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Influence of An Industrial Effluent on A Chikoko Soil

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Abstract: *"Chikoko" is a local name given to a very soft marine clay found in the fresh and salt water swamps of the Niger Delta, Nigeria. The influence of an industrial textile dye effluent on a Chikoko soil, is the subject of this study. The textile dye waste-chikoko soil was tested for index and engineering properties after curing. The Chikoko soil has low undrained strength, fairly high Atterberg limits and natural water contents. In the unconfined compressive strength (UCS) test, there is moderate increase in the compressive strength when stabilized with the textile dye waste. However, the improvement is not satisfactory as they are not up to the 1710kN/mm^2 UCS value for 7days cured specimens recommended by road note 31 (TRRL 1977) for base material. It is therefore concluded that, although the colour of the textile dye waste has no significant effect on the soil properties, the textile dye has soil stabilization potential even though the road note 31 specification was not met.*

I. Introduction

In this era of industrialization, a lot of wastes are generated from commercial, Industrial, domestic and mining activities; and are allowed to pollute the air, water or soil. Industrial waste treated or untreated are generally discharged over land or into water bodies. Like in the crude oil spillage around the Niger Delta, if the wastes are let over soil, it may alter soil properties to improve or degrade its engineering behaviour, which may result to functional or structural failure of the overlying superstructures (Sridharan et al 1981; Barbour and Yang 1993; Abdullah Assa'ad 1998' Sinha et al 2003, Zhang et al 2004) or may result to soil improvement (Bhattacharya et al 2004; Reddy Babu et al 2005).

The textile industry uses over 9000 types of dyes and it is its discharge of effluent in to the environment that is the subject of this study, amongst other effluent from food - processing industry, plastic, paint, paper and pulp etc. 10 to 20% of the dyes used in the textile industry is lost in the residual effluent (Anliker 1977) with about 50% reaching the environment (Karthikeyan, 1989). Not much attention however, have been paid to the influence of textile dye waste on soil properties, except may be, the work of Mallikarjuma Rao and Chinappa Reddy (1966) who reported the influence of a vat dye on the properties of expansive clay, which considerably increased with vat dye waste contamination.

II. Experimental Procedure

Chikoko soils are prevalent in the mangrove forests, which in Nigeria extends from Badagry in the west to Calaber in the East, covering a total area of 10,000km^2 along the Nigerian coast, and forming a vegetation band of 15 to 45km wide parallel to the coast. The Chikoko soil used in this study was obtained from Eagle Island, Port Harcourt, in trial pits at 1.0m depth. The soil was then transported to the soil laboratory of the Rivers State University of science and Technology, Port Harcourt, air-dried, pulverized, sieved through 4.75mm sieve and stored in bins.

Fig. 1: Map of Nigeria showing the location of Port Harcourt

Table 1: Chikoko Soil Classification Test Results

S/NO	Variables	Data
1	Depth of sampling (m)	1.0
2	Specific gravity	2.4
3	Bulk unit weight (kN/m^2)	14.5
4	Natural moisture content (%)	73.0
5	Liquid Limit (%)	78
6	Plastic Limit (%)	35
7	Plasticity Index	43
8	Liquidity Index (%)	0.88
9	Shrinkage Limit	15.6
10	Organic content (%)	5.7
11	pH	6.9
12	Cassagrande Classification	CH
13	Grain size distribution (1) Clay size (%) (< 0.002mm) (2) Silt size (%) (> 0.002 < 0.075mm) (3) Sand size (%) (> 0.075mm)	 52 42 6

Adequate quantity of four different dye wastes (Viz: Black, green, Purple and orange) was obtained from a local textile industry in a neighboring town, Aba in Abia state. Each of the four dye effluent wastes was mixed with 5kg of soil separately and kept in air tight containers, from which required quantity of samples were taken after curing for 2, 4, 7, 15 and 30 days; for laboratory test

Fig. 2: Mixture of purple and black effluent wastes with Chikoko soil

Fig. 3: Mixture of green and orange effluent wastes with Chikoko soil

Tests conducted on treated and untreated Chikoko include: pH, Atterberg limits and unconfined Compression test. All tests were carried out in accordance with BS 1377: 1990.

III. Results and Discussions

The properties of the Chikoko soil tested is shown in table 1; classified as clay of high plasticity following cassagrade classification.Influence of dye waste on the soil pH is shown in Fig 2; which indicates that the pH of the treated soils are less than that of the untreated soil. The low pH leads to flocculated structures, which is known to affect soil properties (Mitchell 1993), particularly its permeability; thus indicating an interaction between the dye effluent and the soil.

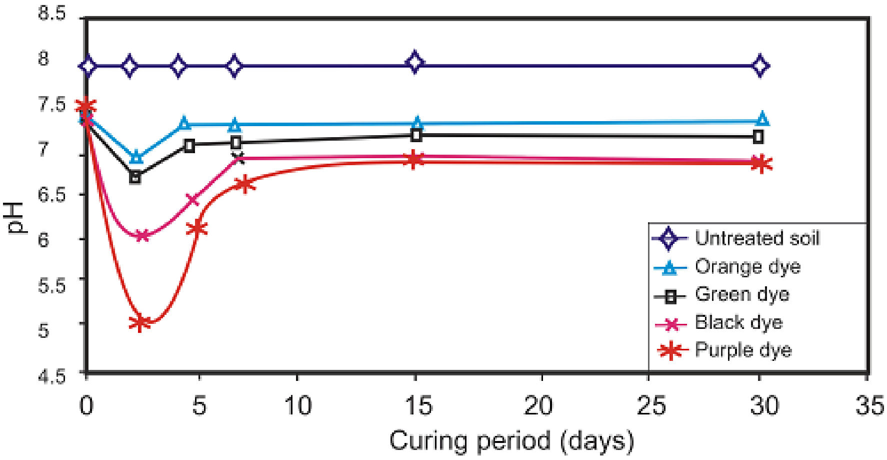

Fig. 2: Variation of pH with curing period

Fig 3 shows a sudden increase in the liquid limit immediately after mixing of the four different dye wastes. This immediate reaction may vary the engineering properties of the soil. However, as curing period increased beyond 7 to 15 days the liquid limit virtually returns to the untreated value and remains almost constant. These changes may be as a result of the presence of N_aCl and Zinc in the dyes (Srimurali 2001), as zinc dissolves in water at low values of pH (Zhang et al 2004), and thereby decreases the liquid limit with curing period.

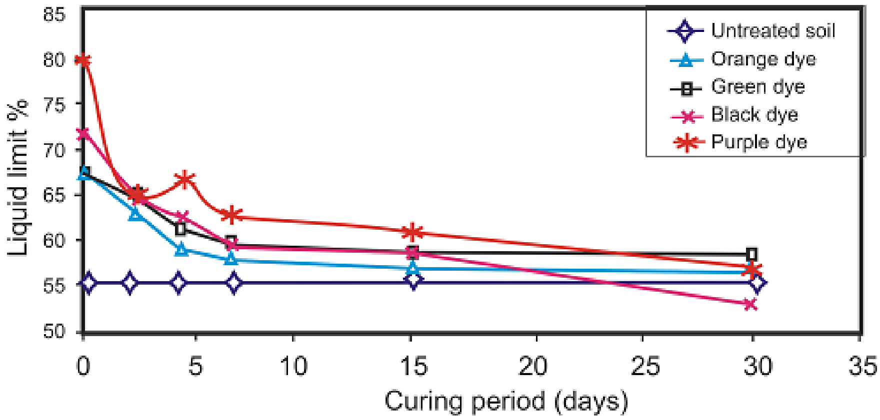

Fig 3: Variation of liquid limit with curing period

In contrary to the liquid limit test Fig 4 shows a sharp reduction in the plastic limit with curing period for the four dye wastes, soon after addition of dye wastes. However after 48 hours, the plastic limit increased with curing period until it is equal to the plastic limit of the untreated soil, and in about 15 days of curing becomes asymptotic to the x - axis; all of which show the interaction of dye waste with the soil.

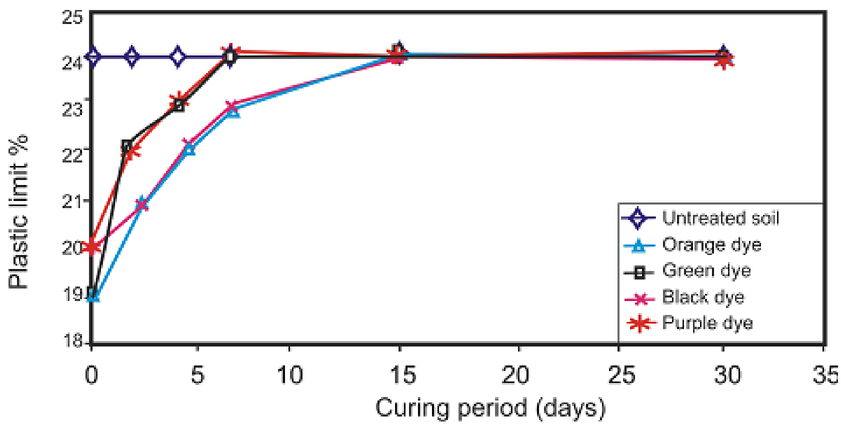

Fig 4: Variation of plastic limit with curing period

The plasticity index indicates the amount of clay in a soil. Fig 5 shows that the plasticity index behave in similar manner as the liquid limit. It increased sharply soon after addition of dye wastes and thereafter, reduced gradually to the control (untreated) level, and remains fairly constant after 15 days of curing. Irrespective of the dye colour, the dye waste effects changes in physical and chemical environment of the soil.

Fig. 5: Variation of plasticity index with curing period

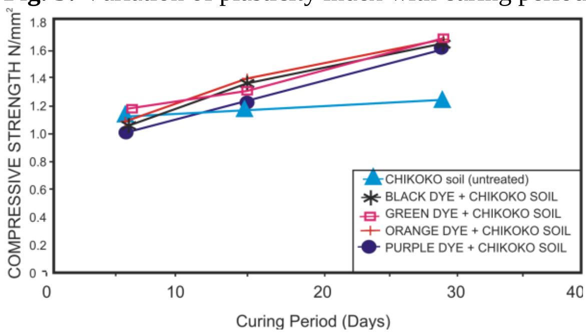

Fig. 6: Variation of compressive strength with curing period

Fig. 6 shows the variation of unconfined compressive strength with curing period; which indicates that the soil samples showed high compressive strength when interacted with various dyes cured for 14 and 28 days; although the dye reduced the compressive strength at 7 days before picking up. Inspite of the strength increase at 14 and 28 days, it did not meet the 1710kN/mm^2 UCS value for 7days cured specimens recommended by road note 31 (TRRL 1977) for base material.

IV. Conclusion

1. The Chikoko soil is classified as a high plasticity clay with over 90% of the soil particles passing sieve BS 200.
2. Test results confirm that the dye wastes improved the geotechnical properties of the chikoko soil as it introduced changes in physical and chemical environment within the soil, irrespective of the dye colour.
3. The compressive strength of the dye waste was also improved at 14 and 28 days age, even though they did not meet the 1710kN/mm^2 UCS value for 7days cured specimens recommended by road note 31 (TRRL 1977)for base material.

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