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Dhaka City Solid Waste Treatment for Saving the Surface Water

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Abstract: Purpose of the study is to reduce waste dumping system on open pit and reduce greenhouse gases (GHG) emission by produce electricity from wastes. Furthermore, safe the surface water from the wastes. The study found that the wastewater from Dhaka city contained a diverse array of chemicals including toxic and nontoxic heavy metals, nitrates, phosphates, and harmful polyaromatic hydrocarbons that from organic or inorganic wastes. The experiment has done on wastewater sample collection and direct data collection. Then the data analyzed by the software simulation. The results are that 80% waste collection rate and High tech solid waste incinerator/treatment plan could produce per day 233MW electricity and potentially reduce totally 1.9-2.0 million tons GHG per year. In addition, by the analysis of this High Tech plan could reduce roughly 60% polluted wastewater effluents.

Key words: green energy, environmental impact, solid waste, wastewater evacuation

1. Introduction

Dhaka is the capital of Bangladesh and is surrounded by four main rivers along with their many small cannels. In addition, there are several inland lakes and low-land inside the city. These water bodies are filled up by the rain and seasonal water. Approximately, the city population is 17.91 million and this highly populated mega city is producing tremendous amount of solid wastes daily. Rising waste volumes and increasing complexity of waste treatment have become major and growing public health and environmental concerns. Due to the population growth, changing lifestyle and consumption patterns of people, the quantity of waste generation is increasing. The quality and composition of wastes are also changing dramatically. Particularly more and more hazardous and toxic wastes are added into wastes and these toxic materials if untreated are destined to the waterways. As a result water pollution is occurring in the water bodies such as lakes, rivers, oceans and groundwater as well.

Water is essential for the survival of life. Clean and fresh drinking water is also essential to human survival as well. All water pollution not only affects organisms and plants that live in these water bodies either to individual species and populations, but it also damages to the natural biological communities.

From the map, we can see rivers around Dhaka city.

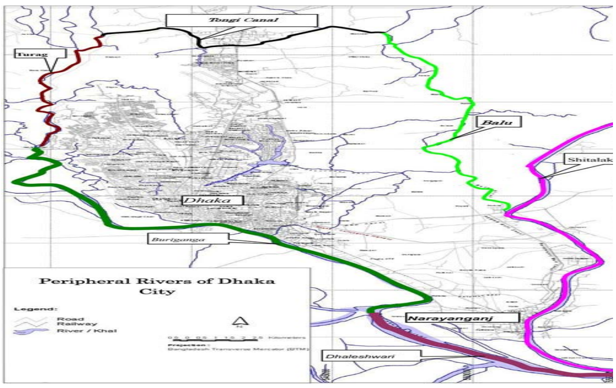

Fig. 1 Dhaka City location map.

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These water-bodies are highly polluted and have reached alarming levels of pollution that is posing significant threats to health and economic activities of inhabitants, particularly among the poor and vulnerable.

Besides house-hold solid wastes, wastes from small industries and tannery effluents are more complex characteristics. It is associated with a high level of organic pollutants, commonly characterized with chemical oxygen demand (COD) together with significant amounts of inorganic compounds, such as trivalent chromium and sulfide, capable of exerting toxic or inhibitory effects on biological system [4, 6, 10]. Rivers are being polluted by over 138 sources from different points. Besides, inhabitants are also throwing wastes directly and indirectly into the rivers. According to Bangladesh Inland Water Transport Authority (BIWTA), Buriganga is being polluted by 53 sources. The biggest sources are Hazaribagh tannery wastes; water containing COD and the toxic stench wafting through the whole area is almost suffocating. The main cause of water pollution in Dhaka city is the lack of waste management system for organic or inorganic wastes. During rainy season wastes and wastewater production is 100% higher then dry season.

In Dhaka city, supply water sources are mainly ground water source (83%) and surface water (17%). The peripheral rivers have undergone major pollution due to indiscriminate discharge of domestic and industrial wastes. As a result, surface and ground waters are highly contaminated by different types of chemicals and microbes. Some other identified contaminants are residual chlorine, coliform and faecal coliform. Dhaka WASA recently found high concentrations of E. coli in the ground water of the downtown area of Dhaka and supply water is also contaminated (WASA, 2003).

The extent and gravity of the environmental degradation of the water resources in Dhaka due to untreated industrial wastes is not fully recognized in the international discourse. Pollution levels affect vast numbers, but the poor and vulnerable are the worst affected, and in the Dhaka watershed has declined by 40% over a period of a decade [2]. Ground water level is rapidly declining 3 m/yr (WASA, 2003) due to a large-scale abstraction. Therefore, ground water is no longer a viable option for water supply and the surface water will be the only option for water sources within the next half-century.

To address the tremendous water pollution problem, wastes need to be collected separately and more specific treatment is necessary to save the surface water and the ground waters. In this framework, the objective of the study was:

- To show how wastes convert to wastewater and ultimately reach to the waterway;
- To compare conventional and high tech waste management system;
- To introduce a high tech advance waste management system in Dhaka city and to show GHG emission load reduction;
- Save the valuable water resources.

2. Material and Methods

Primary and secondary data were used for this study purpose. Primary data was collected through water sample collection and analysis. Secondary data was collected through various books, reports, journals and articles, such as JAICA, Ministry of Environment and Forest (MOEF), Dhaka City Corporation (DCC) reports and different waste management plants in Japan. Water sample were collected from different drains and rivers around Dhaka city. The tannery wastewater investigated in this study was taken from Hazaribagh, Dhaka. Hazaribagh area houses more than 200 large tanneries along with numbers of small tanneries representing a major fraction of animal hide processing in Dhaka city. Conventional characterization of the raw tannery wastewater was carried out on a grab sample collected from drains of the above-mentioned industrial areas. The relevant analyses were performed in duplicate in accordance with the standard methods [3]. COD was the key parameter in this study. We also analyzed waters from different rivers and drains water and found wastewater from Dhaka city contained a diverse array of chemicals including toxic and nontoxic heavy metals, nitrates, phosphates and harmful polyaromatic hydrocarbons.

To proper investigate on waste generation and disposal system, some areas were selected as sampling areas, such as Hazaribagh, Gabtoli, Uttara, Dholpur and Mirpur. Stratified random sampling technique was used for public opinion survey on some attributes, such as waste generation, waste dumping and waste safety. The analysis was done using Urban Co-benefits Evaluation Tools and statistical tools, like Microsoft Excel. The main findings of this study are: (1) how wastes converting as a wastewater stream, (2) chemical pollutants confirmation, (3) greenhouse gases production by conventional waste management procedure, and (4) a solution for saving surface water and GHG reduction

3. Results and Discussion

All types of wastes like household, pharmaceutical, clinical, industrial and other wastes altogether without categorizing are dumped in open pits. Waste collection system is divided in primary collection areas and final dumping areas. Initially, inhabitants throw their wastes directly in primary collection areas or city workers collect waste by their small vehicle and dump to the primary collection areas. Finally, the city corporation collects the garbage from the primary dumping sites to dump in the final dumping sites. The delay time of waste collection and disposal from primary to final dumping sites is about a week. Within this delay time, precipitations do occur and wastes mix up with rainwater. Ultimately, mixing wastewaters flow to drains and rivers. Fig. 2 shows the primary waste collection areas condition and over flow of wastewaters.

Without any proper treatment, wastes are terminated to the final dumping areas or open pits. Most of dumping sites are near to the main streets or close to the city. In the dry seasons, dry wastes are burned on the open pits. In the mean time, the GHG emission also starts from open pit dumping sites and wastes are converting as a wastewater by influence of rainwater or seasonal water, and finally the wastewaters are flowing into the rivers. Fig. 3 shows such situation clearly.

In 1989, total waste production was about 700-1000 tons per day [5]. However, in 2015, per day total waste generation is over 10 thousand tons in the dry season and 20 thousand tons in the wet season per day (estimated 2015). The Table 1 shows total waste production in million tons.

Basically final dumping areas are low-land areas and easily fill up with rainwaters or seasonal waters. Thereby, a huge amount of dissolved chemical components are producing in the final dumping sites.

Fig. 2 Primary waste collection area with rainwater.

Fig. 3 Final dumping area.

Table 1 The annual solid wastes production in dry and wet season in Dhaka City.

Year	Dry season wastes production (million tons)	Wet season wastes production (million Tons)
1980	0.67	0.82
1985	0.95	1.14
1990	1.33	1.64
1995	1.68	2.07
2000	2.1	2.55
2005	2.57	3.16
2010	3.1	3.81
2015	3.66	4.5

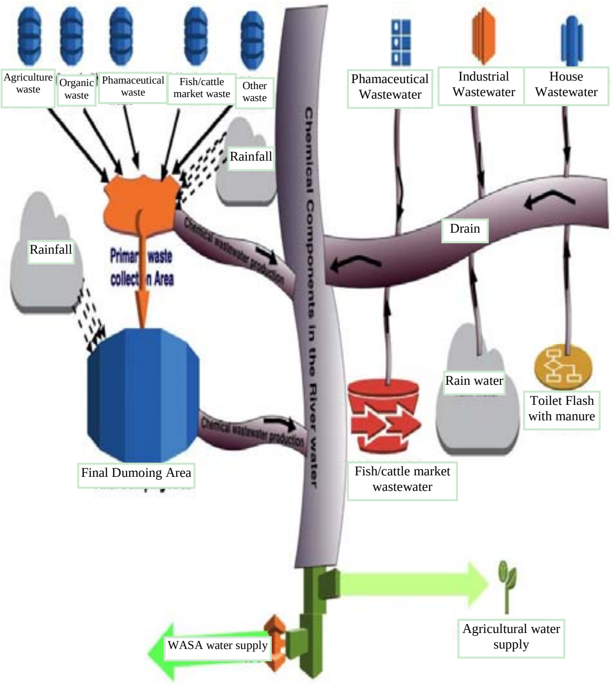


Fig. 4 From wastes to wastewater generation process.

In 2014 alone, precipitation was 1399 mm in average annually (Dhaka Metrological department Data, 2015) and a big part of rainwaters mix up with wastes in the primary and final dumping sites, and produce huge amount of wastewaters with dissolved chemicals. Fig. 4, the following diagram shows the wastewater generation process.

The overall wastewater generation is started first from the primary garbage collection sites where garbage accumulates from the producing sources and is continuing in the final dumping sites. At the final dumping sites, GHG emission and wastewater generation are concurrently occurring for a long period. The pollutants (gas and dissolved chemicals) are continuously added to the environment and rivers every day.

3.1 Chemical Test

Table 2 shows the analysis result of wastewater. All pollutants were present at very high concentration that extremely exceeds the accepted level.

3.2 Recent Approach

The presence of high concentration pollutants in the wastewaters intrigues us to deeply study the present waste disposal system in Dhaka city. We simulated the Conventional and 3R waste management approach in Dhaka city. We found that the conventional system is emitting lot of GHG, heat and health risk. Recent 3R approach can reduce greenhouse gases emission but its capacity is limited (only 50 thousand people out of 17.91 million). The conventional and 3R waste management system in Dhaka city is shown in Fig. 5.

3.2.1 Simulation Result

The simulation result is shown in the Figs. 6-8. The Fig. 6 shows almost 49% for land-fill and open burning is almost 12%. The Figs. 7 and 8 show that greenhouse gas emission is extremely high level in conventional approach.

This 3R approach is very good. However, this approach has its limitation, it can cover only small amount of wastes per day. To tackle huge amount of

Table 2 Hazaribagh area's wastewater test result.

Item test	Result
PH	4-10 MG/L
Total Alkalinity as $CACO_3$	665-1850 MG/L
Electrical Conductivity	670-2200 MICRO-MHOS/CMS
Chloride	1300-5000 MG/L
Chromium	3-36 MG/L
COD	3200-21000 MG/L
BOD	200-650 MG/L
DO	5 MG/L
Ammonia Nitrogen	12-70 MG/L

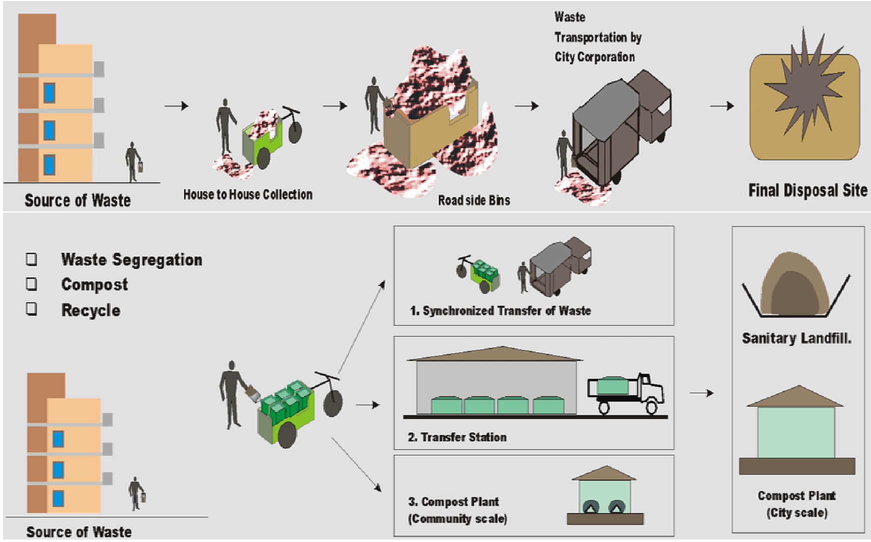


Fig. 5 Present waste management system in Dhaka city.

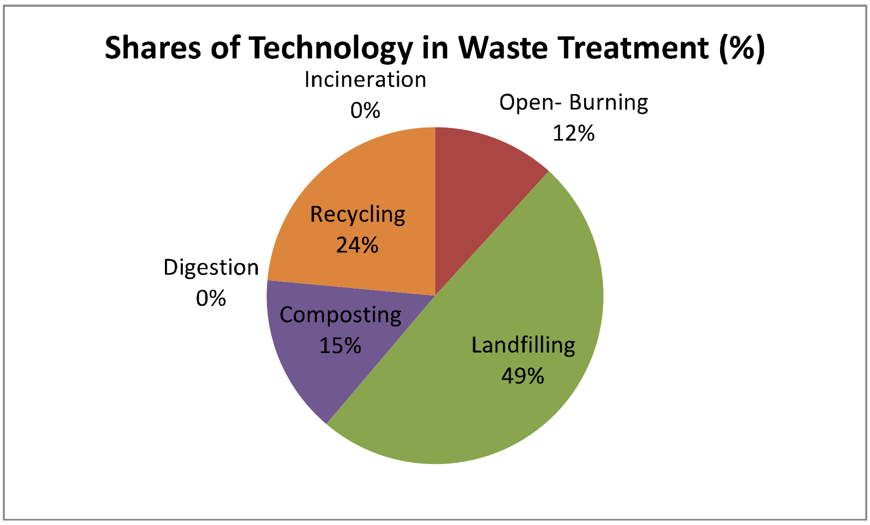
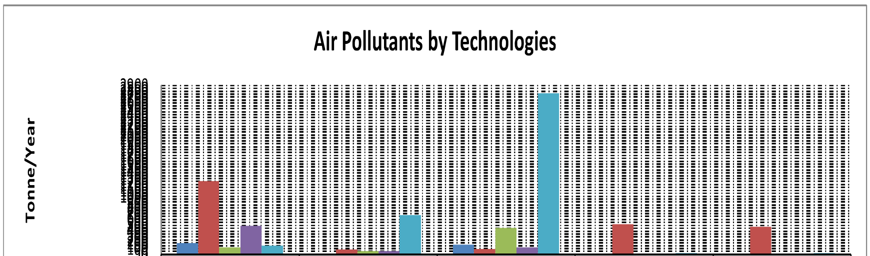


Fig. 6 Present waste disposal.



	CO	SO2	NOX	PM10	PM2.5
Incineration	190.07	3.09	163.01	0.71	0.57
Open-Burning	1257.49	80.47	88.94	511.41	468.42
Landfilling	120.60	51.65	449.48	11.43	11.43
Composting	488.37	52.29	123.11	3.49	2.10
Anaerobic Digestion	150.91	671.88	2756.81	16.15	14.79

Fig. 7 Present GHG emission.

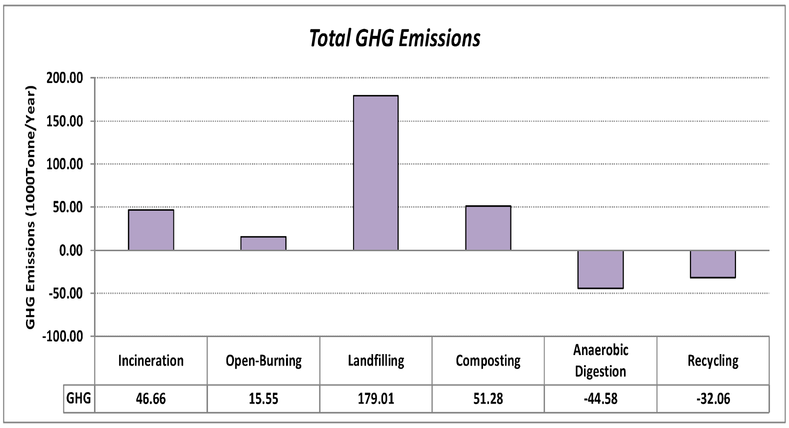


Fig. 8 Present air pollution.

wastes (10-12 thousand tons/day) that produced in Dhaka city, it is not an ideal approach. In this situation, we are proposing an Advance High Tech waste management system that could cover all the wastes in Dhaka city.

3.3 Proposed High Tech Waste Treatment Plant

3.3.1 Waste Life Cycle

After reviewing the traditional waste disposal system and 3R approach in Dhaka city, we propose a design for waste life cycle. By using this life cycle approach, we can arrive our final goal. Fig. 9 shows the projected life cycle for solid wastes. In this approach, waste-classification is started at sources (Burnable, non-burnable, recyclable, organic particularly kitchen wastes) and each of the waste will be treated accordingly.

3.4 Proposed Treatment Plant

The Fig. 10 depicts only incineration structure. Only the burnable wastes are burned at 500 to 600°C to keep valuable aluminum and ferrous metal unoxidized in the reduce atmosphere and can be recovered by the recycling. Non-combustible

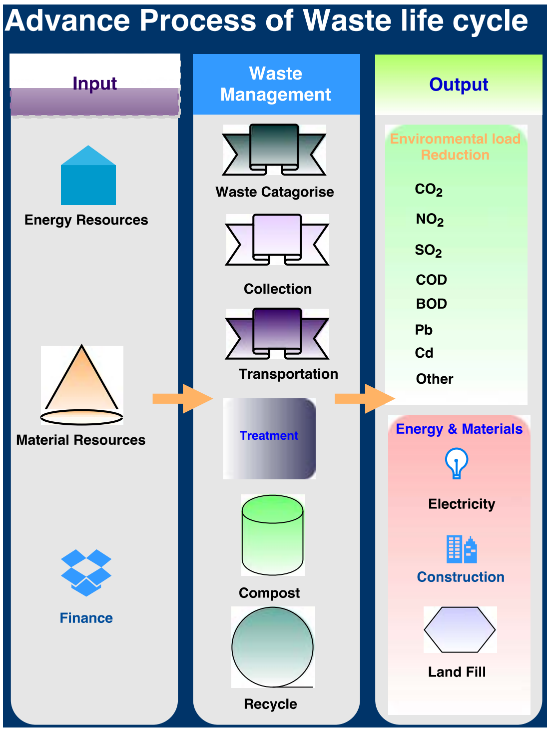


Fig. 9 The projected life cycle for wastes.

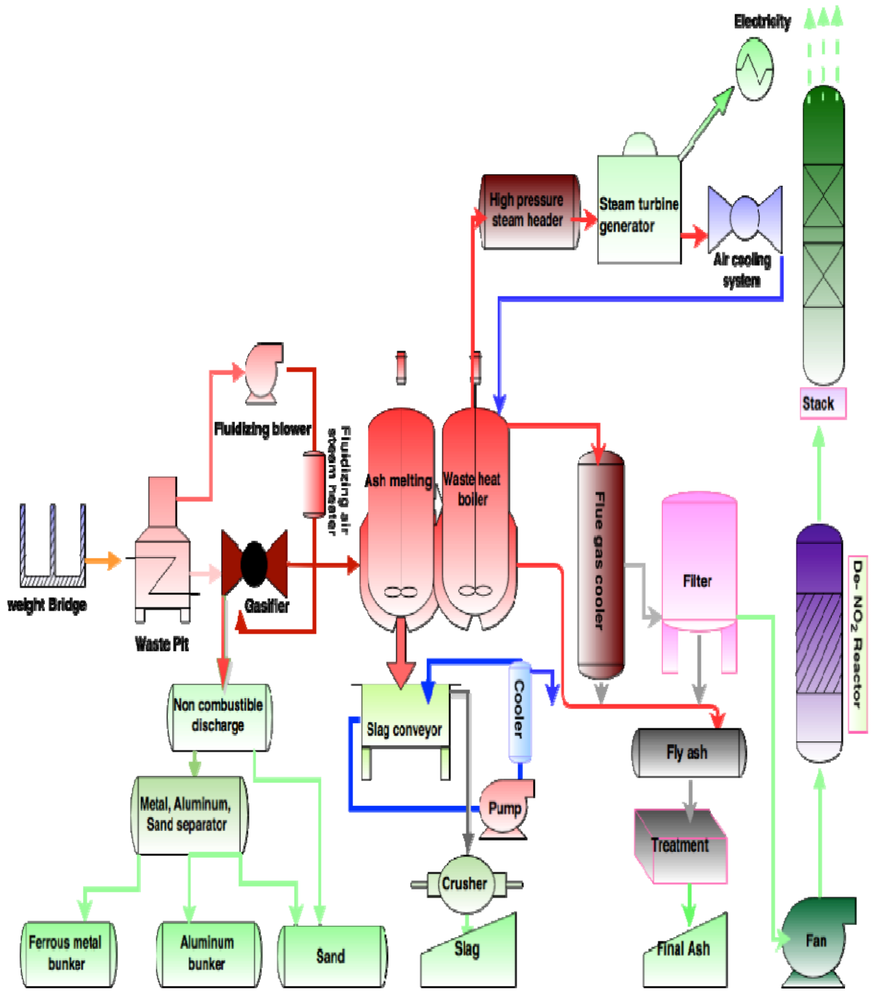


Fig. 10 High Tech waste treatment plant.

materials and sand are discharged from bottom of the furnace through the non-combustible discharge conveyor. There are two types of separators here. If any ferrous metals contained in the non-combustible are recovered with a magnetic separator, and the aluminum is recovered with an aluminum separator. The sand is storage by the sand storage tank.

Second stage is ash melting. The ash melting furnace temperature will be higher, because the pyrolysis gas is combusted while being circulated at the relatively high temperature at 1300 to 1400°C [9]. This high heat melts the ash contained in the gas, turning it into the slag, while greatly decreasing the amount of generated dioxins. The bottom of the ash-melting furnace is discharge system for slag. Slag scraper conveyor is keeping and cooling slag by circulating cool water. This water is cooled by the water cooler and recycled for slag cooling system. Finally slags are crushed by the slag crusher and stored in the slag storage yard.

Ash melting furnace and waste heat boiler are directly connected. Top of the waste heat boiler, there is a high-pressure steam header. This steam is used to generate electricity in the steam turbine generator. The resulting electricity is use to power the facilities and surplus power can sell to other power company. The steam is also use to provide hot water. Bottom of the waste heat boiler is discharging fly ash with flue gas. In this stage flue gas will go back to flue gas cooler and only fly ash will send to the fly ash silo. This fly ash silo is also receiving ash from bag filter. Finally, fly ashes are treated by the treatment facility and sent it to the hopper.

The flue gas cooler incorporates spray nozzles that atomize reused water in order to cool the flue gas and the cold flue gas is filtered through the bag filter. This bag filter is made of fabric filters to remove dust contained in the flue gas. Then the flue gas reheated by the gas re-heater will go through the De-NO_2 reactor. Nitrogen oxides contained in the flue gas react with ammonia through a catalytic reaction and are decomposed along with dioxins. Finally, it will discharge to the atmosphere by the stack. If we can implement this plant, our simulation result showed that GHG emission would be the same as Kuraham waste management plant [9]. Thus, we can control environmental standard.

3.4.1 High Tech Simulation Result

Compared to the conventional waste treatment process, the High Tech system reduced the production of pollutants; particularly GHG is million tones low (180 to 0.03 thousand tones) that shown in Fig. 11 and Table 4.

Table 3 GHG emission from the Kurahama plant, Okinawa, Japan.

Item	Emission level
Dust	0.01 g/m^{3}N or less
Hydrogen Chloride	50 ppm or less
Sulphur Oxides	20 ppm or less
Nitrogen Oxides	50 ppm or less
Dioxins	0.1 ng-TEQ/m^{3}N or less
Carbon Monoxide	30 ppm or less

Table 4 High tech plant emission level (million ton/year).

Treatment technology	Incineration	Open-burning	Land filling	Composting	Anaerobic digestion
Co pollutant	0.00	0.11	0.02	0.00	0.00
SO_2 pollutant	0.00	0.02	0.01	0.00	0.00
NOx pollutant	0.00	0.02	0.08	0.01	0.00
PM10 pollutant	0.00	0.05	0.00	0.00	0.00
PM2.5 pollutant	0.00	0.04	0.00	0.00	0.00

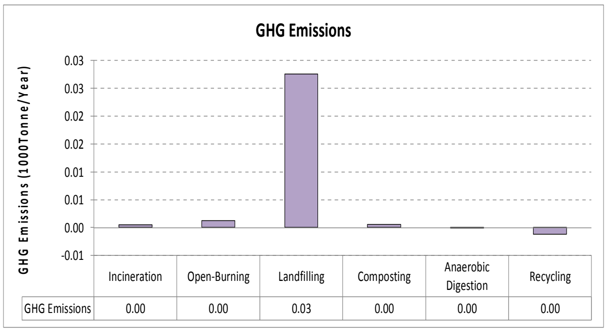


Fig. 11 High tech plant gas emission.

4. Conclusion

The High Tech waste treatment plant can potentially reduce totally 1.9-2.0 million tons GHG per year. The plant can also produce 233MW electricity daily. Thus, the system is self-sustainable and environmental friendly. It will reduce polluted wastewater effluents to flow in the water bodies and GHG emission in the environment significantly.

References

[1] Agamuthu Pariatamby and Masaru Tanak (Eds.), *Municipal Solid Waste Management in Asia and Pacific Island: Challenges and Strategic Solutions.*

[2] M. Ana and D. Nandini, Industrial water pollution in Dhaka, Bangladesh: Strategies and incentives for pollution control in small and medium enterprises, *The International Journal of Interdisciplinary Social Sciences* 3 (11) (2009) 97-108.

[3] APHA, WEF, AWWA, in: Clesceri L. S., Greenberg A. E., & Eaton A. D. (Eds.), *Standard Methods for the Examination of Water and Wastewater* (20th ed.), American Public Health Association, Washington, DC, USA, 1998.

[4] A. Carucci, A. Chiavola, M. Majone and E. Rolle, Treatment of Tannery wastewater in a sequencing batch reactor, *Water Sci. Technol.* 40 (1) (1999) 253-259.

[5] C. Chandan, H. Md. Mazaharul, A. Sobur, v Taslima, M. and Rubel, Analysis of the causes and impacts of water pollution of Buriganga River: A critical study, *International Journal of Scientific & Technology Research* 2 (2013) 245-252.

[6] I. Kabdasli, O. Tunay and D. Orhon, The treatability of chromium tannery wastes, *Water Sci. Technol.* 28 (2) (1993) 97-105.

[7] O. Karahan, S. Dogruel, E. Dulekgurgen and D. Orhon, COD fractionation of tannery wastewater — Particle size

distribution, biodegradability and modeling, *Water Research* 42 (2008) 1083-1092.

[8] H. Man-Hong, L. Yong-mei and G. Guo-wei., Chemical composition of organic matter in domestic wastewater, *Desalination* 262 (2010) 36-42.

[9] Mitsuko Tomon, Kurahama Sanitary Facilities Association, Ecotopia Ikehara (heat Recovery Facility), Ecoloop Ikehaara (Recycling center), Okinawa, Japan, available online at: http://www.kurahama.or.jp.

[10] D. Orhon, R. Tasli and S. Sozen, Experimental basis of activated sludge treatment for industrial wastewaters — The state of the art, *Water Sci. Technol.* 40 (1) (1999a) 1-11.

[11] A. Shaikha Binte and R. Zubayed Bin, Generation and quality analysis of greywater at Dhaka City, *Environmental Research, Engineering and Management* 2 (64) (2013) 29-41.