Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 3159-0040
Vol. 2 Issue 12, December - 2015

Sustainable Eco-Friendly Textile Sludge Management In Bangladesh: Construction And Validation Of Lab Scale Biogas Plant For Generation Of Biogas From Textile Sludge

Arun Kanti Guha
Department of Textile Engineering
Southeast University
Tejgaon, Dhaka 1208, Bangladesh
arunguha70@yahoo.com

Shuchismita Dey
Department of Textile Engineering
Southeast University
Tejgaon, Dhaka 1208, Bangladesh

Mohammad Neaz Morshed
Department of Textile Engineering
Southeast University
Tejgaon, Dhaka 1208, Bangladesh

Md. Saiful Islam
Department of Textile Engineering
Southeast University
Tejgaon, Dhaka 1208, Bangladesh

ABM Foisal
Department of Textile Engineering
Southeast University
Tejgaon, Dhaka 1208, Bangladesh

***Abstract*—Ready-Made Garments are backbone of economy of Bangladesh. About 80% of total exports are done by this sector. The export incomes were US $ 17.9 billion in the year 2010-11, US $ 19.0 billion in the year 2011-12, US $ 21.5 billion in the year 2012-13, US $ 24.5 in the year 2013-14 In Bangladesh, 1500 billion liter ground water is consumed every year by Textile sector. As a result, Textile sector of Bangladesh has been discharging 2 million m^3 effluents every day. For environmental pollution protection effluents are treated in various effluent treatment plants (ETPs). After effluent treatment a semisolid part is separated from Effluent Treatment Plants which is called sludge. A large quantity of sludge has created further problem for safe disposal. There are several sludge management options available. Considering the energy situation of Bangladesh biogas generation from Textile sludge is the suitable option of the country. A lab scale biogas plant was constructed in the Chemistry lab of Southeast University of Bangladesh. To validate the constructed lab scale biogas plant successive experiments were performed. First of all bio sludge obtained from Delta Knit Composite was digested in the digester tank of biogas plant. The maximum biogas obtained at third day of generation. Portable lab scale biogas plant is easy to carry and shifting from one place to another.**

Keywords— Textile Sludge , Sustainable, Eco-Friendly, Biogas Generation

I. INTRODUCTION

Ready-Made Garments are backbone of economy of Bangladesh. About 80% of total exports are done by this sector. The export incomes were US $ 17.9 billion in the year 2010-11, US $ 19.0 billion in the year 2011-12, US $ 21.5 billion in the year 2012-13, US $ 24.5 in the year 2013-14 [1a-b]. In a recent report of Bangladesh Bank [1c] it was mentioned that total export of ready-made garment product rose by 7.9% year-on-year in January-March 2015 and their growth significantly increased by 14.0% points from the previous quarter, October-December 2014. There are different types of Textile industries present in Bangladesh to support Ready-made Garments in Bangladesh. Those are spinning, knitting & weaving and wet processing units. Textiles are huge water consuming industries. In Bangladesh, 1500 billion liter ground water is consumed every year by Textile sector [2]. As a result, Textile sector of Bangladesh has been discharging 2 million m^3 effluent everyday [3]. For environmental pollution protection, effluents are treated in various effluent treatment plants (ETPs) such as physicochemical, biological and biochemical. Among these types of ETPs, Biological ETPs are widely used in Bangladesh because of low operation cost. After effluent treatment a semi solid part is separated from Effluent Treatment Plants. This semi solid part is called sludge. Textile sludge is an unavoidable by-product of Textile wastewater treatment process. Textile sludge is a cluster of organic and inorganic complex with high concentrations of heavy metals such as Fe, Cu, Cd, Zn, Cr etc. because a variety of dyes & chemicals are used in different wet processing steps. In Bangladesh,

2.81 million metric ton sludge generates from Textile sector [1b]. A large quantity of sludge has created further problem for safe disposal. There are several sludge management options available. Those are incineration, brick preparation, sanitary land filling, mixing with cement and biogas generation [4]. Considering the energy situation of Bangladesh biogas generation from Textile sludge is the suitable option of the country. Natural gas is the main fuel of Bangladesh considering energy and diversity of uses. Natural gas is used in different sectors of Bangladesh, such as domestic, CNG, power, industry etc. The main functions of natural gas are exploration, production, transmission, distribution and marketing to the end users are done by Bangladesh Oil, Gas and Mineral Resources Corporation (*Petrobangla*) in Bangladesh [5]. The updated information of *Petrobangla* are available in published reports.

Table 1. Sector Wise Natural Gas Consumption in Bangladesh.

Sector	2009-10 [5]	2013-14 [6]	2014-15 [6]
Power	37.9	41.0	40.17
Industry	16.9	17.0	16.85
Captive	15.8	17.0	17.17
Domestic	12.1	12.0	13.06
Fertilizer	10.7	7.0	6.17
Commercial and Tea-Estate	1.21	1.0	1.14

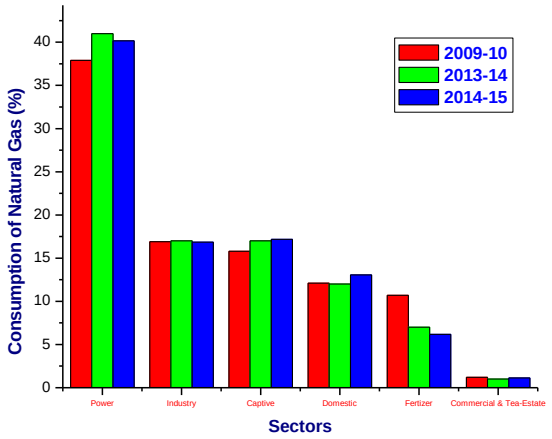

Figure 1. Sector Wise Natural Gas Consumption in Different Years of Bangladesh.

In 2005 Textile and Leather consumed 31% of total industrial natural gas consumption [5]. According to current report of Petrobangla [6], industries consume 16.85% whereas fertilizer consumes 6.17% of total natural gas consumption indicates Textile industries are demanding more and more natural gas for smooth production regularly. In the report of Petrobangla in 2014-15 [6] it was mentioned that the total demand of natural gas in Bangladesh was 3274 MMCFD but the corresponding supplied quantity of natural gas was 2725 MMCFD. From the statistical data it was calculated that 549 MMCFD natural gas was deficit to its demand. So the generation of biogas from Textile sludge could be a great effort to supply biogas for partial fulfillment of gas in Textile industries. In a previous report Guha, A.K. et al. [4] reported results of a pilot project of biogas generation from Textile sludge in Bangladesh. But so many questions remain regarding quantitative estimation of biogas generation, characterization of Textile sludge and residual sludge after biogas generation, identification of change in sludge before and after biogas generation. Designing, construction and validation of lab scale biogas plant is necessary to find out suitable answers of all remaining questions in this work. As per our literature survey we did not find any paper regarding lab scale biogas plant for Textile sludge in Bangladesh. We have designed, constructed and validated lab scale biogas plant from Textile sludge in our lab. The objectives of this work are designing & construction of appropriate lab scale biogas plant from Textile sludge in Bangladesh, validation and carry out experiments to solve relevant problems in our country.

II. Materials and Methods

A. Construction of lab scale biogas plant

A lab scale biogas plant was constructed in the Chemistry lab of Southeast University of Bangladesh. The plant was constructed by connecting a conical flask with two glass bottles (Figure 1). The conical flask is called digester (2.5 L). The middle glass bottle (10 L) is designated as gas collector. The third bottle is (10 L) is called water collector. The digester was connected to gas collector by a plastic pipe by means of three ways gas valve. The generated gas flowed to the gas collector through the gas valve and same volume of water was displaced to the water collector because of pressure of produced gas. The gas collector was connected to the water collector so that displaced water was easily transferred to the water collector. There was another connection between gas collector and gas out let pipe. During the production of biogas this connection was closed but it was opened when the collected biogas was separated out to the gas balloon for flameability and other tests.

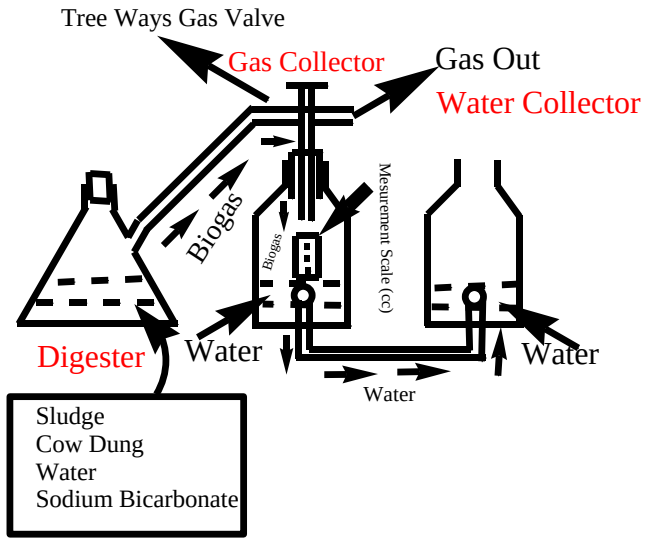

Figure 2. Lab Scale Portable Biogas Plant.

Table 2. Description of Lab Scale Biogas Plant.

Plant Location	No of Tanks	Name of Tanks	Volume (L)
Chemistry Lab Department of Textile Engineering Southeast University Tejgaon, Dhaka 1208, Bangladesh	3	Digester	2.5
		Gas Collector	10
		Water Collector	10

B. Sludge Collection

Sludge was collected from Delta Knit Composite located at Kashimpur, Gazipur, Bangladesh. The effluent treatment plant of Delta Knit Composite is a biological type.

C. Generation of Biogas

To validate the constructed lab scale biogas plant successive experiments were performed. First of all bio sludge obtained from Delta Knit Composite was digested in the digester tank of biogas plant. To generate biogas 1.5 kg of bio sludge, 1 L sludge liquor, 200 g cow dung and 1 g sodium bicarbonate ($NaHCO_3$) was added to maintain pH 8.5. After 18 days 525 cc biogas was produced which was confirmed by odor and flammability test. A graphical scale was attached on the gas collector to measure the quantity of generated gas. The design of the constructed biogas plant was a combined idea of Yousuf et al. [7] and Institute of Fuel Research & Development (IFRD), BCSIR, Dhaka [8].

In another experiment, 500 g bio sludge, 1.5 L sludge liquor, 50 g cow dung and 4 g sodium bicarbonate ($NaHCO_3$) were digested in digester tank. In this case pH was 8.5. After 3 days 350 cc biogas was produced. The amount of produced biogas was monitored for seven days. Biogas from Textile sludge was produced by anaerobic digestion technology [4]. Anaerobic digestion is a process of controlled decomposition of biodegradable materials under managed conditions where free oxygen is absent, at temperatures suitable for naturally occurring mesophilic or thermophilic anaerobic, facultative bacteria and archaic species, that convert the inputs to biogas and whole digest ate. It is widely used to treat separately collected biodegradable organic wastes and wastewater sludge, because it reduces volume and mass of the input material with biogas mostly a mixture of methane (CH_4) and carbon dioxide (CO_2) with trace gases such as hydrogen sulfide (H_2S), ammonia (NH_3) and hydrogen (H_2). The anaerobic digestion of Textile sludge includes four steps, hydrolysis, acidogenesis, acetogenesis and methanogenesis. Thus anaerobic digestion is a renewable energy source in an integrated waste management system.

III. Results and Discussion

The amount of generated biogas depends on the quantity of initial sludge digestion. In this work we got 525 cc biogas from 1.5 kg of Textile bio sludge whereas 350 cc biogas obtained from 500 g of Textile bio sludge. Daily biogas was monitored when initial amount of bio sludge was 500 g at room temperature (25 °C). After three days of digestion we got 350 cc biogas which was reduced to 325 cc at fifth day of experiment. The quantity of biogas was 55 cc at sixth day and it was 3 cc at seventh day. The quantity turned to nil at eighth day of biogas generation. The maximum biogas obtained at third day of generation (Figure 3). Due to unavailability of day wise biogas production data from Textile sludge our result cannot be compared. But day wise data was found for biogas production from Kitchen waste [7]. According to the paper [7], about 200 cc biogas was generated at third day of experiment from kitchen waste at room temperature (25 °C). The quantity of generated biogas was decreased at fourth day of experiment and it was gradually decreased and became nil at tenth day of experiment. This trend is similar to our experimental result. It is usual that biodegradable organic matter could be used as sole feedstock in anaerobic digestion but the digestion process trends to fail without addition of external nutrients for appropriate anaerobic bacteria culture [9]. Co-digestion with animal manure such as cow dung as base feedstock is an effective ways to improve buffer capacity and achieve stable and appropriate bacteria culture for excellent performance [10-13]. For this reason we added a small portion of cow dung with Textile sludge for seeding to generate biogas successively. In a previous report M. Islam et al. [14] proved that without addition of cow dung no biogas was produced from vegetable waste but the quantity of produced biogas was increased with increasing of percentage of cow dung with vegetable waste.

The portable biogas plant was designated as lab scale biogas plant is easy to carry and shifting from one place to another, it will not be affected by flood water because Bangladesh is a flood risk country.

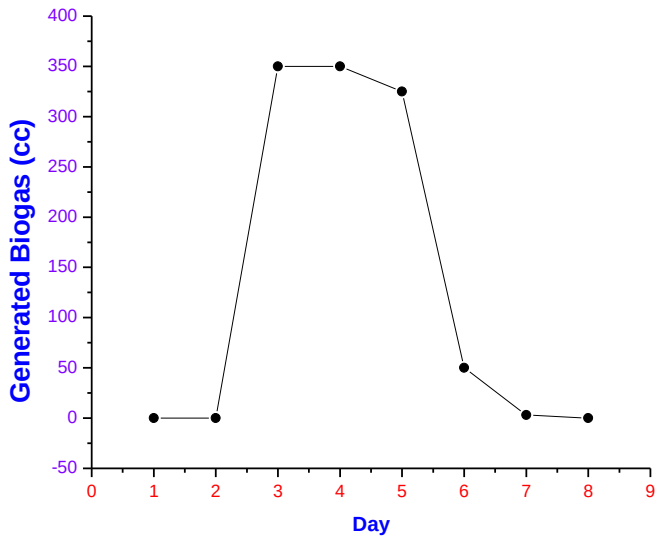

Figure 3. Day Wise Biogas Generation from 500 g Textile Bio Sludge.

IV. Conclusion

The economy of Bangladesh is dependent on Ready-Made Garment industries. This sector is supported by other Textile industries. Wet processing Textile industries are highly water consuming. A large quantity of water is consumed by this sector resulting effluent and sludge. Textile sludge management in Bangladesh is a burning question now. There are several sludge management options available. Those are incineration, brick preparation, sanitary land filling, mixing with cement and biogas generation. Considering the energy situation of Bangladesh biogas generation from Textile sludge is the suitable option of the country. Natural gas is the main fuel of Bangladesh considering energy and diversity of uses. In the report of Petrobangla in 2014-15 [6] it was mentioned that the total demand of natural gas in Bangladesh was 3274 MMCFD but the corresponding supplied quantity of natural gas was 2725 MMCFD. From the statistical data it was calculated that 549 MMCFD natural gas was deficit to its demand. Designing, construction and validation of lab scale biogas plant is necessary to find out suitable answers of all remaining question in this work. Daily biogas was monitored when initial amount of bio sludge was 500 g. The maximum biogas obtained at third day of generation. Portable biogas plant is suitable considering our climate situation.

Acknowledgement

We are grateful to the authority of Southeast University for providing a research grant through Institute of Research and Training (IRT) of this University. Special thanks to Prof. Anwar Hossain (Vice Chancellor), Prof. Dr. Humayun Kabir Chowdhury (Pro Vice Chancellor), Maj Gen Kazi Fakhruddin Ahmed, psc (Retd) (Registrar), Prof. Syed Fakhrul Hassan (Dean, Acting, School of Science and Engineering) and Prof. Dr. AFM Mafizul Islam (Director, IRT), Southeast University for their moral support during this work. Thanks are also due to Mr. Rezaul Karim, Chairman and Wing Commander (Retd) Syed Ahmed Kabir (fawc, psc), Chief Coordinator, Southeast University Trust for their kind support to carry out this research work.

References

1. (a) Information available at: www.bgmea.com.bd
   (b) A. K. Guha, O. Rahman, S. Das, and M. S. Hossain, " Characterization and Composting of Textile Sludge", Resources and Environment, 2015, 5(2): 53-58.
   (c) "Quarterly Review on RMG: January-March", Published by Research Department and External Economics Division of Bangladesh Bank, 2015.
2. PaCT Annual Event, in association with International Finance Corporation (IFC), 2014.
3. World Bank CP Workshop, and Hazardous Waste Management in Bangladesh, A Country Inventory, Department of Environment, Dhaka, 2011.
4. M. N. Morshed and A. K. Guha, "Production of Biogas from Textile Sludge by Anaerobic Digestion, a Sustainable Ecofriendly Sludge Management Method", Bangladesh Textile Today, 2014, June (pp52-56) and July (pp38-44) Issues.
5. M. Rahman, M. Tanim and Rahman, L., "Analysis of Natural Gas Consumption by the Industrial Sector of Bangladesh", Journal of Chemical Engineering, IEB, 2012, Vol. ChE. 27, No. 1, pp1-7.
6. Petro Bangla Annual Report (2013-14) & (2014-15), Information available at: www.petrobangla.org.bd
7. A. Yousuf, S. Akhter, N. C. Sarker, M. N. Hasan and M. S. H. Sarker, , "Optimization and Fabrication of a Portable Biogas Reactor", Journal of Chemical Engineering, IEB, Vol. ChE 27, 2012, No. 2, pp36-40.
8. The Institute of Fuel Research & Development (IFRD), BCSIR, Information available at: http://www.bcsir.gov.bd
9. B. Demird and P. Schere, , "Production of Methane from Beet Silage Without Manure Addition by a Single-Stage Anaerobic Digestion Process", Biomass Bioener, 2008, 32, 203-209.
10. A. Masahnde, A. Kivaisi, M. Rubindamayugi and B. Mattiasson "Anaerobic Batch Codigestion of Sisal Pulp and Fish Wastes", Biores. Technol., 2004, 95, 19-24.

11. M. Mutro, L. Björnsson and B. Mattiasson, “Impact of Food Industrial Waste on Aerobic Co-digestion of Sewage Sludge and Pig Manure”, J. Envirron. Manage., 2004, 70, 101-107.
12. P. Sosnowski, A. Wieczorek and S. Ledakowicz, “Anaerobic Co-digestion of Sewage Sludge and Organic Fraction of Municipal Solid Wastes”, Adv. Environ. Res., (2003), 7, 609-616.
13. K. Umetsu, S. Yamazaki, T. Kishimoto, J. Takahashi and Y. Shibata, “Anaerobic Co-digestion of Dairy Manure and Sugar Beets, Intl. Congr. Ser., 2006, 1293, 307-310.
14. M. Islam., B. Salam and A. Mohajan, , “Generation of Biogas from Anaerobic Digestion of Vegetable Waste”, Proceedings of the International Conference on Mechanical Engineering, 26-28 December, 2009, Dhaka, Bangladesh, Paper No TH-19, pp1-4.

Corresponding author

Arun Kanti Guha

Arun Kanti Guha received BSc (Honours) and MSc in Chemistry in 1990 and 1991 respectively from University of Dhaka, Bangladesh. He received PhD from the Department of Chemistry, Inha University, Korea. Dr. Guha also completed Postdoctoral research from the same Department and University of Korea. Dr. Guha published important scientific papers in ACS, RSC , Wiley and other national and international peer revived Journals. He has experience of twenty years in teaching and research at home and abroad. His research interests are Textile Pollution Control, Arsenic Contamination and Organophosphorus Chemistry.