Comparative Study of Composting and Anaerobic Digestion as a means of Animal manure stabilization: A Case of Cow dung

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Abstract: **T**he practice of using cow dung for soil conditioning and fertilization dates back to the early history of man, even though, it has received greater attention in recent times due to high cost of chemical fertilizer as well as the environmental impacts on sustainable agriculture. This study explores the three methods of cow dung stabilization namely: composting in 3m depth compost pit, composting on plain earth surface and anaerobic digestion in a biodigester. Standard analytical methods were used to determine proximate composition, total viable and coliform counts in each case before and after degradation. Temperature, pH and odour levels of the surroundings were also monitored for ten days using thermometer, Jeanway pH meter and sensory panellists respectively. Microbial identification was based on biochemical analyses. Results show that anaerobic digestion of cow dung is most efficient and effective in cow dung stabilization with very significant odour control within the vicinity. Unlike the composting methods which reduced the values of fat, protein and fibre by less than 70%, anaerobic digestion recorded 100% degradation of fat, protein and fibre respectively. Degradation of other constituents showed similar trend, with composting on earth surface having the least effect. Bacterial identified were similar in all the cases and include *Klebsiella, bacillus pumilus, P. restrictum, Aspergillus niger* and *Psudomonas aeroginnosa* while the total viablet and mould countss were slightly higher in the waste treated by anaerobic digestion.

Keywords: Anaerobic digestion, Compost, Cow dung, sustainable agriculture

1 Introduction

Recycling of organic waste has become a very important aspect of wastes management in recent times. In most developing countries, organic wastes contain high levels of moisture, making biological methods of waste treatment the most attractive option. Some of such wastes that can be managed through biological methods include organic fraction of municipal solid waste, food wastes, night soils and animal manures such as poultry droppings, goat dungs, sheep dungs, cow dungs, etc and plant wastes.

Cow dung is the biomass excreta from bovine animal species such as cow, cattle, etc, which are herbivores. It consists of semi-digested and undigested residues of consumed matter which has passed through the cow's gastrointestinal system. Cow dung is found in large quantities in farms where cows are confined, along the grazing parts and in abattoirs where cow dung constitutesthe main waste generated, in addition to waste waters, etc. Abattoir effluents constitute a major environmental concern within their vicinity. Cow dung is widely studied for its use as organic agricultural fertilizers and extensively explored for its potential as source of alternative fuel in the form of biogas with high methane content (Abdulkareem 2005) [**1**], Kjeldsen,et. all, 2002 [**2**], Okonko, (2012 [3] etc.

In several developing countries such as are found in Asia, South America, Africa, etc, cow dung constitutes important agricultural fertilizer, especially for food production and may be applied directly to soil or pre-treated by composting before soil application. Run off containing cow dung and wastewater streams generated by abattoirs contain high levels of pollutants and can cause water pollution (Omole and Longe, 2008) [**4**]. This suggests that cow dung applied directly or partially decomposed cow dung. as produced in composting and traditionally carried out by local farmers, may be a source of pollution to the atmosphere, farmland as well as food chain.

Proper treatment of waste streams to be used for food production has therefore becomes pertinent.

Governments and industries are constantly on the lookout for technologies that will allow for more efficient and cost-effective waste treatment option (Guruswamy *et al.*, 2003; Alvarez *et al.*, 2006) [**5**,6]. One technology that can successfully treat the organic fraction of wastes is anaerobic digestion (Hill,1983;Verma,2002). [**7**,**8**]. It has the advantages of affording the opportunity of producing energy-yielding high quality fertilizer and also preventing transmission of diseases (Koberle,1995). [**9**]. Anaerobic digestion is the controlled degradation of organic waste in the absence of oxygen and the presence of anaerobic microorganisms.Although composting is widely promoted by governments, in some cases, communities are encouraged to produce composts and sell them. Most of the composting activities are community-based small scale projects. However most animal manures are not composted; thereby creating avenue for impacting the environment through the release of GHGs that are associated with the traditional composts. This work is therefore, aimed at comparatively studying the composting and anaerobic digestion of cow dung with a view to determining the extent of waste and environmental degradation and agricultural benefits of the two processes

2 Materials and Methods

Cow dung used for this study was procured from the Nsukka Central abattoir and divided into 3 parts; one part was subjected to anaerobic digestion in a $0.5m^3$ metallic digester designed and fabricated at the Centre for Energy Research and Development, University of Nigeria Nsukka (Fig. **1**). The second portion was composted in a 3mx3mx3m hole on the soil surface while the third part was composted in a 3mx3m plain earth surface. Distance of 15m separated each of the setups from one another. The temperature and pH of the three degradation systems were monitored daily with the aid of thermocouple and Glass electrode pH metre respectively, while the odour levels of the environment was assessed through sensory evaluation by Sensory panellists.

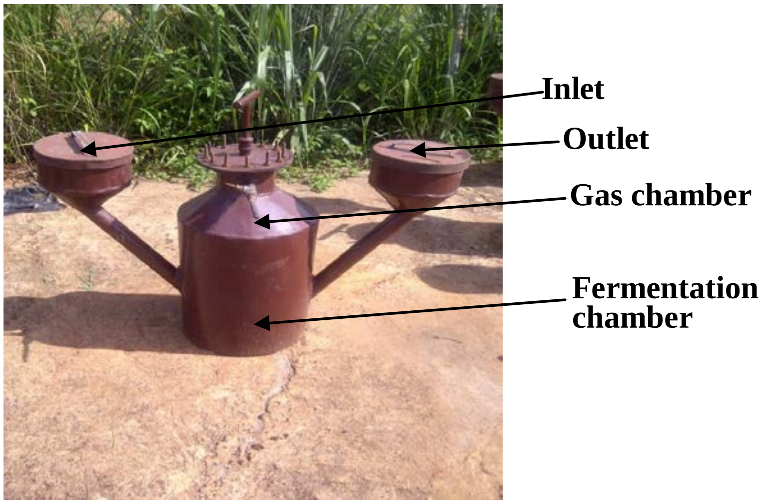


Fig.1: A $0.5m^3$ biogas Plant

3 Analyses

Proximate analysis (moisture content, crude ibre, crude protein, crude fat and ash) were determined using AOAC (2010) standard methods [**10**] while Total viable and Mould counts were carried out using Frazier and Westhoff (1995) method [**11**] **.** Isolation and **i**dentification of bacteria were by biochemical and physiological tests, and Gram staining.

4 Results and Discussion

Results of the proximate composition of the fresh and digested cow dung used for this study are presented in Table **1.** Aerobic and anaerobic transformation of organic materials involve generation and consumption of water. However, aerobic degradation is a net water producer anaerobic degradation is a net water consumer (Tchobanoglous, et al. 1993). [**12**]

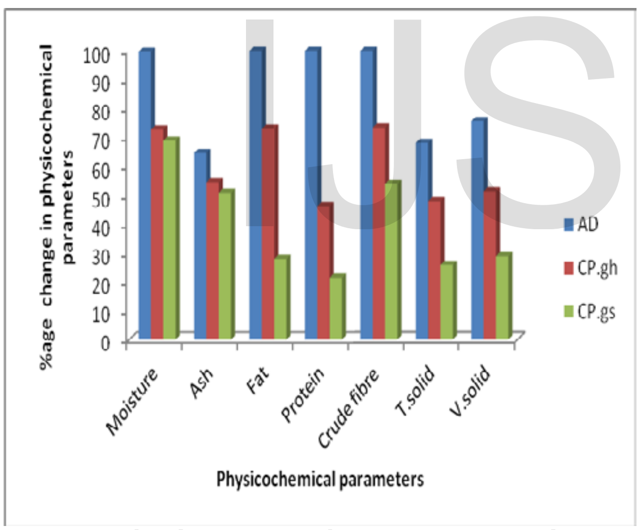
Table 1: Proximate composition of the waste samples

Parameters	Initial	After Digestion X	After Composting Y	After Composting Z
Moisture (%)	80.50	0.20	22.00	25.34
Ash (%)	39.60	14	18.00	19.5
Fat (%)	1.83	-	0.49	1.32
Protein (%)	10.51	-	5.61	8.27
Crude fibre (%)	7.92	-	2.11	3.65
Total solid (%)	18.50	5.90	9.65	13.72
Volatile solid (%)	8.60	2.10	4.19	6.12

X = Cow dung in Digester, Y = cow dung compost in hole and Z = cow dung compost on earth surface

This is evident from the results in Table **1** where the moisture content is shown to have been reduced to 0.2% from 80.50% before digestion. There was also a drastic moisture reduction, though not as much as for anaerobic process, in the composted samples Y and Z, where the levels of moisture fell from 80.50% to 22% and 25% respectively. The higher levels of moisture recorded for the composted sample may be due to availability of oxygen which readily oxidizes hydrogen to water.

The levels of ash changed from 39.60% to 14%, 18% and 19.5% in samples X, Y and Z respectively after composting indicating superior degradation ability of anaerobic digestion to composting. Fat, protein and crude fibre recorded complete degradation in sample X as they were not detected after digestion. However in composted samples, fat changed from 1.83% to 0.49 in Y and to 1.32 in Z while protein changed from10.51% to5.61 in Y and to 8.27% in Z. Crude fibre also showed similar trend with slight difference between the values recorded for the composted samples. The values recorded for Total solids and Volatile solids were also lowest for the sample treated by anaerobic digestion.



AD= Anaerobic digestion, CP.gh= Compost in ground hole, CP.gs= Compost in ground surface
Figure 1: Percent Change in Physicochemical parameters after treatment

All other parameters determined in the proximate analysis showed similar trend having lowest values for anaerobic digestion than for both type of composting. This therefore implies that the percentage of degradation achieved by anaerobic digestion is higher than those achievable with both types of composting Also the Total solids decreased more in sample X compared to samples Y and Z. With this and other parameter values in Table 2, it can then be established that anaerobic digestion, i.e. sample X has the highest degradation rate and ability than both types of composted samples Y and Z.

There were slight changes in temperature and pH as shown in Fig 2. The changes in pH indicate an almost neutrality of the process, fluctuating between 6.21 and 7.8 for sample X, 6.21 and 7.97 for sample Y while 6.21 and 7.52 for sample Z for pH while temperature fluctuated between 25^0C and 35^0C for sample X, 39^0C and 44^0C for sample Y while 36^0C and 42^0Cfor sample Z

The reason for the low pH at the initial period of treatment is attributed to the break down of the organic matter and production of volatile fatty acids by *acidogens*. However, from day 2, the pH started increasing from 6.25 and climaxed at 7.8 on day 8. This could be that the acid formers were probably displaced by the methane forming bacteria while on day 9 and 10 there was a decrease in pH from 7.8 to 7.11. The drop in pH value was evidence that the *acidogens* once more displaced the *methanogens* by the acids formers; thereby inhibiting methanogenesis. This accounted for the breakdown of acids by the methanogens to methane in sample X. This findings is supported by earlier work done by McCarthy (1964), **[13**], who reported that methane proceeds quite well as long as the pH is maintained between 6.1 - 7.8 with an optimum range between 7.0 - 7.2. From day 4 to the last day of treatment, in composted samples Y and Z, the pH increased from 6.71 to 7.97 suggesting that the process was continuously replacing acid formers by methane forming bacteria. From the result above, it could be deduced that pH and temperature are important factors in cow dung fermentation.

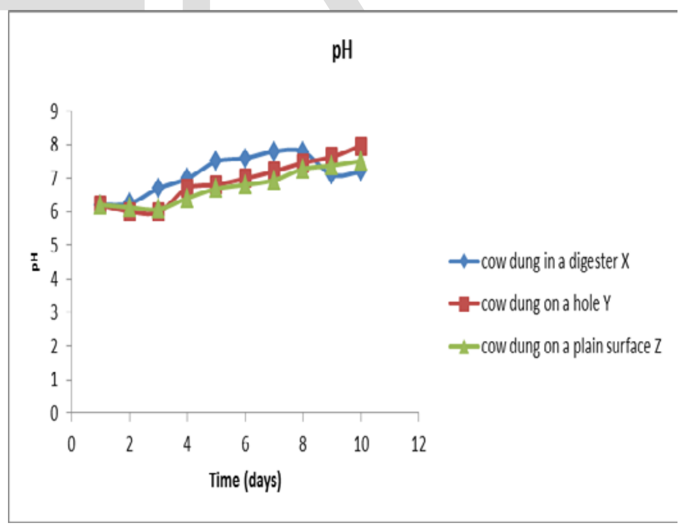


Figure 2: Changes in pH with time of cow dung with different treatments

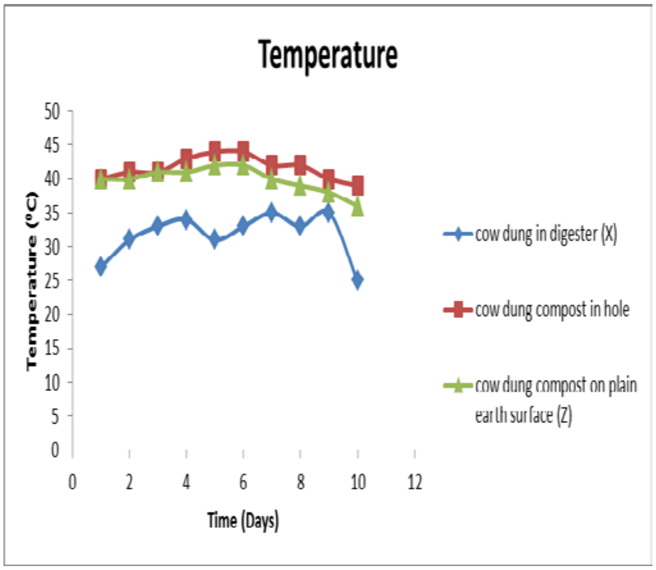


Figure 3: Changes in temperature with time

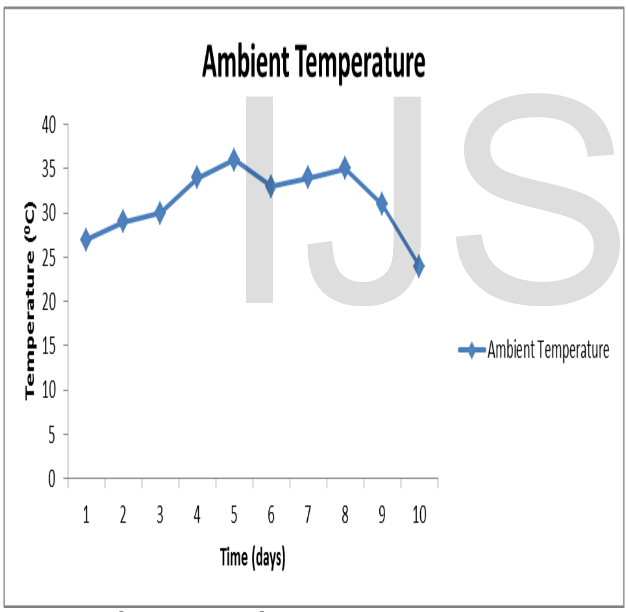


Figure 4: Changes in Ambient Temperature over a time during cow dung fermentation

5 Isolation and Identification of Bacteria

After isolation, two bacterial colonies were identified to be present. Pink pin-point colonies were observed when viewed under the microscope with a magnification of x1000. They were suspected to be Enterococci, possibly Klebsiella. The second colony was identified to be bacillus which belongs to bacteroides, the main protein –hydrolysing bacteria in the digester. Under the microscope, the organism was found to be large, pink and mucoid. The organism found under the microscope was wrinkled white colonies. P. restrictum is also a spore- forming microorganism. The presence of the mycellium was as a result of the cross combination of the hyphae which were formed by the spores after germination.

Aspergillus niger was the predominant fungi isolated from the composts and this is as a result of its ability to adapt to the moderately high temperature of the compost (25-38^{0}C) as reported by (Gray and Briddlestone, 1981).[**14**] The bacteria identified were Micrococcus luteus, *Bacillus pumilus* and *Psudomonas aeroginnosa*. These groups of microorganism isolated from the compost were able to survive under the mesophilic range of temperatures, the almost pH neutrality and the moderately high moisture content of the compost. Blanc et al., (1997) [**15**] isolated Bacillus species from hot compost and also reported that Bacillus species is among the groups of the bacteria isolated from compost. *Bacillus specie* is known to occur in soil water, air and on vegetation. They are able to survive in the compost pile due to their adaptability to mesophilic temperature in the compost. Also, the *Pseudomonas* species is very nutritionally versatile and capable of degrading many natural and synthetic organic compounds (Stainer et al., 1998). [**16**]. They are aerobic and contribute to the decomposition and nutrient-releasing process by attacking a wide variety of organic substrate.

Table 2: Microbial spectrum before and after degradation

Parameters	Before (Control)	X	Y	Z
TVC	$2.6 X 10^6$	5.3 X 10	$4.7 X 10^6$	$3.1 X 10^6$
Mound count	$1.0 X 10^5$	$1.9 X 10^6$	$1.3 X 10^6$	$1.1 X 10^6$

The results in Table 3 showed an increase in the Total viable count (TVC) due to the fact that the organisms were predominately anaerobes and the environment was favourable for them in sample X, and a reduction in organisms load in sample Z which is an aerobic process and Y also an aerobic process has the least load.

Therefore, the generic transformation of solid wastes can be explained by the following equation (Palmisano and Barlaz, 1996). [**17**].

Organic matter + O_2 + Nutrients = New cells + Resistant Organic matter + CO_2 + H_2O + NH_3 + SO_4^{2-} + …… + Heat..........**1.**

while that of anaerobic degradation is captured by the equation below:

Organic matter + H_2O + Nutrients = New cells + Resistant Organic matter + CO_2 + CH_4 + NH_3 + H_2O + Heat.............**2**

During composting/digestion, it was observed that atmospheric air composed mostly of nitrogen and oxygen is trapped in the void spaces (Adeola, 1996) [**18**]. During aerobic transformation, this oxygen, in addition to oxygen dissolved in the solid wastes moisture, supports both aerobic hydrolysis and aerobic degradation. The oxygen is consumed with soluble sugars serving as the carbon source for microbial activities, hence the increase in Total microbial count (table 2). Although at the completion of the aerobic phase, the gases produced are mainly composed of CO_2 Aririatu [**19**]. Other gases such as ammonia and sulphur dioxide are also produced. .The increase in colonies of anaerobic bacteria is most likely attributed to improper aeration of the composting piles which result to increase in methane gas, volatiles (UNEP 2009)[**20**] The release of methane and carbon dioxide contributes to the problem of greenhouse gases in the atmosphere. Poorly operated composting facilities also cause unpleasant odours. This view was strongly and unanimously held by the 20 Sensory Panelists who noted that the cow dung subjected to anaerobic digestion was completely odourless as long as the digester remained tightly closed unlike the other two modes of composting. The cow dung subjected to plain earth composting was rated the worst in terms of odour nuisance,
The most significant potential environmental problem arising from compost use is its potential to convey heavy metals to the soil. This is a serious concern, and sound practice requires controlling impacts through analysis of composts; development and enforcement of land application standards; and research and development on pre-processing and process control mechanisms to limit or reduce contaminants (Janya Sang-Arun sept-oct 2011) [**21**].

The biological conversion of the organic fraction of the solid waste during anaerobic transformation is thought to occur in three steps: hydrolysis (including fermentation), acetogenesis, and methanogenesis.
Anaerobic digestion offers the advantage of ability to collect whatever gases that were emitted. The mixture of gases collected referred to as biogas is rich in methane (55%-70%) and carbon iv oxide (30%-45%) and may be used directly as source of energy or separated and purified even further to meet some energy requirements. Gas recovered from the system can replace approximately 30-50% of liquid petroleum gas (LPG] for household use.

6 Conclusion

Results show that anaerobic digestion of cow dung is most efficient and effective in cow dung stabilization with very significant odour control within the vicinity The proximate composition shows that, there is a greater degradation of organic materials in anaerobic digestion than with any form of composting. Unlike the composting methods which reduced the values of fat, protein and fibre by less than 70%, anaerobic digestion recorded 100% degradation of fat, protein and fibre respectively. Degradation of other constituents showed similar trend, with composting on earth surface having the least effect.

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