THE EFFECT OF USING MICROORGANISMS ON SLUDGE REDUCTION IN WASTEWATER TREATMENT PLANT

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ABSTRACT

Sludge dewatering and treatment may cost as much as the wastewater treatment. Usually large proportion of the pollutants in wastewater is organic. They are attacked by saprophytic microorganisms, i.e., organisms that feed upon dead organic matter. Activity of organisms causes decomposition of organic matter and destroys them, where the bacteria convert the organic matter or other constituents in the wastewater to new cells, water, gases and other products.

The main objective of the present search is to improve an effective way and applicable methods of sludge volume reduction so as to increase the capacity and improve quality of the treatment in lagoon, thickener…etc.

A bench scale model was set at the environmental engineering department laboratory, in the Faculty of Engineering, Zagazig University. Samples of wastewater were collected from Aslogy wastewater treatment plant, Zagazig, Egypt. The using bacteria embed on granular delivered as powder. Two runs of experimental works have been done using bacteria with different doses (0.5, 1, 2 & 4 gm/l) for up to 8 weeks.

Experimental results were indicated that there is no remarkable improvement in COD removal ratio than reference sample in wastewater by adding the used microorganism even at dose of 4 gm/l. However, the sludge volume showed remarkable decrease, due to the use of the bacteria to about 63% more than that of the reference sample.

Keywords: Bacteria, COD, Sludge volume, Organic mass

INTRODUCTION

Most treatment systems for domestic sewage depend on a wide array of aerobic and facultative anaerobic microorganisms, mainly bacteria that can utilize the raw organic material as a carbon and energy source during their growth and reproduction. As a result, these microorganisms decompose much of the organic fraction into simpler, less-toxic compounds; destroy pathogenic (i.e., disease-causing) microorganisms; stabilized the system by decreasing its volatility; and facilitate the recycling of water for domestic, agricultural and environmental use. Wastewater contains various types of bacteria, virus, protozoa, algae, fungi etc. Some of these are pathogens and harmful to the human and animal life, (Metcalf & Eddy, Inc. 1995). Otherwise, a factor often overlooked in the selection of a treatment process is the needs of the owner of the facilities. Owner needs may take the form of limitations of cost and the ability to pay for the project. This mean that cost considerations are a major significance in the selection of the wastewater treatment.

Horng et al. (2004) made an invention. The primary objective of the invention is to provide a cost-effective apparatus and a workable method of reducing biological wasted sludge so as to improve quality of the treated water. The invention includes subjecting a biological wasted sludge to hydrolysis and neutralization treatments to offer an intermediate feed suitable to be treated in the membrane bioreactor (MBR). The hydrolyzed sludge and microorganisms are retained in the MBR, so that a further hydrolysis of sludge and decomposition of organics undergo to achieve the objectives of stabilization of sludge and reduction of sludge.

Banerjee and Hooda (2005) added specialty microorganisms to pulp mill aeration stabilization basins able to reduce sludge in-situ. Laboratory work undertaken to identify the machinist showed that a cell-free extract prepared from the microorganisms decreased the length of pulp fibers that are the principal components of primary sludge. The hemicellulosic components of the fiber degrade upon exposure. A controlled field study was also run in the secondary treatment system of a pulp mill. Primary sludge was held in vials capped with semipermeable membranes that allowed liquid and gas to flow through the vials. Vials containing sludge, to which we added microbes, were placed in the lagoon. No decrease in sludge mass was observed over seven months of exposure to the lagoon water. This proposes that the sludge reduction observed in the field occurs from initial degradation of the fibrous sludge into smaller fragments that are then slowly mineralized. This study helps identify the mechanisms by which specialty organisms are able to break down fibrous sludge in wastewater treatment systems.

Wang et al. (2003) aimed to intensify conventional composting of a mixture of sewage sludge and solid food wastes by a one-stage thermophilic bioconversion of these wastes into an organic fertilizer. An intensive process was carried out in a closed system, with or without addition of a starter culture of Bacillus thermoamylovorans. The most effective thermophilic bioconversion of the mixture of food waste and sewage sludge, with addition of starter culture, was when the pH was buffered with calcium carbonate, or the pH drop in the material was prevented by preliminary removal of sulphides from sewage sludge by hydrogen peroxide.

The using of *biological additives*, like bacteria and extracellular enzymes mixed with surfactants or nutrient solutions, was studied. Some biological additives have been found to degrade or dissipate septic tank scum and sludge, [10].

Some studies suggest that material degraded by additives in the tank contributes to increased loadings of biochemical oxygen demand (BOD), total suspended solids

(TSS), and other contaminants in the otherwise clarified septic tank effluent. The web site (water.me.vccs.edu/courses/Env108/lesson8_3b.htm) showed that filamentous bacteria serve as the backbone of floc formation. Sludge settles most efficiently when it contains a moderate number of filaments which provide structure for the floc and aid in the stripping of the water column. The floc cannot form properly if there are too few filaments, and the floc cannot settle properly if there are too many. During a nutrient deficiency, the bacteria within the floc particles remove soluble BOD from the wastewater. However, when nitrogen or phosphorous is deficient, the soluble BOD is not degraded but it is stored within the floc particles as an exocellular polymer-like material. This slimy material interferes with settling and may cause foam upon aeration. Bulking is a problem consisting of slow settling and poor compaction of solids in the clarifier of the activated sludge system. Filamentous bulking is usually caused by the excessive growth of filamentous microorganisms. Sludge settleability is determined by measuring the sludge volume index (SVI), which is the ratio of the sludge volume (SV), to the mixed liquor suspended solid (MLSS):

$$SVI(mL/g) = \frac{SV \times 1000}{MLSS} \qquad (1)$$

- A high SVI (>150 mL/g) indicates bulking conditions, whereas an SVI below 70 m L/g indicates the predominance of pin (small) floc.
- Filamentous bacteria can be controlled by treating the return sludge with chlorine or hydrogen peroxide to selectively kill filamentous microorganisms.
- Chlorine concentration should be 10-20 mg/L (concentrations greater than 20 mg/L may cause deflocculation and formation of pin-point flocs). However, chlorination is sometimes unsuccessful in bulking control. Hydrogen peroxide is generally added to the return activated sludge (RAS) at concentrations of 100-200 mg/L. However, as shown for chlorine, excessive levels of hydrogen peroxide can be deleterious to floc-forming bacteria.
- Numerous measures for controlling foams in activated sludge have been proposed. Several of these cures are not always successful and have not been rigorously tested under field conditions. The control measures proposed include chlorination of foams, increase in sludge wasting, use of biological selectors, reducing air flow in the aeration tank, reducing pH and oil and grease levels, addition of anaerobic digester supernatant, water sprays, antifoam agents, physical removal and use of antagonistic microflora.

Concept and technology of microorganisms was developed by Professor Dr. Teruo Higa at the University of Ryukyus Okinawa, Japan in 1970. Dr. Teruo Higa' effective microorganisms have shown great promise in wastewater treatment (Higa, 1998). Effective microorganisms' application has included cleaning polluted waterways, lagoons, septic system, and municipal wastewater treatment plants.

El-Monayeri et al. (2007) studied the effect of using effective microorganisms on anaerobic sludge digestion and insure that effective microorganisms have unique ability to stabilize complex organic matter through a shift from anaerobic putrefaction cycles to a fermentative cycle.

An European environmental biotechnology research company, using process called bio fixation which embeds bacteria in granules to degrade virtually all industrial and municipal organic pollutants from water and soil, and which does not require separate tanks, membranes, chemicals, heat or wasting treatment. The products are powders delivered in bags of 25 kg; those powders are manually spread over the polluted area, directly in sewage networks or in aeration tank of wastewater treatment plant. The result of using this product is big costs saving and efficiency improvements to the current methods of wastewater treatments. In 1997, Idrabel trade mark has worked with Construction Authority for Potable Water and Wastewater, CAPW to demonstrate the efficiency of IDRABEL in decreasing the mechanical cleaning of sewage collector, decrease odor and reduction of the sludge to be treated in wastewater treatment plant. The aim of the present research is to provide an effective way and a workable method of sludge reduction so as to increase the capacity and improve quality of the treatment in lagoon, thickener…etc.

MATERIALS AND METHODS

A bench scale model was done in the Environmental Engineering Department laboratory, Faculty of Engineering, Zagazig University, where five cylinders with capacity (one liter) filled with wastewater which taken from Aslogy wastewater treatment plant after grit removal chamber. One cylinder used as reference where operate without adding any bacteria to it. The counts of heterotrophic bacteria in the used mixture were 1100 cfu/g. The microbial consortium utilized in the present research is composed by harmless, widespread, ubiquitous microorganisms with known degrading capabilities, created by 'IDRABEL srl', Italy (www.idrabel.it and literature therein). The product consists of a powder and contains indigenous activated microorganisms, that are inserted or bio-fixed, through an ion-exchange process, within a protective material support composed by natural components (coccolite, grain size > 2 mm). The microbial strains are selected for their capability to degrade organic compounds and are formed by: Bacillus subtilis, Bacillus licheniformis, Pseudomonas putida, Lactobacillus helveticus, Lactococcus lactis, Trichoderma reesci, Trichoderma hazonium, Phanerochaete chrysosporium, Nitrosomonas sp., Acinetobacter genospecies and Arthrobacter sp. Total heterotrophic counts in bacteria mixture was made as, one gram of bacteria mixture was aseptically diluted in 99 ml phosphate buffer and plated on nutrient agar using pour plate technique as described by Demain and Davies (1999). Counts were recorded after incubation for 24-48 hours at 28°C.

The chemical oxygen demand (COD) were measured from samples taken just before and after added bacteria doses. All the measurements were analyzed, accordance with "The Standard Methods for the Examination of Water and Wastewater, 20th Edition, 2000". In this study the experimental program will be done through two runs. Different doses of bacteria are added to the same volume of wastewater, and tested them with time.

COD concentration in the raw wastewater was 730 ppm. In the first run, five cylinders with capacity (one liter) will be used in this experiment; they fill with raw wastewater which brought from Aslogy wastewater treatment plant after grit removal chamber, one cylinder used as reference sample, no bacteria added to it. The other cylinders added bacteria doses as follow 0.5, 1, 2 and 4 gm/l, respectively. After two weeks, the COD was measured in wastewater samples and the COD removal efficiency was calculated, see Table (1).

Table (1) COD removal ratio

Bacteria dose (gm/l)	**COD after 14 days (p.p.m)**	**COD removal ratio (%)**
0	135	82
0.5	130.5	82
1	121.5	83
2	130.5	82
4	126	83

After three weeks the volume of sludge and the concentration of COD in sludge and sludge mass were calculated, see Table (2).

Table (2) Sludge madss (mg)

Bacteria dose (gm/l)	**Sludge volume (ml/l)**	**COD in sludge (p.p.m)**	**Sludge mass (mg)**
0	7	10000	70
0.5	6	9600	57.6
1	6	9500	57
2	4.5	9500	42.75
4	4	9300	37.2

In the second run, the experiment was repeated by using fixed bacteria dose equal (4 gm/l) at different retention times starting from 3, 5, 6, 7 and 8 weeks to test the effect of this dose on raw wastewater with COD concentration 800 ppm. At the end of every retention time the sludge COD and the volume were measured and the sludge mass was calculated, see Table (3).

Table (3) Second run results

Bacteria Dose (gm/l)	Period (weeks)	COD in sludge (ppm)	Sludge volume (ml)	Sludge mass (mg)
0.0	8	10000	4	40
4	3	9000	4.8	43.2
4	5	13000	3.1	40.3
4	6	13500	2.3	31.1
4	7	13000	1.8	23.4
4	8	11000	1.5	16.5

RESULTS AND DISCUSSION

The results of the first run showed that COD concentration versus the different doses of bacteria in the five cylinders from 0.0 to 4.0 gm/l after retention time (14) days were much closed. The COD in reference sample nearly closed to the samples with bacteria dose 4 gm/l were (135) and (126), respectively. The COD removal ratio in the water samples according to the used dose 0, 0.5, 1, 2 and 4 gm/l were 82, 82, 83, 82 and 83% respectively as seen in Fig. 1. From the previous results it's clear that the used doses gave close result. This indicates that these bacteria had little effect on the polluted water samples under these conditions.

The COD concentration in sludge after retention time three weeks; where at reference sample 10,000 ppm while in cylinder with bacteria dose 4 gm/l; was 9300 ppm as seen in Fig. (2). At the same time, the volume of sludge decreases with increasing the dose of bacteria to 4 gm/l. It reached to 4 ml/l while in reference was 7 ml/l, Fig. (3). The sludge mass decreases to 37 mg/l with increasing bacteria dose to 4 gm/l, Fig. (4). The results of the first run showed that this kind of bacteria had affected the reduction of sludge volume.

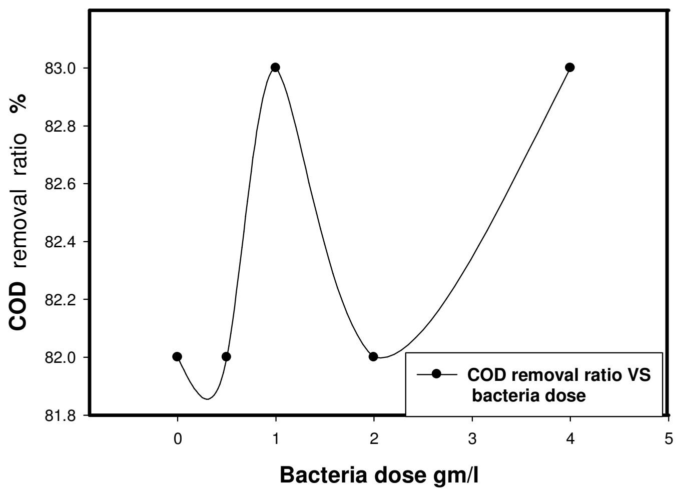

Figure (1) COD removal ratio% versus bacteria doses gm/l after (14) days

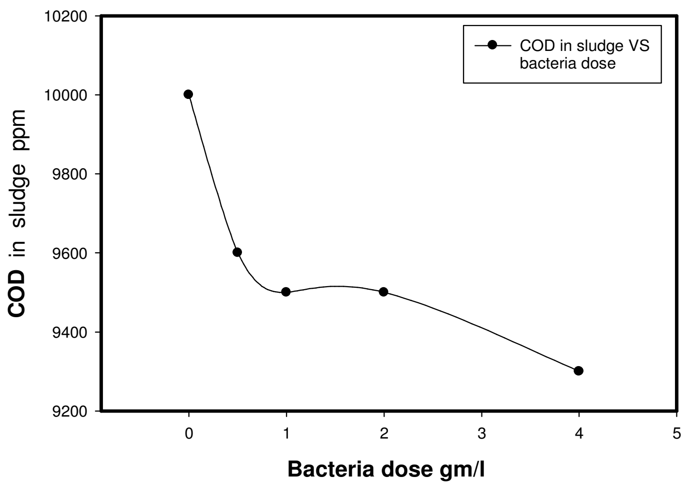

Figure (2) COD concentration in sludge versus after (21) days bacteria doses gm/l

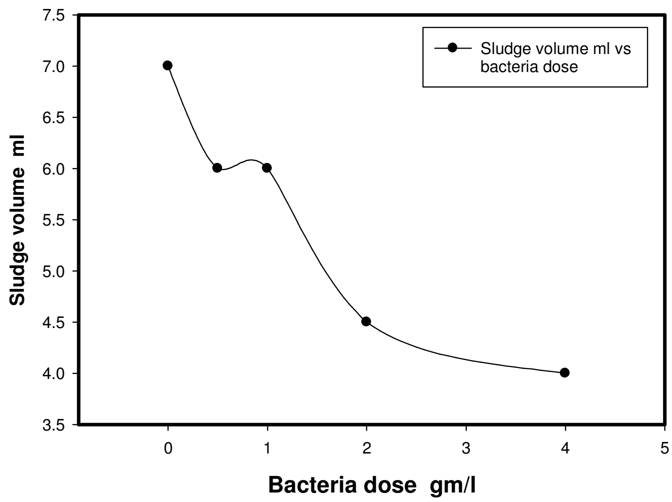

Figure (3) Sludge volume versus bacteria doses gm/l after (21) days

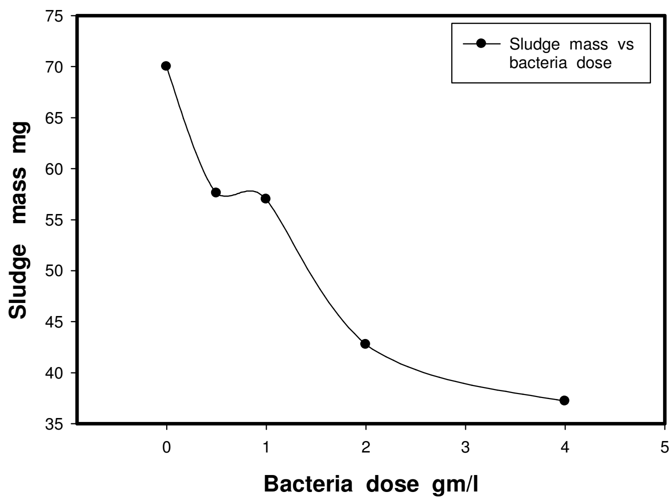

Figure (4) Sludge mass versus bacteria doses gm/l after (21) days

The COD concentration in sludge in the second run was 9000 ppm after three weeks retention time, then with increasing the retention time to 5 and 6 weeks, COD concentration was increased due to the settling of organics material as seen in Figure (5). But after 7 and 8 weeks retention time, COD was decreased again. The volume of sludge was decreased to 1.5 ml/l with increasing the retention time to 8 weeks where in the reference sample at the same time equal 4 ml/l, see Figure (6). The sludge mass after 8 weeks was 16.5 mg/l, where in the reference sample at the same retention time was 40 mg/l, see Figure (7).

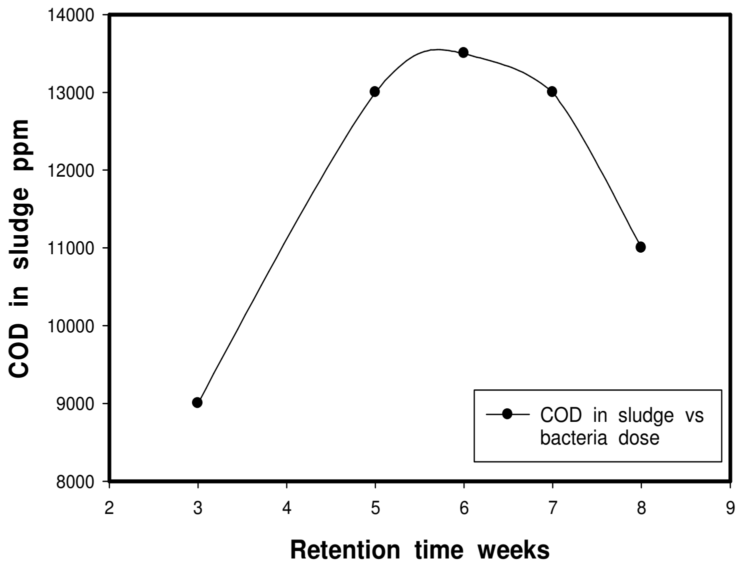

Figure (5) COD in sludge versus retention time (week), at fixed bacteria dose (4 gm/l)

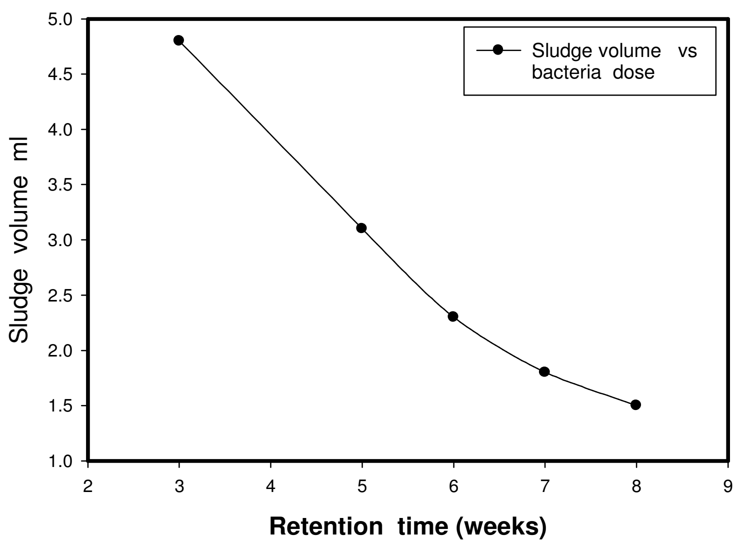

Figure (6) Sludge volume versus retention time (week), at fixed bacteria dose (4 gm/l)

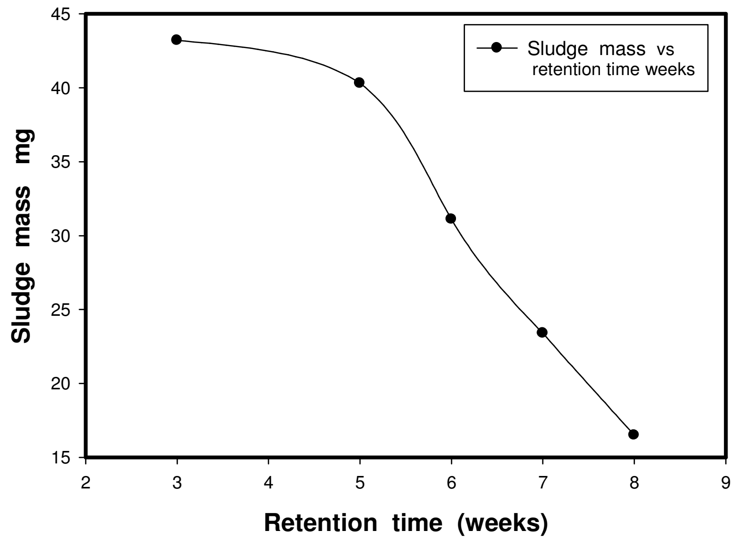

Figure (7) Sludge mass versus retention time,
at fixed bacteria dose (4 gm/l)

The results of the second run show that this kind of bacteria had affected the reduction of sludge volume clearly. The sludge volume was reached 1.5 ml/l and sludge mass 16.5 mg/l after retention time (8) weeks at fixed bacteria dose 4 gm/l.

CONCLUSIONS

Based on the above study under the condition of the experiments which was mentioned before the following conclusions could be deduced:

- The laboratory analyses to the using bacteria were indicated that the microbial consortiums utilized in the present research are composed by harmless, widespread, ubiquitous microorganisms with known degrading capabilities.
- Bacteria dose 4 gm/l gave sludge mass equal to 16.5 mg/l after (8) weeks retention time, while it gave 40 mg/l in the blank sample after the same retention time., i.e. Bacteria dose 4gm/l gave the best result comparing to the different tested bacteria doses under the tested condition in this research.
- As a result of reducing the volume of sludge in all the stages of experimental works, the use of this bacteria increased the capacity of the sludge holding unit, (ponds, thickeners …etc.) and it's expected that the released gases from the sludge will be reduced and the water quality will be enhanced.

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