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Effectiveness of using sugarcane molasses and coal bottom ash on urea contaminated soil.

Eficacia del uso de melaza de caña de azúcar y cenizas de fondo de carbón en suelos contaminados con urea.

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ABSTRACT

The presence of fertilizers in ground water and soil can pose significant threats to human health and ecosystems. The geotechnical properties of soils are strongly influenced by their interaction with industrial wastes, which is of great importance to geotechnical engineers. The study is conducted to determine the effect of sugarcane molasses in removing urea content from soil sample. Sugarcane molasses (SM)is a viscous, dark liquid by-product of sugar cane extraction. The soil which is used has been procured from Mulanthuruthy block panchayat, Ernakulum, Kerala. The percentages of molasses used are 20%, 40%, 60%, 80% and 100% in terms of dry weight of the soil. The analysis of properties of urea contaminated soil is studied. The various soil properties are determined by conducting tests like Unconfined Compressive Strength (UCS) tests, Standard Proctor tests. Coal Bottom Ash (CBA) which is collected from the Thermal power plants in varying percentages (10%, 20%, 30% and 40%) is added to soil with 100% sugarcane molasses. Standard Proctor Test and Unconfined compressive strength test were conducted. UCS value increased with the addition of CBA. The maximum increment in UCS is obtained at 30% addition of CBA.

Keywords: Urea contaminated soil, Sugarcane molasses, Coal Bottom Ash, Unconfined Compressive Strength (UCS) tests, Standard Proctor tests.

RESUMEN

La presencia de fertilizantes en las aguas subterráneas y el suelo puede plantear amenazas importantes para la salud humana y los ecosistemas. Las propiedades geotécnicas de los suelos están fuertemente influenciadas por su interacción con los desechos industriales, lo cual es de gran importancia para los ingenieros geotécnicos. El estudio se lleva a cabo para determinar el efecto de la melaza de caña de azúcar en la eliminación del contenido de urea de una muestra de suelo. La melaza de caña de azúcar (SM) es un subproducto líquido oscuro y viscoso de la extracción de la caña de azúcar. El suelo que se utiliza se obtuvo del panchayat del bloque Mulanthuruthy, Ernakulum, Kerala. Los porcentajes de melaza utilizados son 20%, 40%, 60%, 80% y 100% en términos de peso seco del suelo. Se estudia el análisis de las propiedades del suelo contaminado con urea. Las diversas propiedades del suelo se determinan mediante la realización de pruebas como pruebas de resistencia a la compresión no confinada (UCS) y pruebas Standard Proctor. La Ceniza de Fondo de Carbón (CBA) que se recolecta de las centrales térmicas en porcentajes variables (10%, 20%, 30% y 40%) se agrega al suelo con 100% melaza de caña de azúcar. Se realizaron la prueba Proctor estándar y la prueba de resistencia a la compresión no confinada. El valor de UCS aumentó con la adición de CBA. El incremento máximo en UCS se obtiene con una adición del 30% de CBA.

Palabras clave: Suelo contaminado con urea, melaza de caña de azúcar, cenizas de fondo de carbón, pruebas de resistencia a la compresión no confinada (UCS), pruebas Standard Proctor.

INTRODUCTION

Accelerated industrialization and urbanization have significantly deteriorated the environmental safety of soils. Fertilizer contamination of the soil occurs when fertilizer is applied to the soil for plant growth. It constantly invades underground ecosystems and contaminates soil and water supplies. Hydrocarbon contamination not only affects soil quality, but also changes the physical properties of soils. The most common fertilizers for weed and insect control are urea, monophosphate and potash. Rapid population growth and industrialization have made waste disposal a problem. A common method island-based garbage disposal. As waste mixes with the ground, the geotechnical properties change. The degree of change in properties depends not only on the type of contaminant, but also on the type of soil. In general, industrial waste consists of acid, alkali, sulfate, salt, urea, and oil impurities that affect soil properties and geological nature. Combining food scraps and soil changes both the index and the engineering characteristics. Soil type and contaminant type both affect how much an asset changes. Acids, bases, sulfates, salts, urea and petroleum contaminants are commonly found in industrial waste and affect soil quality. Since soils can contain many contaminants, the strength and deformation properties of soils should be thoroughly studied. Floors are exposed to waste from many operations. Leachateis formed when organic and inorganic contaminants seep into these waste sand combine with sediments. Leachate can naturally settle and contaminate ground water supplies. Changes in soil quality lead to a variety of geotechnical problems, including structural cracks, soil subsidence, building buoyancy, slope instability, and changes in compaction characters.

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MATERIALS AND METHODS

A. *Materials Used*

The materials used in the experimental work are Urea contaminated soil, Sugarcane molasses and Coal Bottom Ash.

1. *Soil*

The soil samples are collected from Mulanthuruthy block Panchayat, Ernakulum, Kerala. The soil is found to have high concentration of urea due to the direct deposition of large amount of formic acid in the soil from the industries. Urea can be irritating to skin, eyes, and the respiratory tract. Urea in soil produces foul smell. Repeated or prolonged contact with urea contaminated soil causes uneasiness in work and health issues. The soil was collected from a depth of 1.5-2 m. Soil is collected after removing the top layer up to 1 m. The soil is reddish brown in colour.

Fig 1: Urea Contaminated Soil

Table 1. Properties of Soil Sample

Properties of Soil Sample	Natural moisture content (%)	Specific Gravity	Liquid Limit(%)	Plastic Limit (%)	Plasticity Index (%)
Value	58.33	2.63	40.2	18.88	21.32

Properties of Soil Sample	Maximum Dry Density (g/cm^3)	Optimum moisture content (%)	Unconfined compressive strength (kN/m^2)	Cohesion (kN/m^2)
Value	1.65	22	103.47	51.73

Properties of Soil Sample	Clay (%)	Sand (%)	Silt (%)	Soil Classification
Value	65	19	16	CI

1. *Sugarcane molasses*

A viscousby-product of converting sugarcane to sugar is cane molasses. The juice extracted from sugarcane is heated during sugar production until the sugar crystallizes and precipitates. Molasses is asyrupthatre main safter crystallization. Molasses contains numerous compounds. Sugar (sucrose) is found mainly in molasses ($C_{12}H_{22}O_{11}$).

Fig 2. Sugarcane molasses

Table 2. Compositions of sugarcane molasses

Compositions	Total Sugar	Fructose	Glucose	Sucrose	Glycerol
Concentration	50.9	3.2	6.7	41	32

(Source: from Manufacturer)

Table 3. Properties of sugarcane molasses

Properties	Specific gravity	pH	Dynamic Viscosity (MPa.s)	Appearance	Solubility
Values	1.39	6.07	3338	Black and Viscous	Soluble in water

(Source: from Manufacturer)

2. *Coal Bottom Ash*

Bottom ashis part of the non-combustible residue from combustion in ther malpower plants. In the industrial realm, the term traditionally refers to the burning of coal and includes traces of combustible material embedded in the formings lag that adheres to the hot side walls of coal furnaces during operation. However, the part of the ash that escapes from the chimney is called flyash. The clinker naturally falls into the lower hopper of the coal kiln and is cooled. Some of the above ash is also known coal bottom ash

Fig 3: Coal bottom ash

Table 4: Chemical Composition of Coal Bottom Ash

Component	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_4	K_2O	Na_2O_3
Content (%)	60.3	19.46	11.78	0.6	0.26	0.2	0.88	0.4

(Source: From Manufacturer)

Table 5: Properties of Coal Bottom Ash

Properties	Loss on Ignition	Specific Gravity	Dry unit weight (kN/m^3)	Water Absorption (%)
Values	1.0	2.4	15.12	1.5

(Source: From Manufacturer)

B. Tests On Soil Sample

The various soil properties are determined by conducting tests like Specific gravity, Hydrometer analysis, Unconfined Compressive Strength (UCS) tests, Atterberg's limit, and Standard Proctor tests.

1. Standard Proctor Test

The purpose of this experiment is to investigate the relationship between soil moisture content and dry density. During the compression process, air was expelled from the cavities, helping to increase bulk density. Maximum dry density (MDD) and optimum moisture content (OMC) are achieved when the soil is compacted with relatively high moisture content, displacing almost all the air.

2. Unconfined Compressive Strength

The maximum axial compressive stress that a cohesive soil sample can with stand without restraint is called the unconfined compressive strength (UCS). It indicates the stress-strain properties of rock sand soils, as well as the undrained strength.

RESULTS AND DISCUSSIONS

A. Analysis of Urea

Table 6: Results Analysis of Urea in soil with addition of different percentages of SM

Percentage of SM (%)	0	20	40	60	80	100
Amount of Urea (%)	3.67	2.88	2.21	1.5	0.98	0.53

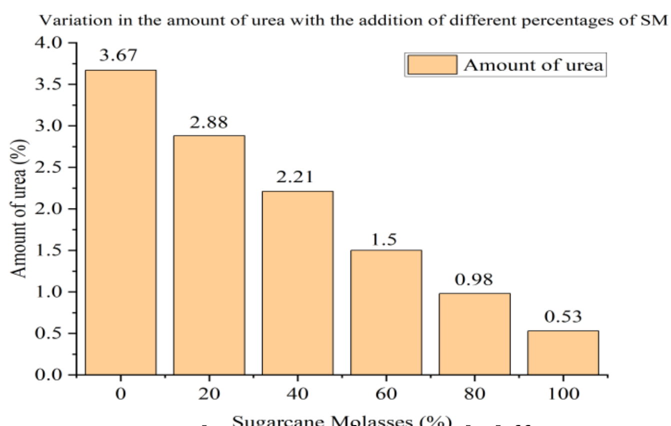
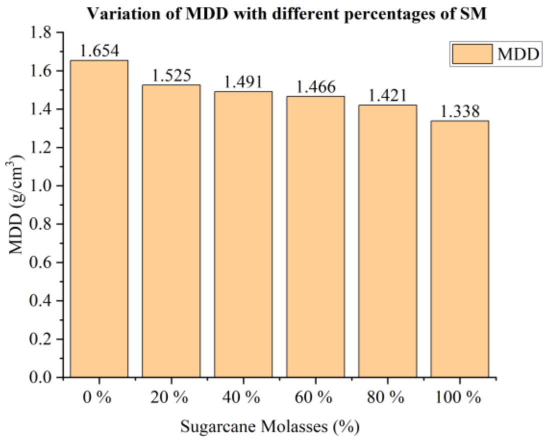


Fig 4: Variation in the amount of Urea with different percentages of SM

B. Standard Proctor Test

Table 7: Results of OMC and MDD with addition of different percentages of SM

SM (%)	0	20	40	60	80	1100
OMC (%)	22	25	28.7	29.2	33	33.7
MDD (g/cm^3)	1.65	1.52	1.49	1.46	1.42	1.33



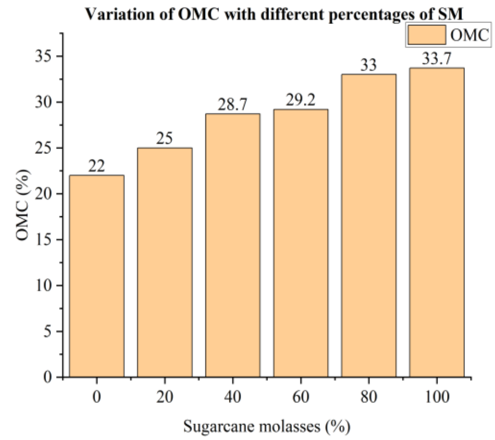


Fig 5: Variation of MDD with different percentages of SM   Fig 6: Variation of OMC with different percentages of SM

From Fig 5, it is observed that the addition of sugarcane molasses to the soil sample, decreases the maximum dry density. This shows the reduction of urea from the soil and the decrease in maximum dry density is due to the reduction in pH of the soil sample. From Fig 6, it is observed that the OMC increases with the increase in percentage of sugarcane molasses. This is due to the reduction in pH of the soil sample.

C. Unconfined Compressive Strength (UCS) Test

Table 8: Results of UCS with addition of different percentages of SM

SM (%)	0	20	40	60	80	100
UCS (kN/m^2)	103.47	78.34	71.98	65.62	61.35	49.4

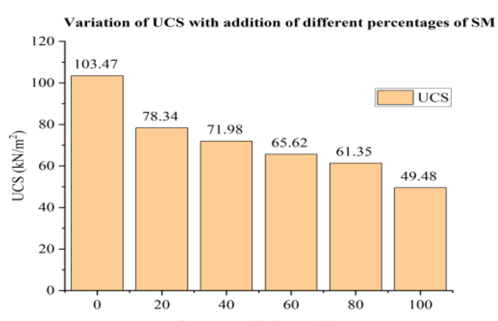


Fig 7: Variation of UCS with different percentages of S

From the Fig 7, it is observed that the addition of 100% of sugarcane molasses on soil sample decreases the UCS strength. The strength decreases from 103.47- 49.48kN/m^2. The decrease in the unconfined compressive strength is due to the reduction of pH of the soil.

Table 9: Results of OMC and MDD with addition of 100% SM and different percentages of CBA

Soil With 100% Of SM and different percentages of CBA	100 % SM	100 % SM+10% CBA	100 % SM+20% CBA	100 % SM+30% CBA	100% SM+40% CBA
OMC (%)	33.7	30.5	27	25	27.2
MDD(g/cm³)	1.330	1.339	1.42	1.46	1.357

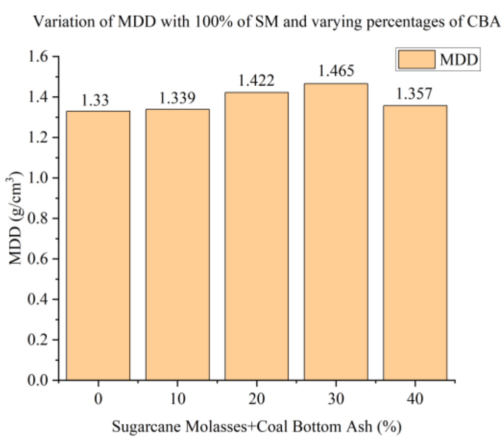


Fig 8: Variation of MDD with 100% SM and different percentages of CBA

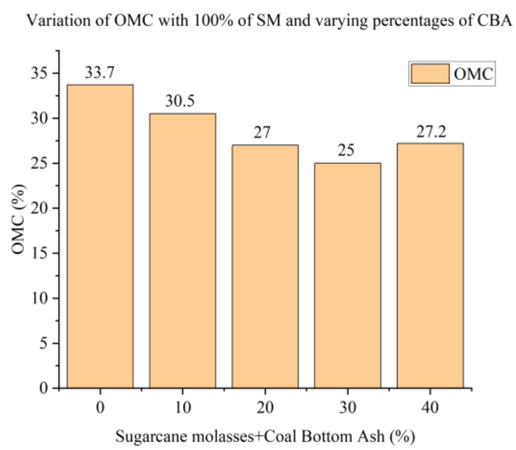


Fig 9: Variation of OMC with 100% SM and different percentages of CBA

With the addition of CBA to the soil, the MDD increases up to 30% addition of CBA and then it decreases. Additions of upto 30% CBA could properly grade soil- CBA mixture sand increase MDD, whereas higher amounts of CBA disrupted inter granular packing and consequently decrease MDD. Further more, since CBA has allow specific gravity compared to soil, adding soil with excess CBA may reduce MDD. The optimum moisture content reduces up to 30% addition of CBA to the soil. Further addition of CBA decreases the OMC. The decrease in optimal water content indicates that soils can be stabilized even at lower water content.

Table 10: Results of UCS with addition of 100% SM and different percentages of CBA

Soil With 100% Of SM and different percentages of CBA	100 % SM	100 % SM+10% CBA	100 % SM+20% CBA	100 % SM+30% CBA	100 % SM+40% CBA
UCS (kN/m²)	49.48	67.88	88.80	117.28	104

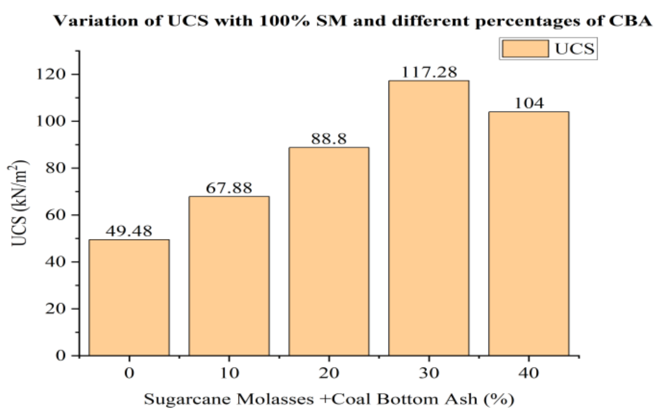


Fig 10: Variation of UCS with 100% SM and different percentages of CBA

UCS of the soil increases from 49.48 -117.28kN/m² at 30% addition of CBA to the soil containing 100% SM. Then UCS decreases to 104 kN/m² with 40 % addition of CBA.CBA is composed of siliceous and aluminous substances known as pozzolans, which chemically react with soil in the presence of moisture at normal temperatures to form cementitious compounds. Formation of cementitious material by this chemical reaction in the presence of water is known as hydration of CBA. Hydrated calcium silicate or calcium aluminum gel can bind inert materials. Lowering the density lowers the particle packing factor and the undrained shear strength at a content of 40%. Based on compression and UCS test results, 30% appears to be the optimum level for further investigation. This is attributed to improved cohesion, better sizing, and binding or packing of soil and CBA. Hence, the optimum percentage of CBA added to the soil containing 100% of SM is found out to be 30%.

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