Mitigation of accumulated solid waste in CIT Campus Kokrajhar, by In-Vessel Composting and Assessing Associated Green House Gas Emissions - A Case Study

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Abstract - The common method of waste disposal are open dumping, landfilling, which alters the vital components of environment. The problem of solid waste management is prevailing in the academic environment of CIT Campus. The increase growth rate over a short period of time has increased the generation of solid waste in CIT Campus Kokrajhar. There is an urgent need for the improved planning and implementation of proper SWM system. The study is to investigate the problems and prospects of solid waste in the Campus and also focus on composting process for mitigation of accumulated solid waste. Solid waste of CIT campus has a high percentage of organic matter .The investigation also includes the existing MSWM practices in CIT Campus. The study was conducted to determine the Physico-chemical characteristics of organic waste part of municipal solid waste using In-Vessel composter. The aeration has influence on various controlling parameters of the compost. During the process mixing was done manually by turning the compost material. For the study an especially designed 0.34m^3 capacity rotary drum reactor, a type of aerobic In-Vessel composter was made. The result indicate that the pH cannot be considered as the main factor for deciding the stability of the compost as during composting process pH were within an optimum range. Emissions of gas during the process were noted with the biogas analyzer. This study reveals that the present system of SWM in CIT Campus is inefficient. The composting method should consider for mitigating the accumulated solid waste in the campus.

Keywords: Composting, Open dumping, Kokrajhar, Temperature, MSWM, Rotary drum, Biogas analyzer.

I. INTRODUCTION

The term solid waste is inclusive all and encompasses all sources, types of classifications, composition, and properties. Generally three categories are considered Solid waste is a broad term, which encompasses all kinds of waste such as Municipal Solid Waste (MSW), Industrial Waste (IW), and Hazardous Waste (HW). The average annual rate of change of world urban and rural population was reported to be 1.92% and 0.45% respectively [1].

The economic growth and rapid urbanization, adds environmental and economic pressure to the urban centers as the result of production municipal solid waste [2]. Approximately 169 tonnes of solid waste from CIT campus goes to open dumping at disposal site of Kokrajhar town every year .The open dumping of the solid waste in the disposal site of Kokrajhar town causes soil pollution, groundwater contamination and contributes to global anthropogenic Greenhouse gas emissions [3]. The most common waste management strategy today is landfilling [4].in many developing countries engineered landfills are replacing the open dumping but due to the negative impact of landfills such as groundwater contamination, anthropogenic gas emissions and limited space in recent year there has been movement to divert waste from landfills as well. The alternative solution should be economical and sustainable, composting is a relatively simple method where the microorganism utilizes the solid waste for derive energy and flourish its population as a result it converts organic waste into compost. The in- vessel composter has been considered as suitable reactor for composting of MSW. The Optimization efforts increase the rate of decomposition.

Over 50 percent of an average city's municipal solid waste stream in developing country could be readily composted [5]. The rotary drum composter is efficient and promising technique of decentralized composting [6]. Rotary drum composting of organic waste has been extensively promoted for higher organic matter degradation. The compost was reported to stabilize within 3 to 6 weeks of composting, with lower emissions of carbon dioxide (CO_2) and oxygen uptake rate [7] [8] [9] Rotary drum provides agitation, aeration and mixing of the compost, to produce a consistent and uniform end

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product. Quality of compost is important from maturity and stability view point but most of the compost plant neglects the quality of compost [10] [11] [12] [13]. For supercharging microorganism responsible for the breakdown of biodegradable matter sufficient aeration is required which is accomplish by turning of drum at suitable intervals. The aim of the project was the characterization of the various quality control parameters and measurement of Greenhouse gas emissions of compost produce from Municipal Solid Waste and feasibility of the in-vessel composting for managing MSW from CIT campus.

II. METHODOLOGY

A. Experimental setup

For conducting the experiment, 0.34m^3 capacity rotary drum reactor was designed especially, made of 15mm thick sheet, the outer diameter of the drum was 0.6m and 1.2m long, Erected 2m above the ground level and supported by stand with rigid base, the bottom of the drum has the leachate outlet, this outlet was also used for inserting the tube of biogas analyzer for measuring the various gases generated during composting process. The aeration was carried out by turning the drum manually at regular intervals with the help of chain attached to pulleys, for the more refined mixing axial pipe with spike was welded inside the drum. The duration of 60 days was considered for the final compost production. The reactor was filled up to approximately 75% to 80% of total volume. The raw material consists of wet volume of food waste, vegetable waste, dry leaves and twigs.

B. Experimental procedure

The experimental In-vessel composter i.e. rotary drum was set up randomly outside, near the Civil Engineering lab at the Campus. Raw material was collect from the CIT campus and sorted manually and systematically for the quantification MSW. Sample was collected carefully after shredding the solid waste a size less than 5cm for physico-chemical characterization and was noted down in Table 1.

Table 1: characterization of the sample

Initial Moisture Content (%)	pH	Size of sample (cm)	C: N ration	Mass in kg	Total Nitrogen (%)	Volatile solid (%)
76±0.91	6.5	1 to 3	29:1	100	1.57	85±0.40

Fig 1: Rotary drum reactor

Fig 2: weighing various constituent

Fig 3: Shredding of solid waste manually

Fig 4: food waste from campus

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C. Analytical procedure

For determining moisture content, for all the 300gm of triplicate samples were collected and dried at the temperature of 103-105°c for 24 hours, the already dried sample was further kept in muffle furnace for a period of 2hours at the temperature of 550°c for determining volatile solids [14]. The total organic carbon was analyzed as describe by [15][16].

Total organic carbon was determined as %C = [VS (%)/1.8].

For determining total kjeldhal nitrogen, kjeldhal method was considered and temperature was measured every time, by inserting the probe of thermometer just before turning the reactor .pH of sample was determined as describe by[15],Dried Sample to water in ration (1:5) mixture stirred for 2 hours, and water extracted were measured using pH meter.

The various gas emissions during composting period in the reactor were measured by Biogas Analyzer (biogas 5000, Geotech) by inserting tube inside the reactor carefully.

III. RESULT AND DISCUSSION

A. Quantification and composition characteristics of the MSW of CIT campus was analyzed and shown below.

Table 2: Types of waste generated from CIT campus

Sl.N	Source	Type of Waste
1	Mess and Canteen	Food, Vegetable peels, Plastic, Paper, Dust.
2	Residential	Food, Vegetable peels, Plastic, Paper, Metal, Glass, Dust, Textile.
3	Academics	Paper, Plastic, Cardboard, Dust.
4	Hostel	Food, Glass, Paper, Plastic, Metal, Dust, Cardboard.
5	Road side	Plastic, Paper, Garden Trimming.

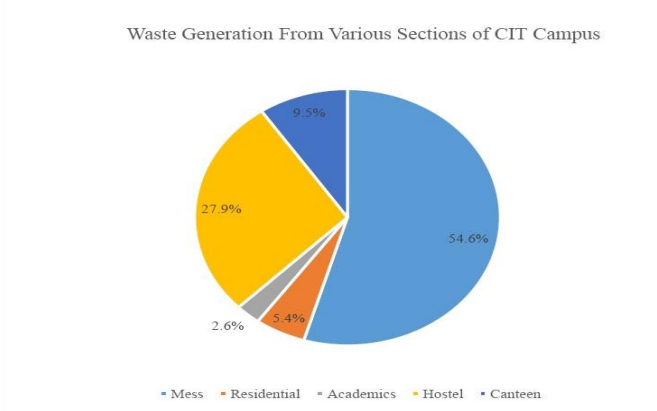

Fig 5: SW generation (%) from various section of CIT campus

Table 3: SW from various sections in CIT campus (kg/day)

Sl. N.	Source Area	Amount of Waste (kg/day)	Percentage
1	Mess	252.5	54.6%
2	Residential	24.78	5.4%
3	Academics	12.25	2.6%
4	Hostel	128.89	27.9%
5	Canteen	43.91	9.5%
Total		**462.33**	**100%**

Table 4: Composition (%) of solid waste in CIT campus

Sl. N.	Type of Waste	Amount (kg/day)	Percentage
1	Food Waste	371.64	85%
2	Plastic	15.95	4%
3	Paper	17.15	3.9%
4	Glass	12.63	2.9%
5	Metal	3.1	0.7%
7	Textile	2.31	0.5%
8	Cardboard	8.81	2.0%
9	Garden Trimming	4	0.9%

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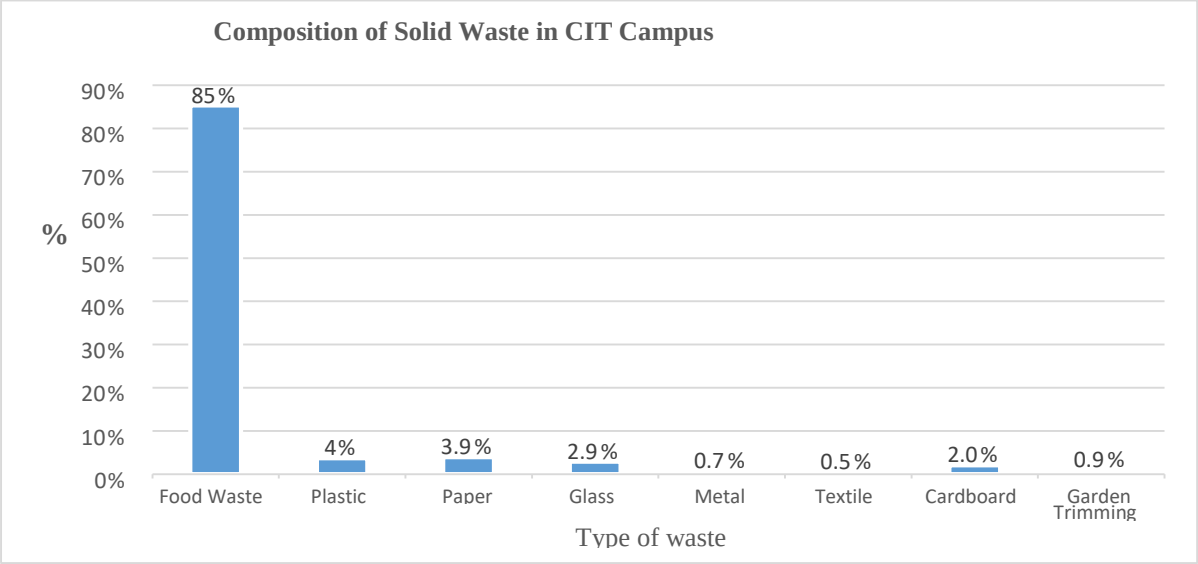

Fig 6: SW generation (%) from various section of CIT campus.

B. The variation of pH over the composting period is shown in figure 5, as expected pH increases over the time of composting and remains alkaline, during the initial phase pH was acidic ,it happens due to insufficient aeration period (shredding ,shifting ,filling) which result in evolution of anaerobic process ,as the anaerobic bacteria produce acids which drop pH value, but as time passes this acids are converted to carbon dioxide by activity of microorganisms.

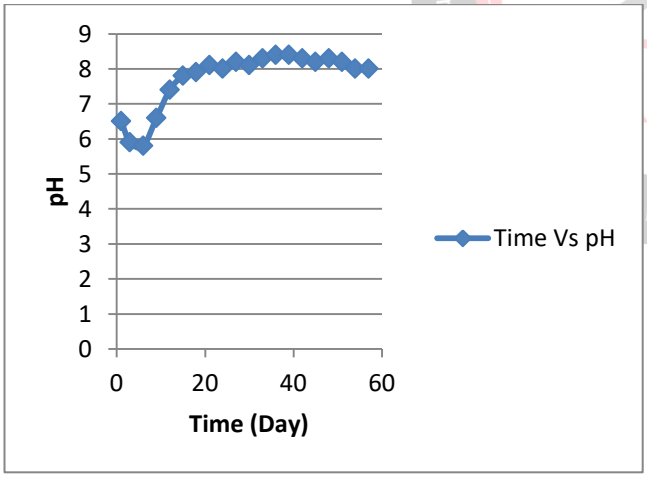

Fig 7: Variation of pH over time of composting.

Temperature according to [12] the optimum temperature for composting is 40-65^{o}C and mentioned that at peak temperature of 50-60 ^{o}C destruct all the pathogens present. The variation of temperature over the composting period is shown in Fig 6. As per the curve temperature was under thermophilic stage (40 to 48^{0}C), after 21 days temperature mesophilic stage starts and by the ending of composting period, temperature drop down to 24 ^{0}C.

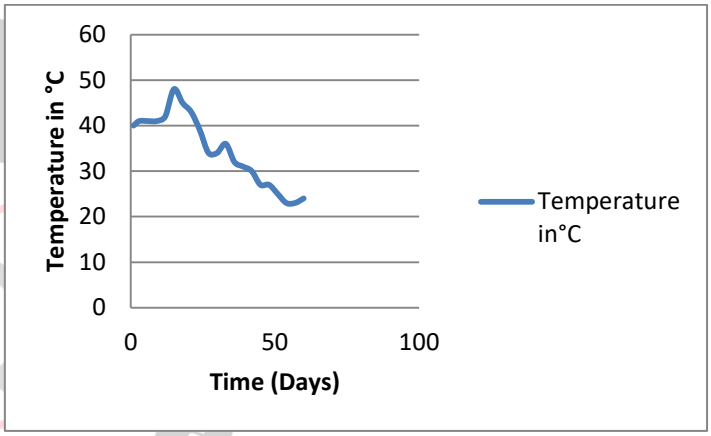

Fig 8: Temperature of composting over time.

D. The gas emission was measured after setting up Biogas analyzer (biogas 5000, Geotech). No CH_4 emission was observed during the composting period. Carbon dioxide (%) emission from the rotary drum was measured and shown in the fig 7, the traces of hydrogen sulphide (ppm) in the initial phase of composting were observed as shown fig 8.

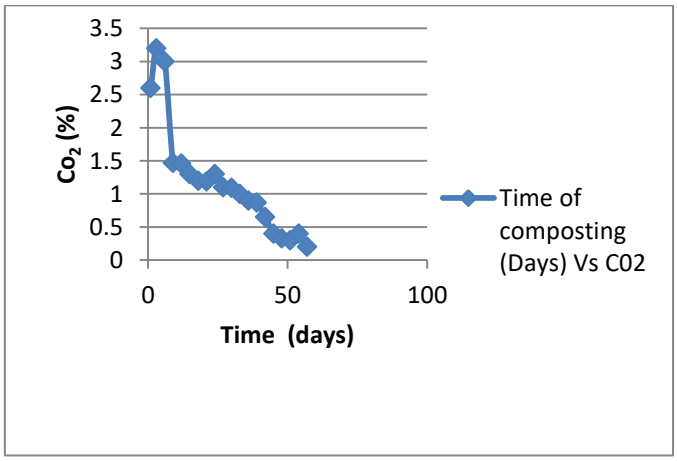

Fig 9:CO_2 (%) emission over the time of composting.

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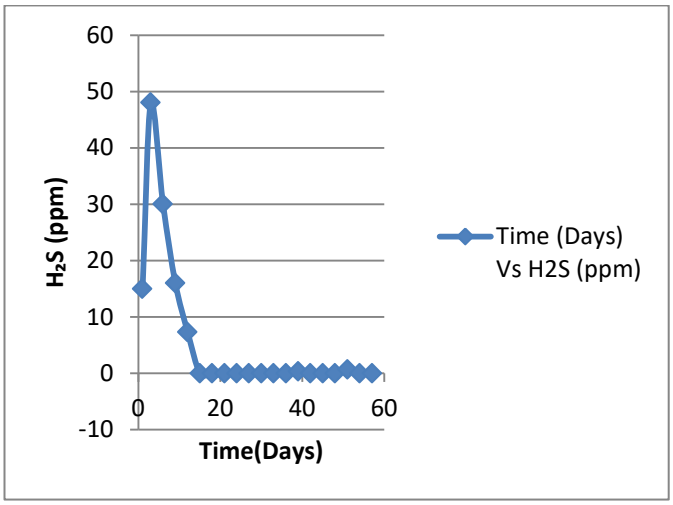

Fig 10: H_2S (ppm) generation over the time of composting.

IV. CONCLUSIONS

The problem of solid waste management is prevailing in the academic environment of CIT Campus the existing solid waste management systems in CIT campus was analyzed and it appears to be inadequate and needs up gradation. This study will help in providing valuable information and data needed for the improved planning and implementation of comprehensive SWM systems for upgrading the environmental scenario of the Campus. Approximately 169 tonnes of solid waste is being generated from the CIT campus every year which contains high percentage of organic waste which goes directly to open dumping and put additional load on the disposal site of Kokrajhar town (Samshanghat) and aggravate the emission of various gas into the atmosphere. Diversion of biodegradable and recyclable from the disposal site will reduce the solid residue and thereby reducing gas emissions and energy generation potential. The solid waste from the CIT campus could be managed onsite by decentralized In-vessel composter which will help in reducing the load on the disposal site as well as environmental pollution. Mitigation of accumulated solid waste and assessment of Greenhouse gases (mainlyCH_4) were done by Experimental set up of rotary drum In-vessel composter. The results showed the variations of controlling parameters such as pH, temperature etc. Temperature can be considered as one of the important factors for deciding the stability of decomposition, pH value remains within alkaline range throughout the composting period. During the progression of the composting process.CO_2 emissions and leachate were observed as the byproduct of decomposition process. From the observation it is concluded the turning of reactor helps in decompose the waste in faster rate. No CH_4 or NO_X emissions were observed. A thorough study with respect to design efficiency, cost, its sustainability, leachate management, material efficiency, recycling and recovery has to be considered.

REFERENCES

[1] UN (2010) World Urbanization Prospects: The 2009 Revision, Director, Population Division , Department of Economic and Social Affairs, UNITED Nations, New York,USA:http://esa.un.org/unpd/wup/Documents/WUP2009_Wallchart_Urban-Rural_final.pdf Accessed 6 July 2011.

[2] Adhikari BK, Tremier A, Martinez J and Barrington SF (2010) Home and community composting for onsite treatment of urban organic waste: perspective in the EU and Canada. Waste Management & Research 28(11): 1039 – 1053.

[3] Paron O and Bharti A., (2019). "Quantitative analysis, characterization and management of MSW in CIT Campus, Kokrajhar, Assam" Pramana Research Journal Vol 9(2) pp 91-100.

[4] Hogg,D.H., Baddeley, Gibbs, A., North, J., Curry,R., Maguire, C (2008). "Greenhouse gas balances of waste management Scenarios" Eunomia Research and Consulting.(www.eunomia.co.uk)

[5] World Bank, (1999) Composting and Its Applicability in Developing Washington, D.C., USA.

[6] Kalamdhad, A.S., and A.A. Kazmi. (2009). " Effects of turning frequency on compost stability and some chemical characteristics in a rotary drum composter " Chemosphere 74:1327–34.

[7] Liao PH, Jones L, Lau AK, et al. (1997) Composting of fish wastes in a full-scale in-vessel system. Bioresource Technology 59: 163–168.

[8] Rodríguez L, Cerrillo MI, Albiach VG, et al. (2012) Domestic sewage sludge composting in a rotary drum reactor: Optimizing the thermophilic stage. Journal of Environmental Management 112: 284–291.

[9] Varma VS, Kumar B, Kalamdhad AS,(2017). "Optimization of waste combinations during in-vessel composting of agricultural waste" Waste Management and Research Vol 35 (1) pp 101-109.

[10] Tiquia, S. M. (2005). "Microbiological parameters as indicators of compost maturity." Journal of Applied Microbiology, 99: 816-828.

[11] Gomez, R.B., Vázquez Lima, F., Sánchez Ferrer, A., (2006). "The use of respiration indices in the composting process: a review." Waste Management Research 24: 37-47.

[12] Bernal, M. P., J. A. Alburquerque, Moral, R., (2009). "Composting of animal manures and chemical criteria for compost maturity assessment. A review." Bioresource Technology 100 (22): 5444-5453.

[13] Heydarzadeh ,N., and Abdoli, M.A., (2009). "Quality assessment of compost in Iran and need for standards and quality assurance." Journal of Environmental Studies. 34(48): 29-40.

[14] BIS 2296: 1982,Standard methods for the examination of surface water.

[15] Thompson, W. H., (2001). Test methods for examination of composting and compost, US Composting Council Research and Education.

[16] Abdullah, N., and Chin., N. L., (2010). "Simplex-centroid mixture formulation for optimised composting of kitchen waste." Bioresource Technology., 101(21): 8205-8210.

[17] Howard S. Peavy, Donald R. Rowe, George Tchobanoglous, "Environmental
Engineering" McGraw-hill International education 1985, 573.

 DOI : 10.18231/2454-9150.2019.0024