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Research Article

ANALYSIS OF PHYSICAL AND CHEMICAL COMPOSITION OF THE SOLID WASTE IN CHITTAGONG CITY

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ABSTRACT

The present study was carried out to determine the physical and chemical composition of the Chittagong city. Fine organic materials comprises the major part of the produced solid waste (35.1%), while fine dust and vegetable matter constitute 28.5% and 20.6% respectively. The major components of municipal waste include food waste, glass, metals, can, debris, bricks, boards, leaves, paper, dirt and ashes, chemical composition found in the solid wastes showed high moisture content, high ash and inorganic contents and comparatively low nitrogen, phosphorus and potassium. The nitrogen, phosphorus and potassium content represent the important ingredients value for fertilizer of the waste and potential conversion of the waste into good compost. The leachate characteristics showed acidic in nature. It is also rich in nitrate and phosphate, whenever this highly polluted leachate got entrapped in ponds with the surface wash, it poses a high degree of pollution threat to ground water as well as surface water and subsequently health hazard.

INTRODUCTION

Solid waste is the garbage, refuse, sludge and other discarded materials including solid, liquid, semi-solid, or contained gaseous material, resulting from industrial, commercial, mining and agricultural operations, and from community activities (Peavy, *et al*., 1985; Kumar, *et al*., 2016). Huge amount of municipal solid waste (MSW) (UN, 2003) is producing day by day since the generation rate is increasing even faster than the rate of urbanization (Hoornweg and Bhada-Tata, 2012). The intensification of solid waste production within 10 years from 0.68 billion tons per year in 2000 to 1.3 billion tons per year in 2010 (Islam, 2016). It is anticipated to reach 2.2 billion tons per year by 2025 and 4.2 billion tons per year by 2050 (Hoornweg and Bhada-Tata, 2012).

Municipal solid waste is a global concern (Adeolu, *et al*., 2011) in developing countries though industrially advanced countries produce large quantities of wastes (Sujauddin, *et al*., 2008; Tchobanoglous and Theisen, 1977). Developing countries generate less solid waste because of lower purchasing power and the consequent lesser consumption (Cairncross and Feachem, 1993). Some factors such as poverty, population growth and high urbanization rates affect the efficient wastes management of developing countries (Cunningham, *et al*., 2005; Zurbrugg, 2003; Sridhar and Ojediran, 1983; Cointreau, 1982; Doan, 1998; El-Salam and Abu-Zuid, 2015).

Bangladesh being a developing country facing serious problem with solid waste. Incredible production of solid waste have been noticed due to fast population growth and ongoing economic development (Bhuiyan, 2010; Ahsan, *et al*., 2014; Afroz, *et al*., 2011). Moreover, Bangladesh, is a densely populated country that is experiencing with rapid urbanization and a huge number of rural people are migrating to urban areas each year (Salequzzaman, 2000; Enayetullah, *et al*., 2005). As a result, unplanned rapid urbanization and slum development icreased, and these areas produce a lot of incontrollable amounts of solid waste in all major cities (Dhaka, Chittagong, Rajshahi, Khulna, Sylhet and Barisal) of Bangladesh (Salequzzaman, *et al*., 2001).

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Tremendous waste generated rapidly and creating lots of problems in Bangladesh (Bhuiyan, 2010). If these solid waste not managed properly, these will certainly have a negative impact on sustainable living style, local environment, and human health (Scarlat, *et al*., 2015; Enayetullah, *et al*., 2005; Hasan and Chowdhury, 2005). Severe negative consequences were reported in a number of cities of different countries like China (Cheng and Hu, 2010), India (Singh, *et al*., 2011), Malaysia (Johari, *et al*., 2012), and Thailand (Chiemchaisri and Visvanathan, 2008). Poor solid waste management has become a challenge for governments of developing countries in Asia and Africa (Calo and Parise, 2009; Halla, and Majani, 2003; Mwangi, 2000; Ogu, 2000; Zia, and Devadas, 2008; Zurrugg, 2002). Solid Waste is humiliating the urban environment and posing a serious threat to the natural resources and consequently impeding equitable sustainable development (Kumar and Bhowmick, 1998). 16,380 tons of waste are being produced in Bangladesh per day (Anonymous, 2004). Approximately 4500 tons of waste produced in Dhaka per day (Hasan and Chowdhury, 2005) even though Dhaka City Corporation (DCC) can collect and dispose only 42% of the solid waste (Salequzzaman, *et al*., 1998).

A significant amount of research work has been conducted on solid waste management in Bangladesh (Salequzzaman, *et al*., 1998; Salequzzaman, *et al*., 2001; Salequzzaman, 2000; Ahmed and Rahman, 2000; Alam, *et al*., 2002; Hasan and Chowdhury, 2005; Enayetullah, *et al*., 2005; Rahman, *et al*., 2006; Sinha, 2006). For sustainable management of these waste it is very important to know the physical and chemical composition of the waste. The present study was carried out to determine the Physical and Chemical Composition of the Solid Waste in Chittagong City.

MATERIALS AND METHODS

Study Site

The present study was carried out for a period of 12 months from January 2000 to December 2000 in Halishahar Munir Nagar Area, Chittagong Metropolitan City, Bangladesh (Fig. 1).

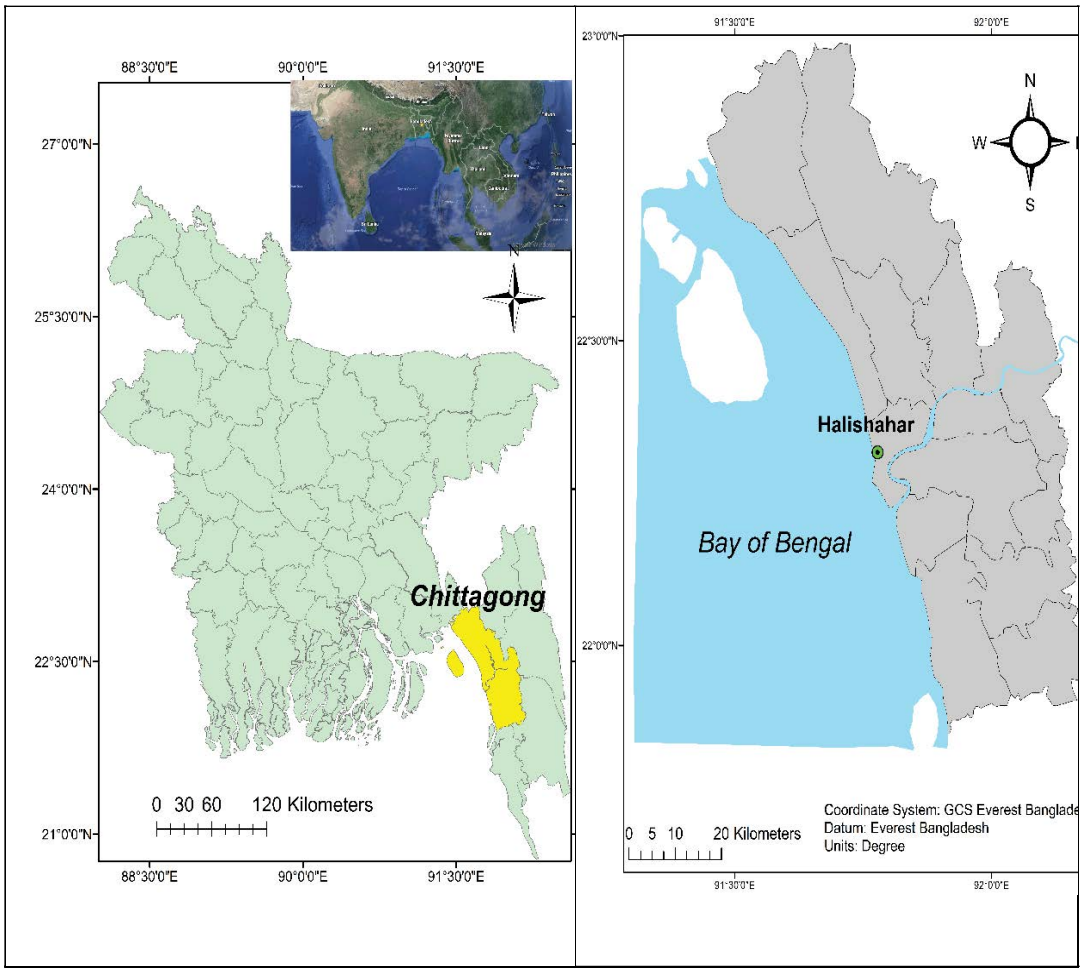

Fig. 1. Map of the study area (Map created by ArcGIS v.10.3).

Sample collection

Sample was collected from dumpsite area. Physical composition is tested by taking waste sample. Chemical composition is tested by taking soil sample from dumpsite area. The soil is the end product of solid waste which is dumped before. Leachate characteristics are tested by taking leachate from the drain near the dumpsite of selected area.

Sample analysis

Physical composition is separated by hand into recyclable, compostable and the residue just after being collection. The value of Hydrogen-ion-Concentration (pH) of water was determined by using pH paper (color pH indicators strips, Cat.9585, made in Germany). To determine the Dissolve Oxygen (DO) the collected samples in BOD bottles were fixed inside according to Azide Modification of (Winkler, 1988) and analysis were made by the same method. Bio-chemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) were analyzed by the method stated by (APHA, 2005). Chloride measured by Volhard Method, Organic Matter (OM) was measured by Walkey and Black wet oxidation. Ion Chromatography was used to measure phosphates and nitrate (APHA, 1999). Moisture content was determined following the method stated by (Baba, *et al*., 2014). Suspended Solid was measured by following the method of (Shahi, 2009).

RESULTS AND DISCUSSION

The present study was conducted to know the physical and chemical composition of the solid waste. The rate of waste generation is an index of socio-economic growth and financial affluence of the region. Growing development and rising incomes lead to greater usage of resources and waste composition is influenced by factors such as extent of urbanization, standard of living and climate (Solomon, 2011; Endalu and Habtom, 2014; Mengie, *et al*., 2015; Mohammed, 2015). The major components of Chittagong City wastes are various in natures which includes fine dust (28.5%), vegetable matters (20.6%), stone, bricks & earthward (8.4%), rags (4.2%), paper (1.8%), leather (0.6%), metals (0.8%) and fine organic matters (35.1%) (Table 1).

Fine organic materials constitute the major portion of the generated solid waste (35.1%), whereas fine dust and vegetable matter constitute 28.5% and 20.6% respectively.

The solid waste was found to consist of glass (9.59%), metal (2.74%), paper (25.83%), plastics (3.87%), compostable organic matter (57.48%), WEEE (0.22%) and other waste (0.27%) (Yusuff, *et al*., 2014). (Titien, *et al*., 2013) reported that domestic solid waste generally comprises of a minimum of 75% organic matter. The composition of the households by weight were food (59.5%); ash and dust (25.08%); yard waste (11.6%); plastics and rubber (2.04%); paper and cardboard (1.12%); while textile, wood, glass and metals accounted only 0.1%, 0.16%, 0.2% and 0.2% wastes, respectively (Goa and Sota, 2017).

Chemical composition found in waste, generated in Chittagong City are moisture content, fixed residue, organic carbon, organic nitrogen, phosphorus and potassium (Table 2).

Organic nitrogen content in solid waste of Chittagong City is high, organic carbon and phosphorus content is also in considerable amount. Typical component values and composition of solid waste presented in Table 3.

(Gidarakos, *et al*., 2005) found moisture content 2.93% in plastics and 17.11% in papers of solid waste in the island of Crete. The physical components were determined: organic materials (73.7%), plastics/ polythene (12.9%), cans/metals (4.3%), bottles/

Table 1. Physical composition of mixed municipal waste of Chittagong City.

Constituents	Percentage
Fine dust	28.5%
Vegetable matter	20.6%
Stone, bricks & earthward	8.4%
Rags	4.2%
Paper	1.8%
Leather	0.6%
Metals	0.8%
Fine organic	35.1%

Table 2. Chemical composition of waste generated in Chittagong City.

Constituents	Refuse from Disposal Site (%)	Domestic Waste (%)	Market Waste (%)	Mixed Refuse (%)
Moisture Content	42-54	44.3	57.6	91.21
Fixed Residue	50-58.2	55.4	53.3	87.13
Organic Carbon	Nil	24.5	27.6	20.83
Organic Nitrogen	0.4-0.7	0.43	0.34	0.39
Phosphorus	0.0-0.06	0.08	Nil	0.03
Potassium	Nil	Nil	Nil	Nil

glasses (4.2%), clothes/shoes (4.3%), and ceramics (0.6%) (John, *et al*., 2006). The mean concentration of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sodium (Na), sulfur (S), organic components contents were 11.0, 3.2, 10.7, 87.7, 18.4, 2.3 and 223.7 g-kg^{-1}, respectively (John, *et al*., 2006). Rahman, *et al*., 2006) recorded average waste density, moisture content, organic matter, C: N 117 kg-m^{-3} (ranging from 136.23-95.36 kg-m^{-3} among the sub sources), 0 (34.13-25.38%), 9.57% (43.03-35.75%) and 17 (20.37-15.08), respectively in the solid wastes of Chittagong Metropolitan Area.

The result of leachate test revealed the presence of suspended solid, chloride, phosphate and nitrate (Table 4).

BOD and COD are too high in the leachate of solid waste of Chittagong City. (Al-Wabel, *et al*., 2011) recorded pH (6.21), COD (17,003 mg/L), Cl- (8971.5 mg/L), NO^{-3} (not detected) and TSS (5604 mg/L) in municipal solid waste in Riyadh City, Saudi Arabia. In the present study, the COD concentrations was found 13,000 mg/L while total suspended solids recorded 10000 mg/L. Physical and chemical analyses of leachate samples collected from sanitary landfills in Alexandria, Egypt shown in Table 5.

These values were extremely higher than the respective values detected by (Chu, *et al*., 1994; Al-Yaqout and Hamoda, 2003). The amount of chloride was recoded 1400 mg/L lower than (Al-Wabel, *et al*., 2011) (5503–11,538 mg/L). The pH values of

Table 3. Typical component values and composition of solid waste.

Component	Moisture (%) Typical	Density (kg/m^3) Typical	C	H	O	N	S	Ash
Glass	2	195	-	-	-	-	-	-
Metal	3	320	-	-	-	-	-	-
Paper	6	85	43.5	6.0	44.0	0.3	0.2	6.0
Plastics	2	65	60.0					10.0
Compostable	25	240	48.5	7.2	22.8	-	-	5.0
(Organic)	10	65	55.0			2.2	0.3	2.5
UMW	20	240	49.5	6.5	37.5	4.6	0.1	1.5
a) Textile	8	480	26.3				5	68.0
b) Wood				6.6	31.2	0.2	0.1	--
c) Rubble				6.0	42.7	0.5	0.2	--
				3.0	2.0	--	--	--
Source: (Tchobanoglous, *et al*., 1977).								

Table 4. Characteristic quality of leachate of Chittagong City.

Parameter	Typical	Range
pH	4.73	4.4-6.20
Suspended Solid (mg/L)	10 000	3,000-1,400
BOD (mg/L)	8 500	6,000-15,000
COD (mg/L)	13 000	5,000-18,000
Chloride (mg/L)	1 400	1,200-4,500
Phosphate (mg/L)	6	0-17
Nitrate (mg/L)	48	0-200

Table 5. Physical and chemical analyses of leachate samples collected from sanitary landfills in Alexandria, Egypt.

Parameters n = 6	Unit	Min	Leachate samples Max	x ± SD
pH	-	7.0	7.8	-
Chlorides	mg/l	9500	16,250	11387 ± 119
Total suspended solids	mg/l	3278	14,464	12985 ± 137
Chemical oxygen demand	mg/l	12,850	16,350	15629 ± 206
Biochemical oxygen demand	mg/l	9620	11,700	10824 ± 95
Total nitrogen	mg/l	382	954	583 ± 76
Nitrate-N	mg/l	0.36	2.9	1.4 ± 0.2
Phosphates	mg/l	0.29	0.52	0.37 ± 0.04
Source: (El-Salam and Abu-Zuid, 2015)				

the leachates were found 4.73 lower than the (Al-Wabel, *et al*., 2011). This indicate the acidic nature of leachates as well as the organic and inorganic acids formed during the decay of the municipal wastes.

CONCLUSION

From the findings of the present study it could be concluded that, except pH and chloride, most of the values as well as the concentrations of parameters were so much higher in the solid waste and leachates in Chittagong City when comparing with some other results. It is urgent to know the physical and chemical composition of the solid waste for sustainable management. Because of improper planning, governmental policy, and administrative and managerial problems, the municipal waste management situation in Chittagong, has become appalling. The irresponsible behaviour of the city dwellers and the commercial units within the residential areas make the situation worse. Furthermore, the city governments failed to educate and motivate the city inhabitants to participate in the waste management programmes. The technology that may be applied to solid waste management in this respect, these include using such litters as a source of raw materials for industrial sector, a source for energy production, as a conditioners in soil development and organic farming.

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