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Full Length Research Paper

Poultry faeces management with a simple low cost plastic digester

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Poultry faeces collected from the research farm of the school of Agriculture, Abubakar Tafawa Balewa University, Bauchi, Nigeria, was anaerobically digested for five weeks retention time using a plastic type digester constructed at the FMEnv/ZERI Research Centre and a follow up system set up in Cameroon at the compound of the National Polytechnic Bambui, Bamenda in the North West part of the country with 200 L poultry faeces collected from a private farmer in Bambui village who reported that composted poultry faeces used to fertilized his plantain field generated stem and root rot disease. Following anaerobic digestion of poultry faeces for 37 days in Nigeria, the raw slurries with a very high mean bacterial counts too numerous to count (estimated as above 10,000 cfu per ml) reduced drastically to only 180 cful ml while mean coliform and *Escherichia coli* counts too numerous to count reduced drastically to 130 and 87 cful ml, respectively. The difference in mean microbial counts from the raw to treated slurries was far more significant than the raw slurry kept on bench and analysed at the end of five weeks as control. Cyst of *Eimeria spp* and ova of *Ascaridia* detected in the raw slurries were absent in the anaerobically digested slurry. Seven species of soil pathogenic nematodes detected in a compost pit and from stem and root rot of plantain trees fertilized with the manure at a local farm in Cameroon were not detected after the poultry faeces was anaerobically digested in a pilot plastic digester in a five week retention time. Biogas produced at the end of the process was used as cooking fuel and burnt for 3 h daily for 5 days. The findings showed that the plastic type digester was efficient in disinfecting contaminated poultry faeces while providing biogas and sterile mineralized fertilizer.

Key words: Plastic, anaerobic, digester, simple, cheap, poultry, faeces.

INTRODUCTION

In most rural communities in Africa, disease, poverty and environmental degradation are apparent. This picture is probably similar to a number of developing nations. There is a high prevalence of communicable diseases such as typhoid, paratyphoid, diarrhea, dysentery and other noxious parasitic infections and this has been exacerbated by poor sanitation amongst others. Communicable diseases have six basic means of dissemination, via food, fluids, flies, fingers, fields, and faeces, the latter being the most prevalent. The use and poor disposal of animal wastes is one of the major sanitation problems faced by most rural areas in developing countries (Chao et al., 2008). In Nigeria and Cameroon, for instance, most people traditionally use animal waste especially chicken droppings and cow manure to fertilize farm for agriculture. This practice has been intensified as a result of the high cost of synthetic fertilizer that has slowed down the pace of farming for most farmers.

Apart from the fact that fresh/semi-dried animal droppings sprayed on the farm as fertilizer is a potential health hazard to both grazing animals, the leaching effect into ground and surface water poses great danger to humans. The hazardous effects of this have been studied by some researchers the world over.

Jones (1980) reported that pathogenic organisms such as *Salmonella* spp., *Escherichia coli*, *Campylobacter* spp., and *Listeria monocytogenes* are common in animal faeces particularly chicken droppings. Their resilience and pathogenicity largely depend on the species, infective propagation (population dynamics), ability to survive,

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serotype, slurry composition, temperature and pH.

Jones (1980) and Larsen and Much, (1982) noted that these pathogenic organisms could survive in animal slurry for a considerable length of time. To this effect, Theresa et al. (1993) reported that *Salmonella typhimurium*, *Salmonella* spp. and *E. coli* survived in raw slurry of cow dung for as up to eleven weeks, and on a dairy farm could be longer in poultry feeds.

Animals are asymptomatic carriers of certain organisms that can infect/cause diseases in other animals especially in situations where poultry liter is dried and mixed as feed supplement. Theresa et al. (1993) observed that poultry are potential carriers of several human diseases causing agents such as New Castle disease, virus, *Chlamydia, Aspergillus, Clostridium, Salmonella* etc. The effect of unsound sanitary practices does not only threaten human/other animal health but also plants. A number of plant pathogenic disease causing agents are also disseminated through untreated chicken manure and the economic losses accruing from these are enormous.

An example of a case in point of the effect of using untreated chicken manure to fertilize a banana field in Bambui Cameroon is shown in the following plates (Figure 1 - 4). Bambui is about five kilometers away from Bamenda, the capital of North West province of Cameroon. The cool climate and mountain topography encourages high plantain and banana yield. A number of rural farmers have had to rear chicken (domestic and exotic) to use the dropping as manure directly or composted to fertilize the banana field. When the farmer was interviewed, he noted that the infection is severe when the manure is used fresh and less severe when composted aerobically for a month.

Anaerobic digestion provides a good alternative for the treatment/disposal of animal waste with a couple of bio-products such as biogas and biofertilizer. Anaerobic bioconversion technology has been in existence for more than a hundred years but the adoption of this technology has been slow in most African countries especially Nigeria. This has been due to the high cost constructing/managing and maintenance of the typical Chineese dome shape/ underground digester.

The simplicity of plastic type digesters means that most rural people are likely to run one for their households. Little work has been done in determining the fate of pathogens in a plastic type digester especially under tropical conditions (Yongabi et al., 2004). It was in this regard that the efficacy of disinfection was monitored for five weeks through microscopy and culture analysis of the raw and treated chicken manure slurries to establish microbial presence in both.

MATERIALS AND METHODS

Digester design and construction

The anaerobic digester used in this study was constructed using a longitudinal wooden and cement brick trough (triangular in shape) the dimension of the trough were: Length of top and bottom, 1.8 and 1.26 m respectively while bottom width and top width, 0.45 and 0.8 m respectively. Equally, the depth and slope of the trough measured 0.3 and 0.4 m respectively (Figure 5).

At both ends of the trough, plastic pipes were initially cut to specifications using the hawk saw and edges smoothened using the half round file. Fairly thick plastic polyethene sheet with opening at both ends was first laid down as bedding in the trough and then folded two-step wise at both ends into two layers and fed in gently through the pipes. The edges of the polyethene were wrapped round the mouth/opening of the pipes and fastened in position with a rubber band (Figure 6). The polyethene sheet was thoroughly checked for holes so as to avoid any leakage when the process was fully operational (Figure 6).

Sample collection (chicken droppings)

The chicken droppings were collected from the poultry farm at the Teaching and Research farm of the school of Agriculture, Abubakar Tafawa Balewa University, Bauchi using a spade and bucket while in Cameroon poultry faeces were collected from a farmer in Bambui, Cameroon.

Slurry preparation

Two 10 L of buckets full of poultry liter (dried) was used. Slurry was made by mixing one part of the poultry liter in two parts of water. This was thoroughly mixed by stirring continuously for some few minutes. All in all, about 100 L of slurry or there about was fed into the digester. As effluents were added to the digester, excess water drained off at the outlet. The digester was actually filled to the brim with space for gas to be collect.

Slurry sample collection for microbial analysis

When the slurry was fully made, three samples (10 ml each) were collected aseptically using sterile stainless steel spatula into sterile test tubes. The test tubes were sealed with cotton wool and then transported to the

FMEnv/ZERI Research Microbiology Laboratory for analysis.

Similarly, the well water that was used in making the slurry, three samples of it were taken aseptically in the same way as described earlier for a comparative microbial analysis. Specimens from stem and root rot of the plantains and composted manure were sent to the plant pathology department of the University of Yaoundé 1, Cameroon for nematode identification.

Microscopy analysis of slurries (raw and treated) and well water samples

Three smears of each of the samples were made on clean grease free slides and examined under the microscope using x100 and x400 magnifications respectively and observations recorded.

Microbial analysis of slurries (raw and treated) and well water samples

1 ml of the raw poultry litre slurry was aseptically transferred into 9 ml sterile distilled water to give a one in ten dilution (10^{-1} dilution).

Figure 1. Broilers feeding in their pen.

Figure 2. Chicken droppings.

Figure 3. Chicken faeces being composted in a compost pit for a month.

Figure 4. Infected banana field with nematodes as a result of using the raw and composted. (See Appendix for the identified nematodes).

Figure 5. Construction of an anaerobic digester.

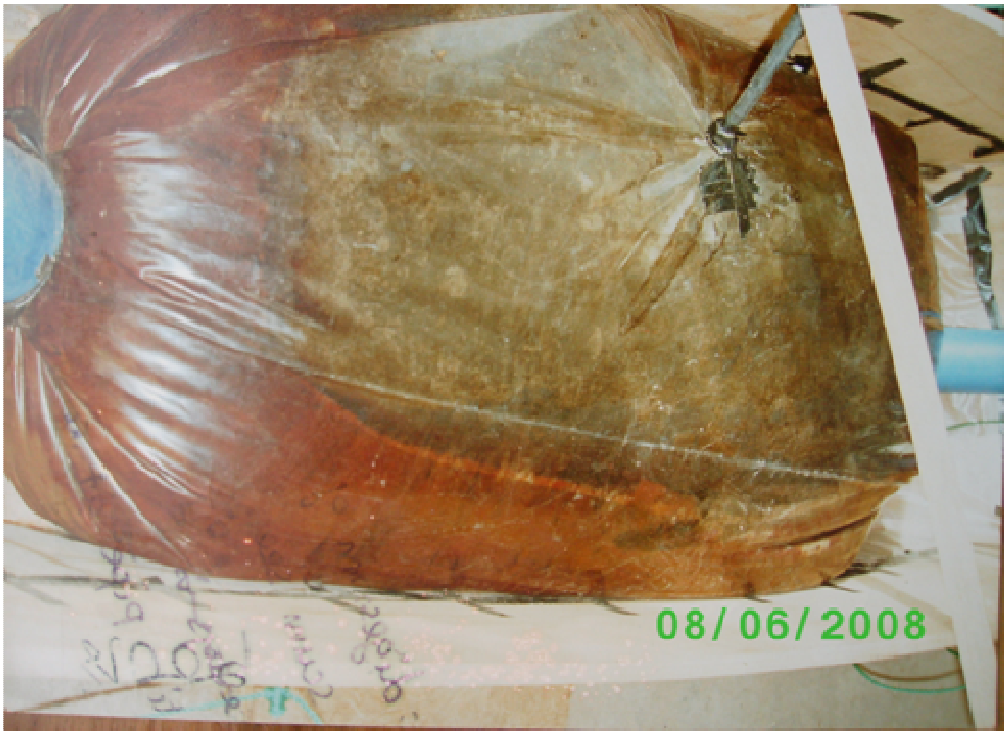

Figure 6. The anaerobic digester.

The diluents were then serially diluted using 9 ml of sterile distilled water up to 10^{-3} dilutions. Using a sterile pipette, 1 ml each of 10^{-1}, 10^{-2} and 10^{-3} dilutions were carefully and aseptically inoculated in triplicates by the pour plate method (1 ml of the suspension mixed onto molten agar) onto Salmonella shigella, nutrient, MacConkey, Eosin methylene blue agars for bacterial isolation and Potato dextrose agar for fungal isolation. All the plates were incubated at 37°C for 24 h for bacteria and at 25°C for four days for fungal isolation. The above standard technique employed was adopted from Harrigan and McCance (1976). Three samples each were cultured and the same procedure was done for both the treated slurry and the well water samples.

Plate reading

Following incubation at 24 and 96 h for bacteria and fungi respectively, the plates were read off. The cultural characteristics such as shape of colonies, colour etc was observed macroscopically and recorded. Then discrete bacterial colonies from each plate were gram stained and observed microscopically at 1500 magnification according to the method of Cheesbrough (1984). Equally discrete fungal colonies were observed microscopically in a lactophenol cotton blue preparation. The cell micromorphologies as well as unique differential features were recorded. The characteristic features collated were compared with taxonomical keys specified in Bergey's manual of determinative Bacteriology (Buchanan and Gibbons, 1980) to give an identity to the bacterial isolates while the keys specified in Barnett and Hunter (1972) were used to identify the fungal isolate.

Microbial analysis of treated slurry

Anaerobic digestion of the raw slurry was allowed for five weeks at mesophilic temperature. Following this treatment and as the gas start to fill in the gas collector, three samples of the slurry now (treated slurry) were aseptically collected and analysis followed the same procedure as earlier described.

Similarly, it was at this time that the well water samples which were initially used in making the slurry and kept at room temperature (37°C) in the laboratory for five weeks were then microbiologically analysed using the same procedure.

pH analysis

The pH of the raw and treated slurries were tested using a combi-9 test strip (a standard strip for routine urinary biochemical analysis), the strip was dipped into the slurries and after 60 s, the colour change noticed was compared with a range of colour standards and when the colour of the strip matched any of the colour standards, the pH label was directly read off.

RESULTS AND DISCUSSION

The results of the microscopy analysis of the raw and treated chicken droppings indicated in Tables 1 and 2 revealed that during the anaerobic digestion process the worms initially in the raw droppings died off and are undetected in the treated slurry. Similarly, the well water which was used in making the slurry contained yeasts and cysts of protozoan while the untreated (raw) slurry contained a wide diversity of pathogens ranging from bacteria to helminthes but were disinfected in the anaerobic digestion process in the plastic digester. The finding herein corroborates previous observations by Chao et al. (2008) in Vietnam who used low cost plastic digesters to disinfect pig wastewater containing pathogenic microbes.

Table 1. Microscopy analysis result of raw and treated slurries (chicken manure).

Raw chicken slurry[*1]	Treated slurry[*2]
Ova of *Ascaridia* spp. (++)	Not detected at all
Cyst of *Eimeria* spp. (+++)	Not detected at all
Other worms (nematode like)+	Not detected at all

+, Very few; ++, few; +++, reasonable.
[*1]pH = 7.0; [*2]pH = 7.0.

Table 2. Microscopy analysis of well water (used in making slurry) and raw slurry before biodigestion.

Well water	Raw slurry (chicken manure)
No ova of helminth +	Ova of Ascaridia seen
Cyst of protozoa seen	Cyst of *Eimieria* spp. seen
Other worms not detected	Other worms seen
Yeast cells present	Yeast cells present
No motile bacteria seen	Motile bacteria seen

In this study, the bacterial and yeast populations were extremely high approximately above 10.000 cells per ml and thus labeled Too Numerous To Count (TNTC), suggesting how dangerous it is handling animal waste. However, the densely populated microbes were drastically reduced to acceptable levels (Table 3). In a related study, Tappouni (1984) credits the role of anaerobic digestion in disinfecting *Salmonella* species from animal waste. Although his study did not utilize the plastic type digester, as in this study, but the mechanism in both is the same. Earlier studies using plastic digesters also lend credence to the findings of the study of Theresa et al. (1993), Audu et al. (2003), SanThy (2003), Yongabi et al. (2004) and Chao et al. (2008).

An interesting observation that may not have been reported elsewhere using plastic type digesters is its ability to disinfect soil nematodes parasitic to agronomic crops (Table 4). The gas generated in the course of anaerobic digestion was burnt for three courses to boil water. Although the primary aim of this study was to disinfect waste, the multiple benefits of the process such as biogas, biofertiliser are stimulus for sustainable agriculture and cleaner energy mechanism in an era of threatening climate change as reported by AnBui et al. (1996) who set up low cost digesters in Vietnam tailored toward generating energy for rural households.

The conclusion drawn is that plastic type anaerobic digester is cheap, effective in disinfecting animal and plant waste while generating biogas and biofertiliser. This can promote sustainable agriculture, cleaner and cheap cooking fuel in a clean environment. There is therefore an

Table 3. Bacteriological analysis results of raw and treated chicken manure slurries at 10^{-3} dilution.

Slurry	Total aerobic mesophilic counts	Coliform counts	*E. coli* counts	Salmonella and shigella counts	Yeast counts
Raw slurry	TNTC	TNTC	TNTC	TNTC	TNTC
Treated slurry (cfu/ml)	180	130	87	Nil	155

TNTC = Too numerous to count; estimated as 10,000 cfu/ml.

Table 4. Bacterial analysis result of well water and raw slurries placed on bench for 3 weeks at 10^{-3}.

Slurry	Total aerobic mesophilic counts	Coliform counts	*E. coli* counts	Salmonella and shigella counts	Yeast counts
At the beginning of experiment	TNTC	TNTC	TNTC	Nil	TNTC
After 5 weeks of biodigestion	TNTC	5.2×10^4	3.7×10^4	Nil	TNTC

TNTC = Too numerous to count; estimated as 10,000 cfu/ml.

exigent need to experiment further on the possibility of disseminating this technology across Africa.

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Appendix I

Nematode identified from the infected plantain trees

Meloidogyne spp
Pratylenchus goodeyi
Helicotylenchus dihystera
Helicotylenchus multicinctus
Unknown Helicotylenchus
Hopiolaimus pararobustus
Radophlus similes

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