Research Journal of Applied Sciences 6 (7-12): 439-442, 2011
ISSN: 1815-932X

The Impact of Open Landfill Operation on the Concentration of Heavy Metals in the Soil of its Proximate Environment

Zaini Sakawi, Sharifah Mastura and S.A. Othman Jaafar
Earth Observation Centre, Faculty of Social Sciences and Humanities,
Universiti Kebangsaan Malaysia, Kebangsaen, Malaysia

Abstract: Landfill is the final destination of waste generation cycle that affects human activities and natural environment. Population increase and poor management are significant factors contributing to waste disposal issues. Development and expansion of townships do affect the efficiency in the generation and disposal of waste in the ecosystem. Impact of waste disposal issues either positive or negative may cut across the boundaries. This research describes a study on a landfill soil and environmental pollutions because of the presence of heavy metals wastes. The elaboration focuses on the level and implication of heavy metal pollution on the physical environment such as soil and underground water and human welfare in the ecosystem.

Key words: Open landfill, heavy metal, solid waste management, environment, water, welfare

INTRODUCTION

Pollution and changes in the environment are only attributed to elements in waste generation and disposal cycle such as its sources, collection, transport, separation and treatment. The landfill and physical changes of its proximity due to development as consequent of population increase is another significant factor. The changes are not confined to the immediacy of the landfill area but also affect the atmosphere, biosphere, hydrosphere systems and also affect the lithosphere, particularly due to the soil pollution linked to pollutants in heavy metals found among the wastes. Generally, there are two main problems affecting the physical environment at a landfill. One is the leachates (waste liquids formed due to mixture of the wastes and rainwater or underground water). Pollution as result of leachates could increase the content of earth metals in the landfill soil (Goncalves *et al*., 2004; Yay *et al*., 2008). Another is an increase in the quantity and variety of waste disposed or buried at the landfill that gives impact to the increase of heavy metals content. Hence, the impact of heavy metals on the neighbouring agricultural plots depends on the soil as medium for the vegetal growth.

Furthermore, the heavy metals can penetrate body of water in the proximity of the landfill through underground water and thus affect the aquatic life. The impact of heavy metals may affect human welfare and various other life forms. Another problem is related to gas emission particularly the methane gas (Riley, 2003; Morcet *et al*., 2003; McLaughlin and Peterson, 2006: Stern, 2007) produced from the biological reactions between living organisms in the soil and waste which can be biologically synthesized by the organisms. The problem generated by the gas at the landfill is also the problem of odour (AERC, 2001; Sironi *et al*., 2005; Sakawi, 2011; Sakawi *et al*., 2011a, b) a pollution which can affect the socioculture and economic activities of the local people.

MATERIALS AND METHODS

This study employed two methods namely field work and laboratory analyses. The fieldwork involved site observation, clinical observation and collection of samples according to major wind directions in relation to the landfill location namely the North, West, East and South (Table 1). The laboratory analysis involved tests on

Table 1: Location of sampling station based on wind direction

Wind direction	Station	Location
North direction	N1	N02°49'167" E101°40'903"
	N2	N02°49'136" E101°40'491"
	N3	N02°49'138" E101°40'489"
	N4	N02°49'430" E101°40'489"
East direction	E1	N02°49'147" E101°40'787"
	E2	N02°49'940" E101°40'546"
	E3	N02°49'940" E101°40'594"
	E4	N02°49'094" E101°40'552"
South direction	S1	N02°49'117" E101°40'798"
	S2	N02°49'110" E101°40'798"
	S3	N02°49'105" E101°40'796"
	S4	N02°49'100" E101°40'793"
West direction	W1	N02°49'117" E101°40'473"
	W2	N02°49'118" E101°40'469"
	W3	N02°49'119" E101°40'468"
	W4	N02°49'120" E101°40'464"

Corresponding Author: Zaini Sakawi, Earth Observation Centre, Faculty of Social Sciences and Humanities, Universiti Kebangsaan Malaysia, Kebangsaen, Malaysia

samples of soil taken during the fieldwork to identify the content level of the selected heavy metals such as Pb, Cu, Mg, Fe dan Cd.

The analyses were also to identify the concentration level of the earth metals using the Atomic Absorption Spectrometer (AAS).

RESULTS

The laboratory analysis on average concentration of the landfill heavy metal content indicated that the highest concentration was found to be the Fe type with a concentration of 1.927 mg L^{-1}. While the heavy metal with the least concentration was the Cd type (0.021 mg L^{-1}). Table 2 shows the overall concentration of the heavy metals from the landfill for 16 stations according the wind directions.

Cuprum (Cu): The analysis on Cu presence indicated that the concentration was high at Station 1 (Table 2). This condition occurred due to the existence or influence of electronic wastes. Furthermore, location 1 was near the in the North side of the landfill.

The sampling at the site also influenced the concentration level that was higher compared to that of other stations. Other than that the texture of the sandy soil at the surface also influenced the level of content of the heavy metals, seeped into the soil through the rainwater (Tels, 2003).

Henceforth, the station with little Cu is Station 2 which was located at a small farm. Even though this station was near the landfill, the content of little Cu which is little may be due to the rate of absorption of the Cu by the tree roots and vegetation which were abound in the farm. The condition occurred due to the existence of Cu as an important element for plant growth especially for green vegetables.

Table 2: The overall concentration of heavy metal from the landfill site

Station	Wind direction	Heavy metal (mg L^{-1})				
		Cu	Pb	Mg	Fe	Cd
1	North	1.737	0.862	2.523	3.211	0.012
2		0.272	0.013	2.015	0.831	0.014
3		0.369	0.061	2.044	1.340	0.016
4		0.292	0.098	0.553	0.622	0.011
5	South	0.421	0.031	1.489	1.732	0.005
6		1.264	0.203	0.732	2.642	0.006
7		1.024	0.044	0.751	2.111	0.003
8		0.566	0.002	0.578	1.481	0.021
9	East	0.655	0.052	2.387	2.055	0.001
10		0.926	0.055	0.937	2.322	0.003
11		0.728	0.069	2.280	2.422	0.014
12		0.291	0.046	1.004	1.635	0.025
13	West	0.923	0.755	1.936	1.288	0.031
14		0.743	0.617	1.667	2.656	0.021
15		0.596	0.406	1.993	2.287	0.029
16		0.599	0.355	1.936	2.202	0.014
Average		0.775	0.229	1.548	1.927	0.021

Plumbum (Pb): The analyses on Pb have shown clear differences in concentration between stations in similar wind directions (Fig. 1). Based on the diagram, it clear shows that the concentration of Pb at Station 1 is very high compared to the samplings of other stations in the same wind direction. This situation could possibly occur because Stations 2-4 were agricultural areas that could influence the concentration of Pb. The presence of vegetation had induced absorption of Pb. Meanwhile, Station 1 is a sandy area with sparse vegetation with did not need substantial Pb.

The analyses of the sampling on the east side of the landfill have indicated Pb concentration was consistently around 0.04-0.055 mg L^{-1}. However, the situation was different from other sampling stations in the south of wind direction that have shown inconsistent concentration. This situation indicated that distance factor did not determine the mobility of heavy metals in the soil.

The analyses of the soil sampling for stations in the west wind direction of the landfill have shown marked increase in the concentration of Pb. This condition occurred due to proximity of the sampling stations to body of water, especially at station 13 which was nearest to the pool. According to underground water flow played important role in transporting metal content to the water retention area. Therefore, higher concentration of Pb was accumulated at the station near water retention area (Fig. 1).

Magnesium (Mg): The analyses of Mg was found the highest concentration at Station 3 (2.523 mg L^{-1}) located in the north wind direction (Table 2). The concentration of the Mg was lowest in the sampling at Station 4 with a reading of 0.553 mg L^{-1} (Fig. 2). An increase in the concentration of Mg in the soil may be influenced by the environmental factor especially human activities in the area. In line with this study, proved that the concentration

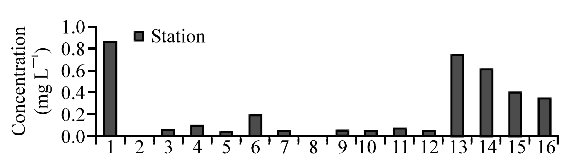

Fig. 1: The concentration of Pb at 16 stations from the landfill site

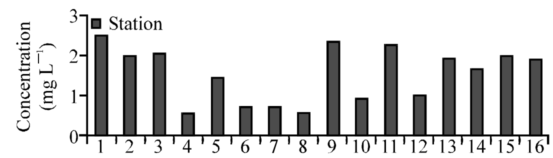

Fig. 2: The concentration of Mg at 16 stations from the landfill site

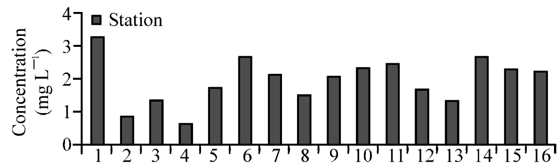

Fig. 3: The concentration of Fe at 16 stations from the landfill site

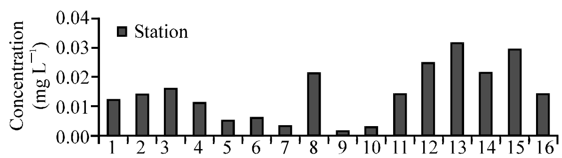

Fig. 4: The concentration of Cd at 16 stations from the landfill site

of Mg in a particular area might increase due to pastoral or animal rearing activities. The high concentration of Mg at station 9 (2.387 mg L^{-1}) and 11 (2.280 mg L^{-1}) were from the samples collected from the oil palm plantations which included cow dungs (Fig. 2).

Ferrum (Fe): The concentration analyses of Fe have found it to be in high concentration at almost all the stations. The analysis indicated that 50% of the stations indicated concentration level above 2 mg L^{-1} (Stations 6, 7, 9, 10, 11, 14, 15 and 16) and 31.25% of the stations were found to have concentration level above 1 mg L^{-1} (Stations 3, 5, 8, 12 and 13). Whilst the highest concentration of Fe among all stations was Station 1 with concentration level at 3.211 mg L^{-1} (Fig. 3). As for Stations 4 and 2, they were found to have the lowest concentration at 0.622 and 0.831 mg L^{-1}.

The Fe concentration was closely linked to the green vegetation in the environment. This phenomena was similar to the study by Tylecote (1992) with the evidence that green environment was a significant factor for lack or absence of Fe. This situation occurred due to high absorption of Fe concentration by the green vegetation and fruit trees.

Cadmium (Cd): The last component of the heavy metal detected at the site was the Cd. Cd was found to be <1 mg L^{-1} at all stations. The Cd concentration was at its lowest level at 0.001 mg L^{-1} (Station 9) and the highest at Station 13 (0.031 mg L^{-1}) (Fig. 4). The Cd concentration is normally influenced by high iron elements in the soil. According to Siegel (2002), old and rusty iron wastes were bound to be oxidized when undergoing the expansion and contraction processes of aeration. Eventually they are exposed to erosion by wind and water elements.

The same conditions may exist at other stations in the area of study even with concentration level of Cd at <1 mg L^{-1} as detected at Station 13; possibly caused by its proximity to water catchments area. It was found that rainwater which flowed through landfill had caused difficulty for detection and separation of wastes such as old electrical equipments and metal works which eventually eroded and with elements of Cd seeped into underground water. Thus, such heavy metal wastes were contributors to the concentration of Cd at the landfill.

DISCUSSION

Overall, it was found that the increase in the concentration of heavy metals from the landfill have positive relationship with the activities in its proximity. In addition, the influence of physical surrounding factor and man, themselves may cause the increase in the concentration of the earth metals. The data also indicated that local activities played an important role in influencing the concentration of the heavy metals in the soil around the landfill. For example, the Mg viscosity detected at Station 3 to the north of study area may be attributed to the cattle grazing area and nearby chicken farm near the sampling station.

Furthermore, the station to the West of the sampling station indicated that the area in proximity of water body (pond) has heavy metal content which is consistent and high compared to other stations. The findings clearly indicated that all parameters of earth metals which were in the west side are high, especially for Cd. This condition was similar to the study by Costa (2000) at Esterraja who found that organic materials and earth metals earth metals such as Pb and Zn could substantially be collected in the soil of riverbanks. The high content of heavy metals like Pb and Zn were attributed to the leakage in the drainage of the waste disposal system which seeped into the river. This study has clearly indicated that the surface water flow which passed on the surface of the Pajam landfill has brought the component of heavy metals with and formed sedimentation collected around the pond on the west side of the station.

Finally, the distance factor from the landfill did not have strong effect in determining the concentration level of the heavy metal in the soil. Other factors such as the conditions of land use at the research station such as agriculture, vegetation-free area, breeding area and ponds were found to influence the concentrations of the heavy metals in the soil. In addition, the depth of soil sample may influence the level of concentration of the heavy metals in the soil. In this study, soil samples were largely taken at the surface level. This condition clearly influenced the concentration level of the heavy metals around the landfills.

CONCLUSION

This study has thus clarified that the specific impact of the landfill waste disposal on soil pollution due to the presence of the heavy metals. In conclusion, the impact of the landfills soil pollution do subsequently affect physical changes and quality of human lives not only in the township ecosystem but also its proximate environment and across territorial boundaries. It is suggested for a further study that a larger and more comprehensive data should be made available for better comparative purposes.

ACKNOWLEDGEMENTS

The researchers wish to gratefully acknowledge financial support for this research by Ministry of Science, Environmental and Technology Malaysia (MOSTI), Faculty of Social Sciences and Humanities, CRIM and Universiti Kebangsaan Malaysia under grant code UKM-SK-07-FRGS0039-2009.

REFERENCES

AERC, 2001. Assessment and control of amenity effects associated with landfills-guidance manual for odour, litter and dust. Cranfield: Guidance Support from Viridor Waste Management Limited, The Environmental Trust Scheme Regulatory Body Limited and under the Landfill Tax Credit Scheme.

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

Goncalves, M.A., J.M.F. Nogueira, J. Figueiras, C.V. Putnis and C. Almeida, 2004. Base metals and organic content in stream sediments near a landfill. Appl. Geochem., 19: 137-151.

McLaughlin, M. and E. Peterson, 2006. Methane mitigation: Monitoring and mitigation of methane at landfill sites. Waste management world (WMW January-February 2006).

Morcet, M., C. Aran, J. Bogner, J. Chanton and K. Spokas *et al*., 2003. Methane mass balance: A review of field result from three French landfill case studies. Proceeding of the Sardinia 2003, Ninth International Waste Management and Landfill Symposium, October 6-10 2003, Cagliari, Italy.

Riley, R., 2003. The monitoring of landfill gas. England: IET May/June 2003. http://www.atsdr.cdc.gov/HAC/landfill/PDFs/Landfill_2001_ch4.pdf.

Sakawi, Z., 2011. Municipal solid waste management in Malaysia. Solution for sustainable waste management. J. Appl. Sci. Environ. Sanitat., 6: 29-38.

Sakawi, Z., S.A. Sharifah Mastura, O. Jaafar and M. Mahmud, 2011b. An analysis of odour concentration using Odour Concentration Meter XP-329 at landfill vicinity. Res. J. Appl. Sci., 6: 324-329.

Sakawi, Z., S.A. Sharifah, S.A. Mastura, O. Jaafar and M. Mahmud, 2011a. Community perception of odor pollution from the landfill. Res. J. Environ. Earth Sci., 3: 143-146.

Siegel, F.R., 2002. Environmental Geochemistry of Potential Toxic Metals. Springer, Heidelberg.

Sironi, S., L. Capelli, P. Centole, R. Del Rosso and M. II Grande, 2005. Odour emission factors for assessment and prediction of Italian MSW landfills odour impact. Atmospheric Environ., 39: 5387-5394.

Stern, J.C., 2007. Use of biologically active cover to reduce landfill methane emission and enhance methane oxidation. Waste Manage., 27: 1248-1258.

Tels, C., 2003. Soil Biology and Biochemistry. Elsevier Academic Press, London.

Tylecote, R.F., 1992. History of Metallurgy. Institute of Materials, London.

Yay, O.D., O. Alagha and G. Tuncel, 2008. Multivariate statistics to investigate metal contamination in surface soil. J. Environ. Manage., 86: 581-594.