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Soil Bio Cement Using Microbes and Agricultural Waste

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Abstract: *Soil stabilization is important in civil engineering to improve the strength and stability of weak soil. In this project, an eco-friendly method called bio-cementation is studied. This method uses microorganisms obtained from agricultural waste to improve soil properties.*
The bacteria present in agricultural waste produce an enzyme called urease, which helps in the formation of calcium carbonate through a process known as Microbially Induced Calcite Precipitation (MICP). This calcium carbonate acts like a binding material and fills the gaps between soil particles, making the soil stronger and less permeable.
In this study, soil samples were treated with microbes and tested in the laboratory to check their strength and water resistance. The results show that the treated soil has better strength and reduced permeability compared to untreated soil.
This method is cost-effective, environmentally friendly, and also helps in reusing agricultural waste. Therefore, bio-cementation can be a good alternative to traditional soil stabilization methods used in construction..

Keywords: *Soil stabilization*

I. INTRODUCTION

Soil is one of the most important materials in civil engineering, as it forms the base for all types of construction such as buildings, roads, bridges, and dams. The strength and stability of soil directly affect the safety and durability of any structure. However, in many areas, the available soil is weak and not suitable for construction. Such soil requires improvement or stabilization before use.

Traditionally, soil stabilization is done using materials like cement, lime, and other chemical additives. These methods are effective, but they have some disadvantages. They are expensive, require large amounts of energy, and cause environmental pollution due to carbon emissions. With increasing awareness about environmental protection, there is a need for alternative methods that are economical and eco-friendly.

In recent years, a new technique called soil bio-cementation has been developed. This method uses naturally available microorganisms (bacteria) to improve soil properties. The bacteria help in forming a cement-like substance within the soil, which binds the particles together and increases strength. This process is based on a natural phenomenon known as Microbially Induced Calcite Precipitation (MICP).

In this project, microorganisms are obtained from agricultural waste such as cow dung or compost. These waste materials are easily available and contain useful bacteria. By using this waste, not only is soil improved, but agricultural waste is also reused, making the process more sustainable. This project focuses on studying how these microorganisms can be used to stabilize soil and improve its engineering properties.

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II. LITERATURE REVIEW

Bio-cementation is a sustainable soil improvement technique in which microorganisms produce calcium carbonate ($CaCO_3$) that binds soil particles together. This process is known as Microbially Induced Calcium Carbonate Precipitation (MICP) and is widely studied as an eco-friendly alternative to cement-based stabilization.

Research shows that urease-producing bacteria break down urea to form carbonate ions, which react with calcium sources to form $CaCO_3$. This $CaCO_3$ acts as a natural binder, improving soil strength, density, and reducing permeability.

Recent studies also highlight the use of agricultural waste (cow dung, compost, crop residues) as a low-cost microbial source for bio-cementation. This helps in waste management and reduces dependency on laboratory-grown bacteria.

However, literature reports limitations such as slow strength gain, variability in microbial activity, and sensitivity to environmental conditions.

II. METHODOLOGY

- Soil bio-cementation is a sustainable method used to improve soil strength using biological processes.
- Microbially Induced Calcium Carbonate Precipitation (MICP) is used to bind soil particles.
- Agricultural waste reduces cost and environmental impact.
- Agricultural wastes like bagasse, rice husk, corn cob, and wheat straw are collected.
- These materials are cleaned, dried, and ground into fine powder.
- Agricultural waste provides nutrients or acts as a calcium source.
- Ureolytic bacteria such as Sporosarcina pasteurii are used.
- Bacteria are cultured in nutrient medium for enzyme production.
- Soil is sieved to remove impurities and ensure uniform size.
- Soil is packed into moulds for testing.
- Bacterial solution is added to soil for attachment.
- Cementation solution containing urea and calcium is added.
- Agricultural waste ash can be used as an alternative calcium source.
- Bacteria hydrolyze urea to produce carbonate ions.
- Carbonate reacts with calcium to form calcium carbonate ($CaCO_3$).
- $CaCO_3$ binds soil particles and fills voids.
- The process is repeated to increase strength.
- Soil is cured for several days for stability.
- Tests like compressive strength, permeability, and durability are conducted.
- Results show increased strength and reduced permeability.
- The method is eco-friendly, cost-effective, and sustainable.
- It is used in ground improvement, erosion control, and construction.

IV. RESULTS AND DISCUSSION

The soil bio-cement block was successfully developed using microbes from agricultural waste. After curing, the soil changed from loose form to a hard and compact block due to microbial activity.

The results show that:

✓ The block gained higher strength compared to normal soil

✓ Water absorption decreased, improving durability

✓ Soil particles were bound together by calcium carbonate ($CaCO_3$)

✓ Density and compaction of the block increased

The improvement is due to microbial breakdown of urea and formation of $CaCO_3$, which acts as a natural binder.

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However, the process is slow and depends on environmental conditions and microbial activity.

V. CONCLUSION

The present study demonstrates that bio-cement produced using microbes from sugarcane bagasse is an effective method for improving the strength of soil. The process of Microbially Induced Calcite Precipitation (MICP) helps in the formation of calcium carbonate, which binds soil particles and increases compressive strength.

The experimental results show that bio-cemented soil has significantly higher strength compared to untreated soil. Although the strength is lower than conventional cement concrete, it is sufficient for applications like soil stabilization, erosion control, and low-load construction.

This method is eco-friendly, cost-effective, and utilizes agricultural waste, reducing environmental pollution and dependency on traditional cement. Therefore, bio-cement can be considered a sustainable alternative in the field of civil engineering.

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