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Best Energy from Lethal Bio-Medical Waste

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ABSTRACT

Present study investigates the eco-friendly disposal, energy extraction, conversion of these lethal bio-medical waste [human anatomical waste, animal waste (animal body parts, carcasses, excreta, bleeding parts and wastes generated at veterinary hospitals), microbiology and biotechnology waste (waste from laboratory cultures, live or attenuated vaccines, human and animal cell culture used in research , waste from biological toxins), discarded medicines, soiled waste (cloth containing blood stains, blood coated cotton balls, soiled plasters, liquid waste (waste generated from laboratory housekeeping activities) etc] to worthy manure. Present methods of disposal through incineration and landfill are not environmental friendly and pollute with activated virus and bacteria. So, the investigation will also help to all municipal corporations, academician related to waste management system, energy and environmental issues in disposing such wastes to worthy resources.

Key words: Bio-medical waste, anaerobic digestion, C/N ratio, co-digestion

1. INTRODUCTION

The Medical Waste Tracking Act of 1988 defines medical waste as "any solid waste that is generated in the diagnosis, treatment, or immunization of human beings or animals, in research pertaining thereto, or in the production or testing of biological matter." Biomedical waste, also known as infectious waste or medical waste is defined as solid waste generated during the diagnosis, testing, treatment, research or production of biological products for humans or animals. Biomedical waste includes syringes, live vaccines, laboratory samples, body parts, bodily fluids and waste, sharp needles, cultures and lancets. Biomedical waste (BMW) consists of solids, liquids, sharps, and laboratory waste that are potentially infectious or dangerous and are considered biowaste. It must be properly managed to protect the general public, specifically healthcare and sanitation workers who are regularly exposed to biomedical waste as an occupational hazard.

The improper management of bio-medical waste causes serious environmental problems in terms of air, water and land pollution. The nature of pollutants is classified in to biological, chemical and radioactive. Pathogens present in the waste can enter and remain in the air in an institution, or any health care unit for a long period in the form of spores or as pathogens itself. This can result in hospital acquired infection (nosocomial infection) or occupational health hazard. The patients and their attendants also have a chance of contracting infections caused due to pathogens and spores, which are air borne. Poor ventilation, carpets, furnitures, equipments used in the consulting rooms as well as Operation Theater, faulty air conditioning may lead to air pollution. When waste without pretreatment transported outside the institution and it is dumped openly, pathogen can enter the atmosphere; the pathogens can find their way to drinking water, foodstuff, soil etc and or remain in the surrounding air and causes diseases in animals and human beings. Proper waste management practices can reduce this pollution to a large extent.

Bio-medical waste can cause water pollution. If the waste is dumped in low-lying areas or in the lakes and water bodies, can cause severe water pollution. Any liquid waste when it spills and gets entry in water, naturally bacterial flora will get favorable media and grows like mushrooms. Therefore, in that case it can cause water pollution and it affects parting case of population. In case of heavy metals which are present in Bio-medical waste. Which can causewater pollution, poor land filling technology may cause in the form of lechates. [Excess nutrient leachates such as nitrates and phosphates from landfills can cause a phenomenon called eutrophication (where surface of water body develop algal blooms)Water pollution can alter parameters such as pH, BOD, DO, COD etc. there are instances where dioxins are reported from water bodies near incinerator plants, dioxin enter water body from the air].

The final disposal of all bio-medical waste is to land. Even liquid effluent after treatment is spread on land hence pollution caused to land is inevitable. However, it can be minimized to large extent through proper treatment. Soil pollution from bio-medical waste is caused by infectious waste, discarded medicines, chemical used in treatment and cadmium, lead mercury etc. which are present in the waste will get absorbed by plant and landfills are also pollutants. Excessive amount of trace nutrient elements and other elements including heavy metals in soil are harmful to crops and also harmful to animals and human beings. According to the WHO, the global life expectancy is increasing year after year. However deaths due to infectious disease are increasing. A study conducted by the WHO in the year 1996, reveals that more than 50,000 people die every day from infectious diseases. One of the causes for the increase in infection diseases is improper bio-medical waste management, because any type of bacteria, viruses or other protozoan requires some media to spread in community. Land is widely considered more valuable when used for housing, development, recreation and agriculture. Public concern for the odors and off-gases associated with landfills as well as environmental impacts of leachate and runoff from landfills has raised much resistance to new zoning of landfills from communities and environmental organizations. Medical waste incinerators emit toxic air pollutants and toxic ash residues that are the major source of dioxins in the environment. The toxic ash residues sent to landfills for disposal have the potential to leach into groundwater. Medical waste has been gangrene, whooping cough etc are the common disease spread due to improper waste management. Human immune deficiency virus (HIV) and hepatitis viruses are spread through bio-medical waste. The general public health can also adversely affected by bio-medical waste. Improper practices such as dumping of bio-medical waste in municipal dustbins, open spaces, water bodies etc. leads to the spread of diseases. Emissions from incinerators and open burning also lead to exposure to harmful gases which cause cancer and respiratory disease. Bio-medical waste can cause health hazard to animals and birds. Plastic waste can choke animals which scavenge on openly dumped waste. Injuries from sharps are common features affecting animals. Harmful chemicals such a dioxin and furans and heavy metals in the soil can affect the reproductive health of animals so one study also reveals that endanger species is due to openly dumped waste.

The main problem associated with the BMW are the pathogenic agents which includes bacteria, viruses and other infectious agents that are responsible for various air borne diseases. So, the proper handling, treatment, disposal of bio-medical waste is very necessary.

Traditionally, land filling and incineration have been the most common treatment and disposal methods for Bio medical waste, however there are major drawbacks to both. Land and air are increasingly viewed as precious resources warranting protection. Land filling requires the digging up of U.S. soil to accommodate over 200 million tons of waste per year.

Identified by an US Environmental Agency as the third largest known source of dioxin is air emission. Dioxins have been linked to cancer, immune system disorders, diabetes, birth defects and disrupted sexual development. The waste put in the incinerator is supposed to burn. They are to be categorized before burning. The constituents either react among themselves to form new chemicals or remain in their original form. These chemicals escape as smoke which is carried through air to different areas. These chemicals are also being consumed by different species. The ash remaining in the first chamber is dumped in open spaces. The said ash contains heavy metals such as mercury, lead, etc. Animals during foraging on vegetating ingest this contaminated ash. Humans then consume animal products like milk, meat, etc. This is called bio-magnification. Autoclaving and Micro waving are also methods which is not suitable for countries like India for the reason that one has to spend crores of rupees for its installation The process is also very complicated which are not suitable for where there are a lot of small hospitals, and clinics. Moreover it is the duty of the Municipal authorities for the establishment of the common treatment plant.

On the investigation of an incinerator plant the stack monitoring was conducted on the day of inspection for PM, SOx and Hcl with measurement of CO_2 and O_2

percentage in flue gas by using Orsat gas analyzer. The result of the monitoring is presented in Table: 01. The PM concentration in stack emission was found 95 mg/Nm^3 with 9.5 % CO_2 in flue gas indicating very near to complete combustion. The emission after CO_2 correction will be 120 mg/Nm^3.The Related data's are given in table-1, Table-2 and Table-3

TABLE-1

S.No.	Parameters	Concentrations(mg/Nm^3)
1	PM	95
2	Hcl	31
3	Sox	331
4	CO_2 %	9.5
5	O_2 %	4.0

Table2. Category 1 – Uncontrolled Metal Pollutant Emission Factors

Metal	Biomedical Waste (kg of pollutant/ tonne of dry waste fed to incinerator)
Cobalt	N/A
Antimony	0.00639
Nickel	0.000295
Manganese	0.000284
Selenium	N/A

Table3. Uncontrolled Emission Factors for Category 2a Substances from Biomedical Waste Incinerators

Category 2a Substance	Emission Factor1 (kg of pollutant/ tonne of dry feed to the incinerator)
Carbon Monoxide (CO)	1.48
Fluoride Compounds	0.0743
Oxides of Nitrogen (NOx)	1.78
Particulate Matter (PM10)4	2033
Polycyclic Aromatic Hydrocarbons 3 (PAHs)	0.05
Sulfur Dioxide 3 (SO2)	1.09
Hydrochloric Acid (HCl)5	1608
Total Volatile Organic Compounds	0.15
Polychlorinated dioxins and furans	.0000465

2. BASIC EXPERIMENTAL WORK

The experimental wastes were collected from hospital situated at Jabalpur. Cow dung was collected freshly from a cattle farm situated at Pariyat village. One-day-old poultry droppings were also collected from a poultry farm at the Barah. The waste samples were stored in black sealed polythene bags to conserve the moisture.

Bacterial growth is very essential for the bio gas production and it depends on seeding. For this experiment, cow dung was used for seeding because the bacteria required for the methane fermentation are present in the cow dung. The substrate was collected in a Polythene bag and immediately prepared after collection by mixing with water in the ratio 1:1 and then placed in the digester for the experiment. Three digester were used in this experiment and each digester was a simple cylindrical batch feeding digester that has no moving parts. Each digester was loaded with cow dung, water and slurry and then sealed off for the production of biogas to begin for the retention time 2-3 weeks. At the end of the experiment, the digester was off loaded by opening the lid and removing the slurry, this digested slurry is ready for the seeding. The pH value of this the slurry was 7.2. The digested slurry was used in this experiment because it will make fermentation faster

A set of 4 containers (each of capacity 15 kg) was used as digesters for this research, that is, one digester for each sample. Another set of 4 flasks was used. Each contained water and was connected to a particular digester by means of a connecting tube and also, on the other side, connected to a measuring cylinder by means of a connecting tube. The gas collecting apparatus was used to run-off and measure water displaced by the collected gas. The gas was collected by water displacement method. This was carried out by measuring and recording the quantity of water displaced daily using a 100 mL measuring cylinder.

Thus, the biogas produced in the digester by the digested slurry (sample) passed through the connecting tube to the flask containing water. The pressure of the biogas produced caused a displacement of the water through a connecting tube on the other side of the flask.

The weighing balance was used to determine the mass of cow dung and Bio medical waste and poultry waste that made up the total solid. The digester was operated at ambient temperatures. A thermometer was used to determine the daily temperature. The average temperature was calculated and assumed to be the operating temperature. A digital pH meter was used to determine the pH of the digested slurry (sample) on the first day of the experiment. The research was carried out under room temperature that varied between 30 and 35°C, which represents mesophilic condition. PH values for samples A, B, C and D were 6.4, 6.9, 7.1 and 6.5 respectively, which were all within the pH range for biogas production. Also a retention time of 20 days was selected for this work.

For the purpose of this research, there were four x:y proportions aimed at investigating the efficiency of bio medical waste in biogas production with poultry waste. The experimental setups for our work are as follows:

All four digester filled with bio medical waste and poultry waste in different proportions in ratio with water and the whole waste then loaded to about 3/4 of the digester volume. Ratio of water and waste is 1:1. The four proportions were as follows: Sample A; 90:10, B; 80:20, C; 70:30, D; 60:40 BMW: Poultry waste on a weight percent basis (Table 4).

Table 4: Proportion of substrate in each sample

Samples	% of X	% of Y
A	90	10
B	80	20
C	70	30
D	60	40

X represents the BMW, Y represents Poultry waste

For the purpose of this research, there were four x:z proportions aimed at investigating the efficiency of bio medical waste in biogas production with cow dung. All four digester filled with bio medical waste and cow dung in different proportions in ratio with water and the whole waste then loaded to about 3/4 of the digester volume. Ratio of water and waste is 1:1. The four proportions were as follows: Sample A; 90:10, B; 80:20, C; 70:30, D; 60:40 BMW: cow dung on a weight percent basis (Table 5).

Table 5: Proportion of substrate in each sample

Samples	% of X	% of Z
A	90	80
B	80	20
C	70	30
D	60	40

X represents the BMW, Z represents cow dung

For the purpose of this research, there were four x: y: z proportions aimed at investigating the efficiency of bio medical waste in biogas production with cow dung and poultry waste. All four digester filled with bio medical waste, cow dung and poultry waste in different proportions in ratio with water and the whole waste then loaded to about 3/4 of the digester volume. Ratio of water and waste is 1:1. The four proportions were as follows: Sample A; 70:20:10, B; 60:30:10, C; 50:40:10, D; 40:40:20, BMW: PW: CD on a weight percent basis (Table 6).

Table 6: Proportion of substrate in each sample

Samples	% of X	% of Y	% of Z
A	70	20	10
B	60	30	10
C	50	40	10
D	40	30	20

X; represents the BMW, Y; represents Poultry waste, Z; represents cow dung.

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Figure1. Photograph-Experimental Setup

3. RESULTS AND DISCUSSION

Co-digestion of Bio medical waste with poultry litter (Case-1)

The trends of daily biogas production with time for all the digesters of case-1 are shown in figure 2. Referring to fig.2 biogas production commenced in all the digesters on 20th day after loading. The fig. also shows that the total biogas production from each of the digester and suggests that digester C produced the highest quantity of biogas (0.39 l/g VS) in 55th days. It can be seen biogas production starts on the 20th day, increased gradually on subsequent days then attained maximum value on 55th days. After that because of the complete digestion of feed material in the digester the digestion process has stopped. The fig.2 also shows that the biogas production from digester A produced the biogas 0.37 l/g VS in 55th days. It can be seen biogas production starts on the 20th day, increased gradually on subsequent days then attained maximum value on 55th days. After that because of the complete digestion of feed material in the digester the digestion process has stopped. Digester A produced less biogas as compared to digester C. The fig. also shows that the biogas production from digester B and D starts on the 20th day, increased gradually on subsequent days then attained maximum value (0.37 l/g for B and0.32 l/g for D) on 50th and 55th days respectively.. After that because of the complete digestion of feed material in the digester the digestion process has stopped.

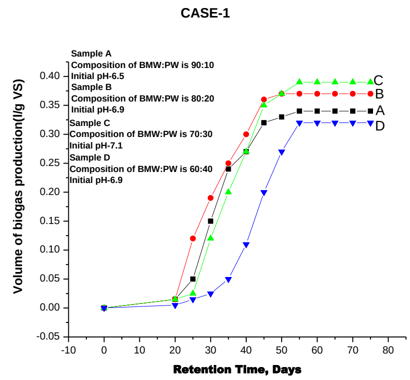

Figure2. Daily biogas production of case-1

Co-digestion of Bio medical waste with cow dung (Case2)

The trend of cumulative biogas production with time for all the digesters of case-2 are shown in figure 3, Digesters A, B and C commenced biogas production from 20th day, while D commenced from 25th day. The cumulative biogas produced was maximum for D (0.26 l/g VS). Digesters B and C produced same amount of biogas (0.24 l/g VS) however the rate of biogas production was marginal better for B than C, therefore B reached the ultimate value one day earlier to C . Digester A produced least biogas of 0.21 l/g VS, this may be because of improper ratio of biomedical waste to cow dung of the slurry.

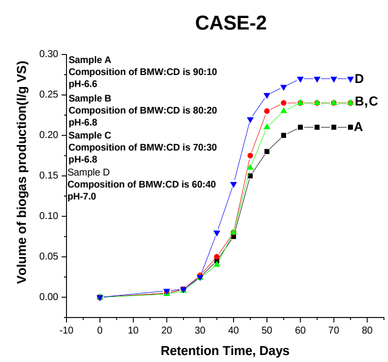

Figure3. Daily biogas production of case-2

Co-digestion of bio medical waste with poultry waste and cow dung (Case3)

The trend of cumulative biogas production with time for digester A, B, C and D are shown in figure 4. From the figure, gas evolution commenced from 25th day and has longer lag phase compared to case-1 and case-2 digesters. The maximum gas produced was 0.23 l/g VS which is better than the performance of digester B (0.21 l/g VS) in the case-2, however the time period for attaining the maximum production rate is longer for case-3 as compared to case-2.

Comparing figure 2 and figure 3, it is clear that anaerobic co-digestion of bio-medical waste with poultry litter produced better results. This could be because poultry litter has high total nitrogen concentration and the breakdown of the proteins during anaerobic digestion result in an ammonia inhibition of the process. Fermentation slurry obtained by mixing bio medical waste with poultry litter has higher nitrogen content, and favorable pH of 7.01 compared to fermentation slurries of series-B. It also contains adequate amount of carbon, oxygen, hydrogen, nitrogen, sulphur, phosphorous, potassium, calcium, magnesium and a number of trace elements for bio-digestion, hence is an improvement over co-digestion of biomedical waste with cow dung.

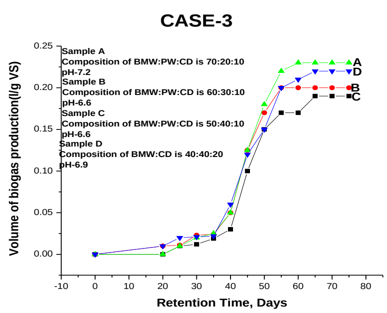

Figure4. Daily biogas production of case-3

4. CONCLUSION

In the present investigation it has been found that bio medical waste is a lethal, highly polluting and cannot disposed through landfill or incineration until and unless a proper measure taken. However this waste can be anaerobically digested and that will not only eco-friendly but also it will generate biogas as high quality manure. For rapid digestion it has been found that BMW with PW in 70:30 leads high gas yield, less RT. whereas co-digestion with cow dung and PW in 70:20:10 ratio yield comparative less gas and taken more RT. The present study will fetch an opening to all accedimician, Municipal Corporation’s, environmental related person in investigation, disposal and energy extraction from lethal BMW.

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