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Managing cow dung with a low tech, cheap plastic digester

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Integrated farming has traditionally involved, among other things, the use of crop residues as feeds and the use of animal manure as fertilizer for the fields. While this intersectoral transfer of materials is necessary for sustainable agriculture, the use of untreated manure has tended to spread pathogens to animals, crops, soil, and water bodies (Jones and Mathew, 1975). The result is the exacerbation of communicable diseases like typhoid, malaria, diarrhoea and Dysentery, Cholera etc. This has been particularly true for Nigeria where the use of untreated manure is rampant, especially in the northern part of the country.

The use and disposal of animal wastes is one of the major sanitation problems in rural parts of most developing countries, and this is particularly true for Nigeria. Outside of the pathogenic bacteria contained in untreated manure, a host of parasitic worms that also affect man, e.g. *Taenia Saginata* and *Fasciola hepatica*, are known to be present. Some of the long-surviving pathogenic bacteria that have been reported to be present in raw manure include *Salmonella spp*, *Escherichia coli*, *Campylobacter spp*, *Listeria monocytogenes* etc (Jones, 1980; Larsen and Munch, 1982; Robinson, 1982; Theresa *et al*, 1993). Jones in 1980 also reported that bacteria associated with manure depends on the species, population size, ability to survive, storage, capacity to remain virulent as well as survive on grass for a considerable period of time, serotype, slurry composition, temperature and pH.

One of the most common processes for 'sterilizing' manure and producing biogas is anaerobic digestion, and some of the popular types are the Chinese-dome underground and Indian digesters. While anaerobic digestion is widely in use in Asia for the management of agricultural waste, the use of these digesters is minimal in Africa. Some of the reasons precluding the use of these digesters especially in the rural communities in Nigeria, for instance, are the cost of construction and the required skillful maintenance of the digesters. In this report, the management and disinfection of manure with a low-tech, cheap, plastic digester is described. The efficacy of disinfection was monitored by carrying out microscopy and culture analysis of the raw and treated manure slurries to establish the microbial presence in both.

Materials and methods

Digester design and construction

The digester was housed in an open top wooden trough of 0.3 m depth, with unequal length rectangles at top and

bottom. The trough is 1.8 m at the top and 1.26 m long at the bottom. The widths at the top and bottom are 0.8 m and 0.45 m respectively.

A 1 m wide and 2.34 m long polyethylene sheet, with open ends, was laid as bedding on the floor of the trough. The polyethylene sheet was folded at both ends longitudinally and pushed gently through PVC pipes (0.65 m long inlet pipe of 0.11 m diameter; and 0.54 m long outlet pipe of 0.09 m diameter). The edges of the polyethylene were wrapped round the file-smoothed mouth of the pipes and fastened in position with rubber bands. At every stage, care was taken to avoid having a hole in the polyethylene sheet.



Figure 1. Overview of the digester being checked for leakages with water



Figure 2. Collected gas being shown in a plastic bag after four weeks of digestion

Sample Collection (Cow Dung)

The cow manure was collected with a spade into a bucket from the Range Farm of the School of Agriculture and Agricultural Technology, Abubakar Tafawa Balewa University, Bauchi.

Slurry Preparation

Two 10 L buckets of fresh cow dung were added and stirred into 40 L of well water to make slurry. 100 L of slurry was prepared this way and introduced to the digester, leaving some space for gas to collect. The system was then left to 'run'.

Microbial analysis

Three 10 ml samples of the slurry were collected aseptically using a sterile stainless steel spatula into sterile test tubes. The test tubes were well sealed with cotton wool and transported to the laboratory for microbial analyses.

Using the standard technique reported by Harrigan and McCance (1976), one milliliter of the cow dung slurry was aseptically transferred into 9 mls sterile distilled water to give a one in ten dilution (1:in 10 dilution). The diluent was then serially diluted using 9 ml of sterile distilled water up to 10^6 dilution. Using a sterile pipette, 1 ml each of 10^{-1} , 10^{-3} and 10^{-5} dilutions were carefully and aseptically inoculated in triplicates by the pour plate techniques (i.e. 1ml mixed onto molten agar) onto *Salmonella shigella* Nutrient, MacConkey, Eosine Methylene Blue agars for bacterial isolation, and on potato dextrose, Sabaraud dextrose and malt extract agars for fungi isolation. All the plates were incubated at 37 °c for 24 hours for bacteria and at 35°C for four days for fungi.

The described procedure was followed in performing the microbial analyses for the fresh well water sample, well water sample that had been left on the shelf for four weeks, and the treated slurry after four weeks of digestion at mesophilic temperatures and gas collection had begun.

Microscopy

Three smears of each sample were made on clean, grease-free slides and examined under the microscope using X100

and X400 magnifications and the findings were recorded for both slurry and water samples.

Plate reading

Following incubation at 24 and 96 hours for bacteria and fungi respectively, the plates were read off. The cultural characteristics such as shape of colonies, colours etc. were observed macroscopically and recorded. Then discrete bacterial colonies from each plate were gram stained and observed microscopically at 1500 magnification according to Cheesbrough (1984). Equally discrete fungal colonies were picked using a sterile inoculating needle and smeared in Lactophenol Cotton Blue and examined microscopically using X400 magnification. The cell morphologies as well as unique differential features were recorded. The characteristics features collated were compared with taxonomical keys specified in Bergey's manual of Determinative Bacteriology (Buchanan and Gibbons, 1980) to give identify to the bacterial isolates and for fungi identity, characteristic keys described in Barnett and Hunter (1972) were used.

Results and discussion

The Microscopy analysis results (Table) revealed the presence of a few ova of helminthes in the raw slurry. In the treated slurry, these ova are not only absent but the Helminthes larvae that are present are dead. Cattle play host to a number of parasitic diseases that also affect man. Nwaedozi (2001) reported that *Trichiuris trichiura* and *Ascaris lumbricoides* amongst others are some of the intestinal parasites of solid wastes from slums and low-income neighbourhoods in Nigeria. Animals are usually intermediate hosts to a number of disease-causing agents in man, e.g. Taeniasis (Tapeworm disease) caused by *Taenia saginata* primarily infects pigs while *Fasciola hepatica* has cow as an intermediate host. Apart from being zoonotic, these infective worms also lead to low production in animal husbandry. The absence of the ova in the digested slurry suggests that the digestion of manure in the described polyethylene bag is an effective way of breaking the cycle of infection in animals and the re-infection of man through his activities in agriculture.

Table 1. Microscopy analysis

	Fresh well water	Well water (After 4 weeks on the shelf at 35°C)	Raw slurry	Treated slurry (after 4 weeks of digestion)
Yeast cells	✓	✓	✓	✓
Motile bacteria	ND	✓	✓	✓
Ova of Helminth	ND	ND	✓	ND
Dead larvae of Helminth	ND	ND	ND	✓
Free-living protozoa (Euglena, Amoeba, Paracium, Spirogyra)	ND	ND	ND	✓

Key: ND – Not detected; " - present

The presence of the actively motile, free-living organisms in the treated slurry (and not in the raw slurry) is an interesting observation, and their path/role in anaerobic digestion may need further study. These organisms – *Euglena*, *Paramecium*, *Amoeba*, and *Spirogyra* – are unicellular, non-parasitic organisms that are sometimes classified in the kingdom, Protista. It is likely that these organisms may be present in their dormant stage in grass fibres that are the usual components of cattle manure. With digestion though, the manure is broken down and a number of nutrients are released to provide hatching conditions for the organisms from dormancy to vegetation. The significance of the presence of these organisms in the treated slurry is that the cow must have fed on grass containing viable cells of *Euglena*, *Paramecium*, *Amoeba*, and *Spirogyra*.

Similarly, the microscopic examination of the well water that was used in making the slurry before feeding onto the digester revealed the presence of yeasts, and the same is true for the raw and treated slurries (please see Table).

The pH of the raw and treated slurries was 7.0. Jones (1980) reported that the operational parameters of anaerobic digesters such as temperature, total solids, hydraulic retention time, volatile fatty acid concentrations and pH are important in determining the rate of gas production, and hence digestion. The well water, which was used in making the slurry, was kept on the laboratory bench for four weeks (for as long as biodigestion took place). A follow up microscopy analysis of the well water, four weeks after storage on laboratory shelf at 35°C, revealed the presence of motile bacteria in addition to yeast cells.

The Figure below gives a profile of the two slurries and well water in terms of the number of counts of Aerobic mesophilic bacteria, Yeast, *Escherichia coli*, and *Coliform*. It is obvious from the Figure that digestion eliminates *E. coli* and significantly decimates *Coliform* and other Aerobic mesophilic bacteria. Faecal pathogens have traditionally being tied to a number of ailments. *E. coli* and *Coliform* are particularly known to be indicators of diarrhoea-causing agents. With digestion, manure is made safer for

application to the fields, as feeds in fish production, and as feed supplement for animals.

This observation tallies with the reports of Dahiya and Vasudevan (1986) and Gadre *et al* (1986) who observed that anaerobic digestion is a good option in the treatment of waste. Similarly, Kunte *et al* (1998) reported that animal wastes show the presence of pathogenic bacteria such as *Salmonella spp*, *Escherichia coli*, *Campylobacter spp*, and *Listeria monocytogenes* etc and that they can survive for a considerable length of time in raw slurry.

The elimination of *E. coli*, ova of helminthes and the drastic decline in the number of *Coliform* count and other bacteria in the anaerobic digester may be traceable to any of the following factors; pH and accumulation of volatile fatty acids, anoxic conditions, temperature or a combination of all of these factors. In an independent study, Tappouni in 1984 reported that maximum biogas production during semi-continuous digestion correspond to a rapid decline in the numbers of bactericidal effect of long chain fatty acids accumulated within the digester.

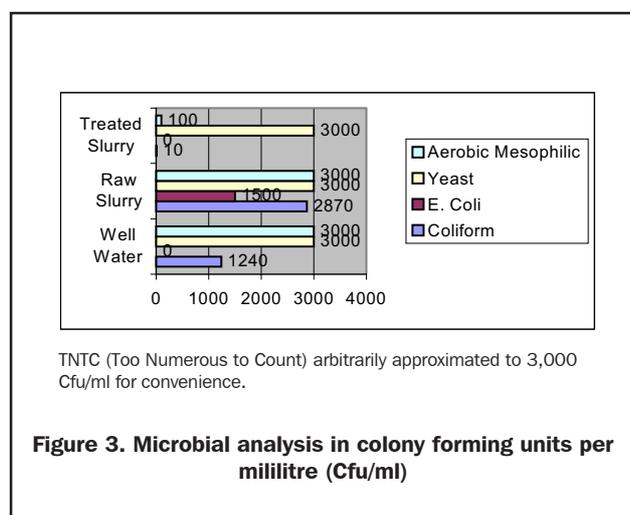
Besides, it is suggested that other metabolites produced by anaerobic bacteria may have had antimicrobial activities, thus leading to the reduction and elimination of the pathogens observed in this study. Furthermore, the possibility of the unicellular protozoa feeding on the bacteria and yeast cannot be dismissed.

The yeast count was drastically less in the treated slurry. Similarly, fungi - *Aspergillus niger* and *Rhizopus sp* - isolated from the raw slurry were absent in the treated slurry. *Aspergillus niger* and *Rhizopus sp* are common ubiquitous fungi that cause decay of fruits and vegetables. In immuno-compromised patients, *Aspergillus sp* can cause bronchopneumonia. Their absence in the digested slurry attests to the fact that the treated slurry is safer for use as biofertilizer than in the raw state.

Incidentally, *Aspergillus fumigatus* and other *Aspergilli* were isolated from the treated slurry. These may be contaminants at the digester exit where the digested slurry is drained out. *Aspergillus spp* are usually airborne.

Conclusion

The polyethylene digester described in this study is cheap, low tech., and produces both biogas and disinfected slurry that may be used as fertilizer for the fields or feeds for fishery production. The digester is easily constructed with little more than a sealing ability to mend leakages. In addition to the minimal maintenance skills required, the visual access of the digester when the polyethylene bag is transparent makes this technology aptly suited for our rural communities in disinfesting and managing solid waste in the agricultural sector. With visual access, the progress of digestion is readily followed through colour changes in the digester rather than solely through the familiar gas production rate. The average cost for a 95-liter polyethylene digester is 45 USD, and all the materials are available in urban and rural markets across the country. Having the



digester on a raised, mud platform with walls on the two long sides may further reduce this cost.

The introduction and practice of this technology in the rural areas across the country would help to improve hygiene in the handling and processing of manure, and lead to the reduction in contamination of soils, water, and crops. One other consequence of this is the improvement in public health arising from the safe management of manure and the application of the mineralized and 'sterilized' product in increasing crop yields.

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