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Evaluation of Soil Characteristics via Bacterial Culture.

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Research Article

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ABSTRACT

Soil engineers have been under increasing pressure to enhance soil qualities in order to support the weight of urban infrastructure such as buildings, bridges, highways, etc., due to the fast expansion of these projects in recent years. Soil enhancement is a growing field that employs a variety of techniques to enhance the mechanical qualities of various soil types, including sand, black cotton, red alluvial, and murum. Soil treatment techniques using chemical and cement grout are extensively used in geotechnical projects. Use of these chemicals and cement changes the pH level below ground and reduces the flow of groundwater. A more long-term solution is urgently required to counteract their impact. Therefore, there has been an effort to enhance the engineering features of soil in a sustainable manner by using microorganisms, nutrients, and biological processes that are naturally present in subsurface soils. An aerobic bacteria often found in soil, Bacillus Pasteuri (NCIB8841 or NCIM2477), was used to accomplish the calcite precipitation. This project's investigations on permeability and shear strength show that native bacteria may cause large amounts of calcite precipitation, which in turn alters the geotechnical soil parameters in a quantifiable way. various percentages of bacteria were flushed through various soils and observed for varied amounts of time. Soils amended with microbes have higher shear strengths and lower permeability. Improved stability, increased bearing capacity, and decreased settlements and lateral deformations are the main goals of microbial soils. As an alternative to the energy-intensive mechanical compaction techniques or the costly and ecologically harmful chemical grouting procedures, geotechnical engineers are exploring the potential of bio-clogging and bio-cementation of soils to enhance the mechanical characteristics of soil. However, a combination of engineering, microbiology, ecology, and design considerations is necessary for the successful adoption of the microbial technique. If we want to solidify the idea of microbial soil even further, we need microstructure research, full-scale model studies, and long-term assessments.

KEYWORDS: biological processes, boiclogging & biocementation , stabilization, improvement in soil properties

INTRODUCTION

For many land uses, the mechanical qualities of soils are inadequate in many parts of the globe. Settlement happens on roads and railway lines, thus they need constant upkeep. Soil erosion may make dykes and slopes unstable, and it can also affect coastlines, rivers, and other bodies of water. For these uses, soil stabilisation, also known as ground improvement, may be a good thing. Compaction, the installation of nails, sheets, or piles, or the mixing of soil with lime or cement are some constructive procedures that are often used at or from the surface to apply soil stabilisation before and during construction. These surface methods are inadequate for stabilising soil masses farther below, thus strengthening procedures such as ground freezing, cement or chemical grouting, or deep mixing are used.
Several limitations characterise conventional ground improvement technologies. As long as the mixing equipment is in close contact, the action radius is restricted. Because of their rapid hardening time or high viscosity, grouts often need high injection pressures. While building, freezing is merely a temporary fix. In addition to being prohibitively costly, most of these procedures also use chemicals that have a major negative effect on the environment, need the use of heavy gear, and disrupt urban infrastructure. Lastly, these techniques greatly improve the soil's shear strength while decreasing its permeability.

Microbial Induced Calcite Precipitation (MICP)

The natural lithification of sediments, digenesis, occurs as a result of physical, chemical and biological processes. After deposition, sediments are compacted as they are buried beneath successive layers of sediment and cemented by minerals that precipitate from groundwater. In general, these natural transitions from soil to rock are slow processes, but in some cases natural digenesis can be relatively quick. In sandy soils of which the mineral composition mainly comprises calcium carbonate (calcarenites), biochemically induced dissolution and precipitation of calcium carbonate, have led to significant cementation of unconsolidated sand. Water uptake or putrefaction of tree roots is considered to play a major role in this process.
When supplied with suitable substrates, micro-organisms can catalyze chemical reactions in the subsurface resulting in precipitation (or dissolution) of inorganic minerals, which change the mechanical soil properties. This study focuses on microbial induced precipitation of calcium carbonate.
Most of the inorganic carbon on the earth surface is present as layers of limestone of which a significant portion is of biogenic origin. Many organisms can induce the precipitation of calcium carbonate, but not all can be used for ground improvement.
Precipitation of calcium carbonate occurs when a solution is oversaturated, the amount of calcium and carbonate ions in solution exceeds the solubility product, i.e. the solution gets oversaturated.
Microbial induced calcite precipitation (MICP) is very economical method. So, we can use this method for the small project also. Potential geotechnical applications of this method are as follows:

A. To prevent piping and to enhance stability of earth dams and dikes.
B. To construct the reservoirs and ponds.
C. Seepage control.
D. To control erosion of the banks or coastal area.
E. To increase slope and excavation stability.
F. To reduce the liquefaction potential of soil to enhance the stability of dams.

G. To increase the bearing capacity of foundations and to decrease soil expansion potential.
H. To fix leakages of ground water in underground constructions.

MATERIALS AND METHODS

MATERIALS

Microorganism-An isolated bacterial culture of Bacillus pasteurii NCIM2477 was used in this study. The source of these bacteria was NCIMB Ltd which was a microbiology and chemical industry.Soils-Black cotton soil, Red alluvial soil, murum and sandThe soil sample passing through 4.75mm IS sieve and sample collected in indapur local area.Chemicals- Agar, Peptone, NaCl, Yeast extract, beef extract,urea.

METHODS

Preparing of urea nutrient agar

This media used for the cultivation of Bacillus pantothenticus. Table (1) and Table (2) showthe Solid contents and liquid contents of this media respectively.

Method of Preparation

Components shown in table 1 to distilled water and bring the volume to 1L. Mix well. Gently heat and bring to boiling. Autoclave for 15mins at 15psi pressure -121oC. Cool to 50-55oC.Aseptically add 50mL of sterile urea solution table 2. Mix well. Immediately after that, urea nutrient agar plate medium was poured into approximately 20 culture plates under laminar flow. The laminar flow hood provided filtered air in order to reduce the risk ofcontaminating the culture growth media prior to introduction of the B.pasteurii cultures.Once the poured plates were solidified (after approximately 15 minutes under the laminar flow hood).

Table 1 shows the details of solid contents of the media

Composition	Quantity
Agar	15gm
Peptone	5gm
Nacl	5gm
Beef extract	2gm

Table 2 shown the details of liquid contents of the media

Composition	Quantity
Urea solution	50ml

* urea solution (Add urea to distilled water and bring the volume to 100mL. Mix well. Filter sterilize.)

Making Bacteria Culture

One loopful of pure colony was taken from the stock bacteria and streaked onto each plate, then all plates were then inverted and incubated for 48-72 hours at 30°C in a incubator, once colony growth of B. pasteurii had occurred.

The preparing for calcium carbonate precipitation agar

For culturing the bacilluspasteurii and test its ability for calcium carbonate precipitation, a special agar was created and known as a precipitation agar, which contain agar for made the medium as a semi solid, urea medium and CaCl2.2H2O. The following components table 3 were mixed to create the urea medium solution.The mixed thoroughly in 500 mL of distilled water until they dissolved. The pH of the resulting urea medium solution was

adjusted to 6.0 using with 5 N HCl prior to autoclaving.

Distilled water was then added to reach the final required volume (1 L) and autoclaving for 15mins at15psi pressure -121oC, the pH of the urea medium was measured to be 7.0 and stirring the solution to aerate it. A 20 ml volume of calcium chloride solution (18.5 g CaCl2/100 mL distilled water) was then added to the aerated urea (1000 mL). Then the resulting solution was poured into culture plates under a laminar flow hood.

Table 3 shows the details of the precipitation agar

Constituents	Quantity
Agar	7gm
Nutrient broth powder	3gm
Urea	20gm
(NH2(CO)NH2	10gm
NH4Cl	2.12gm
NaHCO3	2.12gm
Distilled Water	1 lit
calcium chloride solution/ CaCl2.2H2O	18.5 g CaCl2/100 mL distilled water

RESULTS AND DISCUSSION

Laboratory tests for permeability and unconfined compression were carried out, as previously mentioned. These laboratory studies were conducted to identify the optimal microbe condition duration, optimal dosage, and D10 size for maximal shear stress and minimal permeability. Here we get into the specifics of the laboratory findings for the permeability and direct shear stress testing.

RESULTS OF DIRECT SHEAR TEST

The bacterial solution content of normal stress (N/cm^2) is placed on x-axis and shear stress (N/cm^2) is on y-axis. The plot also variation of shear stress with respect to condition period of 7, 14 and 28 days. The coefficient of shear stress is increase with content of normal stress and condition period.

CONCLUSION

There have been many investigations showing that native bacteria may be employed to make sands much stronger in shear and more permeable by inducing calcite precipitation. The testing included direct shear and a permeability experiment. The results showed that naturally occurring bacteria might alter soil-engineering characteristics by precipitating calcite to a substantial enough degree. We think that one crucial strategy for making biomodification of soils more economically possible is the use of indigenous bacteria to precipitate calcite. Additional testing should allow for the successful use of engineering and construction procedures including the uniform dispersion of high quantities of calcite precipitation.The formation of calcium carbonate and the characteristic structure of calcite are made evident when Bacillus pasteurii is cultured on precipitation agar.A decrease in crystal size with increasing distance from the culturing region supports the idea that bacteria play a role in calcite production, and the creation of calcite in the area where the bacteria were cultivated on the agar supports this idea. Fertiliser for microbes made of

urea and agar.The soil's porosity and permeability might be reduced by filling the spaces with calcite and then cementing the particles together. The presence of microorganisms in sand and soil decreases their permeability. The cementation process may have covered the particles and filled any holes or pores with calcite, which might explain this. in terms of longevity and sustainability.

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