THE EFFECT OF INOCULUM ON ENHANCED BIODEGRADATION

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ABSTRACT

Considering the importance of the environmental concerns associated with hazardous substances, specifically from a public health perspective, the potential of biological treatment was tried for a hazardous waste sludge, viz., and pharmaceutical sludge in the project work. Biological degradation for the complete treatment of pharmaceutical waste sludge and its reuse pattern has the potential for effective, practical and economical remediation from the effect of discharge of toxic and hazardous compounds to the environment. In order to understand and predict the environmental fate of toxic and hazardous compounds present in the pharmaceutical waste sludge, and to develop or improve biological treatment, a case study was conducted. This paper concentrated on the existing problem of a pharmaceutical industry with respect to disposal of secondary pharmaceutical sludge. In order to characterize the changes in the sludge properties that lead to inadequate treatment and disposal problems and to find a key solution, a comprehensive experimental study was conducted. The characterization and the effect of inoculum-substrate ratio on acclimatization of pharmaceutical secondary sludge were studied. The effect of enhanced biodegradation was assessed and evaluated for the conversion of pharmaceutical secondary sludge to biosolids. The enhanced biodegradation was found to be effective for the biosolids conversion by using the conventional inocula adopted for municipal and conventional biological treatment plants.

Key Words: Biosolids, inoculum, pharmaceutical , secondary sludge and biodegradation

INTRODUCTION

Human, animal, and plant life are invariably accompanied by wastes. These wastes are part of the life and are recycled back to the earth. New animal and plant life result from the biomass and nutrients contained in these wastes. This recycling process, if done naturally and wisely, supports life on earth. The challenge is to recycle the naturally

occurring waste materials so that life is sustainable. This project work describes how humans are working to meet this sustainability challenge by increasing knowledge of the properties of waste materials. This knowledge, coupled with a clear vision that waste materials are feed stocks for agronomic and non-agronomic uses, will allow further tailoring of their design for technological and social benefits of society. Such increased knowledge would develop a remarkable impact on the ability to sustain and improve the environment.

This experimental study focuses primarily on the management of industrial wastewater solids collected and treated from pharmaceutical effluent treatment plant. The solids generated from physical and biological wastewater treatment processes have been categorized under sewage sludge depending on their origin. The conversion of sewage / sludge to biosolids has been recognized in the recent years for their recyclability to the earth. Biosolids are the primarily organic solids yielded by municipal wastewater treatment processes that can be beneficially recycled. The benefits of this valuable, recyclable, resource as a fertilizer or soil conditioner.

Like many other industries, the pharmaceutical industry also produces a wide variety of products. During the production of the active chemicals in a pharmaceutical process, considerable volumes of solvents used to selectively extract the compounds from fermentation broths and other media. Many of the best extraction solvents, such as methylene chloride, are also among the more toxic and, therefore, more strictly regulated compounds. The bulk of toxic compounds have to be removed from the emission before discharge, the emissions to the environment. It is also economic to recover and reuse the products. In the recent years, India is experiencing a state of acute land pollution due to recalcitrant and toxic nature of industrial effluents and biosolids. The Indian pharmaceutical industry has established itself as one of the largest as well as fast growing industries in the priority sectors of industrial location across the country. During the past decade it was seemed to be significant that the pharmaceutical industry has registered for a compound annual growth rate of nearly 19%, which is currently valued at about 5.8 billion US dollars contributing for the production of bulk drugs required for major therapeutic applications. Nearly 20000 manufacturing units leading to 250 pharmaceutical

companies (including 50 Multinational Companies), control 70% of the market with a share of around 7%. (Indian industry finder, 2002).

Pharmaceutical industries mainly antibiotic and synthetic drug based industries suffer from inefficient management of discarded pharmaceutical (Musson and Townsend., 1998) and inadequate secondary sludge treatment due to the presence of recalcitrant substance and insufficient carbon substrates and nutrients. Hence the present study focuses on an existing pharmaceutical industry-facing problem due to the treatment and disposal of secondary pharmaceutical sludge. Also the treatment plant shows that it does not require the recycle and reuse of sludge produced. In order to characterize the changes in the sludge properties that lead to the management and disposal problems and to find a solution, a comprehensive experimental study was conducted.

Considering the importance of the environmental concerns associated with hazardous substances, specifically from a public health perspective, the potential of biological treatment was tried in the project work. Biological degradation for the complete treatment of pharmaceutical waste has the potential for effective, practical and economical remediation from the emission of toxic and hazardous compounds to the environment. In order to understand and predict the environmental fate of toxic and hazardous compounds present in the pharmaceutical waste and to develop or improve biological treatment, an insight into the mechanism and pathways of various biodegradation approaches have been aimed for the study exploited by various specific microorganisms. Biodegradation of biosolids by mixed bacterial culture under Methanogenic conditions has been shown to occur by a series of batch experiments. Further, the transformation or conversion of biosolids by bioaugmentation, would further destroy the toxic and hazardous compound in biological treatment system.

MATERIALS AND METHODS

COLLECTION AND PRESERVATION OF SAMPLES

The sludge was collected in the Chemicals and Pharmaceuticals Limited, SIDCO Industrial Estate, Alathur, and stored in a 4°C refrigerator to prevent biodegradation. The

frequency of collection of sludge is once in four months (this is to check variation of parameters over the three periods i.e., 12 months)

CHARACTERIZATION OF PHARMACEUTICAL EFFLUENT PLANT SLUDGE

In the Table .1 presents in the characterization of secondary pharmaceutical waste sludge from Pharmaceutical Effluent Treatment Plant.

EXPERIMENTAL SCHEME

The biological degradation of pharmaceutical secondary sludge was studied under two stages. The stage-I was concentrated on the characterization and acclimatization (biomass activity) under batch system and the stage-II was concentrated on the enhanced biodegradation of pharmaceutical secondary sludge by bioaugmentation method.

Stage-1: Biomass Activity Tests under Batch System

The biomass activity tests under batch system were carried out by three phase investigations. The tests were carried out in five liters plastic canes with a useful volume of 1800mL for various proportions with cow dung and sludge for 1:1, 2:1, 3:1 and 2:0.5 ratios. The tests were conducted for two different dilutions (10% and 50% dilution) of the above proportions. The canes were kept at average ambient temperature varying from 32°C -35°C and the canes are closed tightly, so that the anaerobic conditions are maintained. The analyses for pH, TS, TDS, TSS, TVS, TVSS, VFA, COD and alkalinity were carried out for the above mentioned ratios after mixing at a frequency of once in 4 days. This is the Phase-1 investigation. Following charts shows the Experimental Systems.

In the phase-1 study there is no considerable reduction of COD and VSS. To achieve a considerable reduction of COD and VSS a useful volume of municipal sewage (300mL) was added in the reactor and the measurements are made for reduction. The analyses made in the Phase-1was repeated here also but the frequency of collection of sample was once in 7 days. This is the Phase-2 investigation.

Table .1 Characterization of pharmaceutical effluent plant sludge

Sl. No.	Characteristics	Values*
1.	pH	7.26 - 7.28
2.	Electrical Conductivity	5.13 - 5.15
3.	Alkalinity	7721.4 - 7725
4.	Total Solids	302900 - 303000
5.	Total Dissolved Solids	6650 - 6670
6.	Total Suspended Solids	296250 - 296400
7.	Total Volatile Solids	76200 - 76500
8.	Total Volatile Suspended Solids	75100 - 75250
9.	Total Chemical Oxygen Demand	160000 - 1600100
10.	Soluble Chemical Oxygen Demand	16000 - 16050
11.	Volatile Fatty Acid	1380 - 1400
12.	Total Kjeldahl Nitrogen	1000 - 1014
13.	Phosphorus	5900 - 6000
14.	Specific gravity (32°C)	1.106 – 1.110
16.	Alkalinity / VFA	5.6 – 5.78

*All units are in mg/L except pH and Electrical Conductivity is in mS/cm

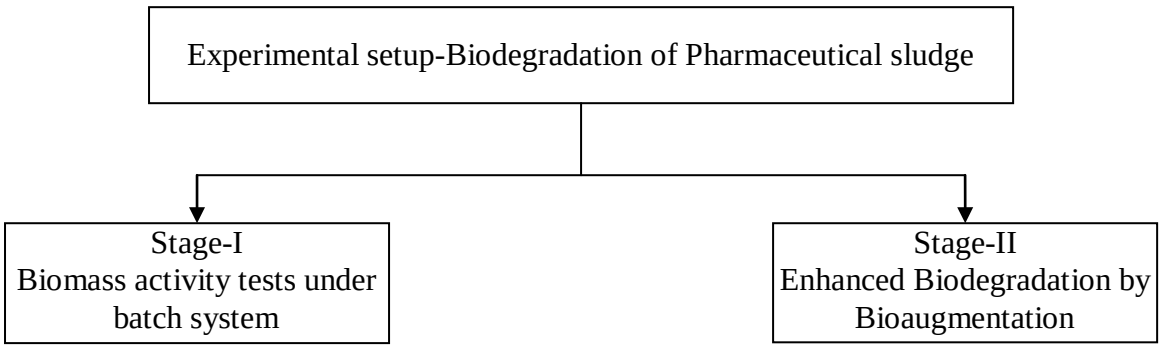

Figure .1 Flow chart for experimental setup- biodegradation of pharmaceutical sludge

In the third phase of the study, to achieve a full reduction of COD and VSS and to increase the destruction rate a useful volume of municipal sewage of 300mL, cow dung of 500mL and nutrient of 45mL was added. All the measurements were carried here also.

Table .2 shows the characteristics of raw cow dung and raw municipal sewage used for the experimental system.

Table .2 Characteristics of the raw cow dung and raw sewage

Sl No.	Parameter	Raw Cow dung*	Raw Sewage*
1.	pH	6.4	7.4-7.5
2.	TS	85900	3750
3.	TVS	76400	1650
4.	TVSS	61800	800
5.	COD	82400	1850
6.	Alkalinity	5985	9113
7.	VFA	2538	-

*All units are in mg/L except pH

Stage-II Enhanced Biodegradation by Bioaugmentation

The Pharmaceutical waste secondary sludge containing hazardous organic compounds, often difficult to treat effectively using conventional anaerobic treatment processes. The difficulty is an inability to maintain a continuously acclimated culture, and is due to factors such as non-steady state composition of waste (Both the easily degraded and the more resistance hazardous constituents), unsteady loading conditions (Spikes and discontinuities), and compound recalcitrance (due to toxicity or slow degradation rates).

To ensure the removal of the hazardous compounds prior to their release in the environment a method called Bioaugmentation was used to enhance the biodegradation of pharmaceutical waste secondary sludge by enrichment cultures in the batch system. The seed taken for the bioaugmentation process was the mixture of the 3:1 and 2:0.5 (Cow dung: Pharmaceutical Sludge) acclimated sludge used in the stage I studies. Table .3 shows the Characteristics of Seed (enrichment cultures) used for bioaugmentation.

Two phases of experiments were conducted to show the utility of using enrichment cultures in the bioaugmentation process. The first phase involved the enhanced degradation of best suited ratio of batch system (2:1) by three successive feeding of enrichment cultures for the F / M ratio of 0.26 at every seven days. The second phase of experiments involved use of the subcultures as inocula in bioaugmentation experiments. In this, four types of composition of subcultures are made (as in Figure .4).

Table .3 Characteristics of seed (enrichment cultures) for bioaugmentation

Sl.No.	Characteristics	Initial*	At Day 7*	At Day 14*
1.	pH	6.13	7.16	7.22
2.	COD	78000	44800	36000
3.	VSS	53000	60000	72000

*All units are in mg/L except pH

Results and Discussion

The experimental results of stage I-batch system, and stage II–bioaugmentation are discussed here. The presentations of results are explained in the following manner to highlight the significance of salient details obtained from the two stages of the experimental studies and the performance of the conductivitimetric biosensor. It is to be realized for this research works that, to explain the effect of biodegradation of

pharmaceutical sludge that led to treatment and disposal problems. In order to characterize the changes in the sludge properties a comprehensive experimental study was made by creating an interaction between pharmaceutical secondary sludge, cow dung, municipal sewage and nutrients by three phase investigations in the first stage of experimental study. Further by extending the work for the potential microbial transformation or conversion of biosolids by bioaugmentation, an attractive way to destroy the toxic and hazardous compounds biologically in bioreactor system in the second stage of experimental study.

BIOMASS ACTIVITY TESTS UNDER BATCH SYSTEM

Volatile Fatty Acids

The concentration of VFA that has been considered as one of the best monitoring parameters since it indicates the metabolic status of some of the most delicate microbial groups in the anaerobic systems. The accumulation of a specific fatty acid may indicate which step in the degradation chain is being inhibited. The volatile fatty acids formation in this study is considered to be the only in the form of acetic acid. The initial VFA was not recorded in this experimental study. The average VFA for the secondary pharmaceutical waste sludge was 1380 mg/L as determined previously.

During the operational period the VFA values of all the reactors are exhibited for varying trend. The reactors had moderate VFA concentrations during the initial period. However after the initial period of four days, the VFA level was raised. This indicates that, apart from a higher concentration of microorganisms, the buffering capacity greater in the reactors. The rise in the VFA concentration corresponding drops in pH because the system had a low buffering capacity. However it is interesting to note that the pattern of VFA accumulation qualitatively different in the reactors.

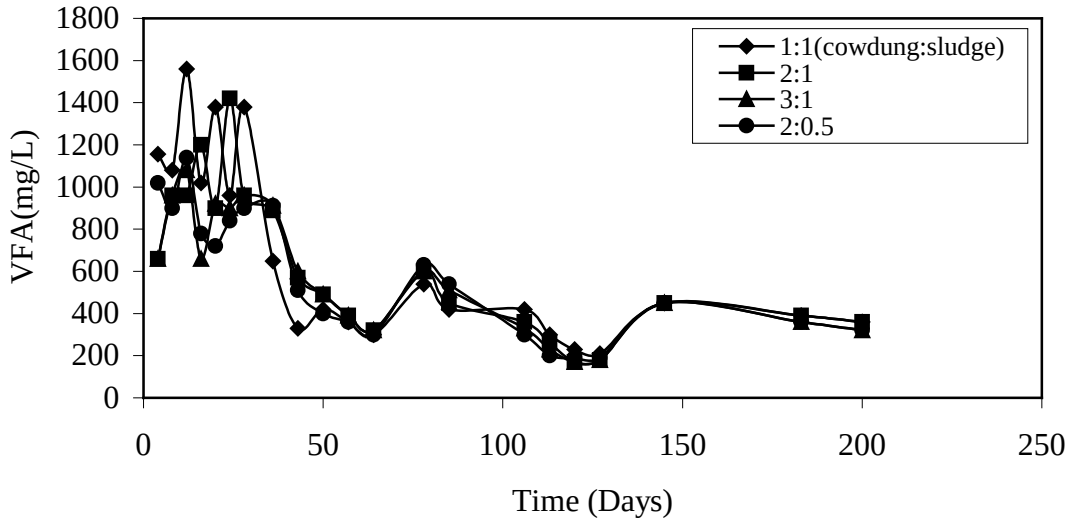

Figure 1 Variation of VFA with respect to time for 10% dilution in batch system

CONCLUSIONS

Based on the analysis and interpretation of experimental results carried out for characterization and enhanced biodegradation of pharmaceutical sludge, the following salient conclusions are drawn

- The characterization and the effect of inoculum- substrate ratio on acclimatization of pharmaceutical secondary sludge were studied.

- Inoculum – substrate ratio viz., 1:1, 2:1, 3:1and 2:0.5 were studied for the biosolids conversion of pharmaceutical secondary sludge. The inoculum-substrate ratio 2:1 (sludge dilution: 50%) was found to be effective for the conversion of sludge into biosolids. The effect of variation of activated biomass on biosolids generation was assessed at Hydraulic Retention Time (HRT) varying from 4 to 7 days.

- It is evident from the stage-I biomass activity test results that the maximum reduction of COD and TVSS are respectively found to be 59% and 55% for 2 : 1

ratio, (cow dung : sludge) at the end of 200th day of batch mode operation for 50% dilution (at a HRT of 7days).

- The effect of enhanced biodegradation was assessed and evaluated for the conversion of pharmaceutical secondary sludge to biosolids. The composition 1(C1) (bioaugmented sludge) was found to be effective for the biosolids conversion by enhanced biodegradation using the conventional inocula, adopted for municipal and conventional biological treatment plants.

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