American Journal of Civil Engineering and Architecture, 2013, Vol. 1, No. 2, 39-42
Available online at http://pubs.sciepub.com/ajcea/1/2/3

DOI:10.12691/ajcea-1-2-3

Characterization of Leachate and Solid Waste of Dhaka City Corporation Landfill Site for Solid Waste Stabilization

M. Aminul Haque[1,2,*], M.A. Hoque[1], M.S.A. Modal[3], M. Tauhid-Ur-Rahman[1]

[1]Department of Civil and Environmental Engineering, Shahjalal University of Science and Technology, Sylhet, Bangladesh
[2]Department of Civil Engineering, Leading University, Sylhet, Bangladesh
[3]Japan International Cooperation Agency Expert Team, Dhaka North and South City Corporation, Bangladesh
*Corresponding author: eman.cee2008@gmail.com

Received December 31, 2012; Revised February 05, 2013; Accepted April 04, 2013

Abstract Rapid urbanization of Dhaka city has created immense pressure on its urban services including solid waste disposal. Both city corporations (Dhaka North, DNCC and Dhaka South, DSCC) have been facing tremendous problem to maintain sustainable waste management over the last few decades. At present, the DNCC and DSCC dump 68% of the total solid waste to the sanitary landfill site at Matuail. Decomposed solid waste is a potential source of heavy metals and toxic chemicals that pollute the soil as well as the surrounding water body. For environmental sustainability, it is now essential to reduce the load of decomposed solid waste at landfill site through the conversion of waste into re-usable product. Proper characterization of solid wastes is pre-requisite for efficient management and solid waste stabilization. In this paper, it is therefore aimed to investigate the physical and chemical characteristics of decomposed solid waste and leachate collected from Matuail landfill sites. The average concentrations of Fe, Cu, and Ni in leachate samples collected from treated pond were found to be 19.11mg/l, 0.71mg/l, and 2.5mg/l respectively exceeding Bangladesh standards. The presence of heavy metals in decomposed solid waste was also found to be significant. In order to reduce the scale of pollution it is recommended to stabilize solid waste to use it as a construction material. Physical properties that were analyzed in this study will also be helpful for selecting stabilizing additive for perfect stabilization.

Keywords: *decomposed solid waste, heavy metal, landfill, leachate*

1. Introduction

Solid waste management of Dhaka North and South City Corporation becomes a vital issue for environmental sustainability demanding the reduction of waste volume at landfill site. Being a fast increasing populated area (DNCC and DSCC), the amount of generated solid waste is found to be more than 4,000 ton/day, but for the lack of proper services only 2,500 ton/day is collected for disposal in open dumping sites [5]. Till now, there is no full sanitary landfill for ultimate disposal of solid waste. Matuail landfill being constructed by DNCC and DSCC is not properly operated to protect the environment and the neighborhood from adverse impacts of landfill gas and leachate. Besides, potential health hazards as well as vegetation damage, unpleasant odors, soil and water pollution are major concerns [8]. Leachate from decomposed solid waste (municipal, industrial and clinical) conveys heavy metals such as Fe, Cu, Cd, Ni, Cr etc. that may get into surface water body or percolate groundwater causing potential water contamination. Such contamination of water resources may possess substantial risk to the local natural environment. Areas near landfills have a greater possibility of groundwater contamination because of the potential pollution source of leachate originating from the nearby landfill site unless significant thickness of natural clay lining or artificial lining (i.e. geotextile) is in place [9]. In context of Bangladesh, the dumping site is found to be highly polluted with toxic metals requiring detail characterization and appropriate remedial measure [8]. To reduce the volume at landfill site it is essential to take the initiatives for stabilization of solid waste via solidification that convert the waste into re-usable products such as construction material, filler material etc. In this current study, the chemical analysis of decomposed solid waste and leachate were carried out to observe the toxicity level of heavy metals and justify the necessity of solid waste stabilization and re-use. Matuail landfill site (having area of 40 hactre) has been selected as study area.

2. Materials and Methods

2.1. Sampling Procedure

In the present study, three different types of samples: a) decomposed solid waste from waste disposal area, b) converted soil (soil used for vegetation) in dumping sites and c) leachate from leachate pond were collected from

Matuail landfill site to determine the physical and chemical parameters including heavy metals concentration. Decomposed solid waste samples were collected from 5 sampling points (SP) of the landfill site (Figure 1). Sampling points were selected based on the age of decomposition of solid waste as presented in Table 1.

Table 1. Sampling criteria for the selection of sampling points at landfill site

Sampling Points	Sampling Criteria
SP-01	7 years old decomposed solid waste
SP-02	5 years old decomposed solid waste
SP-03	4 years old decomposed solid waste
SP-04	3 years old decomposed solid waste
SP-05	1 year old decomposed solid waste

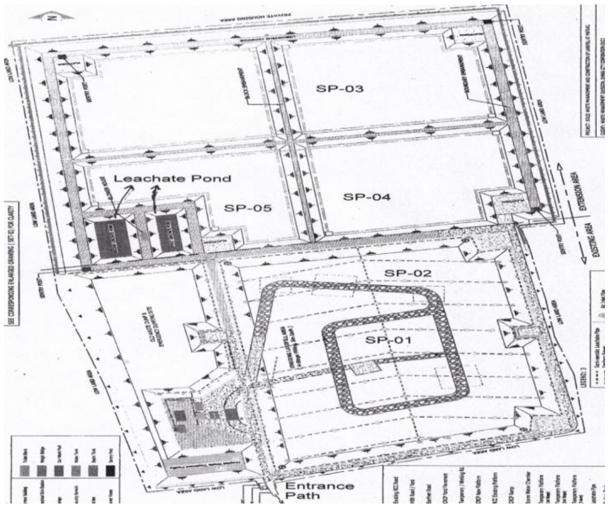

Figure 1. Location of sampling points of solid waste at Matuail landfill site

Converted soil samples were collected from 5 different aged vegetate locations whereas the leachate samples were collected from untreated and treated (aerated) leachate pond of Matuail landfill site. The procedure followed by Mamtaz et al. (2006) [8] was applied in this current study for soil sample collection.

2.2. Analytical Method

After collecting the decomposed solid waste, samples were dried in air and sieved as the requirements of laboratory experiment. To determine the dry density, bulk density, specific gravity, water content of solid waste samples the methods of ASTM-D2216, AATM-D2937-00, ASTM-D854-00 were used accordingly. pH was determined using the LIDA-PHS-25 pH precision meter. Each test was performed 3 times for confirming the reproducibility of experimental data.

Both the decomposed solid waste and converted soil samples were digested for chemical properties analysis using Aqua-Regia digestion method. Parameters related to heavy metals such as Fe, Cu, Cd, Cr and Ni were determined in this study. The concentration of Fe, Cu and Cd were analysed using flame emission atomic absorption spectrophotometer (AAS) (Spectra AA Varian), whereas Cr and Ni were estimated using Hach DR/4000 Spectrophotometer (Method: 8023 and 8037).

The percentage of organic carbon in the decomposed solid waste sample was determined using the methods established by the laboratory of University of Limerick, Ireland [10].

Leachate samples were collected from the untreated and treated (aeration) leachate ponds. Physical characteristics of leachate samples such as TS, TDS, TSS, pH and turbidity were determined following the standard methods (APHA, AWWA and WEF, 1998) [1]. Heavy metals concentration from leachate samples were analyzed using AAS and Hach DR/4000 Spectrophotometer.

3. Results and Discussions

Table 2 represents physical characteristics of decomposed solid waste samples with standard deviations (SD). Dry and bulk density show values less than 1g/cm^3 indicating the presence of organics in soil samples [7]. Though the soil was found to be sandy through sieve analysis, the average specific gravity of waste samples was found 2.15 representing very low value as compared to gravel, sand, silt and clay soil [3]. The maximum value of porosity ranges from 57.85% to 64.55%. In addition, the soil samples were found to be slightly alkaline having the pH in between 7.68 and 8.02.

Table 2. Physical characteristics of decomposed solid waste at Matuail landfill site

Sl. No.	Parameter	Value (Average ± SD)
01	Dry density (g/cm^3)	0.72±0.04
02	Bulk density (g/cm^3)	0.83±0.04
03	Specific gravity (%)	2.15±0.06
04	Porosity (%)	61.0±2.78
05	Water content (%)	16.2±2.78
06	pH	7.83±0.12

The average concentrations of Fe, Cu, Cd, Ni and Cr in decomposed solid waste and converted soil samples are presented in Figure 2. The study reveals that heavy metals concentration in decomposed solid waste is significantly higher than that of converted soil (used for vegetation) pointing out a potential risk of heavy metals insertion into food chain. The average concentration of Fe in decomposed waste and converted soil was found to be12249 and 3411 mg/kg. Previous study conducted by [8] also observed a very high concentration of Fe (9600 mg/kg) in decomposed solid waste at Matuial. The presence of Cd was identified in trace amount 1.27 and 0.61mg/kg in decomposed solid waste and converted soil respectively. The Cr was also detected in this present study. While Cr for SP-01 (oldest sample) was estimated 9.15mg/kg, the concentration was found as high as 16 mg/kg at SP-05(youngest sample). In addition, the accumulation of Ni was detected in this study showing higher concentration as compared to the observation of [8].

The study reveals that both the untreated and treated leachate ponds are safe from Cd and Cr contamination (Table 3). Average concentrations of Fe, Cu and Ni at untreated leachate pond are 25.3 mg/l, 1.5 mg/l and 4.46 mg/l respectively. The conventional treatment process fails to keep these parameters within Bangladesh standards (Table 3) leading to severe water pollution around the landfill site. This demands the pollution source identification and prevention. Though the improvement of the treatment process might be a solution, volume of solid waste at landfill site is the most effective option for sustainable solid waste management.

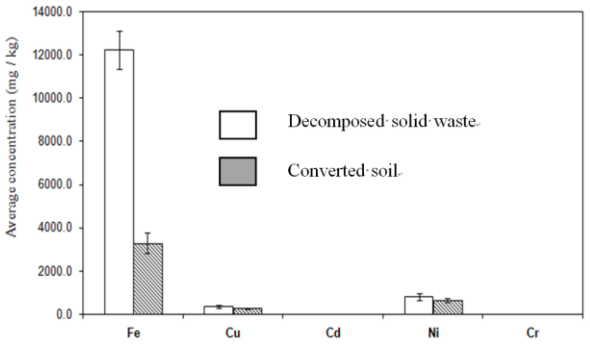

Figure 2. Average heavy metal concentration in decomposed solid waste and converted soil sample

Table 3. Average concentration of heavy metals in leachate samples (in mg/l)

Sl. No.	Parameter	Matuail Landfill site		BECR, 1997 (for inland surface water)
		Untreated Sample	Treated Sample	
01	Fe	25.3±1.75	19.11±1.33	2.0
02	Cu	1.5±0.05	0.71±0.03	0.5
03	Cd	0.20±0.02	0.23±04	0.5
04	Ni	4.46±0.23	2.5±0.11	1.0
05	Cr	0.36±0.02	0.31±0.01	0.5

Table 4 represents the physical characteristics of leachate samples. In this current study, all physical parameters gave similar values as observed by [8]. The treatment of leachate was failed to keep the TDS (7178mg/l) and TSS (1384mg/l) below Bangladesh standard (Table 4). This aggravates the surface water pollution around the solid waste dumping site.

Table 4. Physical characteristics of leachate parameters

Sl. No	Parameter	Present study		Previous study (Mamtaz et al. 2006)	BECR, 1997 (for inland surface water)
		Untreated Sample	Treated Sample		
01	pH	7.87±0.14	7.73±0.12	7.96	6-9
02	Turbidity (FTU)	120±8	97±7	--	--
03	TS (mg/l)	8562±135	7889±115	9607	--
04	TDS (mg/l)	7178±171	6697±147	6133	2100
05	TSS (mg/l)	1384±23	1192±17	3474	150

From this current study, it is very clear that the existing solid waste management system at Matuail landfill site is not safe enough for the environment since the waste contains objectionable level of suspended, dissolved solids and some heavy metals that may cause severe surface water pollution. In addition, the concentration of heavy metals in vegetation area (converted soil sample) is found to be reduced significantly when comparing with decomposed solid waste sample indicating the possibility of heavy metals to get into the crops. Entrance of toxic chemicals to the food chain may prolong adverse impact on human and livestock [11]. Moreover, groundwater contamination may take place due to leaching of heavy metals unless proper lining that is hardly exercise at solid waste dumping sites in Bangladesh. Stabilization of solid waste is practiced in many countries because this process reduces not only the volume of solid waste at landfill site but also reduce the risk of environmental pollution. Contaminated soil can be stabilized by stabilizing additive. After the analysis, average percentage of organic matter in decomposed solid waste was estimated as 19.68% indicating significant quantity of organic matter for which Portland cement can be used as stabilizing additive [12].

4. Conclusion

In this current study leachate and decomposed of solid waste samples collected from Matuail landfill site of Dhaka City Corporations were experimented for heavy metals analysis. Investigation shows that the converted soil used for vegetation around the landfill site contain relatively less concentration of toxic elements as compared to decomposed soil samples indicating substantial quantity of heavy metals to transport to leachate as well as a high possibility to get into the food chain. The analysis also reveals that the quality of leachate sample fail to satisfy the inland surface water quality standard of Bangladesh, even it has been treated through conventional aeration process. Mitigation measure is therefore essential to prevent soil and water pollution. For a sustainable management, it is reasonable to convert solid waste to re-usable product via solid waste stabilization and solidification. Physical analysis of decomposed solid waste was therefore carried out for appropriate stabilizing additive selection and stabilization process optimization. The outcome of this current study is expected to contribute to the next phase research work of investigating the suitability of using stabilized solid waste as construction material followed by the determination of optimum mix proportion of solid waste and stabilizing additives to provide desired compressive strength and environmental compatibility.

5. Acknowledgements

The Authors would like to thank the authority of Dhaka City Corporations for their kind co-operation and giving permission to carry out this study at landfill site.

References

[1] APHA, AWWA, and WEF, 1999. “Standard Method for the Examination of Water and Waste Water”, Washington DC, 20th edition.

[2] BECR, 1997. Bangladesh Environmental Conservation Rules 1997. [Online].Availabe at: http://www.doe-bd.org/2nd_part/179-226.pdf [Accessed 28th August 2012].

[3] Bowels, JE, 1997. Foundation Analysis and Design. 5th Edition, The McGraw-Hill, Geotechnical and Index properties, 29p.

[4] http://www.livestrong.com/article/176005-the-effects-of-soil-pollution-on-humans.

[5] DCC, 2011. Annual Activities Report on Solid Waste Management from July to June in the year 2010/2011. Project for of Solid Waste Management in Dhaka City.

[6] Denutsui,D; Akiti, TT; Osae, S; Tutu,AO; Blankson-Arthur, S; Ayivor,JE; Adu-Kwame,FN and Egb, C, 2012. “Leachate Characterization and Assessment of Unsaturated Zone Pollution near Municipal Solid Waste Landfill Site at Oblogo”, Accra-Ghana.Research Journal of Environmental and Earth Sciences 4(1): 134-141.

[7] http://gcrec.ifas.ufl.edu/Shober/Soil%20Physical%20 Properties%20I/Lab%202-Soil%20Physical%20Properties% 20II.docx [Accessed 4th February 2013].

[8] Mamtaz R and Chowdhury, MH, 2006. "Leaching characteristics of solid waste at an urban solid waste dumping site" Journal of Civil Engineering (IEB), 34(2) 71-79.

[9] Mor, S; Ravindra, K; Dahiyaa,RP and Chandra, A, 2006."Leachate Characterization and assessment of groundwater pollution near municipal solid waste landfill site" [online]. Available at: https://uhra.herts.ac.uk/dspace/bitstream/2299/2039/1/902166.pdf [Accessed 16th August 2012].

[10] O'Flynn J and Liston M. Determination of percent Organic Carbon in Soil, University of Limerick, Ireland, [Online]. Available at: http://www.nce-mstl.ie/files/Ag_Sc_posters/Agricultural%20 Science%20Poster%20%25%20Organic%20Matter.pdf [Accessed 16th August 2012].

[11] Ryskamp, DA, 2010. The effect of soil pollution on humans, [Online]. Availble at: http://www.livestrong.com/article/176005-the-effects-of-soil-pollution-on-humans/ [Accessed 26th August 2012].

[12] USACE, 1984. "Soil stabilization for pavements mobilization Construction, Engineering and Design Manual" (April 1984), Department of the Army, U.S. Army Corps of Engineers, Washington, D.C.