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A Critical Review on Aerobic Thermophilic Sewage Sludge Degradation and its use

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Abstract: Due to increase in demand for recycle and reuse of waste materials, the improvement of existing treatment technologies is required. Several engineering bio-technological processes are commonly applied for sewage sludge treatment. Among these, there is the conventional anaerobic digestion of sewage sludge to produce biogas. It is ineffective for inactivation of potential pathogenic micro-organisms, which restrict it for further use and recycle. Municipal and domestic sludge contain organic and inorganic matters in suspended, colloidal and dissolved forms. The presence of certain industrial waste in public sewers can substantially alter the nature of waste water. From bio-chemical point of view the aerobic sludge treatment process involves, the micro-organism and degradation biocatalysts, the bacteria mediated bio-degradation processes that occur and utilize the substrate-lysis product. After sufficient academic and industrial research, evidence is available which show that aerobic thermophilic sludge (ATS) treatment and thermophilic aerobic digestion (TAD) of sludge have clear advantage over conventional Mesophilic treatment. So lab trial will be conducted through bio-chemical research approach in a pilot scale plant for aerobic thermophilic treatment to improve technology development on sewage sludge digestion by using mixed aerobic Thermophilic bacteria for pollution abetment and reuse of the said waste and pathogens will be reduced or killed due to Thermophilic approach. These sources will lead to development of technique that will replace present Mesophilic treatment to thermophilic treatment approach by developing bio reactor for addressing the public health point of view."

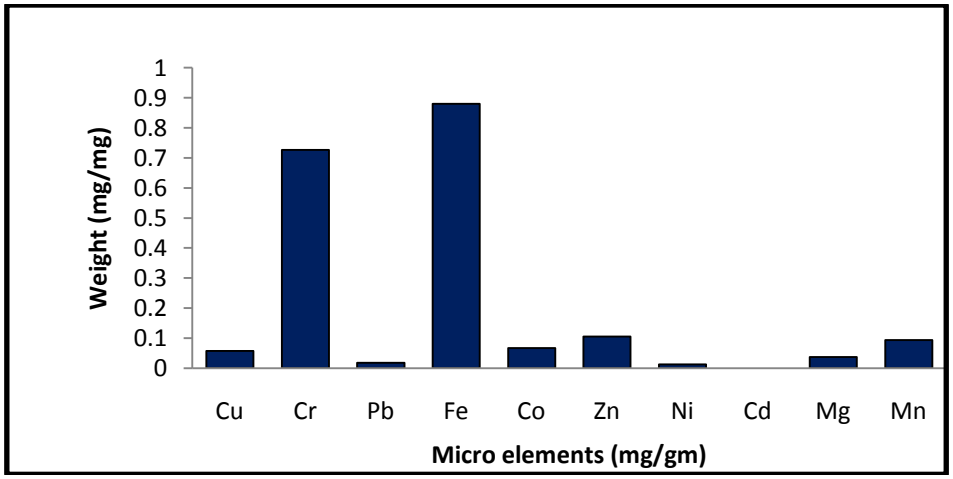
Keywords: Sewage sludge, bio-chemical process, thermophilic bacteria, bio-reactor, aerobic treatment

2. Introduction

In industrial communities environmental problem such as the treatment and degradation of sewage sludge. This is a very cost effective process. Since due to the presence of some type of organic substances, suspended solid and pathogens inside the sludge, it is not used for future use beneficially. So it is disposed in to river or lake and conventional anaerobic type of digestion processes are there which is not so much effective for complete degradation because that process is Mesophilic process**.** Thermophilic aerobic digestion of sludge has clear advantages over conventional Mesophilic digestion. [7] In Thermophilic aerobic digestion the temperature is increased so that all the bacteria and pathogen present inside the sludge will destroy/reduced ultimately.

The major constrain in the biological process include bacterial flocculation and foaming problems. Despite apparent benefits, thermophilic biological treatment system remains largely unexplorated as a viable treatment technology for high strength and temperature. [9]

MICROELEMENTS PRESENT IN SLUDGE



Analysis of sludge has been done and presence of micro elements like Cu, Cr, Pb, Fe, Co, Zn, Ni, Cd, Mn, Na, K concentration is foundout.

3. Advancement in Thermophilic Treatment System Membrane BIOREACTORS

Thermophilic treatment system support a persistent non-flocculating bacterial community that prevents biomass separation from community treated effluent by conventional sedimentation/clarification, thus limiting the application of thermophilic biological treatment system. [17] Looking in to this aspect, membrane bioreactor (MBR) could be an attractive option where sludge retention of 100% can be achieved regardless of the cell flocculation. Moreover MBR supports extremely high levels of biocatalysts and therefore can metabolize the substrate and generate metabolic products at a much faster rate than conventional batch, fed-batch or continuous flow systems.

4. Table -1

VARIOUS BENEFITS OF THERMOPHILIC SYSTEM

Feature	phenomenon	Specific application
Increased rate of degradation of organics	Increased microbial growth rate and rate of diffusion organics	Treatment can be operated with shorter hydraulic retention time(HRT) and higher volumetric loading rate
Higher removal of specific compounds	Higher rate of chemical reactions, specific temperature dependent enzymes	Thermophilic process can produce better effluent quality

(Suvilampi and Rintala, 2003)

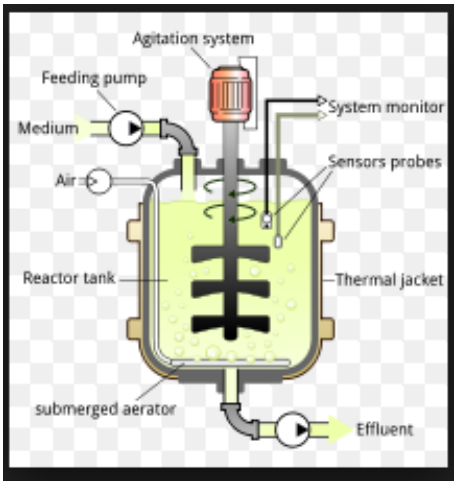
5. Bacillus Stearothermophillus

Bacillus Stearothermophillus is a rod shaped, Gram-positive bacterium and a member of the division formicates. [10] The bacteria is a Thermophile and is widely distributed in soil, hot springs, ocean sediment and a cause of spoilage on food products. It will grow within a temperature range of 30-75 ^{0}c. Some strains are capable of oxidizing carbon monoxide aerobically. It is commonly used as challenge organism for sterilization cycles. The biological indicator contains spores of the organism on filter paper inside a vial. After sterilizing, the cap is closed an ampoule of growth medium inside of the vial is crushed and the whole vial is incubated. A colour and turbidity change indicates that the sterilization conditions were achieved. Otherwise the growth of spores indicates that sterilization process has not been met.

It was first described in 1920 as Bacillus Stearothermophillus. But together with Bacillus thermoglucosidasius, it was reclassified as a member of the genus Geobacillus in 2001.

6. Bio reactors

A bioreactor may refer to any manufactured or engineered device inside which all the degradation reaction takes place. [17] In one case, a bioreactor is a vessel in which a chemical process is carried out which involves organisms or biochemically active substances derived from such organisms. On the basis of operation, a bioreactor may also classify as batch, fed batch or continuous.



(Figure-1)

Organisms growing in bioreactor may be submerged in liquid medium or may be attached to the surface of a solid medium. Submerged cultures may be attached to the surface of a solid medium. [7] Submerged cultures may be suspended bioreactors can use a wider verity of organisms. Since special attachment surfaces are not needed, however in a continuously operated process the organisms will be removed from the reactor with effluent. Immobilisation is a general term describing a wide verity of cell biocatalysts including enzymes, cellular organells, animals and plant cells. Immobilization is useful for continuously operated process, since the organisms will not be removed with the reactor effluent, but is limited in scale because the microbes are only present on the surface of the vessel.

7. Degradation Techniques in Bioreactor

Sludge sample is procured from local sewage. It is taken to the lab after removal of solid, grits and other waste. [11] The sample is sterilized before pilot plant scale experimental approach study**.** [1] The sample of sewage sludge is locally collected analysed for total bacterial count. Each sample is serially diluted in physiological homogenized buffer and is spread on nutrient agar and incubated at 37 ^{o}C. The plates are observed after 24 hrs. After 5 days the number of colony forming units is determined. Isolation and Identification of Wild Strains of Bacteria from Sewage Sludge Sample occurs. Isolation of wild strains of *E-coli* and *Bacillus thermophillus* is reported for further culture and maintenance. Application of Mixed Population of Bacteria for Pilot Plant Experimental Study takes place. The isolated and cultured wild strains of bacteria is inoculated with one more lab strain of *B.stereothermophillus* to see the impact of mixed population by maintaining diluted inoculants, from 10^{-1} to 10^{-4} cell ml^{-1}. All these are obligate aerobic strains. Characterization of Bioreactor for Experimental Pilot Plant Study occurs**.** Characterization of the bioreactors and methods of approach for technical condition particularly for retaining time, volume change frequency, oxygen and power input is carried out. Identification and Optimization of Improved Approach of Operating Parameters and Flexibilities that Influence Sludge Degradation takes place.

In order to attain a high operational flexibility at the pilot plant, the installation of several devices like pumps and connections for sludge and water allows the bio reactors to operate either independently during the experimental works on the process development and scale up or in series, to study the effect of the aerobic thermophilic treatment anaerobic digestion. The volume change frequency for both bioreactors is fixed to one change per day in order to evaluate the impact of initial organic matter content on microbial potential and the system capacity in attaining stabilized sludge. Evaluations of the operating process conditions are compared to the microbial behaviour and degradative capacity of the aerobic thermophilic population in supporting environmental and operational variation by decreasing retention time at first to 14hr and then 7.5 hr. [Block, J and Wiesman, U, 1992]

8. Discussion

The main purpose of this study was to findout the effect of thermophilic degradation of the biological sludge by focusing on the parameters including BOD, COD, TS, VS, and SVI. [7]

According to the findings, it is clear that thermophilic treatment had the major role in degradation of organic matter in municipal as well as industrial sewage sludge. Results of the research showed that by increasing the temperature, the rate of degradation of organic matter in sludge was increased by 4.5 times. This phenomenon was also studied by many other studies. An increase in SCOD in the surfactant is due to the fact that, through the thermophilic process, sludge cells are considerably degraded and this degradation leads to the fracture of sludge density into particles and to the release of a large proposition of intracellular matters from the sludge. [10]

As a result, a significant amount of the sludge COD turns into a supernatant liquid, our results are in accordance with thermophilic treatment. It is found that the application of thermophilic bacteria can degraded the organic substances in sludge at 60 degree celcious. The sludge digestion period can be reduced from 22 days to 8 days as well. [10] This might be due to the facture of sludge cells that leads the generation of particles and disintegration of the sludge. This process releases a large proportion of extracellular polymers in the supernatant of the sludge.

Bomoi, M also found that an thermophilic treatment for the period of 30 minutes, degraded 30.1% of sludge flocs and the volume of solids was reduced by 23.9% as well. The considerable decrease in volatile organic matters is a good practice for sludge degradation. The results of Bomoi, M are in accordance with our findings in the present study. [9] In conclusion, the results reported the remarkable decrease in the COD value of the supernatant by the application thermophilic treatment. The degradation of organic matter in municipal sewage sludge using thermophilic treatment was effectively and rapidly occurred. The SVI value was changed at a relative slow rate. The optimal condition for degradation of organic matter in the sludge was at pH = 3 and contact time = 120 minutes. However, according to the results of the current study, better dewatering condition

of the sludge was not achieved using thermophilic treatment. The results demonstrated that this method can be used as a pre-treatment method for the treatment of the sewage sludge. Moreover, a complementary treatment is necessary to reach the standard limit. [6]

9. Discussion

After all degradation reaction takes place inside bioreactor finally the end product calculation takes place i.e. total solid, suspended solid, volatile solid, BOD, COD, ammonia, etc. Also the reduction of bacterial population inside the sewage sludge found out.

10. Conclusion

The aim of this project is for sewage sludge treatment by aerobic thermophilic process with designing pilot plant bioreactor. So that the volume of the sludge can be reduced and the water is free from waste organic substances as well as the pathogens will be reduced. Hence it can be easily use as a ingredient with fertiliser in plant and ferti-irrigation purpose.

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