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Research article

Performance Evaluation of Biozyme 1070 as Organic Waste degrader for Septic tanks in high water table areas of the Niger Delta, Nigeria.

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Abstract

This study was carried out to evaluate performance of Biozyme 1070 used in the degradation of sewage organic wastes in septic tanks. The study is occasioned by the fact that most Niger Delta areas in Nigeria have waste management and disposal problems from sewage disposal systems due to high water table. In the same vein, there is also high probability of groundwater contamination with faecal wastes resulting in water borne diseases amongst our populations. Septic tanks close to public facilities such as motor parks, office complexes, student hostels and residential buildings were selected in Port Harcourt city for the exercise. Laboratory analysis of organic waste samples obtained from five (5) different septic tanks into a 20 litre sterile plastic buckets were employed using standard analytical methods before application of Biozyme powder in proportions stated by the manufactures and left for 48-72 hours. This involved the enumeration of total heterotrophic bacteria, total coliform bacteria and *Salmonella-Shigella* bacteria using the ten-fold serial dilution procedure. In the case of total or faecal coliform bacteria, the most probable number (MPN) technique using multiple tables' method was used. The range of results showed that the total heterotrophic bacteria increased from $3.1x10^6$ to $14.4x10^6$cfu/ml after application of Biozyme 1070, while *Salmonella-Shigella* bacteria decreased from$12.0x10^4$ to $1.52x10^4$cfu/ml, total coliform bacteria also decreased from 29,000 to 18,000 coliform/100ml, while faecal coliform bacteria decreased from 16,000 to 12,000 coliform/100ml after 48 hours. Physical observation of the waste samples showed reasonable formulation of the waste which turned from semi liquid to completely liquid sample and became odourless. This paper recommends that to avoid contamination of drinking water sources and other problems, decongestion of onsite facilities in urban centres and construction of offsite network facilities (centralized treatment sewer system) in order to safeguard human health.

Keywords: Biozyme 1070, bacterial decomposition, microorganisms, water borne diseases, sewage, septic tank

1.0 Introduction

For many years the common onsite sanitation technology for handling residential and commercial black and gray water has been the “absorption pit” otherwise known as soakaway pit or septic tank. This is a large hole dug in the ground that is capped with a concrete slab into which all kitchen gray water and toilet wastewater empties. Depending on the specific hydraulics of each site, the absorption pit functions as a sealed vault or subsurface wastewater infiltration system. The benefit is that there is no public exposure to open sewage, but the geology and geometry of the pit often result in inadequate sewage treatment and groundwater contamination (Gray, 2001; Stewart, 2005). Locations with porous soil structures allow raw sewage to empty into the ground water table. The geometry of a waste water infiltration system affects how well the water is dissipated and treated by the soils. Infiltration trenches that are long, narrow and shallow are preferred over wide beds and deep pits. A biological mat of microbes forms as wastewater flows to the soil. This mat and cover vegetation capture and consume the organics and nutrients making it possible for high reduction of biochemical oxygen demand (BOD), total suspended solids (TSS), phosphorus, viruses and coliform bacteria(Stewart, 2005). Although such fields have been reported to contain fecal coliforms contamination greater than 2,400MPN/100ml (Morris, 2003). The nearby absorption pit and pit latrine are obvious sources of fecal coliform. Pit latrines may contaminate groundwater to a lesser degree than absorption pits because the reduced fluid volume entering the latrine results in a weaker driving force transporting the waste. The nitrate form of nitrogen is not readily removed by soil so that nitrate levels may be elevated under any system that does not adequately remove it prior to infiltration (USEPA, 2000).

With the primary impacts being from sewage disposal through use of absorption pits and saline intrusion exacerbated by over pumping, the pollution indicators include total and faecal coliform bacteria, nitrate and chloride. Nitrate is the principal form of combined nitrogen found in natural waters. Most surface waters contain some nitrates, however concentrations greater than 5 mg/l may reflect unsanitary conditions, since one major source of nitrates is human and animal excrement. The consumption of waters with high nitrate concentrations decreases the oxygen carrying capacity of the blood. This is particularly important in the health of young infants, who may develop methemoglobinemia.

1.1 Biozymes

Biozymes is a ready to use **bacterial powder formula** made of wheat bran grain- like substance as a substrate, and used for accelerating organic wastes degradation in septic tanks, soakaways, sewer lines, commercial wastewater facilities, polluted underground water sources, lagoons and sewage pits. This bacterial powder has the ability to accelerate the breakdown of difficult to degrade organic compounds in aerobic and anaerobic environments at a pH range of 7.8-8.2. Bacterial strains in the biozyme blend produce small proteins called enzymes which help them to break down large molecules into smaller pieces that can be easily transported into the cell to be metabolized for energy. Application of biozymes enhances organic build up which can potentially lead to back-ups especially for the strains in the biozyme blend. Water spray, carbon dioxide or dry chemical can be used as extinguishing media.

According to the manufacturers, Magna Chemical Canada Inc., it does not contain any explosives that may warrant any fire outbreak. Its bulk density is approximately 0.66-0.77

Treatment of waste in septic tanks occurs by bacterial decomposition. Lack of appropriate microbial activity can slow the degradation process or provide insufficient treatments. Bacteria are very important in the process of breaking down nitrogen containing substances and other organic wastes. Some of the breakdown products include water, carbon dioxide, methane gas, nitrates and other small organic and inorganic substances.

1.2 Justification for the use of Biozymes

Contamination of drinking water sources by sewage can occur from raw sewage overflow, septic tanks, soak away pits, leaking sewer lines, land application of sludge and partially treated waste water. Sewage carries bacteria that transmit organisms that cause gastro-intestinal diseases such as typhoid, dysentery and cholera which affect the health of man. Effluents from septic tanks are as dangerous as raw sewage as it contain effluent concentrations higher than both locally and internationally acceptable limits (Burabai *et al.*, 2007). The dominant bacterial group in septic tanks according to Ochuko and Thaddeus (2013) include total and feacal coliforms, streptococci, anaerobes etc. Ingestions of polluted water infested by these pathogenic microbes on a constant basis enhance the proliferation of water- borne disease (Van and Pur, 1990; Bicki, 2001).

In Nigeria, especially in the Niger Delta region, many soils in the coastal plains are characterized by their hydraulically restrictive layers and seasonally high water table level (Daniels and Weaver, 1987; Burabai *et al.*, 2007). The seasonal high water table conditions restrict the use of conventional septic systems. Effluents from septic systems in these areas contaminate ground and surface water because percolation is impossible since the soil is saturated leading to infiltration and ex-filtration process in the septic tank (Daniels and Weaver, 1987). Under this condition, soil depth which would have served as a universal filter becomes a limiting factor in the treatment process.

Incidences of water-borne diseases in Nigeria urban areas leading to millions of death have been reported. Some of these deaths have been traced to the use of waters grossly polluted by untreated waste (UNEP, 2005). Epidemiological records in the Niger Delta, Nigeria also reveals the prevalence of water-borne diseases such as diarrhea, dysentery and typhoid (Ochuko and Thaddeus, 2013). Empirical data show that 115 cases of water borne diseases representing 20.24% of all cases were reported in Ugheli, Delta state, Nigeria. These reported cases are attributed to high water table and high probability of groundwater contamination with faecal wastes coupled with poor waste management techniques and disposal problems in the area (Ogbonna *et al*., 2002; 2007). Microbes may travel with the plume of percolating water from the septic tank and contaminate the drinking water sources.

Large portions of the population of the people of Niger Delta are still served by septic systems as opposed to public waste treatment facilities. Besides there are also site specific environmental factors around septic tanks and leach fields such as soil properties, water-table location, subsurface geology, climate and vegetation which may affect the quality and quantity of waste water released from the septic tank. This water may seep to the land surface, runoff into surface water or flow directly into the water table to cause contamination.

As our environment gets urbanized, there is always the tendency of population increase and with the attendant increase in industrial development. This implies a rapid increase in domestic sewage generating capacity. Unfortunately, the rate of provision of infrastructural facilities has not been growing fast pari-pasu with the rate of generating domestic waste. Most worrisome is the crude manner in which the sewage is evacuated and disposed of in haphazard manner into bodies of water, streams, open spaces and drainage channels or even composited and used as fertilizer. The issue of concern is the seepage of the liquid content of the sewage that carries feacal materials and other pollutants towards the groundwater bodies. The high porosity and permeable nature of the subsurface geologic formation materials and the shallow depth of water table of the Niger Delta region make the ground water bodies highly vulnerable to these pollutants and subsequent exposure of man to associated dangers and diseases (Plummer and Mc Geary, 1993; Burabai *et al*., 2007; Obasi and Balogun, 2001; Omuta, 1999; Tamunobereton-ari *et al*., 2013; Ochuko and Thaddeus; 2013). Eventually leachates from these wastes find its way into boreholes, lakes, wells and other water bodies. The consequence is that, water quality is highly affected which becomes highly dangerous (Obasi and Balogun, 2001; Mogborukor, 2012). It is therefore the objective of this paper to evaluate the performance of biozymes as organic waste degrader in septic tanks to avoid contamination of water resources and cause water-borne diseases. Basically biozymes contain nutrients and micronutrients that stimulate the germination and outgrowth of the synergistic microbial consortium. Because septic tanks contain pathogens, high concentration of nutrients such as phosphorus and nitrogen, and some toxic chemicals, this waste water needs treatment with biozymes before being released to the environment. The use of biozymes is a biological process which is cost effective and convenient solution to organic waste or waste water treatment. This can be regularly inspected upon application and maintained to function properly to prevent contamination of nearby wells, ground water sources or streams. Also periodic purifying of septic tank keeps solids from accumulating in the tank, reaching the outflow and clogging the drain field. Biozymes are not poisonous but may cause slight eye, nose and skin irritation on prolonged or excessive exposure.

1.3 Description of a septic tank

A septic tank is a settling tank which collects and stores sewage solids and liquid. Raw sewage flows into the tank from the house sewer (Machmeier, 2000). It is the essential first part of an onsite sewage treatment system. It represents a major household wastewater treatment option. A septic tank is made up of concrete, blocks and should last for about fifty years. The tank itself is water tight and divided into two semi-compartments. When wastes flows into the tank, the heavy solids especially feaces sink into the bottom to form a layer of “sludge” while the lighter materials such as grease, fats, small food particles floats on the surface forming a layer of “scum”. Between these two layers is a soup of suspended materials and water soluble chemicals such as urea from urine and many household chemicals (Davis, 2000).

The modern septic tank is made up of block, concrete or fiber glass and buried underground. It consist of a single chambered tank unit, plastered and made water proof on the inside, if they are to be situated in water-logged environments. The block types are predominantly in use in Nigeria. On the other hand, the concrete ones are used for the collection of large sewage. Both the concrete and the fiber glass types are well situated for sites with high water tables. The septic tank provides only partial treatment as the effluent produced requires further treatment before final disposal. This is achieved by combining the tank system with a soil absorption system. Here, the percolation area provides the required secondary treatment for the primary treated effluent released from the septic tank. Generally, the waste content in the septic tank consists of three separate zones; a scum layer on top; a clarified liquid zones in the middle and a sludge layer at the bottom. Generally, for the operation of the tank, the scum layer prevents oxygen transfer through the water interface thus maintaining anaerobic conditions. It also insulates the anaerobic chamber preventing heat loss, hence increasing micro-organic activities. As sludge builds up, the volume of the liquid zone is reduced and settlement efficiency and retention time is reduced. In all, the supernatant process flows through the effluent pipe and the filters into the ground to the zone of saturation where it meets the ground water table.

1.4 Performance of septic tanks

Septic tanks separate solids from liquids by gravity settling which now reduces the BOD and TSS in the effluent. Anaerobic decomposition will also reduce the volume of accumulated solids on the bottom of the tank by 40 – 50% producing methane, carbon dioxide, water and sulfide gases (Seabloom *et al*., 1982; USEPA, 2000) while inorganic solids (i. e. sand) and undigested organic solids form sludge in the bottom of the tank which requires removal before accumulation reaches a volume that hinders performance. The scum layer formed of soaps, oils, greases and light debris should also be removed before it becomes too thick and passes around the sanitary tee and out of the septic tank (Seabloom *et al*., 1982; Rahman *et al*., 1999).

A sanitary tee on the outlet prevents floating scum from exiting and clogging the wetland or tile field receiving the effluent. For a two-chamber tank, the chamber dividing wall allows liquid free of scum and sludge to pass from the first chamber to the second chamber, and it has ventilation above the liquid level to allow pressure equalization between the chambers. Sufficient tank volume is necessary so that after the maximum expected volume of sludge and scum has accumulated, the tank has a minimum of 24-hour fluid retention time for particulate settling (Crites *et al*., 1998; USEPA, 1980; 2000).

2.0 Materials and Methods

2.1 Application of Biozymes

The capacity of a septic tank typically ranges from 3,785 to 7,570 litres (1,000 to 2,000 gallons). Recommended feed rate for application of biozymes in septic tanks measuring 6ft width x10 ft lengthx12ft depth respectively, can take a dosage of 170.1g each but twice weekly for a family of 5-7 persons in a household. As the waste water from a home enters each of the tanks through the PVC pipes, the velocity of flow are reduced providing relatively quiescent conditions, which allow portions of the suspended solids to settle to the bottom, permitting grease and other floatables to rise to the surface and are retained. The partially treated wastewater flow through the overflow elbow pipe into the second compartment where further physical and biological processes occurs. The effluent outlet connects the septic tank to the absorption field which is composed of perforated drain pipes covered with graded sand and gravel as to permit unobstructed passage of water by gravity. The secondary effluent from the absorption field drains by gravity through a horizontal screened outlet close to the bottom of the partition. The filtration process is aerobic at the first layer and anaerobic at the saturated zones of the bottom layers, making it mainly a facultative process (Burubai, 2005; Burubai *et al*., 2007). The entire structure is made of cement, sand and gravel nominal concrete mix. For drain fields and cesspools, dosage on application is 170.1g twice weekly while lagoons dosage is 453.6g daily.

Because it is expected that the BOD mass loading may be high enough to demand aeration, an electric powered (or solar powered panel) snorkel pump aerators may be installed. Although septic tanks maintain an anaerobic system, they are very important in the process of breaking down nitrogen containing substances, and treatment of sewage can take place which may result in tanks containing a floating mass that looked like tiny, dry plant seeds which may be identified as dead crustaceans and rotifiers.

2.2 Quantity of Biozyme powder required based on Demographic data

Each sachet of biozyme powder contains 1kg which is an equivalent of 1000 grammes. According to the manufacturer's prescription for application for a standard household septic tank of 6x10x12ft dimensions,ie width, length and depth respectively shall be 170.1 grammes to be applied twice weekly (ie 340.2 g), for a period of one(1) month a total of 1360.8 grammes shall be required (340.2 x4) This application method for the given standard septic tank will eventually reduce the incidence of contamination and pollution of water resources as a result of the biodegradation process which also eliminates the incessant evacuation of sludges from homes.

2.3 Microbiological analysis

Pilot trials on the Biozyme 1070 were carried out using standard analytical methods. Samples for microbiological analysis were aseptically collected randomly from five (5) septic tanks into 20 litre sterile plastic buckets and tightly closed. The analytical methods employed were as described by Obire and Wemedo (1996), Ofunne (1999) and Collins and Lyne (1980).This involved the enumeration of total heterotrophic bacteria (THB), total coliform bacteria (TCB) and *Salmonella-Shigella* bacteria (SSB). Serial dilution procedure as described by Obire and Wemedo (1996), Ofunne (1999) for cultivation of bacteria in the organic samples was employed. The ten-fold serial dilution was used to obtain appropriate dilutions of the samples. Aliquots of the required dilutions were spread plated in duplicates onto the surface of dried sterile nutrient agar and *Salmonella – Shigella* agar plates for total heterotrophic bacteria and *Salmonell-Shigella* bacteria respectively. In the case of total/faecal coliform bacteria, the most probable number (MPN) technique using multiple tables method described by Collins and Lyne (1980) was employed for estimation of their number in the organic wastes. Appropriate volumes of undiluted waste/effluent samples were inoculated into test tubes of Mac-conkey broth medium. All inoculated media were incubated at 37^0C for 24-48 hours except for faecal coliform bacteria set up incubated at 44.5^0C. After incubation, plates with significant growth were counted and the number of colonies obtained was recorded in colony forming unit per milliliter (cfu/ml) and represent the population of bacteria per milliliter of sample. For total/ faecal coliform bacteria, their numbers were estimated using a statistical table.

3.0 Results and Discussion

The bacteriological quality of the septic tanks analysed was found to be above the threshold level required when samples were analysed as control; that is total heterotrophic bacteria increased from $3.1x10^6$ to 14.4×10^6 cfu/ml on application of biozyme. This increase was due to the addition of the powder to the organic waste which contains bacteria as its component. This increase is also possible because the microorganisms associated with the organic waste used the nutrients available in the wheat bran blend to grow but may not produce the necessary enzyme to degrade the waste. The organic build up due to the application of the biozyme blend can serve as a back up in the subsequent cloning of the indigenous bacteria present in the waste. Biozymes contain nutrients and micronutrients that stimulate the germination and outgrowth of the synergistic microbial consortium. *Salmonella-Shigella* bacteria in the samples decreased from $12.0x10^4$ to $1.52x10^4$ cfu/ml, total coliform bacteria also decreased from 29,000 to 18,000 coliform/100ml while feacal coliform bacteria decreased from 16,000 to 12,000 coliform/100ml after 48 hours of application of the biozyme powder to the organic waste samples (Table1). These organisms are more or less intestinal bacteria and are not well adapted to living outside their host, hence they decreased. *Salmonella-Shigella* bacteria are pathogens and do not survive long in natural environment. The high proliferation of the heterotrophic bacteria may have posed a challenge for competition which the other groups of bacteria could not withstand for a long time. Physical observation of the wastes showed reasonable formulation of the waste sample which was turned from semi-liquid to completely liquid sample and became odourless. This process if well harnessed can produce biogas which can be tapped quickly with an improved technology.

Table 1: Bacterial counts in organic waste samples from 5 septic tanks treated with Biozyme 1070

Replicates	**Control (Day 1) Samples**				**Experimental (Day 3) Samples**			
	THB ($X10^6$ cfu/ml)	**SSAB ($X10^3$ cfu/ml**	**TCB (MPN index/100ml)nutritional**	**FCB MPN index /100ml**	**THB $X10^3$ cfu/ml**	**SSB $X10^3$ cfu/ml**	**TCB**	**FCB**
1.	2.5	13.9	30,000	17,500	12.6	2.10	19,100	11,250
2.	3.6	11.2	27,550	14,800	15.2	0.98	20,000	13,100
3.	2.9	13.0	26,500	13,200	11.9	2.02	13,530	10,950
4.	3.0	12.5	29,450	16,400	14.8	1.88	19,120	12,650
5.	3.5	9.4	31,500	18,100	17.5	0.62	18,250	12,050
Mean	3.1	12.0	29,000	16,000	14.4	1.52	18,000	12,000

Key: THB- Total Heterotrophic Bacteria; SSB- *Salmonella-Shigella* Bacteria; TCB-Total Coliform Bacteria: FCB-Fecal Coliform Bacteria

4.0 Remedial and Alternative Measures

1. **Terracing the sloppy areas**: This will reduce the speed of run off by giving it time to infiltrate into the soil, this will reduce the rate of soil erosion which in turn will reduce the rate of siltation of the wetland. A simulated natural environment in the form of field with grasses can be constructed for the filtration and biological treatment of waste water. This will be in the form of shallow beds filled with rocks or gravel usually planted with aquatic vegetation. The diameter of the rocks or gravel media ranges between 2 to 6 inches or 51-152 mm, both at the entry and exit zones of the wetland bed to facilitate fluid dispersion and prevent plant root encroachment (USEPA, 2000; Reed *et al*., 2001). They are designed to keep the liquid level 3 to 4 inches below the surface of the rock or gravel media to prevent public exposure to the waste water and mosquito breeding (Stewart, 2005). This will reduce waste water BOD, TSS and coliform bacteria (Crites *et al*., 1998; USEPA, 2000; Reed *et al*., 2001).

For large wetlands, it can often be designed with a sloped floor to provide complete drainage and provide the necessary head to overcome an estimated hydraulic conductivity. For a flat floor wetland, the height oiled water will be greater at the inlet, and the media depth should be increased at the inlet end to account for the higher water level. Small wetlands for single-family sanitation systems may use a variety of plants that improve water treatment and add colour to the water garden. Plants such as the soft rushes (*Juncus balticus*, *Juncus effuses*), umbrella palms (*Cyperus alternifolius*, *Cyperus papyrus*) and woolgrass (*Scirpus cyperinus*) have deep roots and do not grow too tall. These are beneficial characteristics. Graceful cattail (*Typha laxmanii*) is a dwarf variety that does not grow too tall but has shallow roots. Iris (*Iris versicolor*) and thalia (*Thalia dealbata*) provide attractive blooms and foliage variety, but may not significantly enhance water treatment (Schellenberg, 2001). Larger SSF wetland beds may use native aquatic plants such as rushes (*Juncus*), cattails (*Typha*), reeds (*Phragmites*) and bulrushes (*Scirpus*) that are tolerant to flooding and wastewater.

2. **Afforestation and conservation of vegetation cover**: Trees are very important in reducing the impact of raindrop on the soil through interception storage. The roots help in holding the soil particles together. When trees die or shed their leaves they increase the humus content of the soil hence improving the soil structure. In more swampy fields pollution effects can be controlled by planting on the wetland with local wild cane (*Gynerium sagittatum*), this will achieve tertiary with nutrient removal (Stewart, 2005). This wetland planted with wild cane will not produce effluent as it function as an evapotranspiration bed to decrease fluid content flow, also reduces ammonia and phosphorus content. Planting of wild cane may last for 10 months to become mature, but new growth will spread to cover the available space so that foliage may be considered young and in a rapid growth stage (Kalliola *et al*., 1991).

3. **Town planning:** The municipal council should come up with sound development plan for the area to get rid off the unplanned mushrooming slums where the fishermen reside. The town planning unit must engage in the monitoring and siting of underground septic tank in each compound to ascertain their compliance

with the minimum standard recommended for their location. Surface drains which carry such discharges must be adequately constructed, covered and disinfected regularly, if they must carry any form of sewage. This is because such subsurface sewage disposal systems are the largest sources of waste water to the ground, and are the most frequently reported causes of groundwater contamination (Miller, 1980; Ogbonna and Idam, 2007).

Efforts should be made by the government to decongest the urban centres of on-site sanitary facilities such as underground septic tanks/soil absorption systems and encourage the construction of off-site network facilities or a centralized sewage treatment system (sewer system) which is presently in use in Lagos and Abuja, Nigeria and then recycle such waste for agricultural purposes. This treatment system is required in regions prone to frequent heavy rains and flooding or in topographical depressions where surface waters accumulate.

6.0 Conclusion

Excess waste water and high concentrations of contaminants can take much longer to treat, especially when the consistency reaches that of a slurry or sludge. On the other hand, irrigation of soil with large quantities of waste water will saturate the soil and overload the biological degradation process. Excess untreated waste water can run off or percolate down to groundwater, causing contamination of drinking water supplies with faecal waste. Therefore the use of biozyme 1070 will help reduce the rate of pollution especially in areas with high water table and high probability of ground water contamination. Finally, since the soil absorption area must remain unsaturated for proper system functioning, it may not be feasible to install septic systems in regions prone to frequent heavy rains and flooding or in topographical depressions where surface waters accumulate.

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