FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 5 No. 1, March, 2021, pp 135 – 139
DOI: https://doi.org/10.33003/fjs-2021-0501-546

EVALUATION OF SOIL PHYSICAL PROPERTY AS A DETERMINING FACTOR OF EROSION: A CASE STUDY OF BEHIND NIGERIA INSTITUTE OF LEATHER AND SCIENCE TECHNOLOGY, ZARIA

[1]Garuba, H.S., [2]Mukhtar, M. K., [1]Ugama, G. N., [1]Jamilu, A., [1]Aliyu, M. K. and [3]Yahaya, G.

[1,3,4,5]Department of Agric. and Irrigation Engineering, NAERLS, A.B.U. Zaria.
[2]Department of Soil Science, Federal University Dutsin_Ma, Katsina State.
[3]Department of Civil Engineering, Federal Polytechnic Auchi, Nigeria.

Corresponding Author's email: E-mail: garubahalimah@gmail.com

ABSTRACT

Soil Erosion is the detachment, transportation and deposition of soil sediment from one place to another. This has led to loss of lives and infrastructure in many parts of Nigeria. Soil properties play a role in it vulnerability and extent to erosion. This study aims to evaluate selected physical properties as they interact to cause erosion in the study area. The study was conducted in 2012 in a gully site in relation to its potential to erodibility of gully channel. This was done by collection of various soil samples at different depth followed by laboratory analysis to determine the plastic limit, moisture content and other engineering properties. The Results indicated that the soil samples have Atterberg limit that might be considered low, while liquid limit (LL) ranged from 25 – 30, the plasticity index (PI) ranged from 1 – 5%, which suggested that the soils are slightly plastic. Moisture content was moderate. The soil properties investigated played a major role in exacerbating the gully erosion in the area, therefore, the existing culvert should be redesigned and reconstructed taking appropriate consideration of the underlying soil properties.

Keywords: Samaru, Gully, Erosion and Soil properties.

INTRODUCTION

Soil Erosion is the detachment, transportation and deposition of soil sediments from one place to another. These continuous processes results to a miniature channel commonly known as rill, may develop into gully channel if appropriate conservation measures are not put in place. A gully channel is an open incised and unstable channel usually more than 30 centimetres deep (Egboka, 1993 and Floyd 1969). Gullies channels could result from natural or anthropogenic induce activities. Many locations especially in the south has experienced this environmental hazards for decades as it leads to environment deterioration and poverty in many parts of the world (Onwuka, 2008 and Abass , 2020). Saliu (2011) reported that the soil properties contribute to the increase in depth and size of gullies. The objective of this study was to determined the soil physical properties such as moisture content, plasticity limit, shrinkage limit, angle of internal friction, bulk density and dry density, void ratio and cohesion and to ascertain how they contribute to gully erosion problem behind Nigeria institute of leather and science technology Samaru, Zaria; the study was conducted between December 2011 to June, 2012. The results from this study could be used as an important input to adopt suitable soil conservation techniques in the area.

MATERIALS AND METHOD

Physiography and Climate of the Study Area.

Samaru, Zaria lies between $11^0$11'N and $7^0$11"N (Yunus *et.al*, 2010) and at an altitude of 686 m above the sea level. The climate of Samaru is described as dry; sub-humid with severe deficit of rainfall from October to May and a surplus from June to September with an annual rainfall of 1000 mm. It experiences a cool dry harmattan season between November and April (Igbadun, 1997). The study area (gully site) has a catchments area of about 1510 m^2 (from contour map). It is located few metres away from God's Time Primary School and few meters away from the rail line, Samaru, behind Nigerian Institute of Leather and Science Technology, Zaria, Kaduna State. The area is a medium density residential area with low motorcycle traffic which affects the soil compaction (Guru *et.al*, 2015).

Sample Collection

Within the limit of time and resources available the information below is presented with regard to the site geological data analysis from soil sample collected from different locations and various depth within the gully erosion site.

Laboratory Analysis of Soil Engineering Properties

Soil physical properties such as moisture content at the time of test, plastic limit and plasticity index, shrinkage limit, particle size distribution as well as the engineering properties such as shear strength, cohesion and angle of internal friction, specific gravity were determined.

Determination of Moisture Content

The natural moisture Content (MC) of the soil sample from the site was determined using the sand Bath Method. A clean, dry tin or container was weighed, then the container and the wet soil were weighed. The sample container was placed on the sand bath and heated on a stove, the soil was stirred at an interval of 5 minutes with a spatula during heating to assist evaporation of moisture and then when dried, the container and the dry soil were weighed.

Determination of Specific Gravity (GS): The specific gravity, also apparent specific gravity refers to actual particles which make up the soil mass. The term "specific gravity" as it is used here refers to particle as they occur naturally. It was determined using the Density Bottle Method (Suleiman, 2011).

Determination of Consistency Limits (Atterberg Limits)

These limits are defines as: liquid limit (LL) the minimum moisture content at which the soil will flow under its own weight. Plastic limit (p.l) the minimum moisture content at which the soil can be rolled into a thread of 3 mm diameter without breaking up. Shrinkage limit (S.L) the maximum moisture content at which further loss of moisture does not cause a decrease in the volume of the soil.

Shrinkage Limit :(SL)

A paste having the same liquid limit was used to fill a mould and tapped gently on the bench to remove air pockets, it was then levelled off along the top edge of the tile mould with spatula. Excess sample adhering to the rim was wiped off and Wipe off. The mould was then exposed to air (draught – free) to dry. It was transferred to an oven for drying.

The Shrinkage limit was calculated using the equation below;

$$S.L = \frac{Lo - Ld}{Lo} \times 100 \quad (1)$$

Where;

S.L is the Shrinkage Limit

Lo is the original Length of specimen,

L_d Length of dried Specimen

Plasticity Index(PI): This was evaluated by using the Atterberg limits method which involves using a Casagrande liquid limit device. The liquid limit and plastic limit were substituted in the relation to obtain plasticity index given as;

$$PI = 2.13 \times SL \quad (2)$$

Particle Size Analysis: This was determine using the wet sieving methods

$$Cu = \frac{D60}{D10} \quad (3)$$

Where;

CU is the Coefficient of uniformity

$D_{60,30,10}$ are the particle size of sieve 60 30 and 10 respectively

$$C.c = \frac{D(30)^2}{D60 \times D10} \quad (4)$$

Where;

C.c is the Coefficient of curvature

Bulk density: The bulk density was determined using the oven drying method and values substituted into the relations below to evaluate dry density and void.

<u>**TEST RUN(1,2,3)**</u>

Volume of sample = 6.0 x 6.0 x 4.0 = 144.0cm^3

Mass of sample = 271.1g

Specific Gravity Gs = 2.69

Moisture content mc = 4.68%

$$\text{Density} = \frac{mass}{volume} \quad (5)$$

$$\text{Dry density} = \frac{density}{1+m} \quad (6)$$

$$\text{Void ratio (e)} = \frac{Gs-1}{ed} \quad (7)$$

Strength of Soils (Shear Box Test)

This is the resistance of the soil to shearing stress under given conditions. It was determine using the shear Box Test procedure. Whose values (Shear and Normal Stress) were used to produce a Mohr circle and envelop failure to determine Angle of internal friction and Cohesion(C and ~~Ɵ~~).

Bearing Capacity: The ability of the underlying soil to support foundation loads without shear failure was evaluated using Terazaghi (1943) equation which is given as;

$$qu = CNc + qNq + 0.5yBNy \quad (8)$$

Where;
qu = Ultimate bearing capacity
q = effective overburden pressure
y = unit weight of soil
C = cohesion
Nc, Nq, Ny = Terazaghi bearing factors(obtained from interpolation)

Results

Table 1 presents the various results from the laboratory analysis of soil samples

Table 1 Laboratory Results of the Soil Samples

A 1	**Physical/Index Properties**	**Units**
1	Moisture content mc	4.69%
2	Bulk density ed	1.87 g/cm^3
3	Dry density ed	1.79 g/cm^3
4	Specific gravity Gs	2.69
5	Coefficient of curvature Cc	1.46
6	Coefficient of uniformity Cu	5.08
7	Void ratio e	0.94
8	Liquid limit LL	28.93%
9	Plastic limit pl	11
10	Shrinkage limit SL	10.75
11	plasticity index	18.05
12	Angle of internal friction	Ɵ =23°
13	Cohesion	7 kN/m^2
14	Bearing Capacity	203.5 kN/m^2

DISCUSSIONS

From Table 1, the plasticity index which is a measure of the elasticity of the soil is 18.05% which indicates that the soils have a medium plasticity state and non-cohesive (Burmister, 1997 and Khann, 2009). This explains why there is an increase in depth and size of gully during the rainy seasons as the soil particles are detached and transported easily.

The moisture content and optimum dry density obtained are 4.69% and 1.79 g/cm³ respectively. These values indicate that the soil is in a loose form, thus encouraging erosion in the area (Hunt and Glikes, 1992). A value of 1.87 g/cm^3 was obtained as bulk density which is similar to bulk density value reported by Aminu and Jaiyeoba (2015). This shows that the soil is moderately compacted (FAO, 1988 and Berhane *et.al*, 2019). The values of Angle of internal friction (φ) as well as cohesion(C) obtained from shear strength analysis of the sample shear strength are; 23^0 and 7 kN/m^2. The low values of C and φ indicates that the sample have less ability to resist shearing deformation stresses. The estimated ultimate bearing capacity(qu) was 203.5 kN/m².

CONCLUSION

From the study, the soil bulk density was 1.87 g/cm^3 and a plasticity index of 11 which explains why the study area is characterised by poor vegetation as a value of 1.87 g/cm^3 would limits root growth as well as a poor structural stability of the soil. Hence, one of the contributing factors to the problem of increasing depth and size of the gully in the study area is as a result of the type of soil found in the site. Therefore, the existing culvert should be redesigned and reconstructed taking appropriate consideration of the underlying soil properties.

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