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Study of Solid Waste Management and its Impact on Climate Change: A Case Study of Dhaka City in Bangladesh

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Abstract--**Rapid global warming has caused fundamental changes to our climate. Specially, the people living in Dhaka city are facing the worst sufferings than any other cities in Bangladesh. The waste in Dhaka comprises mainly 60% of organic waste which can produce landfill gas (methane) upon decomposition. It could be added that waste management generates carbon dioxide and methane, with emissions occurring during almost all stages from transportation through to recycling, recovery and final disposal. This paper looks at the relationship how solid waste dumped in open space or landfill site can contribute to the generation of landfill gas and contribute to climate change in the context of Dhaka city. The waste generation, characteristics and composition are studied for Dhaka city and the landfill gas is estimated using Inter Governmental panel of Climate Change (IPCC) guideline tier-1 based on different projected scenarios. Based on these scenarios, potential measures to reduce the landfill gas emission are recommended.**

INTRODUCTION

Bangladesh is one of the most vulnerable countries to the impact of climate change. Rapidly growing mega cities like Dhaka is expected to face a major challenge with its booming population of 13.5 million [1]. The amount of waste generated in urban area is proportional to the population and the average income of the people. In addition, other factors such as climate, level of education, social and public attitude also may affect the amount and composition of waste [2]. Bangladesh is a low carbon dioxide (CO_2) emitting country with per capita emission of 0.2 ton/year that is far below the average 1.6 ton/year for developing countries [3].

Dhaka the capital city of Bangladesh is ranked ninth among the megacities of the world [1] in the world and every day 10% of total population migrates to Dhaka for their different activities. The city, its municipalities and its adjoining urban areas have an annual population growth rate of 6.6 per cent [4] and over half the population of Dhaka (55%) is poor, and many live in slums and squatter settlements with no access to municipal sanitation services [5]. As the population is increasing, the management of solid waste has become a major challenge particularly in Dhaka city. The waste in Dhaka comprises mainly of organic waste which can produce landfill gas (methane) upon decomposition. This paper looks at the relationship how solid waste dumped in managed and unmanaged way can contribute to the generation of landfill gas and contribute to climate change in the context of Dhaka city.

Methane only stays in the atmosphere around 8-12 years while carbon dioxide can last for centuries. But methane (CH_4) has a bigger effect in its short time—methane is responsible for 75% as much warming as carbon dioxide measured over any given period of 20 years [6]. This means methane reductions could have an immediate beneficial effect on our climate, faster than comparable reductions to CO_2. According to Watson, [6] cutting methane requires only modest investment as compared to CO_2. Cooling follows within a decade when we stop methane emission unlike centuries to reduce CO_2. That's why emphasis has been given on cutting down methane emissions from waste management in the current study. Global emissions of methane from landfilled waste have been estimated at approximately 40 million tonnes per year. The waste sector is accountable for approximately 5% of the global green house; about 1300 $MtCO_2$-eq in 2005 as reported by IPCC [7]. This 5% consist of methane (CH_4) emission from anaerobic decomposition of solid waste. Since the pre-industrial era, atmospheric concentrations of have more than doubled [8]. Only methane (CH_4) is accounted for the estimation of GHG emissions from solid waste practice.

In Dhaka, 45 to 55% of the total waste (2,200 ton/day) are unmanaged waste (less than 4 m depth) and dumped in open space. These sites can be the optimal candidates for Landfill gas emission. Each day huge amount of municipal solid waste (MSW) is disposed in the dumping sites, which produces significant amount of methane (CH_4) for emission into the atmosphere. Although a significant portion of the waste in the dump has already decomposed or has burnt. For the greenhouse gas (GHG) calculation, it is assumed that municipal solid waste at land filled site in a year would be converted completely into methane (CH_4) which would be emitted from the landfill site in the same year.

MUNICIPAL SOLID WASTE IN DHAKA CITY

Currently, there are four Clean Development Mechanism (CDM) projects that are under development. Supported by developed countries like the Netherlands, Canada and Japan, these projects aim to earn a significant amount of foreign currency as well as contribute to the energy sector of the country through the efficient treatment of waste. Two of these projects named 'South North Project' and 'Composting of Organic Waste in Dhaka' have already commenced.

Altogether, the different components of the project are expected to reduce about 15,000 tons of carbon dioxide from the atmosphere and earn a benefit of about $120,000 per year [3].The second CDM project prepared by Waste Concern and the World Wide Recycling (WWR) of the Netherlands with support from the UNDP is the first composting project using CDM globally. This innovative project is now under implementation with an aim to reduce about 90,000 tons of carbon dioxide (CO_2) each year.

Waste generation and Characteristic of waste

There are a number of studies available on Dhaka City waste generation and characterization. According to

Alamgir and Ahsan [9], waste generation rate is ranging from 0.325 to 0.485 kg/cap/day, while highest rate is 0.485 kg/cap/day in Dhaka City. It has also reported that about 78% solid waste is coming from residential sector and 20% from commercial sector, 1 % from the institutional sector and rest from other sectors. Waste characteristics are important to determine its possible environmental impacts on nature as well as on society. According to the sources, waste can be categorized i.e. a) domestic waste, b) commercial waste, c) institutional waste, d) industrial waste, e) street sweepings, f) clinical waste and g) construction and demolition waste [10]. Furthermore, waste can be classified as organic and inorganic characters. The percentage of waste composition from all locations was about 74.4% organic matter, 9.1% paper, 3.5% plastics, 1.9% textile and wood, 0.8% leather and rubber, 1.5% metal, 0.8% glass and 8% other waste. The biodegradable fraction (organic matter) is normally very high as compared to other fractions, essentially due to the use of fresh vegetables and foods, which is common in each city. Based on available data and information, it is estimated that Dhaka City Corporation itself generates more than 4800 tons/day solid waste. On the other hand the waste generated in developing countries comprises waste rich in organic and moisture content (300–550 kg/m^3), thereby could be compacted to a great extent [11].

Collection and Transportation system

Dhaka City Corporation (DCC) is the responsible authority for waste collection and transportation. In many parts of Dhaka city, the community based waste management is working very smoothly and effectively while City Corporation failed to deliver the desired service. According to Hasan and Chowdhury, [12] 50% of the daily generated waste remains uncollected in the city. Waste generated at home is stored and collected daily by a primary collector employed by the Non-government organization (NGO), who transports the waste to nearby transfer points, normally in a rickshaw van. Disposing of waste in open dumps is the most common method used for final disposal of urban solid waste. In some areas, there are designated dumping sites where the collected waste is dumped in unsanitary manner. No waste segregation, waste compaction or daily top seal are used in these dumpsites in low-lying areas, nearby water bodies or on a vacant lot. It is estimated that existing sites will fill up shortly and DCC will have to arrange for new dumping sites for waste disposal. The only one sanitary landfill site located at Matuail has an area of 40 hectares.

RESULTS AND DISCUSSIONS

In Bangladesh, around 60% waste [13] is rapidly biodegradable and the rest are slowly biodegradable with small portion of non-biodegradable. The sufficient data for green house gas emission calculation is not available. To calculate methane emission the following expression is used from IPCC tier-1:

$$\textbf{Methane Generation} = (A \times B \times C \times D \times E \times F \times G - R) \times (1 - OX)$$

where,

A = Total MSW generated (Giga gram)
B = Fraction of MSW disposed at landfill sites (Giga gram)
C = Methane correction factor
D = Fraction of Degradable Organic Carbon (DOC) in MSW
E = Fraction of Degradable Organic Carbon (DOC) which actually degrades
F = Fraction of Carbon (C) as methane
G = Conversion factor from Carbon (C) to methane (CH_4)
R = Recovered methane (Gg/year - 0 in the present case)
OX = Oxidation factor (0 in the present case)

The methane correction factor has been considered as 0.4 due to unmanaged landfill site in Dhaka city based on Inter Governmental Panel of Climate Change IPCC 2006 guidelines. It is found from the previous study of Bangladesh Centre for Advanced Studies (BCAS) that Fraction of Degradable Organic Carbon (DOC) in MSW is (15%). Moreover, the fraction of actual Degradable Organic Carbon (DOC) in MSW is 77% which value is close to that in other South Asian Countries. Fraction of Carbon (C) as methane has been considered 0.55 based on IPCC value (range 0.50 to 0.60). In Bangladesh, the recovered methane is zero. As there is no burning in any landfill site, Oxidation factor is also zero. It was found from the calculation that, there are about 26.89 Giga gram (Gg) methane (CH_4) emitted from municipal solid waste at Dhaka city 2010. It is also found from the GHG emission calculation on the basis of IPCC Guideline tier-1 that there are 20.5 Gg and 16.96 Gg methane emitted from the landfill site at Dhaka City for 1670 ton and 1375 ton municipal solid waste in 2005 and 2001.

Almost every steps of solid waste management can contribute to the emissions of GHG. Therefore, solid waste management can reduce GHGs by affecting one or more of the following:

(1) Energy consumption (specifically, combustion of fossil fuels) associated with making, transporting, using, and disposing the product or material that becomes a waste.

(2) CH_4 emissions from landfills where the waste is disposed.

(3) CO_2 and nitrous oxide (N_2O) emissions from waste combustion.

Management of municipal solid waste presents many opportunities for GHG emission reductions. Source reduction, in general, represents an opportunity to reduce GHG emissions in a significant way. Source reduction and recycling can reduce GHG emissions at the manufacturing stage, increase forest carbon sequestration, and avoid landfill CH_4 emissions. Landfill CH_4 emissions can be reduced by using gas recovery systems and by diverting organic materials from landfills. Landfill CH_4 can be flared or utilized for its energy potential. When used for its energy potential, landfill CH_4 displaces fossil fuels, as with MSW combustion. Using compost as landfill cover on closed landfills provides an excellent environment for the bacteria that oxidize CH_4. Under optimal conditions, compost covers can practically eliminate CH_4 emissions. Furthermore, the covers offer the possibility of controlling

these emissions in a cost-effective manner. This is particularly promising for small landfills, where landfill gas collection is not required and the economics of landfill gas-to-energy projects are not attractive. Use of Bioreactors can accelerate the decomposition process of landfill waste through controlled additions of liquid and leachate recirculation, which enhances the growth of the microbes responsible for solid waste decomposition. The result is to shorten the time frame for landfill gas generation, thereby rendering projections of landfill gas generation rates and yields that are much more reliable for landfill gas recovery.

The temperature of Dhaka city has increased over last 20 years. The maximum annual temperature has increased from 35.4^{o}C to 39.6^{o}C from the year 1990 to 2009 [13]. The waste generation has increased as well. The climate change impact has been observed with less rainfall during dry period followed by longer warming days in summer and shorter winter days particularly in Dhaka city over the last 50 years. The precipitation pattern has also changed drastically in Dhaka city as compared to the surrounding areas located at its periphery. The secondary impacts are increase in dust level resulting in air pollution [14], scarcity of water due to decrease in precipitation [15].

CONCLUSION

Introducing the alternative community based waste management techniques which involves waste minimization at household level with local level recycling would be a low-cost in house mechanism to manage the waste at local level. Awareness should be raised on the disposal of waste and its impact on the climate change and people should be motivated to segregate recyclable materials from organic materials by providing separate containers for collection of waste. Necessary incentives such as collection charge may be reduced for those households properly segregating the wastes as per the types of containers provided. It has been recommended that Local governments should update general plans to reflect solid waste sustainability issues such as green house gas (GHG) reduction goals, landfill gas recovery and programs based on specific targets. The landfill site should be designed taking into consideration of tapping landfill gas. The monitoring and update of records should be done on a regular basis to check performance of reduction strategies.

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