# Application of $Alcl_3$, $Mgcl_2$, $Cacl_2$, $Ca(OH)_2$ and $Caco_3$ For Stabilizing Erosive Soil of Oraukwu Gully, in Anambra State

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***Abstract:*** **Soil erosion is one of the natural disasters that have greatly affected Anambra State; for it has affected the welfare and wellbeing of different communities in the State. This research therefore aims at stabilizing an erosive soil in Oraukwu (a town in Anambra State) with the use of the solutions of some inorganic chemicals such as $AlCl_3$, $CaCl_2$, $MgCl_2$, $Ca(OH)_2$ and $CaCO_3$. Laboratory analyses to determine the percentage of the particle size distribution was carried out; after which 10g and 15g each of the erosive soil sample was applied with 2 mL solution each of the $AlCl_3$, $CaCl_2$, $MgCl_2$, $Ca(OH)_2$ and $CaCO_3$ salt solutions. From the result of their particle size distribution, it was obtained that the erosive soil sample has a high percentage of sandy soil particles compared to the clay and the silt soil particles. After the different masses of the soil sample was stabilized with the use of the salt solutions, it was discovered that $MgCl_2$, $AlCl_3$, $CaCl_2$ gave the highest stabilizing power while $Ca(OH)_2$ and $CaCO_3$ gave the least stabilizing power. This was found out by using a pocket penetrometer. This then means that $MgCl_2$, $AlCl_3$ and $CaCl_2$ will be very useful in stabilizing erosive soil samples when the applied to the soil sample in the right proportion.**

***Keyword:*** **Chemicals, Gully, Erosion, Penetrometer, Soil, Stabilization**

## I. INTRODUCTION

Gully erosion is a global phenomenon. It is an enormous category of environmental denudation which leads to loss of land mass valuable for agricultural, domestic, industrial and aesthetic uses, and can also lead to loss of lives and properties (Obiadi et al. 2011). Soil erosion is a well-known environmental problem in south eastern Nigeria (Nwobodo et al. 2018); and of all the natural menaces being reported in various regions around the world, gully erosion and mass wasting are peculiar to several areas of Nigeria (Egueri and Igwe, 2020).

Igwe (2012) opined that the main danger to south-eastern environment in Nigeria is the slow but continuous dismemberment of the landscape by the soil structure due to water erosion. Although the initial stages of soil erosion through rill and interrill are managed by the people of the State, through endorsed soil management practices, the ways these gullies are formed are threatening the human settlements and scarce arable land. Therefore, formation of gullies and its attendant challenges have become a topic of conversation among soil scientists, geographers, geologists, engineers and social scientist.

The creation of gullies have become one of the chief disasters in the environment facing several towns and villages in the Southeastern part of Nigeria (Ezezika and Adetona, 2011), and Anambra State is generally underlain by constituents that are prone to gullying and other environmental challenges that are water-induced such as landslides, slope failures, etc. (Okoye et al. 2014). In 1994, Anambra State government, estimated that erosion severely affected more than 70% of the land masses at varying degrees of growth (Osadebe et al. 2014).

Soil is one of the most significant resources for humans. It is a limited but strategic resource of great significance (Telles et al. 2013), nevertheless, several parts of the Nigerian environment have been degraded through the ruins of soil erosion (Mallam et al. 2016). One form of erosion or the other has virtually affected all communities in Anambra State (Obi and Okekeogbu, 2017); soil erosion, being the detachment and movement of particles of soil, together with plant nutrients from the surface of the land by different agents of denudation (Amangabara et al. 2017).

The study now aims to find out the suitable chemicals that can be used to stabilize these erosive soils; and to confirm the level of stabilization using a pocket Penetrometer.

The objectives of the study were employed as follows:

- To find out the percentage of soil particle sizes of the erosive soil sample.
- To prepare solution of the chemicals for stabilizing the soil particles.
- To administer those chemicals solutions separately on the soil sample.
- To find out the level of stabilization of these chemicals on the soil sample with the use of pocket penetrometer.

*1.1 Study Area*

Anambra State is the eighth most populous State in Nigeria, and the second most thickly populous State in Nigeria after Lagos State. The stretch of more than 45 km between Oba and Amorka comprises of a group of many densely populous communities and small townships, which gives the region an estimated average density of 1,500–2,000 persons per square kilometre (Retrieved on $15^{th}$, July, 2020, from https://www.anambrastate.gov.ng/history).

Oraukwu town is in Idemili South, in Anambra State, which is situated about 209 mi (or 336 km) south of Abuja, the capital of the country (Retrieved on $15^{th}$, July, 2020, from https://www.tripmondo.com/nigeria/anambra/idemili-south/oraukwu/).

## II. MATERIALS AND METHODS

*2.1. Collection of the Soil Samples*

The soil samples were collected with plastic bags and labelled. They were then taken to the laboratory for analyses.

*2.2. Determination of Percentage Silt, Clay, Sand (Particle Size Analysis).*

Thirty grams of the soil sample was weighed into a 250mL beaker. A beaker was filled with distilled water to 200mL mark. Each soil sample was washed four times with distilled water. Twenty five (25) percent of sodium hexametaphosphate solution was prepared. 20mL of the solution and 200mL of distilled water were added to the washed soil sample, and then allowed to stand for 16hrs (overnight). The soil sample was transferred into 0.1µm sieve. During sieving, the sample that was left on the sieve was the sand while the sample that passed through the sieve was the silt. The sample was then dried to a constant weight (AOAC, 1973).

$\%\text{Sand} = \frac{\text{Residue wt.} \times 100}{\text{sample wt.}}$, $\%\text{Silt} = \frac{\text{Residue wt.} \times 100}{\text{sample wt.}}$, % Clay = 100 – (% Silt + % Sand).

*2.3. Preparation of the Stabilizing Chemicals*

The inorganic chemicals used for stabilizing the soil were: Aluminium Chloride ($AlCl_3$), Magnesium Chloride ($MgCl_2$), Calcium Chloride ($CaCl_2$), Calcium Hydroxide ($Ca(OH)_2$) and Calcium Trioxocarbonate (IV) ($CaCO_3$). Their solutions were each prepared by placing 20g each of their salts into 200mL of water.

*2.4 Preparation of the Soil Sample*

The erosive soil sample was dried in the sun for more than 20 hours so as to remove some moisture from the particles of the soil. Then it was dried in the oven for 1 hour so as to remove the left-over moisture.

Figure 1: Fabricated metallic Pipes

Metallic pipes that are flat-bottomed, with the diameter of 25mm and height of 60mm each were fabricated.

*2.5. Steps for the Chemical Stabilization Process*

Ten gram of the soil sample that has been dried in the oven was weighed into the fabricated pipe, and 2 mL of the $MgCl_2$ was poured out into the pipe. The pipe, which contains the mixture of the soil and chemical solution, was set on an electric heater for 7-10 minutes. This was done to allow the remaining water solvent to evaporate; and left behind was the soil sample and the salt solute. The pipe was taken down from the heater. The above experiment was repeated for the other chemicals. Also the complete experimental procedure was repeated using 15 g of the soil sample.

Figure 2: Pocket Penetrometer

Penetrometer is an instrument used to measure the level of resistance offered by the soil penetration. The resistance offered by the soil is in proportion to soil strength (Jaiswal, 2003).

This penetrometer was then used to find out the unconfined compressive strength (UCS).

The penetrometer was used as follows:

The tip of the penetrometer was placed perpendicular to the surface of the soil. The handle of the penetrometer was then gradually pressed into the soil with the penetrometer tip. When the pressured handle of the penetrometer was released, it returned to its original position, with the plastic ring being left behind on the calibrated steel rod of the penetrometer (Jaiswal, 2003).

## III. RESULTS AND DISCUSSION

### *3.1 Particle Size Distribution*

Table 1: Percentage of Clay, Silt and Sand (particle size distribution)

| Parameters | Oraukwu soil |
|---|---|
| *% Sand* | 56.8 |
| *% Silt* | 29.7 |
| *% Clay* | 13.5 |

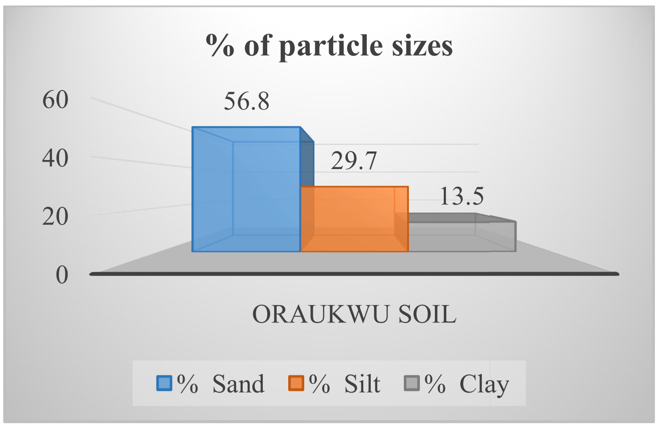


Figure 3: Percentage of the particle size distribution of the soil

From Figure 1, the Oraukwu soil samples contain a reasonably high percentage of sandy soil and low percentage of clay. This explains why Oraukwu soil is prone to erosion. This reason is because when clay particles are high in a given soil sample, it helps to hold the soil structure from easy disintegration, but where the soil samples have a low clay content, the soil tends to disintegrate faster. Bashari *et al.* (2013) states that clay performs as a material that cements which holds the soil particles together in an aggregate; and increasing the clay content relates with increasing the stability of the aggregate.

Oraukwu soil is susceptible to agents of erosion. This is because it contains a high percentage of sand and silt particles in it. According to Manyiwa and Dikinya (2013), soils with more quantities of sand and silt are more susceptible to erosion by water due to lack of stability of soil particles.

Table 2: Penetrometer confirmation of the Unconfined Compressive Strength (UCS) (in kg/cm$^2$) of the stabilization of 10g of the erosive soil using the chemical solution

| Soil mass | $AlCl_3$ | $MgCl_2$ | $CaCl_2$ | $Ca(OH)_2$ | $CaCO_3$ |
|---|---|---|---|---|---|
| 10g | 4.60 | 5.00 | 4.40 | 0.80 | 1.45 |

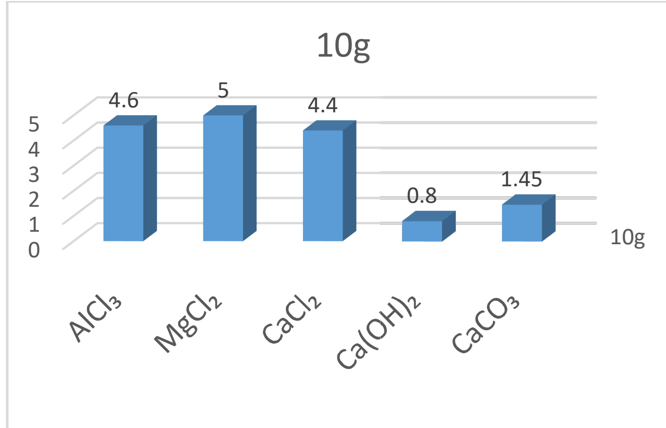


Figure 4: Penetrometer confirmation (in kg/cm$^2$) of the Unconfined Compressive Strength (UCS) chemical stabilization of 10g of Oraukwu erosive soil

The UCS values for the five chemicals on 10g each of the erosive soil were as follows: $MgCl_2$ (5.00kg/cm$^2$), $AlCl_3$ (4.60kg/cm$^2$), $CaCl_2$ (4.4kg/cm$^2$), $CaCO_3$ (1.45kg/cm$^2$) and $Ca(OH)_2$ (0.8kg/cm$^2$). The results showed that $MgCl_2$ salt solution was the best for stabilizing it while $Ca(OH)_2$ was the least for the soil particles stabilization.

Table 3: Penetrometer confirmation of the Unconfined Compressive Strength (UCS) (in kg/cm$^2$) of the stabilization of 15g each of the erosive soil using the chemical solution

| Soil mass | $AlCl_3$ | $MgCl_2$ | $CaCl_2$ | $Ca(OH)_2$ | $CaCO_3$ |
|---|---|---|---|---|---|
| 15g | 5 | 5 | 5 | 0.15 | 3.74 |

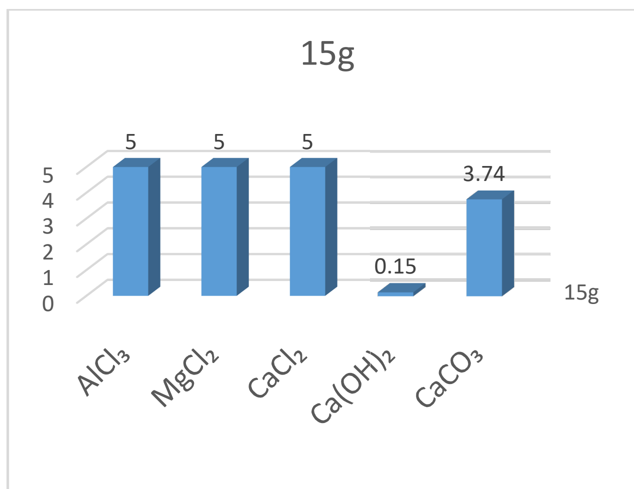


Figure 5: Penetrometer confirmation (in kg/cm$^2$) of the Unconfined Compressive Strength (UCS) chemical stabilization of 15g each of Oraukwu erosive soil

The UCS values for the five chemicals on 10g each of the erosive soil were as follows: $MgCl_2$ (5.00kg/cm$^2$), $AlCl_3$ (5.00kg/cm$^2$), $CaCl_2$ (5.00kg/cm$^2$), $CaCO_3$ (3.74kg/cm$^2$) and $Ca(OH)_2$ (0.15kg/cm$^2$). The results showed that $AlCl_3$, $MgCl_2$ salt solution was the best for stabilizing it while $Ca(OH)_2$ was the least for the soil particles stabilization.

Table 4: Penetrometer confirmation of the Unconfined Compressive Strength (UCS) (in kg/cm$^2$) of the stabilization of 10g and 15g each of the erosive soil using the chemicals

| Soil mass | $AlCl_3$ | $MgCl_2$ | $CaCl_2$ | $Ca(OH)_2$ | $CaCO_3$ |
|---|---|---|---|---|---|
| 10g | 4.60 | 5.00 | 4.40 | 0.80 | 1.45 |
| 15g | 5.00 | 5.00 | 5.00 | 0.15 | 3.74 |

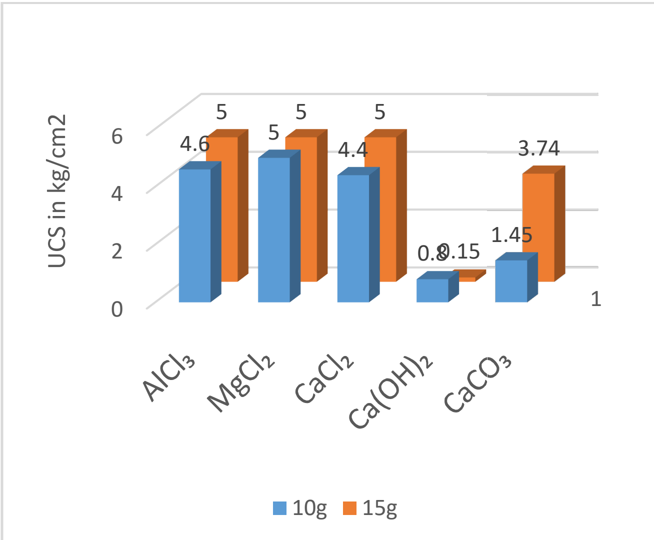


Figure 6: Composite result for the Penetrometer confirmation (in kg/cm$^2$) of the Unconfined Compressive Strength (UCS) chemical stabilization of 10g and 15g each of Oraukwu erosive soil

The values on Table 2 and Figure 2, shows composite result of the level of stabilization of these chemicals on the 10g and 15g soil samples of the Oraukwu erosive soil. The following was observed:

$MgCl_2$ gave the UCS value of 5.00kg/cm$^2$, for both 10g and 15g soil sample is best suitable for stabilizing both the 10 and 15g soil masses using 2 mL of 20g of the chemical solute in 200mL of water; followed by $AlCl_3$ gave values of 5.00 and 4.60kg/cm$^2$ for 15g and 10g of the soil respectively; and then by $CaCl_2$ which gave values of 5.00 and 4.40kg/cm$^2$ for the 15 and 10g of the soil sample respectively. $CaCO_3$ gave the values of 3.74 and 1.45kg/cm$^2$ for the soil sample respectively, while $Ca(OH)_2$ gave gave the least values, which are:0.15 and 0.8kg/cm$^2$ of the soil sample respectively.

From the overall results, the increase in the rate of stabilization of the following salts as it relates to the soil samples are:

$MgCl_2 > AlCl_3 > CaCl_2 > CaCO_3 > Ca(OH)_2$

## IV. CONCLUSION

The research used particle size distribution in the erosive soil of Oraukwu to indicate the reason the soil is erosive, by showing that the soil contains high level of sandy soil.

The research also went ahead to use some chemicals for the stabilization of this erosive soil sample. These chemicals were: $AlCl_3$, $MgCl_2$, $CaCl_2$, $Ca(OH)_2$ and $CaCO_3$. After stabilizing the erosive soil with these chemicals, the Unconfined Compressive Strength (UCS) was tested with the use of a pocket penetrometer. The results showed that $MgCl_2$ gave the best stabilization capacity while $Ca(OH)_2$ gave the least stabilization capacity. The level of increase in the stabilization of all the chemical used on the soil sample is as follows:

$MgCl_2 > AlCl_3 > CaCl_2 > CaCO_3 > Ca(OH)_2$

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