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title: **Groundwater contamination at landfill sites in Selangor**

author(s): **Saim Suratman**
National Hydraulic Research Institute of Malaysia (NAHRIM), Malaysia,
saim@nahrim.gov.my

Anuar Sefie
National Hydraulic Research Institute of Malaysia (NAHRIM), Malaysia,
anuar@nahrim.gov.my

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INTRODUCTION

A study was performed to determine the total number of landfill sites and their operating status in Selangor. It was also conducted to evaluate the impact of landfills into groundwater and surface water systems. This paper presents some of the study findings related to the impact of landfills on water resources especially on groundwater. Evaluation of the extent of pollution at landfills was made and immediate remedial measures to be taken were suggested.

Sanitary landfills are generally classified into 5 levels (Department of Local Government, 2006). They are:

- Level 0: open dumping
- Level 1: controlled tipping
- Level 2: sanitary landfill with a bund and daily soil cover
- Level 3: sanitary landfill with leachate recirculation system
- Level 4: sanitary landfill with leachate treatment facilities.

OBJECTIVES OF THE STUDY

The study was carried out to assess and evaluate the extent of pollution at landfills and to select the most critical site especially in term of groundwater as well as surface water quality which would require immediate remedial measure to be taken. The 3 main objectives of the study are:

- To carry out desktop study on operational and close landfills (rehabilitated of abandoned)
- To assess the impact of leachate into the surface and groundwater systems, and
- To recommend remedial measures for the protection of surface and groundwater systems.

OVERVIEW OF THE LANDFILLS

There are 20 landfill sites in the state in which 7 of them are still operating and 13 are closed. Most of the landfills could be classified as Level 0 or 1. The engineered landfills (Level 4) are very few but one more would be built in Tanjung Dua Belas, Banting. Figure 1 shows the location of all the landfills in Selangor.

The landfills are either sited on alluvial deposits comprising of unconsolidated coarse grain sand, clays and peat, or metasedimentary deposits of Devonian to Carboniferous age, or granitic rocks of Triassic age. The alluvial deposits are regarded as one of the promising aquifers in Selangor.

The landfills are located in 5 major river basins; Sg. Selangor (7), Sg. Klang (5), Sg. Langat (6), Sg. Bernam (1), Sg. Buloh (1). None is located in the Tengi River Basin. Most of the landfills are sited very close (<100m) to river/stream.

Most of the landfills in Selangor are built and operated without proper monitoring facilities and pollution controls such as liner materials, groundwater monitoring wells, leachate collection and leachate treatment ponds, and methane gas ventilation pipes. They are not subjected to the requirement of EIA because they were built prior to 1989 (in which EIA requirement was enacted).

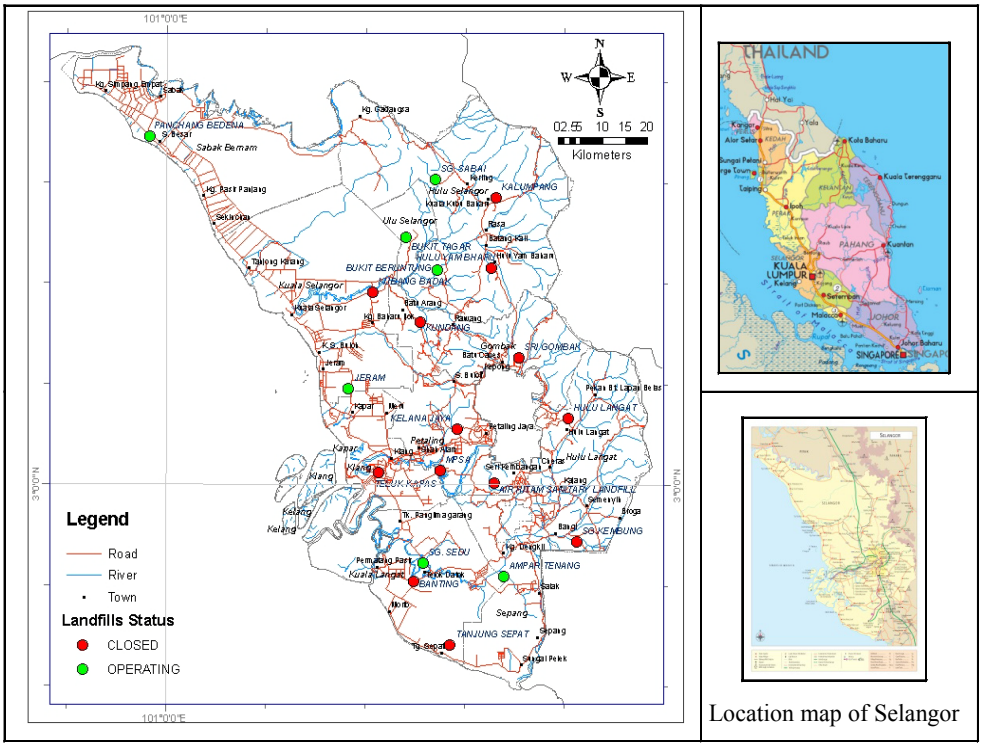

Figure 1. Operational status of identified landfill sites in Selangor.

They are not properly managed, wherein the leachate produced by the landfill is allowed to seep into the ground (no liner materials) as well as flowing to the nearby drainage or river (Figure 2) without any treatment. Only 25% are equipped with monitoring wells to monitor groundwater quality.

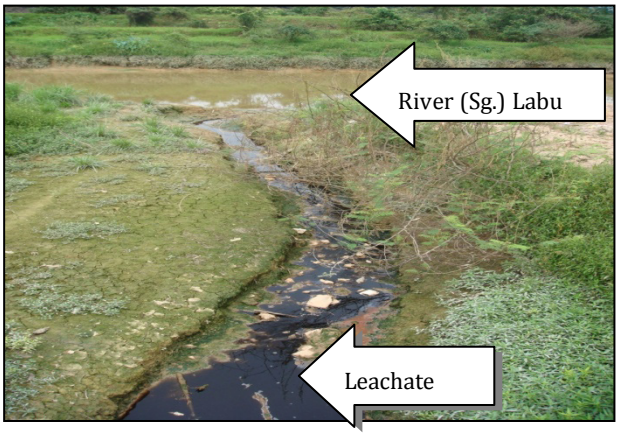

Figure 2. Leachate from Ampar Tenang landfill flows directly to River (Sg.) Labu.

Table 1. List of landfills in Selangor.

No	Local Authorities*	Site name	Locations	Level	Status	Landfill Liner	Distance to river/ stream (m)	Location of water intake
1	MB Shah Alam	MPSA	3°1'39.40"N; 101°33'3.64"E	0	Closed (waste removed)	Natural clay	10	Downstream
2	MP Ampang Jaya	Hulu Langat	3° 7'58.87"N; 101°48'20.68"E	0	Closed	None	20	Upstream
3	MP Kajang	Sg Kembong	2°53'15.49"N; 101°49'34.99"E	0	Closed	None	5	Upstream and downstream
4	MP Klang	Teluk Kapas	3°02'47.27"N; 101°23'33.70"E	I	Closed	None	20	None
5	MB Petaling Jaya	Kelana Jaya	3° 6'34.26"N; 101°35'29.96"E	0	Closed & developed	Natural clay	20	None
6	MP Selayang	Kundang	3°18'43.91"N; 101°30'24.48"E	0	Closed	None	10	None
7	MP Subang Jaya	Air Hitam Sanitary Landfill	3°00'07.44"N; 101°39'46.22"E	IV	Closed (post closure)	Various	5	None
8	MP Sepang	Ampar Tenang	2°49'07.69"N; 101°40'47.68"E	I	Operating	None	25	Downstream
9	MD Hulu Selangor	Sg Sabai	3°36'21.00"N; 101°32'25.80"E	0	Operating	None	2 km	None
10	MD Hulu Selangor	Bukit Beruntung	3°25'32.14"N; 101°32'56.6"E	0	Operating	None	5	None
11	MD Hulu Selangor	Hulu Yam Bharu	3°25'48.70"N; 101°39'14.71"E	0	Closed	None	No river nearby	None
12	MD Hulu Selangor	Kalumpang	3°34'07.08"N; 101°34'20.60"E	0	Closed (waste removed)	Not known	No river nearby	None
13	MD Selayang	Seri Gombak	3°15'07.72"N; 101°42'26.08"E	0	Closed	None	No river nearby	None
14	MD Kuala Langat	Tanjung Sepat	2°40'23.41"N; 101°31'33.91"E	0	Closed	Not known	No river nearby	None
15	MD Kuala Langat	Sg Sedu	2°50'38.77"N; 101°30'59.63"E	I	Operating	Natural clay	20	None
16	MD Kuala Selangor	Kubang Badak/ Kg. Hang Tuah	3°22'59.59"N; 101°24'52.38"E	II	Closed (post closure)	Natural clay	20	None
17	MD Kuala Selangor	Jeram	3°11'27.63"N; 101°22'02.54"E	IV	Operating	Various	70	None
18	MD Sabak Bernam	Panchang Bedena	3°41'26.36"N; 100°57'50.06"E	I	Operating	Natural clay	>1 km	None
19	MD Hulu Selangor	Bukit Tagar	3°29'46.64"N; 101°28'50.35"E	IV	Operating	Various	100	Downstream
20	MD Kuala Langat	Banting	2°48'24.98"N; 101°30'10.19"E	I	Closed	Natural clay	20	None

* MD=Majlis Daerah (District Council), MP=Majlis Perbandaran (Town Council), MB=Majlis Bandaraya (City Council)

METHODOLOGY

Information regarding landfill sites such as construction, operational status, geological characteristics and water quality data collected and reviewed were obtained from reports, technical papers, manuals, guidelines and research thesis from various government agencies, universities and private organisations. Site reconnaissances were carried out to verify and update the existing information and data. During the field investigation, landfill inventories and sampling of surface water, groundwater and leachate were carried out within the vicinity of selected landfills depending on availability of facilities. A number of landfills are not equipped with monitoring wells and as a result groundwater samples could not be collected.

The sampling technique, sample preservation and analytical procedures followed the standard methods recommended by APHA (1995 & 2005). The data on the composition of leachate is important in determining its potential impacts on the quality of nearby surface water and groundwater. This leachate often contains high concentration of organic matter and inorganic ions including heavy metals (Chian and DeWalle, 1976). In carrying out the landfill inventories, questionnaires were also distributed to landfill operators to update information on the current condition of landfills, environmental impact conditions, land utilisation after closure, and landfill closure and monitoring. Interviews with a small number of residents relatively near the landfills were also conducted. *In-situ* analysis was performed for DO, pH, temperature, salinity and conductivity using YSI multi parameter to evaluate the current status of water and leachate quality. Heavy metals were analysed using Inductively Coupled Plasma Mass Spectrophotometry (ICPMS). Ammoniacal nitrogen (NH_3-N), phosphate, nitrate and sulphate were analysed using spectrophotometry HACH DR 2800.

Out of 20 landfills, only 5 sites are equipped with groundwater monitoring wells and hence sampling activities for groundwater were done only at these landfill sites. Surface water from the nearby streams/rivers and leachate were also collected for chemical analysis to determine the effect of leachate to water resources. Table 2 shows the quality of leachate and the effect of landfill (leachate) on the groundwater and surface water quality from selected landfill.

Table 2. Leachate quality and effect of landfill (leachate) on the groundwater and surface water quality from selected landfill (equipped with groundwater monitoring wells) in Selangor.

Landfills	Groundwater	Surface Water	Leachate
Kelana Jaya	Slightly contaminated. Cr, Ba, Pb, Fe, As and Hg are slightly higher than the standard.	Class III Coliform exceeds the INWQS Class III limit.	Most parameters are less than the Effluents of Standard B except for BOD, COD and TSS.
Air Hitam	Slightly contaminated. Nitrate, Cr, Cd, Pb, Fe and Se are slightly higher than the standard.	BOD, COD, TSS, Sulphide, Cd, Cr, Pb, Fe, oil and grease are higher than the Effluents of Standard B.	BOD, COD, TSS, Sulphide, Cd, Cr, Pb, Fe, oil and grease are higher than the Effluents of Standard B.
Ampar Tenang	Contaminated. TDS, nitrate, Cr, Cd, Pb, Fe and Se exceeded the standard.	Contaminated (Class III). Increase in BOD, nitrate, As, Mn, Pb, Fe, Cu and Zn.	Most parameters are less than the Effluents of Standard B except for BOD, COD, As, Cr, Fe and Zn.
Jeram	Very slightly contaminated. BOD, COD, Fe, Pb, Cr, Zn, Hg and Ba are above background data.	Not available	Not available
Bukit Tagar	Not contaminated. All parameters below the standard except Fe (natural condition)	Class III	Not available

Results from the chemical analysis of groundwater, surface water and leachate quality were analysed and evaluated by comparing them with [Leachate] - Effluent Quality (Sewage and Industrial Effluents) Regulations, 1979 in Environmental Quality Act, 1974; [Surface water] - Interim National Water Quality Standards for Malaysia (INWQS), Department of Environment (DOE) (1995a); [Groundwater] - Guidelines for Raw Drinking Water Quality Benchmark for Groundwater Quality, Ministry of Health (2000), and Malaysian Environmental Impact Assessment Guidelines for Groundwater and/or surface water Supply Project, Department of Environment (1995b). Chemical analysis results from Jeram and Bukit Tagar landfills were referred to standard and background data obtained from EIA reports of these landfills.

Results from chemical analysis showed the leachate from Kelana Jaya, Air Hitam and Ampar Tenang exceeded the Parameter Limits of Standard B of Effluent Quality (Sewage and Industrial Effluents) Regulations, 1979 in Environmental Quality Act, 1974. Groundwater quality from selected landfills equipped with monitoring well indicates COD, BOD, TDS, Cd, Cr, Cu, Pb, Fe, As and Hg slightly higher than the standards for the Raw Drinking Water Quality Benchmark for Groundwater Quality and background data except the Bukit Tagar landfill. Data from surface water quality for samples taken from streams/rivers adjacent to landfill sites showed certain parameters are higher than standards and classified polluted according to INWQS except Bukit Tagar landfill which adopts a zero discharge target.

CONCLUSION

Groundwater quality from the groundwater monitoring wells of five landfill sites showed the value for various parameters are higher than standards. This indicates that the groundwater within and surrounding the landfills are contaminated by the leachate. More than 70% of the landfills are located within 100m from the stream/river. Most of the water quality of the rivers adjacent to landfill sites is slightly polluted and classified into Class III of INWQS classification. The leachate quality from most of the landfills exceeded the Standard B of Effluents Limits by the DOE.

The clean-up measures are recommended to prevent further movement of contaminant into the groundwater and surface water system as well as to ensure environmental sustainability. Action such as waste removal, construction of containment wall and pumping of contaminated groundwater may need to be considered. It is also recommended that specific guidelines and standards to address issues related to landfill be established. Several landfill sites such as Sg. Kembong, Ampar Tenang, Sg. Sedu, and Bukit Beruntung are recommended for safe closure since they have had surpassed the operation capacity. The Sg. Kembong, Ampar Tenang, Sg. Sedu landfills are also located in areas with high groundwater development potential. Further study on the closed Kelana Jaya landfill is required as the site is already developed into a residential area, in order to determine the extent of risk to human health posed by the landfill knowing the degree of the contamination.

REFERENCES

APHA, 1995: *Standard Methods for the Examination of Water and Waste Water (19th edition).* Baltimore: Port City Press.

APHA, 2005: *Standard Methods for the Examination of Water and Waste Water (18th edition).* Washington, American Health Assoc, AWWA, MPCE, 1193p.

Bull J.S., Evans J.V. and Wecnsler R. M., 1983: *Biological technology at the treatment of leachate from sanitary landfill.* J. Water Reseach, 17(11), pp. 1473-1481.

Chian S.K. and DeWalle F.B., 1976: *Sanitary Landfill Leachate and Their Treatment.* J. Environmental Engineering Division, 102, pp. 411-431.

Department of Environment, 1995a: *Water Quality Criteria and Standard for Malaysia.* Ministry of Science and Technology, Malaysia.

Department of Environment, 1995b: *Environmental Impact Assessment Guideline for Groundwater and/or Surface Water Supply Projects* (1995). Ministry of Science and Technology, Malaysia.

Department of Local Government, 2006: *The Technical Guideline for Sanitary Landfill: Design and Operation.* Ministry of Housing and Local Government Malaysia.

Environmental Quality Act, 1974: Government of Malaysia, Act 127, 33 p.

Ministry of Health, 2000: *National Guidelines for Raw Drinking Water Quality.* Engineering Services Division, Ministry of Health Malaysia, Putrajaya.

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