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Research Article

The Analysis of Heavy Metal Concentration per Distance and Depth around the Vicinity of Open Landfill

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Abstract: Heavy metal is a source of environmental pollutant affecting the aquatic and terrestrial ecosystems. The sources of heavy metal pollution are the industries, domestic sewage and landfills. Landfill operation is a sourceof heavy metal pollution which not only affected the biospehere, hydrospehere and athmosphere, but also the litosphere systems around it. This study aims to analyse the heavy metals concentration around the landifill vicinity for indication of heavy metal pollution. This study analysed the soil content of the heavy metal based on the distance and depth around the vicinity of the landfill. Field sampling of the soil and laboratory analysis were used. The field study involved 20 stations and 60 samples according to the wind directions: North, East, South and West.The analysis was conducted through the use of Inductively Coupled Plasma Mass Spectroscopy (ICP-MS). Seven types of heavy metals were identified as indicators for pollution namely Mg, Ca, Mn, Fe, Cu, Zn and Pb. The results indicated that the concentration of Fe was the most dominant per specific distances and depths and exceeded the DOE minimum standard (301 mg/L) in North, East and West directions. While Cu was the second most dominant, with concentraion exceeding minimum DOE standard (19.8 mg/L) per specific distance and depth, mainly in the West direction.

Keywords: Heavy metals, land contaminated, land contaminated guidelines, open landfill site, waste management

INTRODUCTION

Heavy metal pollution is a component of environmental pollutant closely related to human activities. Studies on the pollution have been conducted by various researchers of various fields such as chemistry, biology, geography, engineering and environment. Among studies on the heavy metal pollution were those conducted by Kendrick *et al.* (1992), Costa (2000), Baker *et al.* (1994), Chen *et al.* (2004), Callender (2004), Brad and Xenidis (2005), Ward *et al.* (2005), Albina *et al.* (2008), Rodriguez *et al.* (2009), Machado *et al.* (2002) and Long *et al.* (2011).

Other than general studies on heavy metal, heavy metal pollution studies also covered various sources of ecosystem such as the aquatic ecosystem (Denton *et al.*, 2007; Elmaci *et al.*, 2007; Sabihin *et al.*, 2008a; Bronius and Vaida, 2009; Shuhaimi-Othman and BarzaniGasim, 2005; Abderahman and Abu-Rukah, 2006; Buccolieri *et al.*, 2006; Udomporn *et al.*, 2008; Kar *et al.*, 2008) and terrestial ecosystem (Prabpai *et al.*, 2009; Sabihin *et al.*, 2008a; Urase *et al.*, 1997).

Studies on heavy metal pollution also combined analysis of specific metal concentration and aspects on management of the sources of pollution. Examples are studies on relationship between heavy metal pollution and its management by Mico *et al.* (2007), Sahibin *et al.* (2008b) and Natrah *et al.* (2009). Specific study on factors influencing distribution, management and control of heavy metal pollution was conducted by Hsu *et al.* (2005).

There is still a dearth of studies on heavy metal pollution in Malaysia, particularly those related to soil pollution and its management. Among a few studies conducted on soil pollution around the dumpsite were by Jain *et al.* (2005), Erses *et al.* (2005), Oluyem *et al.* (2008), Kasassi *et al.* (2008), Zaini *et al.* (2009), Esmail *et al.* (2009), Zaini *et al.* (2010), Akoteyun *et al.* (2011), Chaari *et al.* (2011), Zaini *et al.* (2011) and MohdRozaimi (2012).

It was only recently that any guideline for management and control of soil pollution in Malaysia was made available. The Contaminated Land Management and Control Guidelines 2002 was gazetted only in 2009, fifty two years after independence. The guidelines were of three series, namely Malaysian Recommended Sites Screening Levels for Contaminated Land, Assessing and Reporting

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Contaminated Sites dan Remediation of Contaminated Sites (DOE, 2009a, b and c).

Primarily this study aimed to analyse the concentration of heavy metal discovered in the soil around the open landfill. Specifically, this study was to identify and analyse the concentration of heavy metals per the distance and depth of up to 90 cm from the soil surface around the landfill.

MATERIALS AND METHODS

The location of the landfill was at the altitude 2°49'09.62"N 101°40'50.50"E at Ampar Tenang open landfill, Selangor Malaysia. This study was conducted in April-June 2012. The size of the site is 10 acres. Table 1 shows the location of the sampling stations according to the wind directions. The sampling was done in parallel according to the distance from the landfill, leading outward with the marked distances of 10, 20, 30, 40 m dan 50 m, respectively. The soil samplings were taken using Auger instrument and the depth of the soil per soil surface were marked at 30, 60 cm dan 90 cm, respectively. 500 g of the soil was taken from each station from the depths and distance prescribed.

Samples were dried for 3 days at room temperature of 25^{0}C before pounding and sifting to obtain particles size of less than 2 cm for homogenenic samples. Dried samples were pounded using mortar and pestle, then sifted using Laboratory Test Sieve model BS 410 pore size 63 µm. Sifted soil then put into a labelled plastic pack prior for subsequent analysis. The soil extract then analysed using the Inductively Coupled Plasma Mass Spectroscopy (ICP-MS). The ICP-MS instrument could detect the presence of heavy metalas such as Mg, Ca, Mn, Fe, Cu, Zn dan Pb/in the soil around landfill test site.

Table 1: Location of sampling station based on wind direction

Wind direction	Station	Location	
North direction	N1	2°49'12.19"N	101°40'50.44"E
	N2	2°49'12.52"N	101°40'50.44"E
	N3	2°49'12.77"N	101°40'50.44"E
	N4	2°49'13.31"N	101°40'50.42"E
	N5	2°49'13.31"N	101°40'50.48"E
East direction	E1	2°49'09.39"N	101°40'54.18"E
	E2	2°49'09.40"N	101°40'54.60"E
	E3	2°49'09.40"N	101°40'54.90"E
	E4	2°49'09.40"N	101°40'55.20"E
	E5	2°49'09.40"N	101°40'54.90"E
South direction	S1	2°49'07.19"N	101°40'50.63"E
	S2	2°49'06.91"N	101°40'50.73"E
	S3	2°49'06.76"N	101°40'50.75"E
	S4	2°49'06.57"N	101°40'50.76"E
	S5	2°49'06.33"N	101°40'50.83"E
West direction	W1	2°49'11.70"N	101°40'47.30"E
	W2	2°49'11.80"N	101°40'46.90"E
	W3	2°49'11.90"N	101°40'46.80"E
	W4	2°49'12.00"N	101°40'46.40"E
	W5	2°49'12.11"N	101°40'45.90"E

Table 2: Standard of heavy metal limit in soil (mg/L) in Malaysia

Heavy metal	Maximum limit (mg/L)	Minimun limit (mg/L)	Mean (mg/L)
Mg	507.2	0.9	141.4
Ca	TB	TB	TB
Mn	3.99	3.95	3.97
Fe	44500	301	12140
Cu	19.8	4.0	13.8
Zn	54.3	6.9	21.9
Pb	36	0.18	10.37

Sumber: Adapted from Department of Environment, 2009a, b and c

The DOE standard for heavy metal limit is a benchmark in determining the level of soil pollution occurence per the concentration of heavy metal in a particular soil sample. The standard used in this study was the DOE (2009a). For this study, 7 types of heavy metals were analysed per the DOE guidelines. Table 2 shows the standard of heavy metal limit in soil adapted from list of standard by DOE. Based on the table, there are variances in concentration of each metal in the tested soil samples.

RESULTS

Concentration of heavy metal in Northdirection: Table 3 shows the results of the analysis for the concentration of the heavy metals per the distance and depths detected at the station the North direction of the landfill. Generally, the concentration of Fe was dominant for all distances and depths compared to other two metals. Based on Table 3, the concentration of Fe was also found high at the set maximum depth (90cm). The concentrations per distances for 10 m, 20 m, 30 m, 40 m and 50 m were respectively at 125.9, 406.8, 259.6, 725.6 and 866.7 ml/g, respectively. The Fe concentration detected for 20 m, 40 m dan 50 m exceeded the DOE minimum standard (Table 2).

The second highest concentration was Caat 55.35 ml/g at the depth of 90cm at 10 m from the landfill. This was caused by soil properties around the north side of station which contained calcite, gypsum and fluorite containing calcium carbonate. This was similar to the Cu detected at 30m on surface soil, which exceeded minimum DOE standard. For Mn, Zn and Pb, the lab analysis indicated that their concentration were very low for every distance and depth.

The concentration of heavy metal in the east direction: Based on the lab analysis, the concentration of heavy metals in the eastern side showed similar trend per distance and depth as the results for the northern side. The concentration of Fe was found dominant towards the East at 90 m cm depth. Table 4 shows the high Fe concentration for all depths per the distances. An example is at 10 and 50 m, the concentration of Fe was at 273.1 and 463.7 mg/L respectively. Meanwhile the concentration of Fe at 50m exceeded the DOE minimum standard (Table 2).

Table 3: Heavy metal concentration based on distance and depth from landfill (North direction)

Distance (m)	Depth (cm)	Heavy metal Mg	Ca	Mn	Fe	Cu	Zn	Pb
	0	4.85	0.00	0.00	0.00	4.13	0.22	0.52
10 m	30	2.79	9.34	1.14	111.4	0.21	0.29	0.14
	60	9.54	35.64	0.28	94.02	0.31	0.74	0.20
	90	12.84	55.35	0.42	125.9	0.41	1.04	0.25
	0	12.05	0.00	0.00	0.00	0.00	0.21	0.65
20 m	30	2.15	3.57	0.05	61.79	0.03	0.06	0.10
	60	1.94	1.83	0.03	406.8	0.21	0.13	0.17
	90	1.26	1.21	0.03	215.6	0.02	0.04	0.10
	0	11.84	0.00	0.00	0.00	22.58	0.20	0.66
30 m	30	1.65	3.60	0.05	52.86	0.07	0.12	0.09
	60	4.32	4.39	0.07	116.3	0.04	0.17	0.12
	90	2.89	4.53	0.04	259.6	0.04	0.11	0.15
	0	0.12	0.00	0.00	4.81	0.00	0.20	0.72
40 m	30	0.17	0.27	0.03	13.13	0.01	0.01	0.02
	60	4.22	0.53	0.05	725.6	0.04	0.10	0.18
	90	4.45	3.00	0.08	336.4	0.07	0.12	0.16
	0	1.90	0.00	0.00	0.00	0.00	0.19	0.79
50 m	30	2.55	1.05	0.04	83.04	0.06	0.06	0.09
	60	1.21	1.17	0.03	334.7	0.02	0.05	0.11
	90	5.27	1.04	0.04	866.7	0.02	0.07	0.15

Fieldwork 2012

Table 4: Heavy metal concentration based on distance and depth from landfill (East direction)

Distance (m)	Depth (cm)	Heavy metal Mg	Ca	Mn	Fe	Cu	Zn	Pb
	0	14.23	0.00	0.00	0.00	11.27	0.13	1.12
10 m	30	9.13	6.01	0.07	142.9	0.16	0.12	1.28
	60	8.08	5.81	0.08	190.5	0.09	0.11	0.09
	90	8.54	6.59	0.08	273.1	0.11	0.11	0.14
	0	6.63	0.00	0.00	0.00	7.31	0.16	1.12
20 m	30	6.72	2.50	0.09	143.4	0.11	0.12	0.13
	60	10.13	2.30	0.10	218.8	0.09	0.13	0.16
	90	0.00	0.03	0.00	0.04	0.00	0.01	0.00
	0	2.38	0.00	0.00	0.00	20.17	0.16	1.09
30 m	30	3.34	5.45	0.13	55.59	0.08	0.09	0.09
	60	2.61	4.67	0.05	75.77	0.22	0.08	0.14
	90	11.36	7.34	0.15	67.56	0.12	0.19	0.15
	0	1.58	0.46	0.00	0.00	0.00	0.15	0.45
40 m	30	15.72	4.18	0.25	271.6	0.86	0.23	0.24
	60	7.10	1.42	0.09	538.2	0.06	0.12	0.12
	90	6.24	1.46	0.08	365.8	0.07	0.10	0.16
	0	6.23	0.00	0.00	0.01	0.00	10.18	1.07
50 m	30	6.09	4.06	0.15	463.7	0.21	0.18	0.18
	60	3.48	3.97	0.10	207.6	0.24	0.20	0.15
	90	0.71	0.48	0.03	91.95	0.01	0.03	0.07

Fieldwork 2012

The lab analysis also indicated that the Cu concentration was a little higher compared to Mg, Ca, Mn, Zn and Pb. High Cu concentration was detected at the surface level at distance 30m from the landfill (20.17 mg/L), which exceeded the DOE minimum standard (19.8 mg/L). High concentration of the Cu was due to the presence of electronic wastes such as disused wires in the eastern side of the landfill.

Concentration of Mg was found highest at a distance of 10m of soil surface ((14.23 mg/L) and at distance of 40 m with a depth of 30cm (15.72 mg/L). The Mg concentration for both distances exceeded the minimum standard (0.9 mg/L) set by DOE (Table 2). The presence of Mg in the area was influenced by the vegetative environment. This phenomenon occurred due to Mg pre-existence in the plant chlorophyll and its function in the photosynthesis. Hence this condition directly affected the concentration of Mg in the soil.

Henceforth, the mean analysis of Mn and Zn indicated that both metals had lowest concentration in the soil. Laboratory analysis indicated that at all depths and distances from the landfill, both heavy metals were weighed less than 1 ml/g.

Concentration of Heavy Metal in South Direction: the lab analysis indicated that Ca and Fe showed highest concentration at all distances and depths. For instance, the concentration of Ca was highest at the distance of 20 m at the depth of 60 cm (148.9 mg/L) and 90 cm (132.9 mg/L), respectively. Compared to

Table 5: Heavy metal concentration based on distance and depth from landfill (South direction)

Distance (m)	Depth (cm)	Heavy metal Mg	Ca	Mn	Fe	Cu	Zn	Pb
	0	5.93	0.00	0.00	0.00	1.81	0.18	0.53
10 m	30	2.73	12.82	0.11	238.0	0.33	0.13	0.08
	60	4.31	13.19	0.11	401.2	0.07	0.12	0.10
	90	10.18	67.98	0.78	382.8	0.44	0.98	0.24
	0	0.84	0.00	0.00	0.00	0.00	0.19	0.53
20 m	30	10.40	111.3	1.09	94.19	0.87	1.30	0.25
	60	13.24	148.9	1.25	99.85	2.16	1.70	0.31
	90	13.05	132.9	1.13	97.21	0.65	1.51	0.33
	0	0.06	0.00	0.00	0.00	0.34	0.19	0.57
30 m	30	7.16	42.99	0.24	113.2	0.29	0.64	0.17
	60	5.54	23.03	0.21	180.2	0.16	0.34	0.12
	90	3.20	7.38	0.10	108.1	0.05	0.11	0.05
	0	2.19	0.00	0.00	0.00	0.00	0.19	0.65
40 m	30	12.11	42.83	0.77	113.6	0.20	0.60	0.11
	60	9.40	23.29	0.31	106.6	0.15	0.36	0.15
	90	0.96	1.17	0.05	61.7	0.02	0.05	0.03
	0	3.84	0.00	0.00	3.22	0.00	0.19	0.61
50 m	30	0.47	4.55	0.05	8.31	0.03	0.07	0.04
	60	7.92	1.30	0.30	157.6	0.06	0.11	0.11
	90	0.26	0.63	0.02	44.04	0.01	0.02	0.02

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Table 6: Heavy metal concentration based on distance and depth from landfill (West direction)

Distance (m)	Depth (cm)	Heavy metal Mg	Ca	Mn	Fe	Cu	Zn	Pb
	0	0.08	0.00	0.00	0.00	10.58	0.55	3.07
10 m	30	9.59	54.78	0.71	94.82	0.10	0.36	0.08
	60	7.94	35.85	0.39	109.7	0.20	0.41	0.09
	90	7.66	29.56	0.61	175.1	0.37	0.77	0.22
	0	0.82	0.00	0.00	0.00	11.57	0.07	0.75
20 m	30	0.68	1.51	0.07	40.84	0.01	0.04	0.03
	60	3.71	9.56	0.36	101.5	0.10	0.22	0.10
	90	2.25	12.26	0.25	62.85	0.07	0.15	0.05
	0	7.91	2.03	0.00	0.00	29.71	0.11	1.40
30 m	30	0.20	0.62	0.03	5.07	0.01	0.03	0.04
	60	0.19	0.57	0.03	8.72	0.01	0.03	0.04
	90	6.93	8.47	0.16	107.7	0.09	0.17	0.15
	0	0.01	0.00	0.00	0.00	127.5	0.11	0.00
40 m	30	9.70	6.15	0.23	149.0	0.10	0.19	0.19
	60	0.19	0.57	0.03	8.72	0.01	0.03	0.04
	90	13.64	3.69	0.11	337.2	0.10	0.19	0.21
	0	2.58	0.00	0.00	0.00	301.9	0.12	0.54
50 m	30	9.40	6.53	0.24	159.0	0.08	0.20	0.19
	60	0.19	0.58	0.02	8.64	0.01	0.13	0.05
	90	14.65	4.19	0.13	342.2	0.12	0.19	0.22

Fieldwork 2012

distance of 10 m and 40m, the high concentration of Ca was at 67.98, 42.99 and 42.83 mg/L, respectively. The concentration at distance 20 m was higher compared to other distances, this occurred due to the influence of the composition of the soil samples mix.

Henceforth, the concentration of Fe was dominant at all distances and depths. Based on Table 5, it shows that Fe concentration at distance of 20 m was higher than any other distances. The trend was similar to the concentration of Ca at 20 m, which was due to the composition of soil samples mix. An instance of concentration at 90cm depth was 401.2 mg/L, the highest concentration of Fe at 20 m and for other distances.

Meanwhile, Pb, Zn and Mn indicated low concentrations compared to other heavy metals for all distances and depth around the landfill site. Even though Zn and Mn showed slight difference of concentration at distance 20m with concentration exceeding 1.0 mg/L. For Zn, the concentration at 30 cm, 60 and 90 cm depths were respectively at 1.30, 1.70 and 1.51 mg/L, respectively under the minimum DOE standard (6.90 mg/L) (Table 2).

Concentration of heavy metals in west direction: the West direction concentration of Fe was consistently high at all distances and depths from the landfill (Table 6). The highest concentration of Fe was detected at farther distances and at 90 cm depth, particularly at 40 m distance (337.2 mg/L) and 50 m (342.2 mg/L), respectively. The concentration of Fe for both samples exceeded the minimum DOE standard (301 mg/L) (Table 2). The effect of Fe occurred due to fertilizing process conducted at the oil palm plantation around the landfill site. Meanwhile the Cu showed high concentration at surface level for every distance. The high Cu concentration at 50 m distance (301.9 mg/L) exceeded the minimum DOE standard (19.8 mg/L) (Table 2). High concentration of Cu at this distance occurred due to the effect of recycling activities nearby the sampling stations, particularly the disintegration of electronic wastes (Table 6).

In contrast, the Mg and Ca concentration was a little higher at distance nearer to the landfill site compared to the farther ones. This occurred due to the influence of drier soil surface nearer to the station vicinity compared to the more watery ones farther outward. The watery condition was a factor which influenced the concentration of the heavy metal for it reduced their viscosity.

The metal with the lowest concentration, with less than 1.0 mg/L were Mn and Zn. Based on Table 6, the laboratory analysis of surface soil around the landfill vicinity for all distances did not indicate any concentration of Mn. An only highest concentration of Mn was found at the depth of 30 cm at the distance of 10 m (0.71 mg/L, which was not exceeding the minimum standard, set by the DOE (Table 2).

DISCUSSION

The study indicated that the concentration of heavy metals around the landfill vary per the sampling stations. Fe concentration was found to be highest at the Northern site, followed by Mg and Ca. Other metals were found only in small concentration. The same was with the Eastern direction , which also showed Fe dominating compared to other metals. Analysis of soil samples in the southern direction, indicated an increase in Ca and Fe as metals with the highest concentration.

Collectively, the analysis of samples in the West direction, indicated low concentration of heavy metals compared to those in the North and East directions, except for Fe which was the most dominant heavy metals at all sampling stations around the landfill.

CONCLUSION

Heavy metal pollution at the landfill is a chronic environmental problem. The pollution not only prevails around its vicinity during its period of operationbut may lingeron for a long time after the landfill or dumpsite ceased operations. To overcome the problem, the management aspect should be systematic and efficient not only at the early phase of operationbut also during and after the landfill is closed from active operation.

A regime of actions required to manage the issues of heavy metal pollution require substantial reduction of the waste sources through application of integrated management of waste through reducing generation of wastes at their respective source; recycling, compositing and thermal burning which could reduce the concentration of heavy metal in the wastes.

Finally, a sanitary landfill or dumpsite is a viable alternative to reduce the concentration of heavy metals for its design and water caption pond using High-Density Polyethylene(HDPE) may prevent leachate from seeping into the soil around the landfill andlarger environment.

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REFERENCES

Abderahman, N. and Y. Abu-Rukah, 2006. An assessment study of heavy metal distribution within soil in upper course of Zarqa River Basin/Jordan. Environ. Geol., 49(8): 1116-1124.

Akoteyun, I.S., U.A. Mbata and G.A. Olalude, 2011. Investigation of heavy metal contamination in groundwater around landfill site in a typical sub-urban settlement in Alimosho, Lagos-Nigeria. J. Appl. Sci. Environ. Sanitation, 6(2): 155-163.

Albina, V., R. Cioffi, B. De Vito, M. Marraccoli and L. Santoro, 2008. Release of heavy metals from a municipal solid waste incineration residual stabilized in non-traditional matrics. Stud. Environ. Sci., 60: 789-800.

Baker, A.J.M., R.D. Reeves and A.S.M. Hajar, 1994. Heavy metal accumulation and tolerance in British populations of the Metallophyte *Thlaspi caerulescens* J. and C. Presl (Brassicaceae). New Phytol., 127: 61-68.

Brad, H. and A. Xenidis, 2005. Heavy metals in the environment: Origin, interaction and remediation. Interface Sci. Technol., 6: 165-261.

Bronius, J. and L. Vaida, 2009. Investigation of influence of lapes landfill leachate on ground and surface water pollution with heavy metal. Environm. Engin. Landsc. Manage., 17(3): 131-139.

Buccolieri, A., G. Buccolieri, N. Cardellicchio, A. Dell'Átti, A. Di Leo and A. Maci, 2006. Heavy metals in marine sediments of Toranto Gulf (Ionian Sea, Southern Italy). Mar. Chem., 99(1-4): 227-235.

Callender, E., 2004. Heavy metal in the environment historical trends. Environ. Geochem., 9: 67-105.

Chaari, I., M. Medhioub and F. Jamoussi, 2011. Use of clay to remove heavy metals from jebel chakir landfill leachate. J. Appl. Sci. Environ. Sanitation, 6(2): 143-148.

Chen, J., X.J. Wang, S. Tao, R.M. Liu, Z.H. Zhang and W.R. Shen, 2004. Vertical distribution polycyclic aromatic hydrocarbon in soil in Tianjin area. Acta Scientiae Circumstantiae, 24: 286-290.

Costa, C.J.R., 2000. Site Investigation on Heavy Metals Contaminated Ground in Estrreja-Portugal. Elsevier Academic Press, Boston.

Denton, G.R.W., M.C. Olsen and Y. Wen, 2007. Solid waste disposal on guam: The impact of an unsanitary landfill on the heavy metal status on adjacent aquatic community representatives. Environ. Sci. Technol., 1: 1169-1179.

DOE (Department of Environment), 2009a. Contaminated Land Management and Control Guidelines No. 1: Malaysian Recommended Sites Screening Levels for Contaminated Land. Department of Environment Malaysia, Putrajaya.

DOE (Department of Environment), 2009b. Contaminated Land Management and Control Guidelines No. 2: Assessing and Reporting Contaminated Sites. Department of Environment Malaysia, Putrajaya.

DOE (Department of Environment), 2009c. Contaminated Land Management and Control Guidelines No. 3: Remedetion of Contaminated Sites. Department of Environment Malaysia, Putrajaya.

Elmaci, A., A. Teksoy, F. Topac, N. Ozengin, S. Kurtoglu and S. Baskaya, 2007. Assessment of heavy metals in Lake Uluabat, Turkey. Afr. J. Biotechnol., 6(19): 2236-2244.

Erses, A.S., M.A. Fazal, T.T. Onay and W.H. Craig, 2005. Determination of solid waste sorption capacity for selected heavy metals in landfills. J. Hazard. Mater., 121(1-3): 223-232.

Esmail, A.S., A. Rahim, W.Y. Wan Zuhairi, A.N. Fadhla and A.S. Fares, 2009. Leachate composition and groundwater pollution at municipal solid waste landfill of Ibb City, Yemen. Sains Malays., 38(3): 295-304.

Hsu, M.J., K. Selvaraj and G. Agoramoorthy, 2005. Taiwan's Industrial Heavy Metal Pollution Threatens Terrestrial Biota. Elsevier Academic Press, London.

Jain, P., H. Kim and T.G. Townsend, 2005. Heavy metal content in soil reclaimed from a municipal solid waste landfill. Waste Manage., 25(1): 25-35.

Kar, D., P. Sur, S. Mandal, T. Saha and R. Kole, 2008. Assesment of heavy metal pollution in surface water. Int. J. Environ. Sci. Tech., 5(1): 119-124.

Kasassi, A., P. Rakimbei, A. Karagiannidis, A. Zabaniotou, K. Tsouraras, A. Nastis and K. Tzafeiropoulou, 2008. Soil contamination by heavy metals: Measurement from a closed unlined landfill. Bioresource Technol., 99(18): 8578-8584.

Kendrick, M.J., M.T. May, M.J. Plihka and K.D. Robinson, 1992. Metal in Biological System. Ellis Hardwood Ltd., London.

Long, Y.Y., D.S. Shen, H.T. Wang, W.J. Lu and Y. Zhao, 2011. Heavy metal source analysis in Municipal Solid Waste (MSW): Case study on Cu and Zn. J. Hazard. Mater., 186(2-3): 1082-1087.

Machado, W., M. Moscatelli, L.G. Rezende and L.D. Lacerda, 2002. Mercury, Zinc and Copper accumulation in mangrove sediments surrounding a large landfill in Southest Brazil. Environ. Pollut., 120(2): 455-461.

Mico, C., M.P.L. Recatala and J. Sanchez, 2007. Baseline Values for Heavy Metal Decontamination of Polluted Soils Using Crops of Metal-Accumulating Plants. Elsevier Academic Press, Oxford.

MohdRozaimi, A., 2012. Kajiankonsentrasilogamberat around the site pelupusan Ampar Quiet, Sepang. LatihanIlmiah Geography Program, Pusat PengajianSosial, danPersekitaran Development, FakultiSainsSosialdanKemanusiaan (Indonesion), UKM.

Natrah, M., H. Umar and R. SabihinAbd, 2009. Kepekatankandunganlogamberat in soil in a landfill Kembong River, Bangi, Selangor, Malaysia (Malay). Sains Malays., 38(6): 841-850.

Oluyem, E.A., G. Feuyit, J.A.O. Oyekunle and A.O. Ogunfowokan, 2008. Seasonal variation in heavy metal concentrations in soil and some selected crops at a landfill in Nigeria. Afr. J. Environ. Sci. Technol., 2(5): 89-96.

Prabpai, S., L. Charerntanyarak, B. Siri, M.R. Moore and B.N. Noller, 2009. Effects of residues from municipal solid waste landfill on corn yield and heavy metal content. Waste Manage., 29(8): 2316-2320.

Rodriguez, L., E. Ruiz, J. Alonso-Azcarate and J. Rincon, 2009. Heavy metal distribution and chemical speciation in tailings and soils around a Pb-Zn mine in Spain. J. Environ. Manage., 90(2): 1106-1116.

Sabihin A.R., A.R. Zulfahmi, G. MuhdBarzani, M.R. Wan and M.T. Mohamad, 2008a. Komposisiunsur-unsurutamadanlogamberatdalamtanih in sekitarbukitbatukapur Perlis (Idonesian). Sains Malays., 37(4): 341-350.

Sahibin, A.R., M.R.I. Wan, A.R. Zulfahmi, M.D. Kadderi, L. Tukimat, H. Azman, Y. Sharilnizam and H.K. Low, 2008b. Kandungan logam berat terpiih dalam tanih ultrabes dan mengkudu (*Morinda citrifilia*) dari Kuala Pilah, Negeri Sembilan. Sains Malays., 38(5): 637-644.

Shuhaimi-Othman, M. and M. BarzaniGasim, 2005. Kepekatan logam berat dalam air di lembangan Sungai Semenyih, Selangor. Sains Malays., 34(2): 49-54.

Udomporn, C., W. Wapen, C. Punya, M.H. William and L. Rungruang, 2008. Asessment of heavy metal from landfill leachate contaminated to soil: A case study of Khan Bon Landfill, KhonKhen province, NE Thailand. Appl. Sci., 8(8): 1383-1394.

Urase, T., M. Salequzzaman, S. Kobayashi, T. Matsuo, K. Yamamoto and N. Suzuki, 1997. Effects of high concentration of arganic and inorganic matters in landfill leachate on the treatment level. Water Sci. Technol., 36(12): 349-356.

Ward, M.L., G. Bitton and T. Towsend, 2005. Heavy Metal Binding Capacity (HMBC) of municipal solid waste management landfill leachates. Chemosphere, 60(2): 206-215.

Zaini, S., M.A. MohdHairimi, R. Katiman and M.N. Abd Rahim, 2010. Impakpengur usanta pakp elupusankeataskualiti river in Malaysia: Ikhtibar daripengalamantapakpelupusanPajamdan Pajam River, Queensland (Malay). Malays. J. Soc. Space, 6(1): 50-59.

Zaini, S., R. Katiman and B. Rafidah, 2009. Analisisaspekfizikal in tapakpelupusan. KajiankeatastapakpelupusanPajamdantapakpelupusan Beringin.Dlm Park. JumaatHj Adam, Muhammad BarzaniGasim and ZainiSakawi (Pnyt). 2009. Bio-Kejuruteraan dankeles tariane kosistem. Book Pro Publishing Services, Madhya Pradesh (Malay), pp: 91-114.

Zaini, S., S.A. SharifahMastura and J. Othman, 2011. The impact of open landfill operation on the concentration of heavy metals in soils of its proximite environment. Res. J. Appl. Sci., 6(7-12): 439-442.