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A Study of the Ampang Landfill Leachate Characteristics and its Effects on River Water Quality Parameters

Fatimah Kamal Batcha[1], **P. Agamuthu**[2] and **Shaliza Ibrahim**[3]

[1,2]Institute of Biological Sciences, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia
[3]Department of Civil Engineering, Faculty of Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia

ABSTRACT Physical and inorganic parameters have been measured for leachate from the Ampang Municipal Landfill before and after the landfill was closed. Although there were significant reduction in the parameter concentrations after the landfill closure, the COD value was still 20 times higher than the requirement of EQA 1974 Standard A. BOD, TSS, Fe, Mg, Cd and Pb were also higher than the Standards requirements after closure. The effects of leachate seeping into the Michu River, have been investigated through analyses of water samples taken along the Michu and Langat Rivers up to the Puncak Niaga Langat River water intake point. Reduction in the parameter values occurred with increase in time from the closure and distance from the leachate source. Occasional increase in the parameter values at certain sampling stations could be attributed to discharge from various anthropogenic activities upstream. However, geogenic aspects such as the impact of river hydraulics on microscopic conditions could also be important in determining the quality of river water. These factors, however, were beyond the scope of this study.

ABSTRAK Parameter fizikal dan bukan organik telah disukat bagi larutlesapan daripada tapak pelupusan Ampang sebelum dan setelah ia ditutup. Walaupun terdapat penurunan kepekatan parameter selepas tapak pelupusan ditutup, nilai COD masih 20 kali lebih tinggi daripada keperluan Piawai A EQA 1974. Nilai BOD, TSS, Fe, Mg, Cd dan Pb selepas penutupan juga lebih tinggi daripada keperluan Piawai. Kesan larutlesapan mengalir ke dalam Sungai Michu telah dikaji dengan analisis sampel air yang diambil di sepanjang Sungai Michu dan Sungai Langat sehingga titik pengambilan air Puncak Niaga. Berlaku penurunan nilai parameter dengan peningkatan masa daripada tarikh penutupan dan jarak daripada punca larutlesapan. Peningkatan nilai parameter pencemar di stesen pensampelan tertentu boleh dikaitkan dengan kegiatan antropogenik di hulu. Namun aspek geogenik seperti impak hidraulik sungai terhadap keadaan mikroskopik mungkin juga penting dalam menentukan kualiti air sungai. Faktor ini, walau bagaimana pun, adalah diluar skop kajian ini.

(Ampang Landfill closure, leachate characterization, river pollution, water quality, physical and inorganic parameters)

INTRODUCTION

Landfill is the primary route for solid waste disposal in most developing countries around the world. It is a relatively cheap, simple and effective way of disposing large volumes of wastes. Among the main concerns arising from landfilling activity is the generation of leachate (150 litres / ton waste) which if not properly contained and treated, can cause substantial pollution to water bodies. Sanitary landfills have been designed with pit lining and soil coverage to prevent the migration of leachate. A study in 1990 [1] showed that less than 5% of landfills in Malaysia are sanitary landfills.

The Ampang Landfill was an open dump covering an area of 15 hectares in the Bukit Seputeh Forest Area, which is located at 14th mile, Hulu Langat Road, Selangor, 2 km from the Hulu Langat town. The waste was dumped on a steep slope facing a small valley where the Michu River runs (Figure 1, [2]). The landfill was closed in 1998 after about ten years of

operation, following various incidences including fire and property damage due to waste slide.
The main objectives of this study are to characterize and compare the leachate from the Ampang landfill before and after its closure, and to investigate the effects of leachate flowing into the Michu River. The results of this study could make a useful reference if similar cases arise in the future.

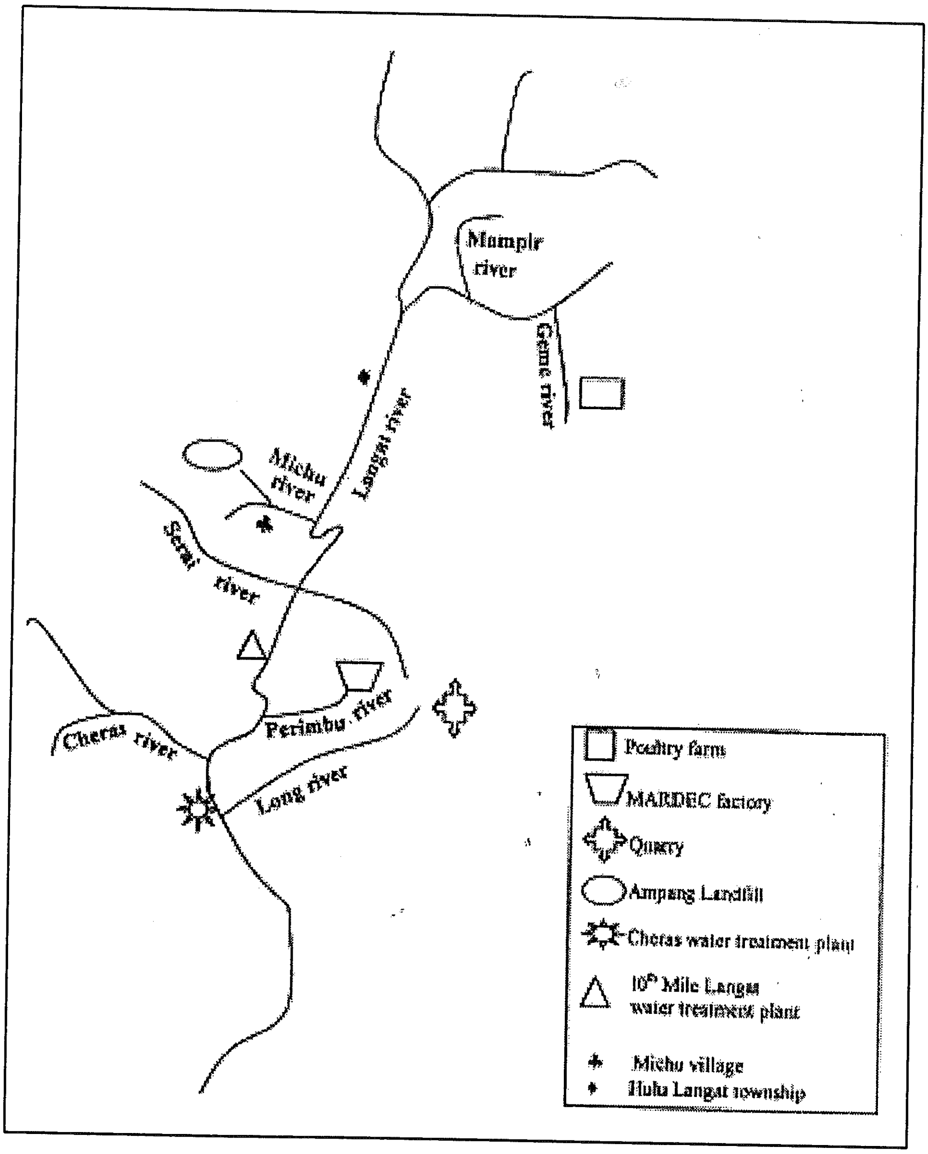


Figure 1. Sungai Langat's River Basin

MATERIALS AND METHODS

Sampling Sites

Samples were taken from eight stations starting with leachate from a leachate pond at the bottom of the landfill slope, and ending with treated pipe water from a residential area after a Puncak Niaga water treatment plant (WTP). Figure 2 shows six sampling points S1, S2, S3, S4, C2 and PN along the Michu and Langat rivers. Samples collected from all eight points were analysed for the levels of physical and biological pollution parameters.

Station S1 is the first sampling station on the Michu River. It is located about 2 km downstream from the leachate pond, before the settlements. This site was chosen because it represents the direct effect of leachate on the river. Station S2 is located after 5 houses and S3 at the end of the Michu River settlement. These sites are expected to show changes in the river water quality due to the presence of a few residents and a larger community, respectively.
Point C2 is stationed at the Langat River, before it meets the Michu River and water samples from this station may indicate the impact of the operation of illegal factories, and the dumping of untreated effluents into the river. Station S4 is at the meeting point of the Michu and Langat Rivers, and this station was chosen to see the mixing effects of pollutants from S3 (predominantly organic pollutants) and C2 (industrial pollutants).

PN, which is the Puncak Niaga's water intake point at 10th mile Langat Water Treatment Plant is the second last station before pipe water.

Water Sampling

Samplings were done every other week and were collected in 5 replicates at each station. The samples were collected in clean plastic bottles of 500 ml. For microbial analyses, samples were collected in sterile culture bottles. All the samples were stored temporarily at 4°C in the laboratory.

Laboratory Analyses

Table 1 summarizes the methods of analytical measurements employed for this study. Details on the methods of analyses are given elsewhere [3]. The samples were also analysed for heavy metals, but the results are reported in a separate paper.

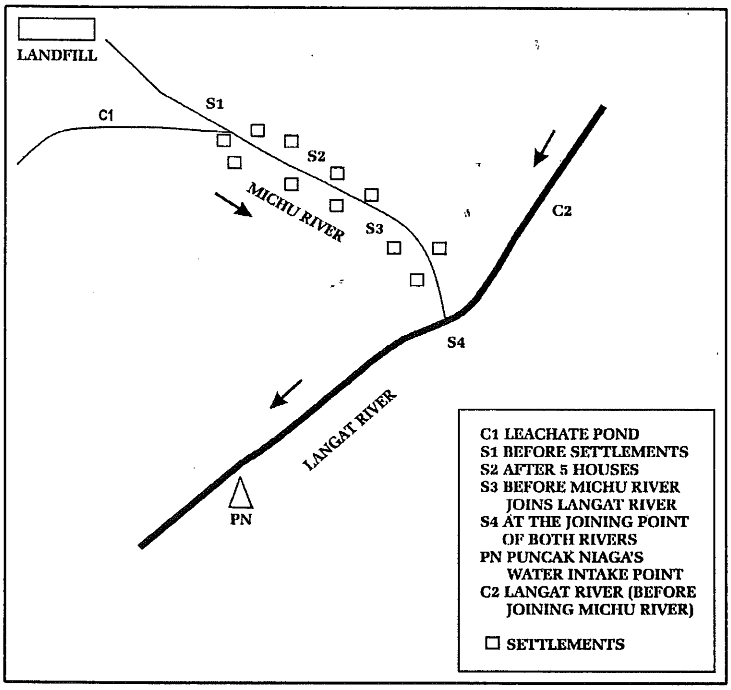


Figure 2. Sampling stations along Michu and Langat Rivers

Table 1. Summary of Methods for Laboratory Analyses

Parameter	Method
pH	pH meter (model 8033)
Total Suspended Solids (TSS)	Gravimetric analysis involving the difference in weights of filter paper, before and after a filtration process of sample.
Total Solid (TS)	Difference in weights of a porcelain dish containing samples, before and after an evaporation process.
Biochemical Oxygen Demand (BOD)	Winkler method
Chemical Oxygen Demand (COD)	Oxidation with boiling acidified potassium dichromate solution (TECATOR COD digestion unit).
Ammoniacal Nitrogen	Devarda alloy method
Other determination (Chloride, water hardness, sulphite, total alkalinity)	Hanna Instruments HI 4817 test kit
Microbiological Analysis	• Presumptive coliform test – Durham tubes and McConkey Broth (selective medium) • Confirmed presumptive coliform test – Eosin Methylene Blue Agar (EMB) • Salmonella-Shigella isolation – Salmonella-Shigella Agar (SS)

RESULTS AND DISCUSSION

Leachate characteristics

Published data on the composition of solid waste in Kuala Lumpur city (since the Ampang landfill was also used to dump the city waste), shows that 45.7% of the total weight of the solid waste comprised organic materials, 20.0% paper, 9.0% plastics and the rest glass, ferrous metal and others [4].

The characteristics of leachate samples collected before and after the closure of the landfill are shown in (Table 2). Some of the data are compared with data for other landfills within and outside Malaysia.

The average pH value of the samples before and after closure was 7.85 and 7.7, respectively. This indicates a methanogenic phase, where the bacteria consume the organic acids produced in the nonmethanogenic phase and raises the pH of the leachate to the range 7-8. In this phase, leachate characteristically has a near neutral pH, low volatile fatty acids and low total dissolved solids [5].

There is 21% drop in alkalinity of the leachate after closure. The constituents of alkalinity which are bicarbonate, carbonate, and hydroxide result from the dissolution of minerals from the soil, while hydrogen sulfide and ammonia may be the products of microbial decomposition of organic material in the landfill [6].

The TSS and TS values were reduced by 69% and 71%, respectively, after closure. The TSS value was 194.0 mg/l after closure. By comparison, the TSS values of leachate from a closed landfill in Vancouver ranged from 10 to 308 mg/l with a mean of 67 mg/l [7]. The turbidity value after closure was 125.5 NTU. Soaps, detergents and emulsifying agents produce stable colloids, which increase turbidity.

The BOD after closure reduced by 91% to a low value of 88 mg/l which indicates that the organic matter is no more easily biodegradable. The COD reduction was 65%. The COD concentration recorded in the Ampang landfill leachate during its active life was found to be much higher than the leachate from Sabak Bernam landfill (1250 ppm mean) [8]. The BOD: COD ratio of 0.08 for the Ampang landfill leachate is similar to the leachate from Taman Berigin landfill (0.05) [9]. The Taman Beringin landfill received mainly domestic refuse, construction refuse and garden refuse from residentials in Selayang, Kepong and Sungai Besi, while the Sabak Bernam landfill received more agrowaste [8].

Ammoniacal nitrogen after closure at 690 ppm is high compared to only 8 ppm for the Sabak Bernam landfill. Leachate from a closed landfill in Vancouver recorded only 202 ppm ammoniacal nitrogen [7]. Ammoniacal nitrogen undergoes initial acetogenic decomposition and once it is released into the anaerobic condition of the landfill, there is no significant biochemical pathways whereby the ammonia can be further converted [10].

The chloride content although reduced by 52%, was much higher (1200 ppm) compared to the chloride content in the leachate from Sabak

Bernam and Kelana Jaya landfills which were recorded at 420 mg/l and 23-30 mg/l, respectively. Chloride is abundant in both municipal and industrial refuse and is essentially unretained by soil mechanisms because it is non-reactive both physically and biologically, and diffuses quickly. Chlorides occur naturally in ground and surface water, but concentrations in fresh water of 500 mg/L or more may indicate sewage contamination [11].

Sulphate is the most common form of sulphur in landfills. It's mobility makes it helpful in monitoring the leachate movement. Sulphate is easily reduced to sulphite, which readily forms complex with metals. The sulphite concentration was reduced by 28.0% after the landfill closure.

Sodium (Na) is the principal alkali metal and tends to remain in solution and is not subjected to attenuation. Its presence in leachate may stem from the extensive use of Na salts in industry and domestic activities (paper, soap, baking, borax etc.). Potassium (K) is released during refuse decomposition and its major sources are plants and discarded food. Both are reduced by about 55%. The amount of ferum (Fe), zinc (Zn), cadmium (Cd) and magnesium (Mg) exceeded the effluent standards stipulated in the EQA 1974 even after significant reductions. For example, the magnesium concentration in the leachate after landfill closure was 9.1 ppm while the EQA limit is below 0.2 ppm for standard A. Sources of magnesium (Mg) in the landfills are cosmetics, cement and textiles. The Sabak Bernam landfill leachate contained higher concentrations of Mg (55.3 ppm) and Na (1289 ppm). The concentration of ferum after closure was 22 ppm, while the EQA limit is only 5 ppm... The Fe concentration at the Taman Beringin landfill was of the range 3.2-17.4 ppm, while at the Air Hitam landfill was 3.6-15.7 ppm. The disposal of scrap metals in the Ampang landfill may explain the higher strength of ferum found in the leachate. The lead (Pb) concentration at 0.03 ppm was low compared to the Taman Beringin leachate which was about 100.5 ppm.

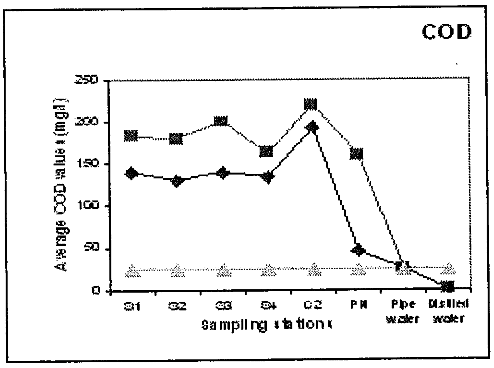
Overall the data shows higher leachate strengths before the landfill closure. Even after the landfill was closed, most of the chemical and physical parameters analyzed do not comply with the standard set in Standard A of EQA 1974 with the exception of copper (Cu) and Zn.

Table 2. Composition of Ampang Landfill Leachate

Parameter	Ampang landfill (mean)		% Difference (before and after closure)	EQA 1974	
	Before closure	After closure		Standard A	Standard B
BOD (mg/l)	1025.8	87.8	91.44	20	50
COD (mg/l)	3087.5	1071.5	65.30	50	100
PH	7.85	7.7	1.91	6.0-9.0	5.5-9.0
Turbidity (NTU)		125.5	-		
TSS (mg/l)	618.0	194.0	68.61	50	100
Ammonia-N (ppm)	-	690	-	-	-
TS (mg/l)	7.57.0	2029.0	71.25	-	-
Total Alkalinity (ppm)	3600	2850	20.83	-	-
Hardness (CaCO3) (ppm)	680	510	25.0	-	-
Chloride (ppm)	2500	1200	52.0	-	-
Sulphite (ppm)	60	43	28.33	-	-
Chromium (ppm)	0.135	0.115	14.81	-	-
Manganese (ppm)	0.187	0.041	78.07	-	-
Ferum (ppm)	45	22	51.11	1.00	5.00
Nickel (ppm)	0.044	0.026	40.91	-	-
Copper (ppm)	0.073	0.071	3.74	0.2	1.00
Zinc (ppm)	0.271	0.095	64.94	0.2	1.00
Cadmium (ppm)	0.035	0.034	2.86	0.01	0.02
Plumbum (ppm)	0.030	0.027	10.0	0.01	0.50
Magnesium (ppm)	35	9.1	74.0	0.2	1.00
Barium (ppm)	0.074	0.031	58.11	-	-
Potassium (ppm)	785	350	55.41	-	-
Sodium (ppm)	687	315	54.15	-	-

Analyses of river water samples Physical Parameters

Figures 3-8 show higher COD, TSS, TS, total alkalinity and water hardness before the landfill closure. The treated pipe water samples was not affected by the leachate. Both before and after closure, the TS, TSS and water hardness curves show a continuous drop with increasing distance from the landfill, while the COD was about the same level all along the Michu River at stations S1, S2 and S3 and the confluence point S4. Point C2 however, had significantly higher COD levels, which could be due to discharge from factories operating along the Langat River upstream from the point. Before the landfill closure the COD level at the PN intake point was also high. As for sulphite, Figure 8 shows a gradual decrease with increasing distance from the landfill but after closure, the level increased at point S3 and became higher than before closure at S4, while other points downstream remained lower.



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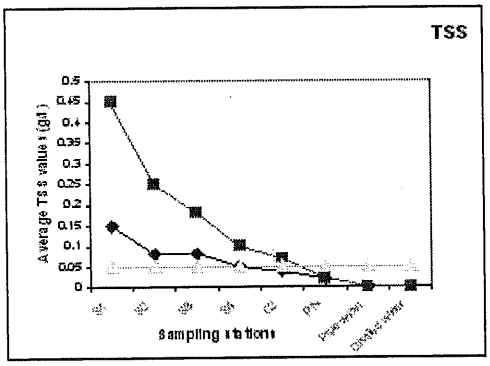

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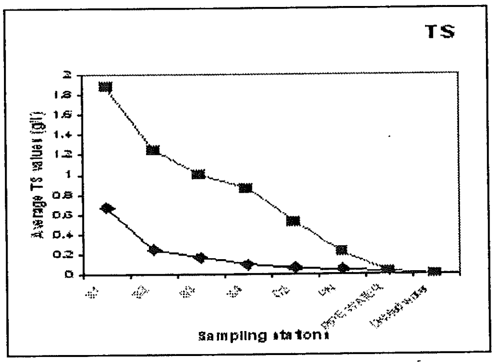

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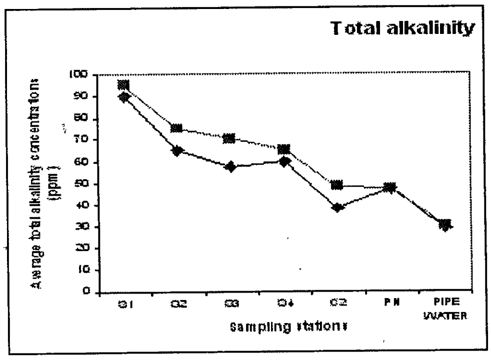

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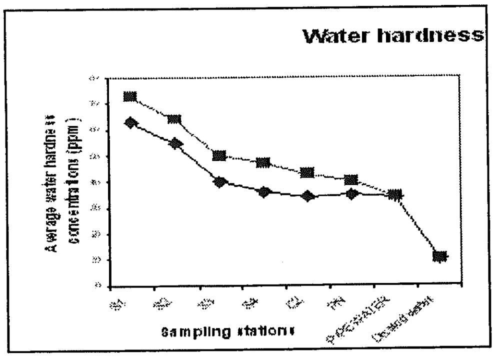

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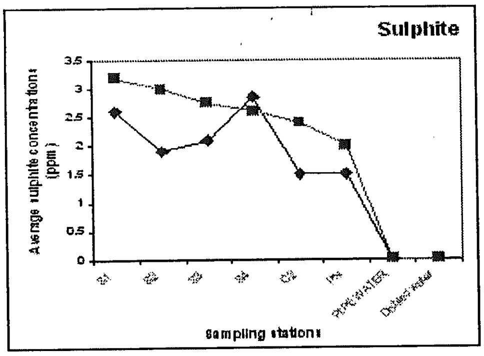
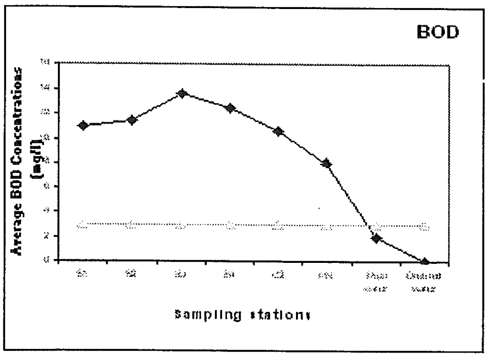


Figure 8

Figures 3 to **8**. Average concentrations of physical water parameters along the Michu and Langat Rivers **before and after** the Ampang Landfill **closure**.



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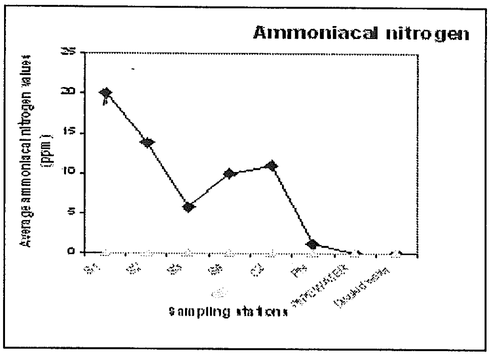


Figure 10

Legend:

—◆—	After landfill closure
—△—	Standard for class II A

Figures 9 & 10. Average concentrations of BOD and ammoniacal nitrogen along the Michu and Langat Rivers **after** the Ampang Landfill **closure.**

Figures 9 and 10 show BOD and ammoniacal nitrogen levels, respectively, after the landfill closure. The highest BOD value of 15.8 mg/l was low compared to data reported 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 [7]. Two obvious differences between the two landfills are that the Taman Beringin Landfill is active whereas the Ampang landfill has been closed for over a year; and the ponds are closed systems while rivers are mobile systems. The ammoniacal nitrogen was the highest at S1, the station closest to the landfill. The level progressively reduced until point S3, increased again at S4 and C2, but was very low at the intake point. The unusual rise in the values of the sulphite and ammoniacal nitrogen at the respective stations could be attributed to discharges upstream from the points. However, there is also the possibility of certain river flow conditions or environment in those areas, which may have affected some biochemical reactions, leading to the rise in these parameters.

Figures 11 to 18 are data of samples taken during a period of 3 months after the landfill closure. In most cases the levels of pollution in the rivers decreased with increase in the duration of closure, and with distance from the leachate source. The levels of TSS, TS, total alkalinity, water hardness and ammoniacal nitrogen are all highest at S1 during the first two or three samplings. For TS, TSS, total alkalinity and ammoniacal nitrogen the initial values at S1 are markedly higher than the other stations. The highest levels for COD, BOD, and sulphide are at C2, S3 and S4, respectively.

The water hardness, sulphite, BOD, and ammoniacal nitrogen showed very low values at certain stations on the fourth sampling, which was 19 June 1999. A heavy rainfall had occurred the previous day and the high water volume caused dilution of the parameters. The most affected was BOD at station PN. The values, however, rose again during the next sampling a month later on 17 July 1999. On the other hand, for TSS, the value increased at S1 on 19.6.99. This could be from soil erosion due to the rainfall.

The effects of heavy rain on the other parameters, namely, COD, TS, and alkalinity are less apparent in the plots. Figure 11 shows a general decrease in COD levels of the river water, but at station S3 the values fluctuated over time. COD for water samples from the Puncak Niaga' s intake point 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.

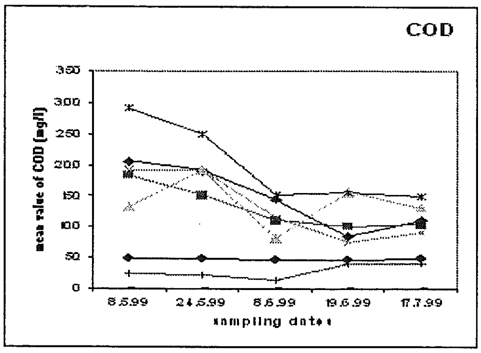
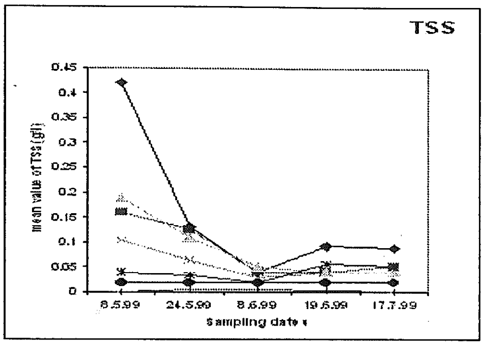


Figure 11



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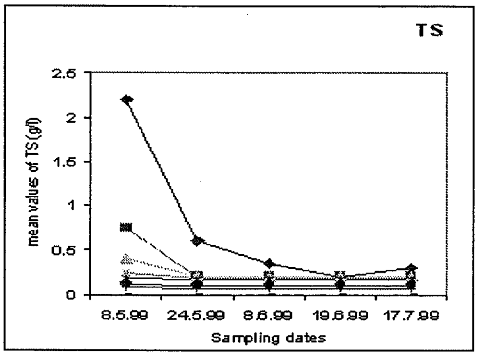

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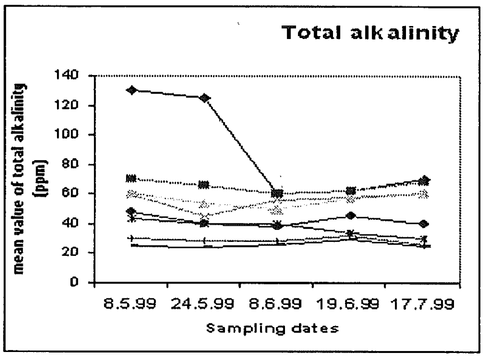

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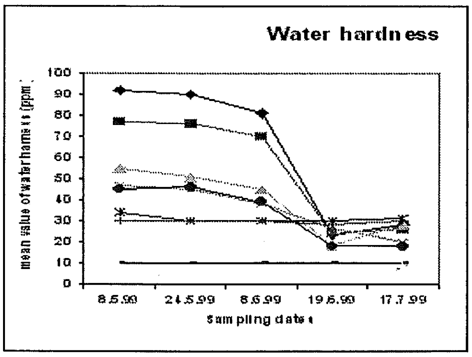

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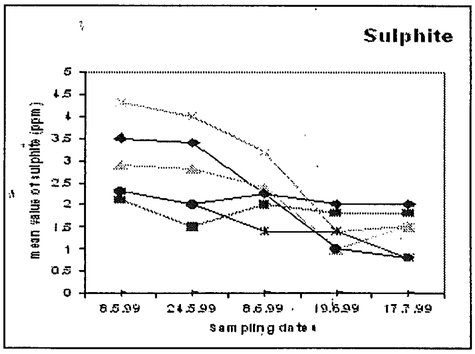

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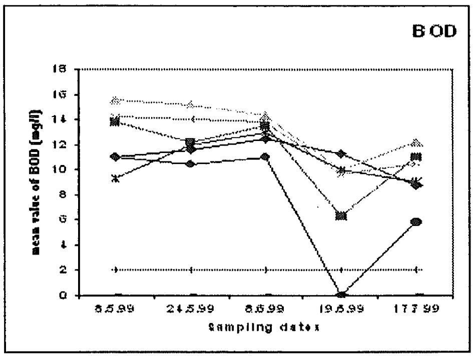

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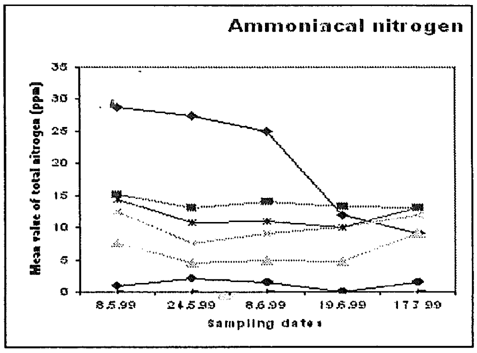

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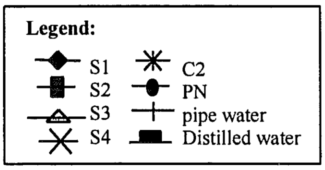

Figure 11-18 Average concentrations of physical water parameters along the Michu and Langat Rivers **over 3 months after** Ampang Landfill **closure.**

Microbiological analyses

The fecal coliform count (Table 3), shows that most stations along the Michu and Langat river were contaminated with fecal matter. C2 station which is located on the Langat river had days with lower fecal coliform counts compared to the rest of the stations. This could be due either to dilution factor from the higher water volume in the Langat River, or the inhibition of coliform multiplication from high level of heavy metals and other chemicals. However, point S1 despite recording the highest values in most of the physical and inorganic parameters including heavy metals (reported separately), still had high coliform count.

Approximately 20% of 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 gastroenteritis while typhoid is caused by *Salmonella typhi*. (Table 4) shows the *Salmonella-Shigella* count done on the water samples. Colonies with dark centers (dc) indicate the presence of Salmonella typhi whereas colorless (c) colonies may indicate the presence of other *Salmonella* species or *Shigella*. Stations C2 and S4 were found to contain the highest number of *Salmonella* and *Shigella* pathogens with an average of 20 colonies/100μL. This was followed by Puncak Niaga' s intake point (PN) and station S3 with an average of 17 and 16 colonies per 100μL, respectively. The source of these pathogens in the river could be garbage disposed into the river. Furthermore, most of the residents here rear chickens, which could also be a potential source of *Salmonella* pollution. Fecal pollution from a duck farm at Geme River could explain the presence of high *Salmonella* and *Shigella* pollution at C2. These pathogens were detected at Puncak Niaga's water intake point. Overall, the microbiological content of the river water was above the National Water Quality Standard for Class I (Total coliform count =100). However, the pipe water was without any *Salmonella* and *Shigera* colonies.

Table 3. MPN Results of the Michu and Langat River Water Samples

Samples	Mean value (number/100ml)				
	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
DISTILED WATER	0	0	0	0	0

Table 4. *Salmonella-Shigella* Count of the Michu and Langat River Water Samples

Mean value (number of colonies) in 100μL											
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
DISTILED WATER	0	0	0	0	0	0	0	0	0	0	0

dc: dark centered (*Salmonella typhi*) c: colorless (other *Salmonella* and *Shigella* species)

CONCLUSION

The objectives of this study were to characterize the leachate of the Ampang Municipal landfill and compare its characteristics after the landfill was closed, and observe the effects of the leachate on the quality of river water. The leachate characteristics were observed to be comparable to those of other landfills in the country. Differences in the parameter values could be attributed to variations in the composition of waste dumped into the landfill.

Data collected over three months from the time the landfill was closed showed a general trend of decreasing concentration of the pollution parameters with increase in distance from the leachate source, and increase in the duration from the time of closure. There were a few exceptions to this general trend, with the parameter values being higher or lower at certain points of sampling. With the limited scope of this study it was not possible to find all the reasons for the rise and fall of the parameters. While anthropogenic activities are responsible for creating pollution, geogenic factors are also important in determining the levels and distribution of pollution. During the course of this study, weather conditions such as a heavy rainfall had been observed to cause a marked dilution of most pollution parameters while simultaneously increasing the total suspended solids, possibly due to soil erosion. River hydraulics which include the flow rate, depth, and cross section, affect the movement and stagnation of water and pollutants, which in turn, can affect microscopic activities within the river. Hence, this report may provide a general impression that effluent discharges do affect the quality of the Michu River and a section of the

Langat River, but it is not really possible to relate the observed conditions to any particular activity due to multiple factors involved.

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