the international water association

Feasibility of using Acti-zyme in Biological Sewage Treatment

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INTRODUCTION

Acti-zyme, a biocatalyst has been used for vast applications such as wastewater treatment, drains cleaning and odor elimination for the past 50 years [1]. Acti-zyme has been reported to treat wastewater either aerobically or aerobically, reducing wastewater contaminants properties such as total nitrogen (TKN), total phosphates (TP), nitrates, ammonia, biochemical oxygen demand (BOD) and total suspended solids (TSS) by >40%. Acti-zyme also increases dissolved oxygen (DO) by >100% in treated wastewater promoting aquatic life [1]. The use of Acti-zyme like any biological catalyst under anaerobic conditions has the potential to favor biogas production [2]. On the other hand sewage, a form of wastewater is being generated every day resulting in huge quantities of sewage sludge. There is need for sustainable and economical ways of treating this sewage; harnessing biogas being one of them [3]. Biogas is mainly composed of methane and can be used to meet electricity demands as well as other energy requirements of the sewage plants [4]. Acti-zyme therefore poses an economic and environmentally friendly way of treating sewage utilizing its biochemical properties [1]. This study focused on biochemical analysis of Acti-zyme so that its use in sewage treatment as a biological technique can be validated. Furthermore, application of Acti-zyme in sewage treatment, sludge digestion, biogas and biosolids production were investigated.

METHODS

Determination of Acti-zyme biochemical properties

8 biochemical tests were performed on the Acti-zyme. Acti-zyme obtained from Austech, Australia, was inoculated in a vial containing sterile media (pH of 7±0.2) containing peptone water. The vial was incubated (37.5° C, 24 hours). After incubation, the sample was plated on the following media: MacConkey Agar, Starch Agar, Kliger Agar, Urease Agar, Sulphide Indole and Motility Agar. Growth on the various agars was noted in terms of size of colonies, color and odor. Afterwards various biochemical tests such as Catalase test, Mannitol test, Urease test, Kligler test, Indole test and Motility test were performed in order to determine the properties of Acti-zyme especially for application in sewage treatment and biogas production.

Determination of Acti-zyme effect on sewage treatment

The collected raw sewage was stored at 0° C to avoid microbial activity in the sewage before addition of Acti-zyme. Experiments were carried out in 250 ml flasks with a 75% working volume. The raw sewage was tested for pH, total TP, TKN, chemical oxygen demand (COD), BOD_5, DO, sulphate ions concentration (SO_4^{2-}), chloride ions concentration (Cl^-), TSS, total dissolved solids (TDS) and electrical conductivity (EC). Sewage was inoculated with Acti-zyme loadings of 35-70 g/m^3 at retention times 0-60 days (37° C; agitation rate 60 rpm). TKN, TP, BOD_5, DO and COD, Cl^-, SO_4^{2-} values were measured using titration methods in accordance to the Alpha Standards Methods of determination [5]. TSS and TDS were measured througl using a Hanna HI electrode probe.

Determination of digestion of sludge using Acti-zyme for biogas production

Experiments were done for digesters with and without Acti-zyme for through determination of effect of Acti-zyme. The sewage sludge was filtered and dried to 80% moisture content using a Mermet oven. Anaerobic conditions were ensured **(Fig. 1)**. Sewage sludge organic loadings 5-10 g/L. day were employed to determine the optimum biogas production conditions [6]. Biogas quantity from the sewage sludge was measured through the displacement of water in milliliters per day (mL/day). A GC 5400 gas chromatography analysis was used for analyzing the biogas content and the composition was expressed as a percentage.

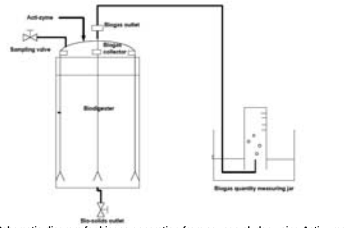

Fig. 1: Schematic diagram for biogas generation from sewage sludge using Acti-zyme

RESULTS

Acti-zyme biochemical properties

1. Acti-zyme was found to be an immotile biocatalyst, a suite of several enzymes: catalase with a detoxifying effect, protease, and amylase degrading macromolecules in sewage.
2. Urease which promotes ammonia production & a potential to cause eutrophication was absent.
3. Acti-zyme did not promote hydrogen sulfide production. Hence, biogas produced will be of good quality and will not need to go through further treatment processes.
4. Acti-zyme did not contain *Enterobacteriaceae* especially *E. Coli* and *Salmonella* which are pathogenic and are found in sewage. Therefore, Acti-zyme usage is not associated with health hazards and can efficiently promote biogas production in anaerobic sewage treatment.

Effect of Acti-zyme on sewage treatment & Biogas Production

Table 1– Sewage physicochemical properties before and after treatment with Acti-zyme

Parameter	Raw sewage	Treated sewage	EMA Guidelines
TKN (mg/L)	245±5.5	9.4±0.36	10-20
BOD_5 @20° C (mg/L)	557±15.3	41.8±1.08	30-50
TSS (mg/L)	608±16.1	37.3±1.02	25-50
TDS (mg/L)	535±13.2	59.4±0.53	500-1500
EC @25° C (μS/cm)	3887±32.1	1070.4±0.36	1000-2000
Cl^- (mg/L)	833±11.2	263.3±4.02	-
pH @25° C	9±0.3	6.3±0.1	6.0-9.0
Coliforms (cfu/mL)	$1x10^{11}$	$1x10^8$	≤1000
TP (mg/L)	52±3.0	1.4±0.24	0.5-1.5
SO_4^{2-} (mg/L)	1192±70.8	53.6±2.71	-
DO (mg/L)	7±0.2	87.0±0.20	≥ 60
Temperature (° C)	22±1.5	37±0.5	< 35
COD (mg/L)	738±12.6	77.9±2.24	60-90

1. Sewage was effectively treated with Acti-zyme to meet the effluent regulatory limits as stipulated by the Environmental Management Agency (EMA) **(Table 1)**.
2. Acti-zyme promoted sewage sludge digestion as determined through the biogas produced. Biogas production increased with increasing Acti-zyme loadings from 35 g/m^3 to 50 g/m^3 on all sewage sludge loadings from 5 g/L. day to 10 g/L. day as compared to digesters without Acti-zyme **(Fig. 2)**.
3. Optimum bio-methane rich biogas of 394 mL/day was obtained at 50g/m^3 of Acti-zyme and a sewage sludge loading of 7.5 g/L. day. Acti-zyme loading of 50 g/m^3 was found to be optimal in terms of bio-degradability of sewage [7] **(Fig. 2)** .

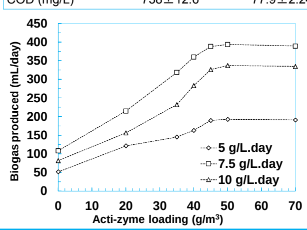

Fig. 2: Biogas production from sewage sludge with Acti-zyme

RESULTS

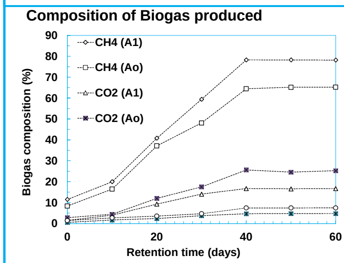

Fig 3: Composition of biogas from digestion of sewage sludge using Acti-zyme

A biomethane rich biogas was produced with CH_4 composition ranging from 72-78 **(Table 2)** % with a peak being obtained for sewage loadings of 7.5 g/L. day at an Acti-zyme loading of 50 g/m^3 as compared to Acti-zyme free digesters which had a bio-methane composition of 53-65% **(Figs. 2 & 3)**

Table 2: Summary of Biogas Composition

Gas	% Composition
CH_4	72-78
CO_2	16-20
Traces (H_2S, N_2, H_2)	5-9

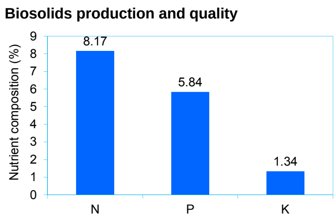

Fig 4: Biosolids from anaerobic digestion of sewage sludge using Acti-zyme composition

The biosolids obtained from the anaerobic sewage digestion using Acti-zyme had a final moisture content of 20% after drying. The bio-solids NPK content ranged from 8.17±0.15%, 5.84±0.03% and 1.32 ±0.02% (**Fig. 4**)

DISCUSSION

1. Acti-zyme effectively treated sewage removing all the wastewater contaminants to meet the required guidelines for effluent disposal in Zimbabwe at loadings of 50 g/m^3 and retention time of 40 days (Fig. 4, Table 1).
2. Sewage treated with Acti-zyme showed an overall > 90% reduction in the sewage contaminants. This makes Acti-zyme suitable for biological sewage treatment due to the digestion effect Acti-zyme on the sewage pollutants.
3. The biogas produced from sewage sludge activated with Acti-zyme contained CO_2 in the range 16-20 % and trace amounts of H_2S, N_2 and N_2. H_2S, N_2 and H_2 (Fig. 3).
4. CO_2 (22-27%) and trace gases (8-12%) were in higher quantities in digesters without Acti-zyme.
5. Acti-zyme promoted high quality biogas production due to the capability of Acti-zyme to hinder the production of contaminating gases, effectively improving the quality of the biogas [7].
6. Biomethane was found in high quantities due to the enhanced bio-degradability of the sewage sludge by Acti-zyme [7]. Sewage sludge loading of around 6.9-9.2 g/L. day have been recommended for optimal biogas production [6].
7. The bio-solids NPK content ranged from 8.17±0.15%, 5.84±0.03% and 1.32 ±0.02% as indicated in Fig. 4 and therefore can be classified as high nitrogen content biosolids. The reduction of water content in the bio-solids from 80% to 20% as well as the hindering effect from Acti-zyme resulted in a significant decrease in *E. Coli* content from 10^{12} to 10^6 cfu/L. Lower moisture levels hinder *E. Coli* growth making the bio-solids safe for application

CONCLUSIONS

Acti-zyme has biochemical properties that allows it to be used in sewage treatment. Biological treatment of sewage with Acti-zyme results in an effluent that has physicochemical characteristics that meet set effluent disposal standards. Digestion of the sewage resulted in a biogas that is rich in biomethane.

Additionally, bio-solids which are rich in fertilizer NPK nutrients are produced and can be utilized as bio-fertilizers. This can result in sustainable management of sewage sludge in developing countries

The integrated approach reported in this study highlights energy recovery and waste management. This will have significant economic and environmental impact.

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Acknowledgements: Harare Institute of Technology and Cape Peninsula University of Technology are thanked for funding this work.