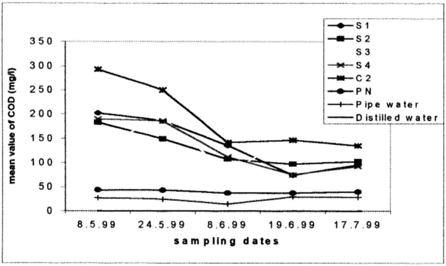

Figure 4-2 : Mean COD concentration at each station (after landfill closure)

Generally the COD pattern observed before and after the landfill closure are similar, with the highest COD being recorded at station C2 followed by S3.

In general, there is a gradual decrease in the COD values except at station S3 whereby the values fluctuate over time. Water samples from the 10th Mile Water Treatment Plant was found to be quite constant with an average value of 40.518 ± 2.9 mg/l, which is above the National Water Quality Standard for Class IIA.

4.3.2 BOD

Figure 4-3 shows the average BOD values in the water samples collected after the landfill closure.

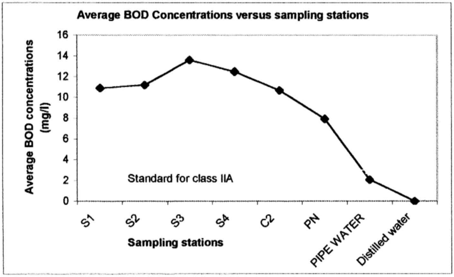

Figure 4-3 : Average BOD values in the water samples collected after the landfill closure

The organic loading in the water body is indicated by the biological oxygen demand (BOD) and chemical oxygen demand (COD). The BOD values were found to generally fall in the range between 0 to 15.8 mg/l. This value is much lower compared to data reported by Mohd. Kamil (1999) on the BOD values of water bodies (stagnant ponds) within Taman Beringin landfill, which ranged from 16.5 mg/l to 39.40 mg/l, with an average value of 23.48 mg/l. A higher BOD value is recorded here because Taman Beringin Landfill is an active landfill whereas Ampang non-sanitary landfill has been closed for almost one and a half years. Furthermore, the pond within Taman Beringin landfill is a closed system whereas rivers are mobile system.

The highest average BOD value was recorded at S3 (13.6 ± 1.44 mg/l) station followed by S4 (12.48 ± 2.1 mg/l), S2 (11.2 ± 2.6 mg/l) and S1 (10.906 ± 1.0 mg/l) respectively. The residents have been disposing organic and kitchen waste into the stream and this may explain why there is a higher value at S2, S3 and S4 stations. During site investigation, bags of garbage were seen floating in the river causing foul odour. The effect of landfill leachate was observed to be low at S1 station. Figure 4-4 shows the changes in the BOD values over time.

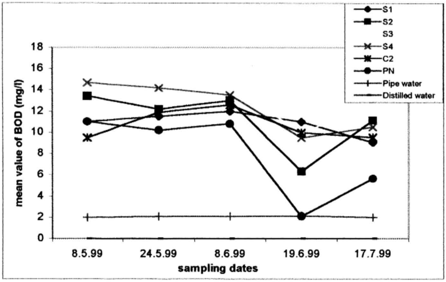

Figure 4-4 : Mean BOD concentrations at each station (after landfill closure

On 19.6.99, all the stations record a significant drop in the BOD concentrations. This is probably due to heavy rain that occurred the day before sampling was done, causing the dilution factor in the river to be higher.

4.3.3 Total Suspended Solid

Figure 4-5 shows the average TSS values of the water samples collected before and after landfill closure.

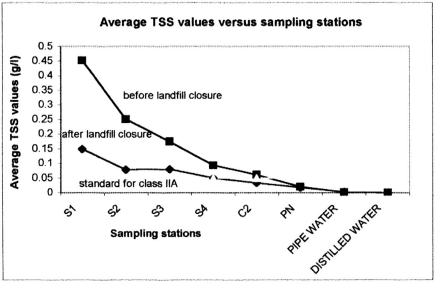

Figure 4-5 : Average TSS values in the water samples collected before and after landfill closure

The mean concentration of total suspended solid after the landfill closure at all the stations ranged between 0 and 0.1492 g/l. The highest value was recorded at station S1 with an average of 0.1492 g/l and a standard deviation of 0.136. The second highest concentration was recorded at station S3 with an average value of 0.0798 ± 0.01 g/l followed by 0.0784 ± 0.05 g/l at S2. TSS concentration at C2 and PN was found to be relatively low with an average of 0.034 ± 0.01 g/l and 0.018 ± 0.002 g/l respectively. Samples obtained before the landfill closure shows a higher TSS value and the difference was found to be significant (P=0.05). The concentration of TSS at station S1 was 0.45 g/l, three times higher than the samples collected after the landfill closure. Figure 4-6 shows the changes in the TSS values over time.

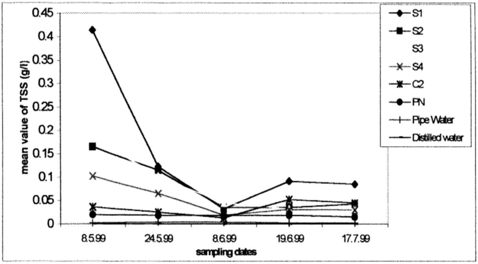

Figure 4-6 : Mean TSS concentrations at each station (after landfill closure)

On 8.6.99, all the stations were recorded with low TSS values ranged between 0 and 0.044 g/l, but these values increased in the next sampling on 19.6.99, except at station S3. The heavy rain which occurred the day before sampling was done could have caused erosion and sedimentation in the river resulting in a higher TSS values. Water samples from station PN was found to show a constant TSS trend between 0.015 and 0.020 g/l.

Overall the TSS values obtained from station S1, S2 and S4 are above the Water Quality Standard for class IIA whereas values at other sampling stations comply with the standard.

4.3.4 Total solid

Figure 4-7 shows the average values of total solid at all the stations.

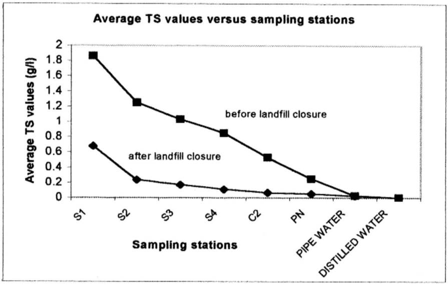

Figure 4-7 : Average TS concentrations in the water samples collected before and after landfill closure

The highest value after landfill closure was recorded at S1 with an average value of 0.6762 ± 0.075 g/l followed by S2 (0.2364 ± 0.025 g/l), S3 (0.1694 ± 0.02 g/l), S4 (0.1084 ± 0.05 g/l), C2 (0.067 ± 0.01g/l) and PN (0.0494 ± 0.01 g/l) respectively. Comparison with the TS values in the samples collected before the landfill closure shows much higher values. At S1, the value recorded before the landfill was closed is three times higher than the value obtained after the landfill closure. Whereas at station S2, 1.2 g/l of TS concentration was recorded before landfill closure compared to only 0.2 g/l after the landfill was closed. The ANOVA analysis shows that the difference in concentration of TS between the samples collected before and after landfill closure is significant (P=0.05).

Overall there has been an improvement in the quality of the river water after the landfill stopped operating. Figure 4-8 shows the mean value of TS in the water samples collected over a period of time after landfill closure.

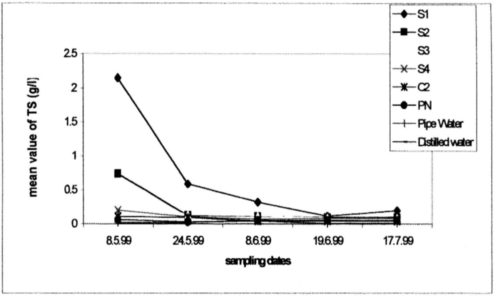

Figure 4-8 : Mean TS concentrations at each station (after landfill closure)

Generally, the pattern observed is similar to the changes in TSS values over time whereby the samples collected at station S1 recorded a very high value during the first sampling but dropped drastically in the next sampling taken on the 24.5.99. And over the next few samplings, the concentration of TS was found to be low indicating good quality of water.

4.3.5 Ammoniacal Nitrogen

Ammoniacal nitrogen is a useful indicator of organic pollution. High concentration of ammoniacal nitrogen could be an indication of organic pollution such as from domestic waste, industrial waste and fertilizer run off.

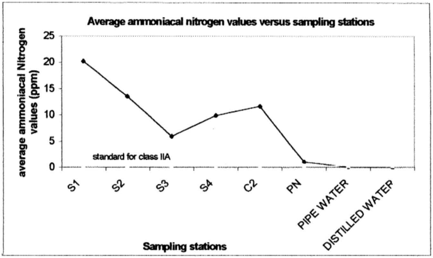

Figure 4-9 : Average ammoniacal nitrogen concentrations in the water samples collected after the landfill closure

Based on the ammoniacal nitrogen profile along the stations, the water quality improves from S1 to S3, while at S4 the water quality starts to degrade and peaks up at C2 (Figure 4-9).

The highest ammoniacal nitrogen concentration was found to be at S1 station with an average of 20.22 ± 8.5 ppm. This was followed by station S2 with an average concentration of 13.53 ± 1.2 ppm and C2 with an average of 11.64 ± 1.5 ppm. Whereas, S3 and S4 stations recorded an average value of 5.93 ± 2.0 and 9.95 ± 1.9

ppm respectively. S1 and S2 stations are heavily polluted with organic materials due to influx of leachate and domestic wastes discharges by the residents. C2 is heavily polluted by industrial discharges which release ammonia into the river. As reported before, the presence of many illegal factories disposing toxic waste for example oil and grease and ammonia pollution from poultry farm contributes to the high level of nitrogen at this station.

Figure 4-10 shows that all the stations excluding S1 records a constant value for ammonia-N over time. At station S1 there was significant drop in the ammoniacal ammonia concentration on the 19.6.99. The high dilution factor due to heavy rain on the previous day explains the drastic decrease in the ammoniacal nitrogen concentration.

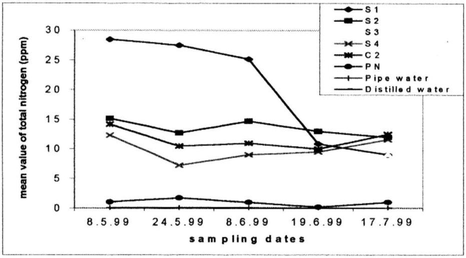

Figure 4-10 : Mean ammoniacal nitrogen concentrations at each station (after landfill closure)

4.2.6 Water Hardness

Based on the water hardness profile from the upstream to downstream location,. the water quality status shows recovery (Figure 4-11).

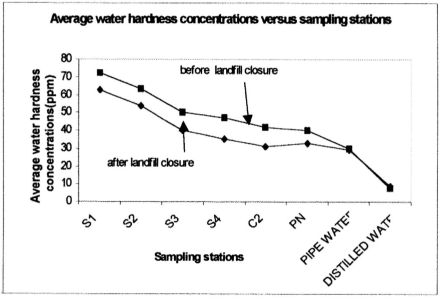

Figure 4-11 : Average water hardness concentrations in water samples collected before and after landfill closure

The hardness of the water samples collected after the landfill closure from all the eight stations ranged between 9 and 62.6 ppm. The highest water hardness concentration was found to be at station S1 with an average value of 62.6 ± 30.6 ppm and this could be attributed to the leachate from the landfill which contaminates the river. This is followed by S2 station with an average concentration of 53.8 ± 25.3 ppm, S3 (39.8 ± 13.8 ppm), S4 (35.4 ± 10.1ppm), PN (33 ± 12.4 ppm) and C2 (31 ± 2.1 ppm) respectively. Water samples collected before landfill closure shows higher water hardness concentration. This is probably due to the presence of various chemicals and inorganics that originates from the leachate.

Although there are differences in the values between the samples collected before and after the landfill closure, the ANOVA analysis for a single factor (P=0.05) shows that the difference is not significant.

Most rivers in Malaysia is soft with less than 60 mg/l of hardness although some 10% of them may have hardness of more than 100 mg/l. According to Peter and Vladimir (1980), hardness is known to have an antagonistic effect on the toxicity of the heavy metals to aquatic life. An increase in hardness of water decreases the toxicity of heavy metals.

Figure 4-12 shows the profile of the water hardness concentration over time at each station after the landfill was closed.

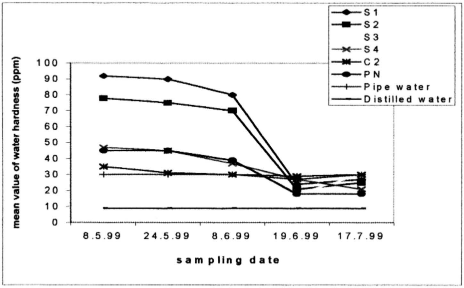

Figure 4-12 : Mean concentrations of water hardness at each station (after landfill closure)

On the 19.6.99, there is significant drop in the water hardness concentration at S1, S2, S3, S4 and PN stations. This is probably due to the heavy rainfall on the previous day which increased the dilution factor in the river. After this sudden drop, the values at all the stations seem to fall in a narrow ranged between 18 and 30 ppm.

4.3.7 Sulphite

Figure 4-13 shows the average sulphite concentrations at all the eight stations.

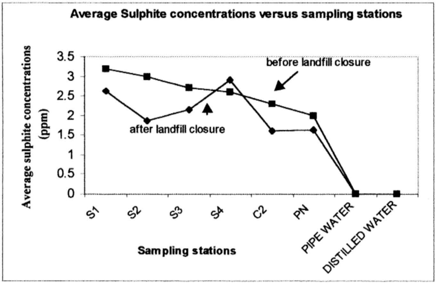

Figure 4-13: Average sulphite concentrations in the water samples collected before and after landfill closure

It was found that the mean sulphite concentration of the water samples collected after landfill closure ranged between 0 and 4.3 ppm. The results obtained for sulphite from different sites showed that S4 has the highest concentration with an average concentration of 2.9 ± 1.2 ppm followed by S1 (2.62 ± 0.68 ppm), S3 (2.14 ± 0.73ppm), S2 (1.86 ± 0.17 ppm), PN(1.64 ± 0.61ppm) and C2 (1.6 ± 0.55 ppm) respectively. A higher concentration at S4 suggests that the residents are probably contaminating the river with sewage. S1 also records a high concentration of sulphite which may be contributed by the contamination of the leachate. Figure 4-13 shows that the concentration of sulphite in the water samples collected before landfill closure is higher than the samples collected after the landfill closure. It is interesting to note that the concentration of sulphite found at station S4 was higher after the landfill closure compared to before landfill closure. This is possibly due to the disposal of sewage from the residents residing around station S4. Figure 4-14 shows the changes in sulfite concentrations over time.

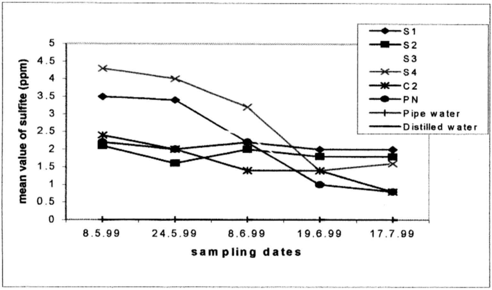

Figure 4-14 : Mean sulphite concentrations at each station (after landfill closure)

Station S1, S3, S4, C2 and PN shows reduction in sulfite concentration over time whereas the concentration at S2 seems to fluctuate in a narrow range between 1.6 and 2.1 ppm.

Sulfite formation in surface water is principally through anaerobic bacterial decay of organic substances in bottom sediments and stratified lakes and resevoirs. Traces of sulfite ions occur in unpolluted bottom sediments from the decay of vegetation, but the presence of high concentration often indicates the occurrence of sewage or industrial wastes. When appreciable concentrations of sulfite occur, toxicity and the strong odour of the sulfite ions make the water often unsuitable for drinking and other uses.

4.3.8 Total Alkalinity

Figure 4-15 shows the average total alkalinity in the water samples collected before and after landfill closure.

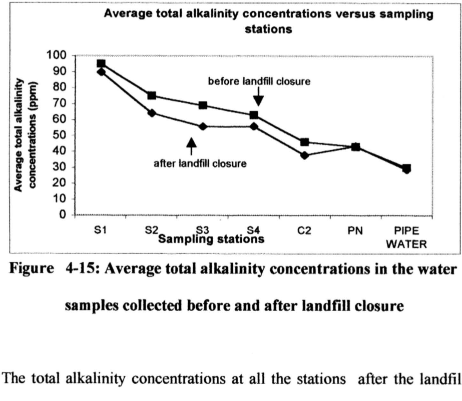

Figure 4-15: Average total alkalinity concentrations in the water samples collected before and after landfill closure

The total alkalinity concentrations at all the stations after the landfill closure fall in the range of 27 and 130 ppm. The highest average total alkalinity concentration (89.8 ± 30.9 ppm) was recorded at station S1 followed by station S2 (64.2 ± 3.7 ppm), S4 (56 ± 5.25 ppm), S3 (55.8 ± 4.57 ppm), PN (43.4 ± 3.7 ppm) and C2 (37.8 ± 5.2 ppm) respectively. The high concentration at station S1 is probably due to the continuos influx of leachate from the landfill. Comparison with total alkalinity concentration in the water samples collected before landfill closure shows a slightly higher value in the samples collected before landfill closure but the difference is not significant (P=0.05).

Figure 4-16 shows the profile of total alkalinity at each station over time in the samples collected after the landfill closure. Generally all the stations except S1 seems to show constant values over time. The high concentration of total alkalinity at S1 station during the first two samplings could be due to the presence of high concentration of leachate here.

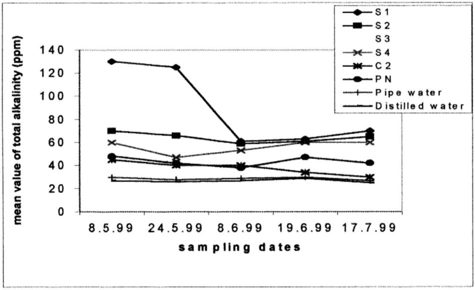

Figure 4-16 : Mean total alkalinity concentrations at each station (after landfill closure)

4.3.9 pH

pH is a measure of the intensity of acidity or alkalinity and has no known health effects as such. It can however, have consequences with other properties of water. The pH values obtained from the water samples collected after the landfill closure generally fall in the range between 7.2 and 7.6, which is in the neutral range (Figure 4-17).

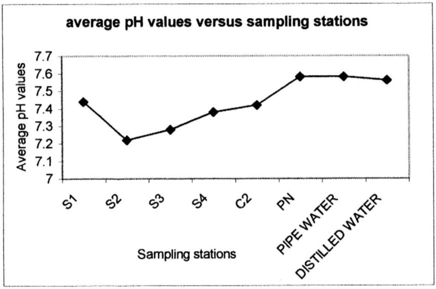

Figure 4-17: Average pH values of the water samples collected after the landfill closure

4.4 Microbiological analysis

Pathogens that are associated with waterborne disease are the primary causes of intestinal infections. Waterborne pathogens include bacteria such as *Salmonella* and *Escherichia*, viruses such as hepatatis and poliovirus, and protozoa such as *Entamoeba*. Organisms transmitted by water usually grow in the intestinal tract and leave the body in the feces. Fecal pollution of water supplies may then occur and if the water is not properly treated, the pathogens enter a new host when the water is consumed. Because water is consumed in large quantities, it may be infectious even if it contains only a small number of pathogens. Bacterial indicators are used to assess the quality of drinking water and it plays a major role in the control of waterborne diseases.

From the results obtained for the fecal coliform count (Table 4-3), it can be concluded that most of stations along the Michu and Langat river are contaminated with feces.

Table 4-3 : MPN Results Of The Water Samples

	Mean value (number/ 100ml)				
Samples	**8.5.99**	**24.5.99**	**8.6.99**	**19.6.99**	**17.7.99**
S1	>1100	1100	>1100	>1100	1100
S2	>1100	1100	>1100	>1100	1100
S3	>1100	>1100	>1100	1100	>1100
S4	>1100	>1100	1100	>1100	1100
C2	1100	>460	1100	1100	460
PN	>1100	>1100	>1100	>1100	>1100
PIPE WATER	0	0	0	0	0
DISTILLED WATER	0	0	0	0	0

C2 station which is located at the Sungai Langat has a lower fecal coliform count compared to the rest of the stations. This is probably because 1) the high level of heavy metals and other chemicals may inhibit the multiplication of the coliforms, 2) there are less residents staying along this river compared to the Sungai Michu therefore reducing the probability of fecal pollution.

Approximately 20% of the reported outbreaks and illness associated with water borne diseases are attributed to bacterial pathogens belonging to the genera *Salmonella* and *Shigella*. Salmonellosis usually involves acute gastroentritis with diarrhea and stomach cramps. One of the most important disease transmitted by the water route is typhoid caused by *Salmonella typhi*.

Table 4-4 shows the Salmonella-Shigella count done on the water samples. Colonies with dark centers indicates the presence of *Salmonella typhi* whereas the colorless colonies may indicate the presence of other *Salmonella* species or *Shigella*.

Table 4-4 : Salmonella-Shigella Count Of The Water Samples

mean value (number of colonies) in 100uL											
Samples	8.5.99		24.5.99		8.6.99		19.6.99		17.7.99		mean
	dc	c	dc	c	dc	c	dc	c	dc	c	
S1	3	8	-	13	5	12	2	15	3	16	15
S2	4	15	1	14	3	12	3	12	4	11	15
S3	4	12	3	13	4	11	3	13	6	12	16
S4	5	20	4	16	6	15	5	12	5	12	20
C2	7	10	7	14	8	13	7	13	8	13	20
PN	5	13	6	12	5	12	6	11	6	10	17
PIPE WATER	0	0	0	0	0	0	0	0	0	0	0
DISTILLED WATER	0	0	0	0	0	0	0	0	0	0	0

dc : dark centered (*Salmonella typhi*) c: colorless (Other *Salmonell*a and *Shigella* species)

Stations C2 and S4 were found to contain the highest number of *Salmonella* and *Shigella* pathogens with an average of 20 colonies/ 100uL. This is followed by 10th Mile Water Treatment Plant (PN) and station S3 with an average of 17 and 16 colonies

per 100 uL respectively. The source of these pathogens in the river could be attributed to the garbage disposal into the river by the residents. Furthermore, most of the residents here rear chickens which could also be a potential source of *Salmonella* sp pollution. Fecal pollution from the duck rearing farm at Geme river explains the presence of high *Salmonella* and *Shigella* pollution at C2. This contaminated water is being carried downstream and the presence of these pathogens were detected at 10th Mile Water Treatment Plant. Overall, the microbiological analysis of the river water shows values above the National Water Quality Standard for Class I (Total coliform count = 100).

4.5 Metal analysis of the water samples

Metals are often introduced into aquatic systems as result of the weathering of soils and rocks, from volcanic eruptions, and from a variety of human activities involving the mining, processing, or use of metals and/or substances that contain metal contaminants. Although some metals such as manganese, iron, cuprum, and zinc are essential micronutrients, others such as mercury, cadmium and lead are not required even in small amount by any organism.

In this study the heavy metal content in the river adjacent to Ampang non-sanitary landfill is analysed. All the samples were collected **after the landfill closure**. The heavy metal pollution which occurs in the river is expected to rise from three sources which are; influx of leachate, industrial discharge and domestic refuse.

4.5.1 Chromium

Figure 4-18 shows the changes in the mean concentration of chromium at all

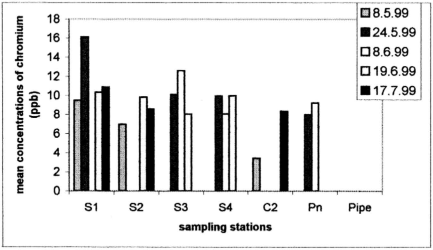

Figure 4-18 : Mean concentrations of chromium in the water samples the stations at different sampling dates. On 8.5.99, significant concentration of chromium was only detected at S1, S2 and C2 with mean concentrations of 9.5 ppb, 6.98 ppb and 3.46 ppb respectively. On the 24.5.99 the presence of chromium in the river was detected at 4 stations. S1 had the highest concentration with an average value of 16.1 ppb followed by S3 (10.1 ppb), S4 (9.96 ppb) and PN (8.01 ppb) respectively. The highest concentration was found to be at S1 because this is the nearest station to the leachate pond and therefore it receives continuous reflux of leachate. On the 8.6.99, chromium was not recorded at S1 but its presence was observed at station S3, S4 and PN with an average concentration of 12.6 ppb, 8.1 ppb and 9.25 ppb respectively. Whereas on the 19.6.99, concentration of chromium found at S1 and S2 were with an average of 10.35 ppb and 9.83 ppb respectively. S3 recorded a lower mean concentration on 19.6.99 (8.07 ppb) compared to samples taken on the 24.5.99 and 8.6.99. However the chromium concentration at S4 was higher with an average of 9.99 ppb compared to the earlier samplings.

In the last sampling done on the 17.7.99, the average chromium concentration at S1 was found to be 10.9 ppb and the concentrations at S2 and C2 were 8.6 ppb and 8.37 ppb respectively. Chromium was not detected at S3, S4 and PN stations. Generally, the highest mean concentration was found to be at S1 (9.37 ppb) followed by S3 (6.154 ppb), S4 (5.61 ppb) and PN (5.082 ppb), S2 (5.082 ppb) and C2 (2.4 ppb). There is no limit set in the National Water Quality Standard for this metal.

The presence of chromium in Sungai Langat, detected at stations S4, C2 and PN, could be attributed to the waste discharge from timber industries located along the

Sungai Langat. These factories uses chromium in the impregnation process of wood and timber.

4.5.2 Manganese

Figure 4-19 shows the mean concentration of manganese in the water samples.

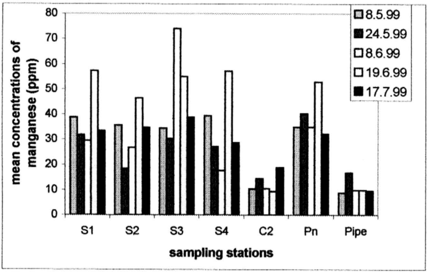

Figure 4-19 : Mean concentrations of manganese in the water samples

The concentration of manganese in the water samples collected at the Michu and Sungai Langat was found to fall in the range between 10.5 ppb and 74.0 ppb. On 8.5.99, the highest concentration of manganese was found to be at S4 with an average concentration of 39.5 ppb. This was followed by S1 with a mean value of 38.8 ppb, S2 (35.7 ppb), S3 (34.5 ppb) and C2 (10.5 ppb). On 24.5.99, PN recorded the highest average concentration of manganese which was about 40.3 ppb. The second highest concentration was found to be at S1 with 31.8 ppb, and this was followed by S3 (30.3 ppb), S4 (27.2 ppb), and C2 (14.2 ppb). In the next sampling done on 8.6.99, the manganese concentration at S3 station was higher than the rest with 74.0 ppb. This suggests that the residents have disposed waste which is highly contaminated with manganese into the Sungai Michu. The manganese concentration at PN have reduced to 35 ppb but on the 19.6.99, the average concentration of manganese at PN have increased to 52.9 ppb. S1 was found to contain a low level of manganese on 8.6.99 which was 29.5 ppb but the amount detected in the next sampling done on 19.6.99 showed an increase of almost two fold. S4, S3 and S2 also recorded a high value with 57.2 ppb, 55 ppb and 46.4 ppb respectively. In the last sampling, it was observed that the average concentration recorded at all the stations ranged between 18.8 ppb and 33.5 ppb, and the stations located at the Sungai Michu generally had higher concentrations of manganese with S1 (33.5 ppb), S2 (34.8 ppb) and S3 (38.8 ppb). Overall, the concentration of manganese recorded in the water sampels are within the National Water Quality Standard of 100 ppb.

In a study done on the water bodies within the vicinity of Taman Beringin and Jinjang Utara Landfill , it was found that the mean concentration of manganese found was 0- 175 ppb in the former and 50 ppb in the latter. These reported values were found to be quite close to the manganese concentration in the water samples collected from Michu and Sungai Langats.

4.5.3 Ferum

One of the metal that was present in high concentration in the leachate sample was ferum. Due to continous influx of leachate into the Michu river, the concentration of ferum at station S1 was recorded high during each sampling (Figure 4-20). This site generally had high ferum concentration at most analysis.

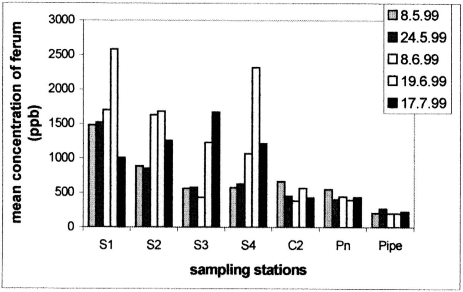

Figure 4-20 : Mean concentrations of ferum in the water samples

On 8.5.99, the mean concentration recorded at S1 was 1480 ppb, followed by S2 (885 ppb), C2 (663 ppb), S4 (574 ppb), PN (550 ppb) and S3 (559 ppb) respectively. Similar trend was observed in the next sampling done on 24.5.99, whereby S1 recorded the highest concentration followed by S2. S4, S3, C2 and PN stations recorded an average concentration of 629 ppb, 579 ppb, 453 ppb and 409 ppb respectively.

On 8.6.99, the mean concentration at S1 and S2 stations increased to 1700 ppb and 1630 ppb. A higher concentration of ferum was also detected at S4 with a mean concentration of 1070 ppb and on 19.6.99 this value increased to 2320 ppb. The mean concentration of ferum at S1 and S2 stations continued to increase and recorded 2585 ppb and 1680 ppb on 19.6.99. Mean concentrations at S3, C2 and PN were 1230 ppb, 563 ppb and 395 ppb respectively. On 17.7.99, the highest concentration was recorded at S3 with a mean value of 1670 ppb and this was followed by S2 (1254 ppb), S4 (1212 ppb), S1(1010 ppb) , PN(435 ppb) and C2(427 ppb). The concentration of ferum in the pipe water samples were found to range between 205 ppb and 267 ppb.

Overall, the ferum concentration in the water samples were found to exceed the limit set in the standard (300ppb). The high Ferum concentration observed at S1 station is most probably due to leachate contamination. The leachate was found to contain high concentration of ferum (22 ppm) which is also above the limit set in the standard A of EAQ 1974. Whereas its presence at S2, S3 and S4 stations is most likely due to the garbage disposal into the Sungai Michu by the residents in this area.

4.5.4 Nickel

Nickel was not detected in most of the samples collected. Its presence was detected in the first and the last sampling (Figure 4-21). On 8.5.99, concentration of nickel recorded at stations S1 and S2 were 9.48 ppb and 4.9 ppb. On 17.7.99, significant concentration of nickel was detected at S1, C2 and PN. The highest concentration was found to be at C2 with a mean concentration of 7.75 ppb followed by S1 (3.61 ppb) and pipe water (2.88 ppb). The presence of nickel at C2 could be attributed to the untreated waste discharged by the industries operating along the Sungai Langat. Nickel is widely used in the production of alloys, as pigments in ceramics, catalysts in chemical industries and batteries. Overall the nickel concentration in the water samples comply the National Water Quality Standard of 50 ppb.

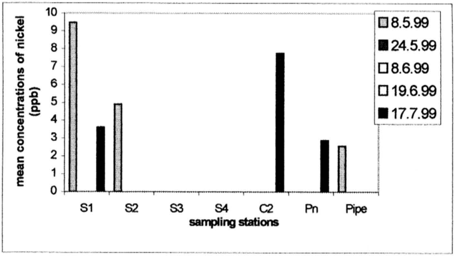

Figure 4-21 : Mean concentrations of nickel in the water samples

4.5.5 Cuprum

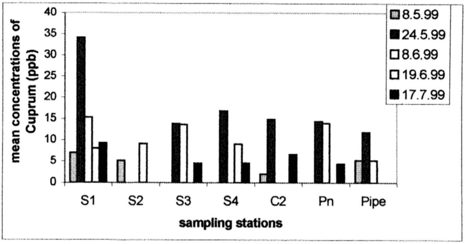

Figure 4-22 : Mean concentrations of cuprum in the water samples

The presence of cuprum in the river often indicates industrial pollution. According to Figure 4-22, on the 8.5.99, the average concentration of cuprum was found to be 7. 023 ppb at S1, 5.2 ppb at S2 and 1.96 ppb at C2. In the next sampling, done on 24.5.99, the concentration of cuprum were found to be the highest at S1 station with a mean concentration of 34.1 ppb. Its presence was not detected at S2 station, but it was present at all other stations with the following mean concentrations: S3 (13.9 ppb), S4 (16.8 ppb), C2 (14.9 ppb) and PN (14.4 ppb). In the subsequent sampling done on 8.6.99, the concentration of cuprum detected at S1 station was 15.3 ppb, 14 ppb at PN station and 13.7 ppb at S3 station. A lower mean concentration of cuprum was recorded on the 19.6.99 with only 8.05 ppb at S1, 9.07 ppb at S2 and 9.03 ppb at S4. On 17.7.99, S1 recorded the highest concentration with 9.25 ppb, followed by C2 (6.61 ppb), S4 (4.53 ppb), S3 (4.51 ppb) and PN (4.37 ppb). On 8.5.99, the average concentration of cuprum was found to be 7. 023 µg/l at S1, 5.2 µg/l at S2 and 1.96 ppb at C2. Concentration of cuprum detected in the pipe water samples ranged between 4.56 and 11.9 ppb. The cuprum concentration in the water samples were found to be within the National Water Quality Standard of 1000ppb.

4.5.6 Zinc

Figure 4-23 shows the mean concentrations of zinc in the water samples.

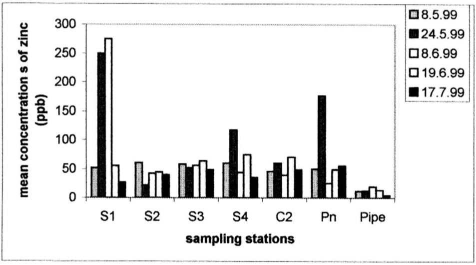

Figure 4-23 : Mean concentrations of zinc in the water samples

On 8.5.99, S2 had the highest concentration with a mean value of 60.9 ppb followed by S4 (60.5 ppb), S3 (58.5 ppb), PN (50.2 ppb) and C2 (46.3 ppb).

In the second sampling done on the 24.5.99, the concentration of zinc was found to be the highest at S1 station with a mean value of 250 ppb and this was followed by PN (177 ppb), S4 (118 ppb), C2 (60.3 ppb), S3 (52 ppb) and S2 (22.1 ppb) respectively. The concentration of zinc at S1 remained high on the 8.6.99 with a mean value of 275 ppb but dropped to 55.8 ppb on 19.6.99. Concentrations of zinc at other stations on the 8.6.99 seemed to fall in the in the range between 25.8 ppb and 56 ppb. On the 19.6.99, S4 recorded the highest concentration with an average value of 75.1 ppb followed by C2 (71.1 ppb), S3 (63.9 ppb), PN (49.3 ppb) and S2 (44.6 ppb) respectively. In the next sampling done on the 17.7.99, the zinc concentration at S1 seemed to have decreased with a mean value of only 27.2 ppb, but however on the 8.5.99, the mean concentration recorded at this station was 51.5 ppb. PN station had the highest zinc concentration on 17.7.99 with a mean value of 55.9 ppb.

Overall, the highest mean concentration was found to be at S1 (131.9 ppb) followed by PN (70.54 ppb), S4 (66.4 ppb), S3 (55.8 ppb), C2 (53.28 ppb) and S2 (42.0 ppb). These values were found to be within the standard as stipulated in the National Water Quality Standard.

4.5.7 Plumbum

Figure 4-24 shows the mean concentration of Plumbum in the water samples.

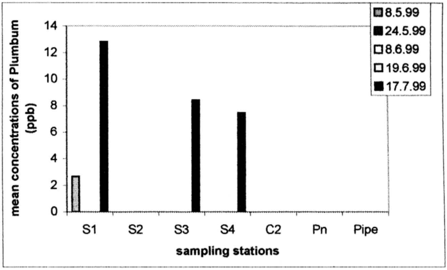

Figure 4-24 : Mean concentrations of plumbum in the water samples

Plumbum is used widely in the production of batteries. Other uses of significance from the standpoint of environmental pollution and human health are the use of plumbum in ammunition, paint pigments and gasoline additives.

On 8.5.99, concentration of plumbum was only detected at S1 with a mean concentration of 2.67 ppb (Figure 4-24). The presence of plumbum was not detected in the next three samplings, but it was present in the last sampling done on the 17.7.99. The highest concentration of plumbum was found to be at S1 with a mean value of 12.8 ppb and this is within the National Water Quality Standard set for plumbum. This standard allows a maximum concentration of 50 ppb in river water for Class IIA. However the average concentration of plumbum at S3 and S4 was found to be lower with 8.40 ppb and 7.45 ppb respectively. The concentration of plumbum found in water bodies vicinity to Jinjang Utara and Taman Beringin Landfill was found to be higher with mean concentration of 79 µg/l at Jinjang Utara landfill and 0-260 µg/l in Taman Beringin Landfill. This is probably because Taman Beringin Landfill is an active landfill, generating highly contaminating leachate whereas Ampang non-sanitary Landfill has been closed for almost one and a half years.

4.5.8 Magnesium

Overall, the level of magnesium detected in the river water samples were observed to be quite high above the National Water Quality Standard of 50 ppb.

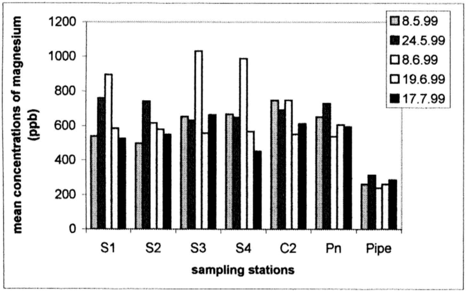

Figure 4-25 : Mean concentration of magnesium in the water samples

Referring to Figure 4-25, it was found that in the first sampling the concentration of magnesium were found to be highest at station C2 with an average of

747 ppb and this was followed by S4 with 665 ppb, S3 with 652 ppb, PN with 650 ppb, S1 with 539 ppb and S2 with 498 ppb. But in the next sampling done on 24.5.99, a tremendous increase in the concentration of magnesium at S1 and S2 stations were observed with mean values of 760 ppb and 741 ppb respectively. A higher concentration was also detected at PN with 728 ppb, but the magnesium concentration at C2 have reduced to 690 ppb. On 8.6.99, S3 recorded the highest level of magnesium with an average concentration of 1030 ppb followed by S4 (987 ppb), S1 (895 ppb), C2 (747 ppb), S2 (615 ppb) and PN (537 ppb). Whereas on 19.6.99, the magnesium level in almost all the samples showed a decrease with the concentration ranging between 551 ppb and 605 ppb. Similarly the samples collected in the last sampling also recorded lower concentration of magnesium ranged between 550 ppb and 661 ppb.

Overall observation showed that the highest mean value of magnesium was found to be at station S3 with 706.2 ppb followed by C2 (669.4 ppb) and S1(661 ppb) respectively. The presence of high magnesium content in the river water samples collected from S3 station can be attributed to the domestic waste disposal into the river. Its presence at C2 station is most likely due to the industrial discharges which contains high level of magnesium. Leachate could be the main pollutant at S1 station because the level of magnesium found in the leachate was recorded high at 9.1 ppb.

4.5.9 Barium

On the 8.5.99, S1, S2, C2 and pipe water samples recorded a mean concentration of 14 ppb whereas PN, S3 and S4 recorded an average concentration of 13.5 ppb, 12 ppb and 13.2 ppb respectively (Figure 4-26).

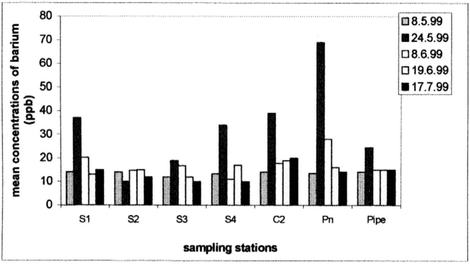

Figure 4-26 : Mean concentration of barium in the water samples

On 24.5.99, the mean concentration of barium at PN was 69 ppb, followed by 39 ppb at C2, 37 ppb at S1, 34 ppb at S4, 24.5 ppb in the pipe water samples, 19 ppb at S3 and 10 ppb at S2. On 8.6.99, the highest concentration of barium was recorded at PN with a mean value of 28 ppb followed by S1 (20.3 ppb). Barium concentrations at other stations fell within a narrow range between 11 and 17.8 ppb. Whereas on the 19.6.99, C2 station was observed to contain the highest average barium concentration with a mean value of 19 ppb followed by S4 (17 ppb) and PN (16 ppb). The mean concentration found in the pipe water samples was 15 ppb. On the 17.7.99, the highest concentration was recorded at C2 with a mean concentration of 20 ppb. This was followed by S1 (15 ppb), PN (14 ppb) and S2 (12 ppb). S3 and S4 recorded the same mean concentration which was about 10 ppb. In general, the highest barium concentration was found to be at the PN station and this was followed by C2, S1, S4., S3 and S2.

In general, the concentration of barium in the water samples is within the limit set in the National Water Quality Standard of 1000ppb.

4.5.10 Potassium

Potassium is found in abundance in natural water, and is normally harmless if present in small quantities. The concentration of potassium in the river water was found to fall in the range between 2 020 ppb and 15 900 ppb (Figure 4-27).

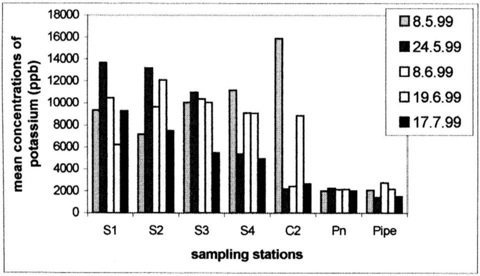

Figure 4-27: Mean concentration of potassium in the water samples

On the 8.5.99, the concentration of potassium was found to be the highest at station C2 with a mean concentration of 15 900 ppb. Whereas on the 24.5.99, the concentration of potassium at S1 station was found to be the highest with an average concentration of 13 700 ppb, and this was followed by S2 (13 200 ppb), S3 (11 000 ppb), S4 (5 370 ppb), PN (2 270 ppb) and C2 (2 210 ppb). Similar trend was also observed on the 8.6.99 whereby S1 recorded the highest concentration with an average value of 10 500 ppb, and stations at S2, S3, S4 , C2 and PN recorded 9 670 ppb, 10 400 ppb, 9 100 ppb, 2 430 ppb and 2 160 ppb respectively. However on the 19.6.99, the mean concentration at S1 was relatively low with only 6 230 ppb, whereas the concentration at S2 increased to 12 100 ppb. There was a significant increase in the potassium concentration at S2 to 8 860 ppb. On the 17.7.99, the highest concentration was found to be at S1(9 320 ppb) followed by S2(7 520 ppb), S3(5 480 ppb), S4 (4 950 ppb), C2 (2 660 ppb) and PN (2 020 ppb). During the last sampling on the 8.5.99, C2 recorded the highest mean concentration with 15900 ppb followed by S4 (11 200 ppb) and S3 (10 100 ppb). The mean concentration in the pipe water samples was found to fall in the range 1 420 ppb and 2 750 ppb.

The concentration of potassium in the leachate samples was found to be quite high with 350 ppm after the landfill closure and this explains the presence of high concentration of potassium at S1 station. Food is the main source of potassium and the disposal of kitchen waste into the streams causes the concentration of potassium along the Sungai Michu to be high.

4.5.11 Cadmium

Figure 4-28 shows the mean concentrations of cadmium in the water samples. In the first sampling done on 8.5.99, cadmium was found present at S1, S2, C2 and pipe water with mean concentrations of 2.98 ppb, 1.72 ppb, 4.36 ppb and 3.99 ppb respectively. On 24.5.99, the concentration of cadmium was found to be the highest at PN with an average concentration of 17.6 ppb, followed by S4 (10.2 ppb), S1 (9.01 µg/l), S3 (5.29 ppb) and C2 (4.32 ppb). Pipe water samples collected from the residentials also recorded a high value which was 8.15 ppb. However, on the 8.6.99, cadmium was not detected in the pipe water samples but it was present at S3, S1, C2 and PN stations. The highest concentration was found to be at S3 (10.6 ppb), followed by PN (9.1 ppb), S1 (8.75 ppb) and C2 (4.97 ppb). Cadmium was only detected at

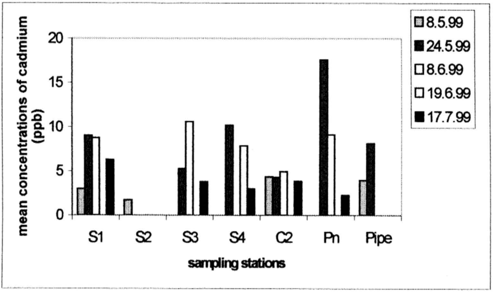

Figure 4-28 : Mean concentrations of cadmium in the water samples

station S4 in the next sampling done on the 19.6.99 and the mean concentration recorded was 7.88 ppb. In the subsequent sampling done on 17.7.99, the presence of cadmium was detected at S1, S3, S4, C2 and PN. The highest concentration was found to be at station S1 with an average of 6.3 ppb, followed by C2 (3.86 ppb), S3 (3.79 ppb), S4 (2.97 ppb) and PN (2.26 ppb).

Overall the mean concentration of cadmium was found to be the highest at PN with 6.64 ppb and this was followed by station S1 with mean concentration of 5.4 ppb , S4 with 4.21 ppb and S3 with 4.0 ppb. The high concentration at PN could be attributed to the discharge of industrial effluents which contains cadmium into the river. And the high concentration at S3 and S4 could be because of sewage pollution, and generally the large fecal excretion appears to represent unabsorbed cadmium from food. Cadmium is also widely used in batteries, radios, calculators, portable appliances, tires and discharge of these materials into the river by the residents may also be the cause of cadmium pollution.