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Next Generation Low Cost Bio Concrete for Sustainable Building

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Abstract: *The main aim of this paper is to develop a geopolymer bacterial concrete using waste activated sludge. The experimentation work focus on the isolation of bacterial strain that adapt as a bacterial concrete. Bacillus an isolate from waste activated sludge is identified and observed that it has the ability to stay alive in aerobic and anaerobic conditions. This research work focuses on the investigation on ability of bacillus species to improve the strength and durability of geo polymer concrete based on calcification and geo polymerization. The study recommends an introduction of Bio-concrete which acts as an exciting material for life.*

Keywords: *Bacillus, Bio concrete, Waste activated Sludge, Strength.*

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I. INTRODUCTION

Excess sludge generation from municipal sewage treatment has been an environmental nuisance in disposal. To eradicate the accumulation of organic content it has to be co-digested which will automatically leads to easy biodegradability. Bio concrete is being the most upcoming research area in the field of environmental and civil engineering. Bacillus species predominantly present in waste activated sludge was observed to be the application oriented microorganism in construction materials [1].

As per Indian concern the investigation on the ability of bacillus species to improve the strength and durability of geo polymer concrete based on calcification and geo polymerization has not yet been studied. The bacterial species Bacillus in waste activated sludge is used for analyzing the performance of ordinary and geo polymer concrete. It was found that the geo polymer bacterial concrete had high compressive strength when compared to ordinary bacterial concrete at 90^{th} day. Geo polymer bacterial concrete had the least weight than ordinary concrete at different ages [2]. Bacillus, an isolate from sewage sludge has the ability to survive both in aerobic and anaerobic conditions. Under aerobic conditions, many organic compounds are completely oxidized into soluble inorganic compounds and oxygen acts as a terminal electron acceptor. In anaerobic metabolism, the organic compounds are incompletely oxidized into simple organic acids and the by-products are methane and hydrogen gas [3]. The scheme behind the research is that to isolate Bacillus species both in aerobic and anaerobic condition. The principle behind the metabolic activity of bacteria in bio concrete preparation, is that they germinate spores, swarming takes place, quorum sensing occurs, further levans glue is produced, which leads to filamentous cell formation and calcium carbonate precipitation [4]. These activities occur in the concrete, which increases the strength and durability.

Geo polymers have become increasingly popular in recent years as an environmental-friendly alternative to ordinary Portland cement. Municipal sewage has high composition of heavy metals. Geo polymer has an ability to encapsulate heavy metals. The characterization of sewage sludge and kaolin shows similarity, were kaolin is being widely used as raw material for geopolymer [5]. In the present study, a mixture of geopolymer concrete specimens are adopted using water, 10 mm aggregate, fine sand, fly ash, sewage sludge, sodium hydroxide, sodium silicate and super plasticizer.

This study promotes a new innovation in building construction materials by providing durable roads, high strength buildings with more bearing capacity, long lasting river banks also cost effective durable housing. The intention of this investigation is to introduce a stimulating cost effective construction material. This concrete along with specially developed polymer acts like conventional steel rods that can be activated to shrink and close gaps. Thus the research project targets building industry.

1.1 Objective of the work

The specific objectives are to isolate thermophilic protease secreting bacteria Bacillus from municipal sewage sludge and to enhance the sludge biodegradability by adding citric acid in bacterial pretreatment to achieve 25-30% solubilization. To investigate the performances of anaerobic biodegradability of pretreated at different SRT. To prepare geo polymer bacterial concrete test specimens to prove the concept of polymerization process and strength development.

1.2 Scientific Basis on bacterial application

Sludge is pretreated by the process of hydrolysis (breaking cell wall), where solubilization increases the potential of biodegradability. At first, the excess sludge is made amenable to biodegradation by adding citric acid. Secondly, the bacterial pretreatment is carried out by isolating bacterial species followed by solubilization (suspended solids reduction and soluble COD removal). These pretreatments permit the release of organic substances into the aqueous phase. After the matter is solubilized, this becomes more available for bacteria and increases the biodegradability and biogas production. Producing biogas from organic waste is not only providing a clean sustainable indigenous fuel, but also reducing the ecological and environmental deterioration. The efficiency of sludge pre-treatment is measured by the percentage of organic compounds solubilisation and SS reduction. The pretreated sludge is then subjected to anaerobic digestion, which is carried out in a laboratory scale 5L semi-continuous reactor. During anaerobic treatment, the pretreated sludge is subjected to biodegradation by methanogens. The treatment efficiency is assessed by mass balancing the amount of carbon consumed and methane released. Also, optimum sludge loading and retention time for efficient anaerobic digestion is observed. The nutrient rich sewage sludge normally lacks carbon to nitrogen ratio, which helps in increasing biogas yield and fermentation rate of anaerobic digestion.

II. MATERIALS AND METHOD

The research work is carried with citric acid addition and bacterial pretreatment of waste activated sludge. The optimum conditions of these pre-treatments are investigated before feeding to anaerobic digester. The target level, standardization of protocol is given in figure 1.

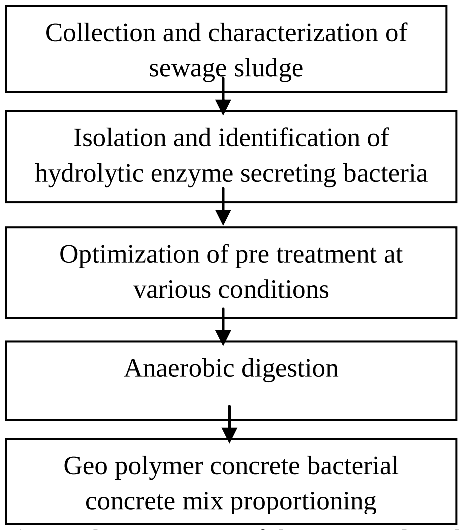

Fig:1 Schematic view of the proposed methodology

The optimization of pretreatment is carried out at varying conditions such as pH, treatment temperature, and treatment time. Simultaneously the anaerobic digestion process is subjected for bacterial enrichment. Finally to compare the compressive strength and durability of ordinary and geo polymer bacterial concrete mix cubes at different ratio.

III. RESULT AND DISCUSSION

3.1 Characterization of Sludge:

Raw sludge was collected from a municipal sewage treatment plant. Initial sludge characterizations are analyzed according to standard methods (APHA, 2005) [6] and are shown in Table 1. The enzyme secreting bacteria is isolated from sludge by serial dilution followed by spread plate technique. Milk protein media is used for screening, enzyme secreting bacteria is selected by assay technique and the strain is identified through 16S rDNA technique.

Table 1: Characteristics of sludge

S/No	Parameter	Values
1	pH	6.41
2	TCOD (mg/L)	10180
3	SCOD (mg/L)	196
4	Total Solids (mg/L)	13740
5	Suspended Solids (mg/L)	9815
6	Volatile Solids (mg/L)	7180
7	Soluble Protein (mg/L)	765
8	Soluble Carbohydrate (mg/L)	314

3.2 Optimization of growth condition of bacteria:

pH, Temperature and time for the growth of isolated enzyme secreting bacteria is optimized by subjecting the bacteria to various range of pH such as 4 – 9, temperature ranging from 20ºC-60ºC and incubated at different time intervals. The turbidity of the broth indicates the extension of bacterial growth at different conditions. From the optical density obtained: pH, temperature and time for the growth of enzyme secreting bacteria is optimized with Response Surface Methodology (RSM) Software.

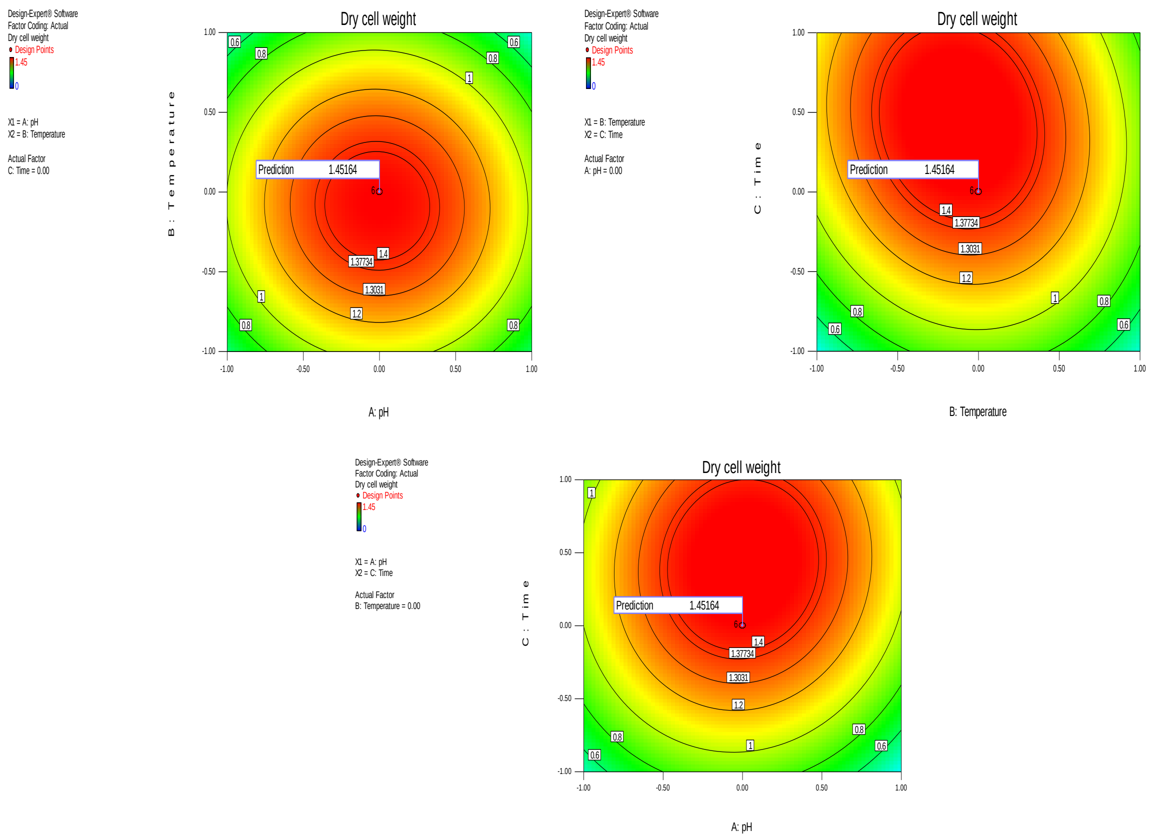

Fig 1: Optimized growth condition of Bacteria

3.3 Bacterial Pretreatment:

Pretreatment of sludge is carried out with enzyme secreting bacteria at the optimized pH, Temperature and Time along with citric acid. The efficiency of the pretreatment is analyzed based on the COD solubilisation and SS Reduction as shown in figure 2. Aerobic treatment shows 24% suspended solids reduction and 26% COD Solubilization.

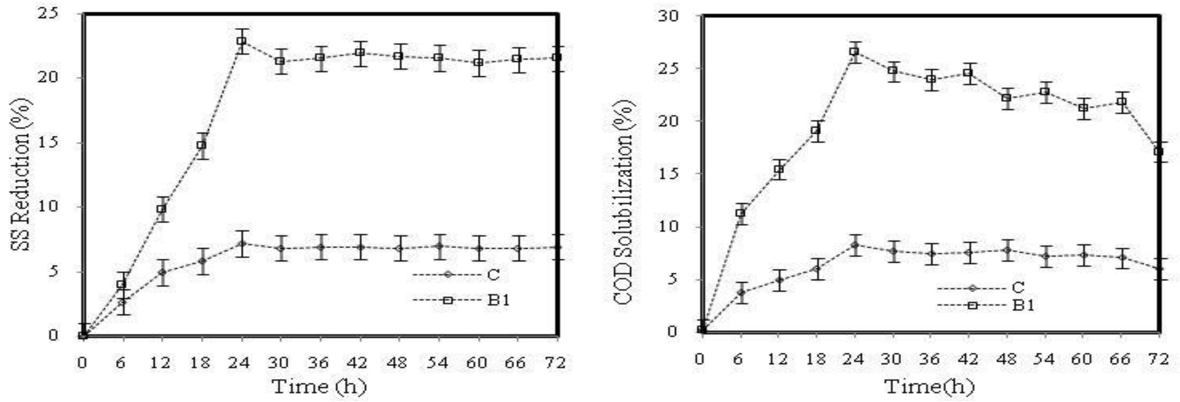

Fig 2: Biodegradability of sludge by bacterial pretreatment

3.4 Anaerobic Digestion Study:

After the successful start-up, the reactor is fed with pre-treated sludge. During this period, the effect of loading rate on biodegradability are evaluated by varying the organic concentration in the pre-treated sludge as well as varying the retention time of the substrate in the reactor. The efficiency of biodegradation is assessed in terms of organic carbon utilization and volatile suspended solids reduction. The quantity of methane released is measured by passing the gas through alkaline solution followed by its flow measurement in gas flow meter. Based on the amount of methane generated and substrate carbon utilization, a mass balance is arrived. The operational parameters of digesters are shown in figure 3.

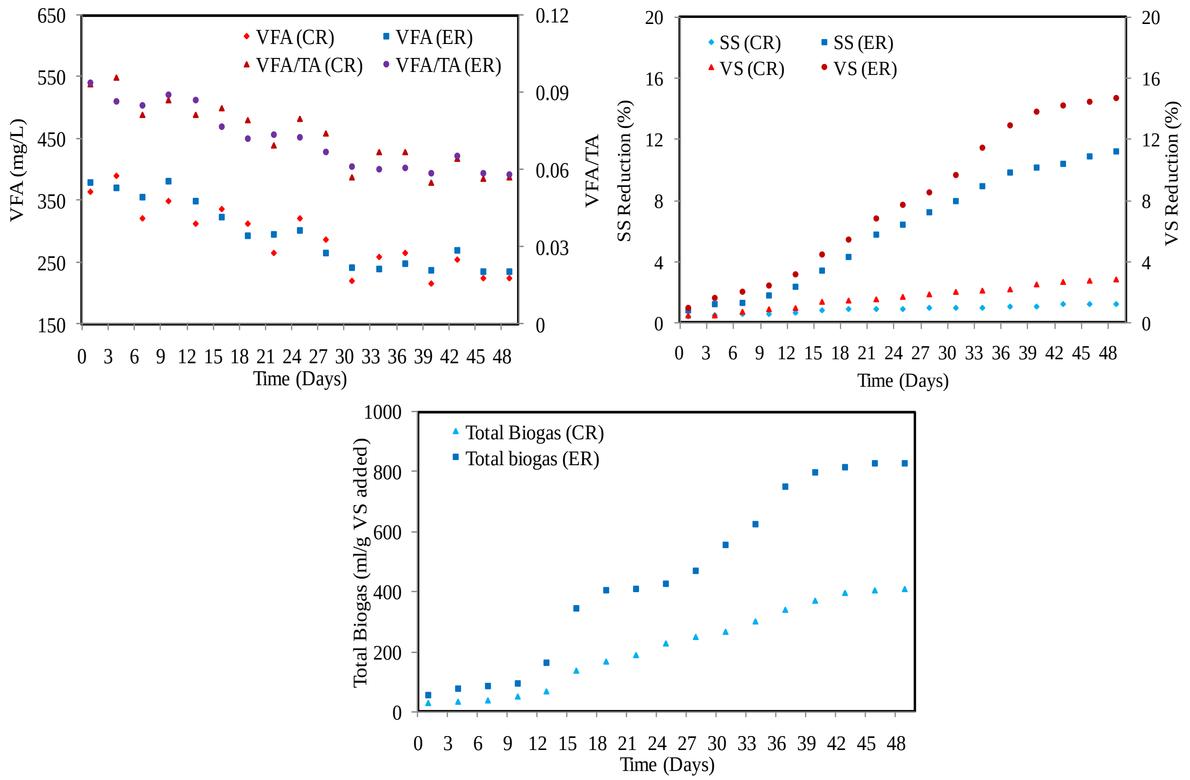

Fig 3: Operational parameters of the anaerobic digester

3.5 Compressive Strength of Bacterial Concrete:

The geo polymer concrete mix was based on the different ratio of materials to optimize the best mixture. The mix proportions are assigned to be 30:70, sludge: flyash. The appropriate cell concentrations of microorganism ($30*10^5$ cells) are introduced to ordinary portland cement concrete and Geo-polymer concrete by way of the mixing water per ml for the current experimental research.

The 150 mm x 150 mm cubes are cast and are vibrated to compact in a vibration machine. After demolding, all cubes are cured in ambient conditions at room temperature 26± 4°C. The compressive strength of the cubes is determined at different ages for different types of concrete. To study the durability of Geo-polymer bacterial concrete against aggressive agents (acidic conditions), the specimens are immersed in a 5% solution of sulfuric acid to compare with other types of concrete at different ages. The geopolymer made with sludge waste gives a compressive strength up to 22 MPa for 9 days compressive strength, which is comparable [7].

The fundamental difference between ordinary and Geo polymer concrete is the binder which is obtained from a certain concentration of alkaline activator and Ash mixing. The appropriate cell concentration of bacteria is introduced in ordinary and Geo-polymer concrete by way of the mixing water to compare their strength and durability. The specimens are tested by compression testing machine after continuous curing.

IV. CONCLUSION

Fly ash and waste activated sludge are identified as an alternative to cement. In the production of cement, carbon dioxide is emitted which is the root cause for ozone depletion. But in this experimental work waste product is going to be an application oriented end product in near future. The biodegradability of citric acid pretreated sludge enhanced in terms of organic compounds solubilization. Further biosolids reduction and recovery of energy from waste obtained. Reusable treated wastewater was obtained, which solve the water scarcity problem.

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