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Environmental Degradation: Impact of Plastic Materials (Polyethene) on Soil in University of Nigeria, Nsukka

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Abstract: The amount of waste polyethene plastic waste materials have increased in the resent years and the management and disposal method to cub its attendant environmental effect is a challenging problem. Predominantly, recycling of this polyethene plastic waste is very low because the processes of recycling are not economical. The present ways of reclaiming and disposing poyethene pastic waste is by incineration which is unsustainable because of its hazardous effect in our environment. Hence, the need to adopt sustainable approach to effectively manage this waste is of utmost importance. This research presents a sustainable alternative engineering management approach to tackle the degradation consequences of polyethene plastic waste. This was done by utilizing the polyethene plastic waste as a civil engineering material for soil improvement and stabilization processes. The stabilization was carried out experimentally by conducting liquid and plastic limits test, compaction and triaxial compression test. Different percentage by weight of shredded polyethene plastic waste (0, 2, 3 and 4%) of 2 different aspect ratios was mixed with clay soil. The result obtained reveals that the strength parameters (shear strength, angle of internal friction and reduction in the optimum moisture content and maximum dry density) of the soil were increased. Hence, using polyethene plastic waste for soil stabilization and improvement is a sustainable approach in plastic waste management system.

Key words: Environmental, degradation, impact, polyethene, soil, stabilization

INTRODUCTION

Environmental degradation is a process through which the natural environment is compromised in some way, reducing biological diversity and the general health of the environment. This process can be entirely natural in origin or it may be caused by human activities (Raleigh and Urdal, 2007; MacDonald, 2010; Chen *et al*., 2005; Kwame, 2008).

Soil is a basic engineering material and for agricultural production. But considering the soil as an engineering material is of great importance to engineers, especially to civil engineers (Roy and Bhalla, 2017). Almost all civil engineering structure (buildings, roads, stanchions and hydraulic structures like dams, reservoirs, etc.) are all build and supported by soil. Hence, the imperativeness of considering efficiency and sustainability approaches in the management strategies of conserving and preserving the soil as a matter of utmost importance. Clay soil is one of the most problematic soils encountered in civil engineering construction and requires improving and stabilizing (Aprin, 2017).

Plastic (polyethene) waste is often one of the most obnoxious kinds of rubbish and will be visible for millions of years in landfill sites without degrading. Disposal of plastic waste particularly plastic bag, plastic bottles has become a serious problem, especially in urban areas in terms of its misuse its dumping in the dustbin, clogging of drainage systems reduce soil fertility and aesthetic problems, etc. The risk to the family health and safety is on the increase and above all the environmental burdens are manifold. Hence, the need that plastic product must be recycled and re-use not to end in landfills site.

The issues of global warming and greenhouse effect have necessitated alternative, effective and sustainable management approach in disposing these plastic wastes which this research is set to solve. There are so, many practice and process of disposing of plastic waste that are detrimental to the health of the environment. Some of the practices are incineration and land filling.

There is need to encourage cleaner and a healthier environment, further reduce landfill (waste dump-hills) occurrences increase the available material for civil engineering construction, reduce pressure on soil as a backfill material by substituting it with plastic waste,

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engineering construction, reduce pressure on soil as a backfill material by substituting it with plastic waste, especially plastic bottles, etc. Hence, the objectives of the study are as follows:

To find an alternative and sustainable method of disposing plastic (polyethene) waste by using it as civil engineering material for various construction and soil stabilization processes. To find out the appropriate aspect ratio of plastic (polyethene) material for soil improvement.

MATERIALS AND METHODS

Materials used for the research were waste polyethene plastic and clay soil. The soil used was collected from a pit of depth 2 m in the Valley of Vertinary Medicine Mountain in the Western part of University of Nigeria, Nsukka (UNN) in Enugu State. The soil was certified as clay soil. Clay soil is chosen because it is one of the most problematic soils encountered in civil engineering construction and requires be improving and stabilizing. The polyethene waste materials were collected from Eni-Njoku hostel waste dumping site and canteen in the faculty of engineering premises. They included different kinds of polyethene plastic bottles (e.g., water bottle, lacasera bottle, coca cola bottles). They were of varying colours ranging from orange, green, white and red colours. Figure 1 shows the polyethene plastics.

Method of sample preparation: The sample (waste polyethene plastic bottle) was prepared manually by chopping or shredding the polyethene plastic wastes. Shredding was done using scissors. The bottles were shredded into rectangular pieces or shapes of different aspect ratios (ratios of 2.0 and 2.7). Figure 2 shows the shredded plastics. The soil sample collected was air-dried. The shredded plastics were mixed with the clay soil in different proportions or percentages by weight. The following percentages by weight of the soil were

Fig. 1: Polyethene plastics

Fig. 2: Shredded polyethene plastic

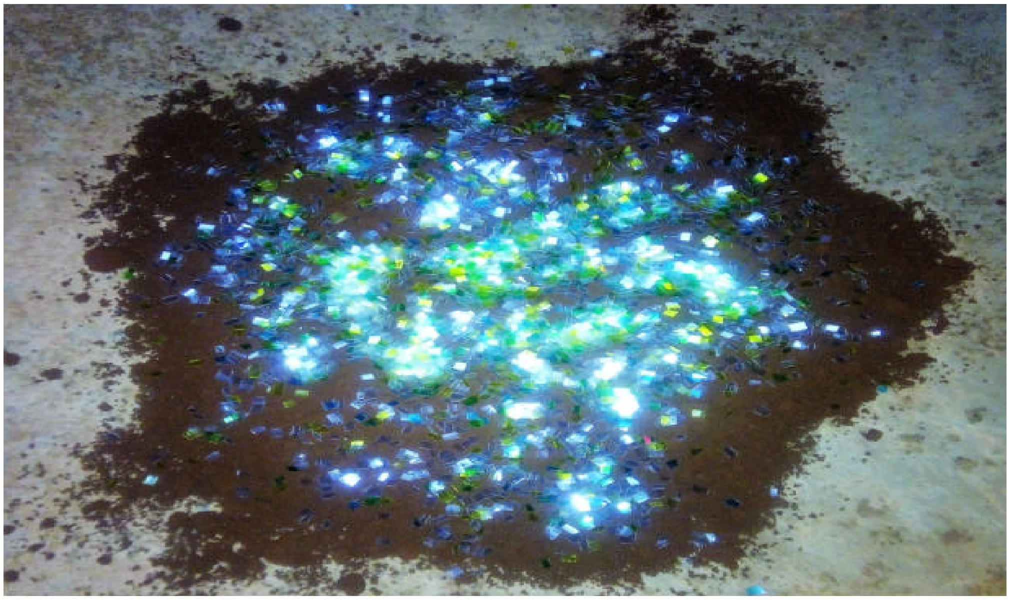

Fig. 3: Clay soil mixed with shredded polyethene plastic

used: 0, 2.0, 3.0 and 4.0% (Fig. 3). Triaxial compression test, liquid limit and plastic limit test, compaction test and moisture content test were carried out on the samples using recognized standard procedures.

RESULTS AND DISCUSSION

From the result obtained (Fig. 4 and Table 1 and 2) it is obvious that the Optimum Moisture Content (OMC) of clay soil decreases with polyethene plastic inclusion. The value of OMC with 0% polyethene plastic is 17.2% while OMC with 2% plastic is 13.22%. This can be attributed to the fact that polyethene does not absorb water. The addition of polyethene decreases the Maximum Dry Density (MDD) of the soil. This effect of polyethene in the soil property can find application in the construction of embankment.

The decrease in the maximum dry density of the soil may be attributed to the fact that the increase in percentage polyethen plastic reduces the bulk unit weight of the soil and the specific gravity. Figure 5-7 shows that the graphs of Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) is linear and this indicate that there is a linear relationship between percentage polyethene plastic inclusion and MDD, OMC.

Liquid limit and plastic limit test: It is observed from Table 3-5 that increase in the polyethene decreases the liquid limit, plastic limit and plasticity index. At 0% (LL = 41%, PL = 28.32%, PI = 16%), adding 2% polyethene plastic (LL = 38%, PL = 25%, PI = 15%) from the plasticity

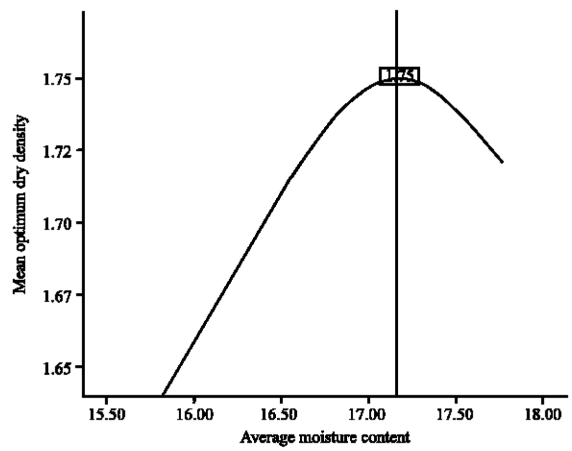

Fig. 4: Compaction curves with 0% polyethene plastic

Table 1: Result of compaction with polyethene plastics

Dry density	OMC	Percentage of plastic
1.75	17.20	0
1.80	13.98	2
1.72	15.84	3
1.70	14.25	4

Aspect ratio = 2

Table 2: Results of compaction with polyethene plastics

Dry density	OMC	Percentage of plastic
1.75	17.20	0.0
1.85	13.22	2.0
1.68	15.00	3.0
1.67	14.45	4.0

Aspect ratio = 2.7

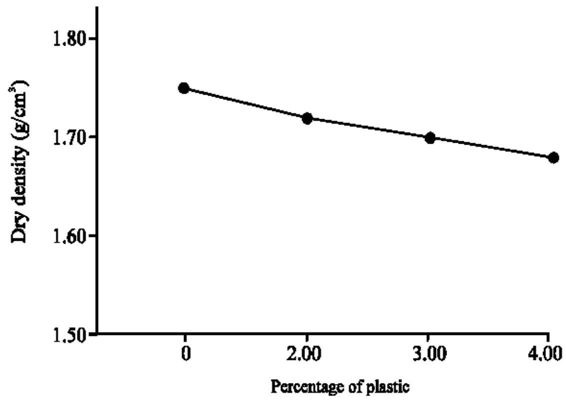

Fig. 5: Relationships between Maximum Dry Density (MDD) percentage plastics for aspect ratio = 2

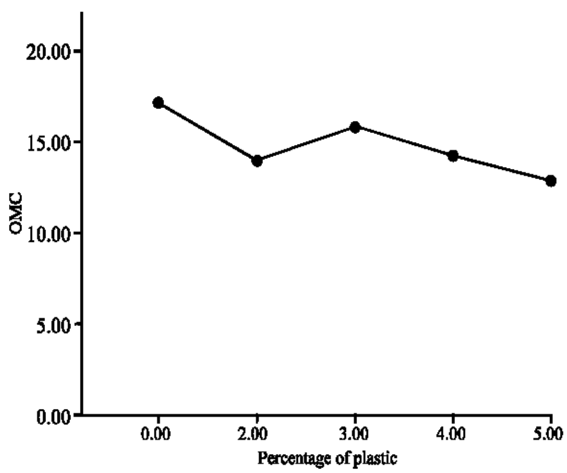

Fig. 6: Relationships between Optimum Moisture Content (OMC) percentage plastics for aspect ratio = 2

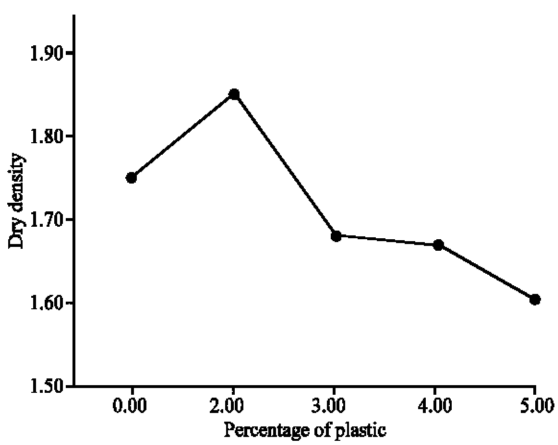

Fig. 7: Relationships between maximum dry density (MDD) percentage of plastics for aspect ratio = 2.7

Table 3: Liquid limit and plastic limit with 0 % polyethene plastics

	Liquid limit				Plastic limit	
Test No.	1	2	3	4	1	2
Wt. of wet soil+tin (g)	54.2	64.2	60.2	63.7	36.20	38.00
Wt. of driedx soil+tin (g)	47.6	52.8	48.4	51.5	32.10	34.80
Wt. of empty container (g)	24.0	22.8	23.5	22.9	22.50	23.10
Wt. of moisture (g)	9.3	11.4	11.8	12.2	4.10	3.20
Wt. of dried sample (g)	23.6	30	24.9	28.6	9.60	11.70
Moisture content (%)	27.97	36.0	47.3	42.66	29.29	27.35
No of blow	34	28	17	22	28.32	

Table 4: Liquid limit test with plastics

Liquid limit	Plastic limit	Percentage of plastics	Plasticity index
41	25	0	16
38	22.5	2	15.5
36.5	21.5	3	15
35	19	4	14.5

Aspect ratio = 2

Table 5: Liquid limit test with plastics

Liquid limit	Plastic limit	Percentage of plastic	Plasticity index
41	25	0	16
38	21.8	2	15.1
35	20	3	15
32.5	18.5	4	13

Aspect ratio = 2.7

chart, (Fig. 13) inclusion of polyethene plastic changes the classification of the clay soil from a soil of medium compressibility to a soil of low compressibility as it can be seen in the chart above. And this indicates improvement in soil strength. Figure 8-12 also reveal that as the aspect ratio of the polyethene plastic decreases, liquid limit, plastic limit and plasticity index also increased.

Table 6 and 7 summarize the result of the shear parameters obtain from undrain compression test. Cohesion holds the soil mass together. This parameter (cohesion, C) of the soil increases with increase in the percentage inclusion of polyethene plastic from 33 kN/m^2 (0% plastic) to 34.5 kN/m^2 (2% plastic).

There is a significant increase in the angle of internal friction (?) from 8.5° (0% plastic) to 10.5° (2% plastic) with addition of different percentage of polyethene plastic. The increase in the friction between surfaces of the polyethene plastic and the particle of clay soil may be responsible the increase in the angle of internal friction. This is in line with the findings of Naaif (2013).

The graph of the angle of internal friction against percentage polyethene plastic (Fig. 13-16) is linear and this may be attributed to the way the plastic is distributed in the soil. This is a slight deviation from the observation of Naaif (2013).

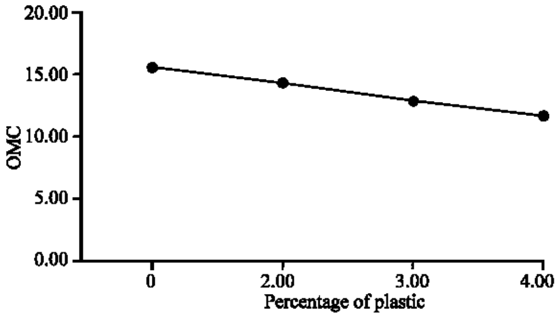

Fig. 8: Relationships between maximum dry density (OMC %) plastics for aspect ratio = 2.7

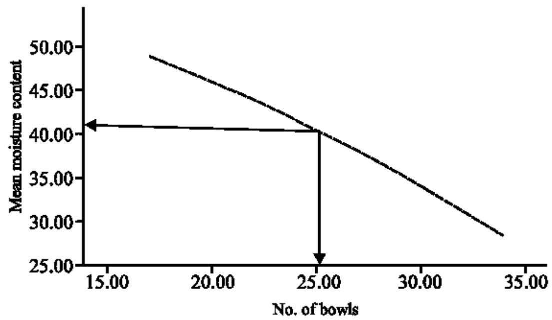

Fig. 9: Relationship between water content and no of blows with 0% pastic inclusion; Liquidity limit = 41 percentage

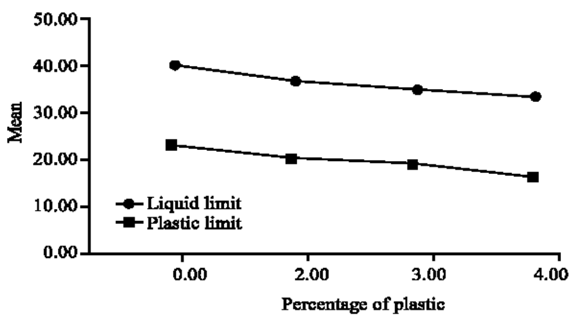

Fig. 10: Relationship between liquid and plastic limits and percentage plastics of aspect ratio = 2

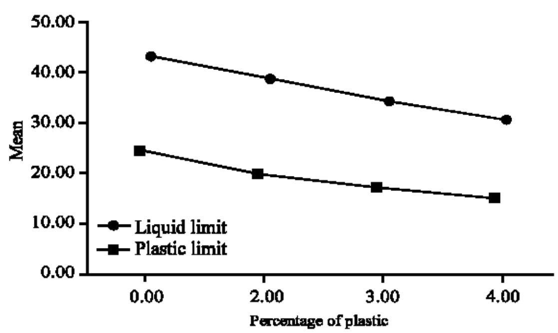

Fig. 11: Relationship between liquid and plastic limits and percentage plastics of aspect ratio = 2.7

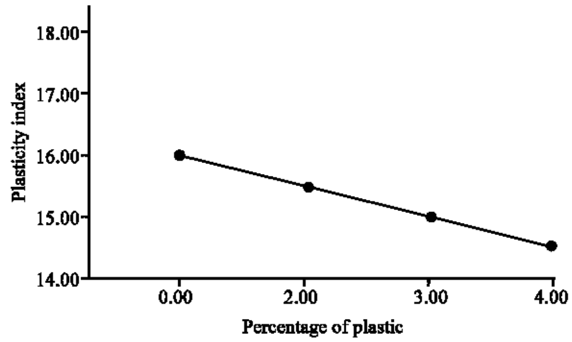

Fig. 12: Relationship between plasticity index and percentage plastic inclusion of aspect ratio = 2.0

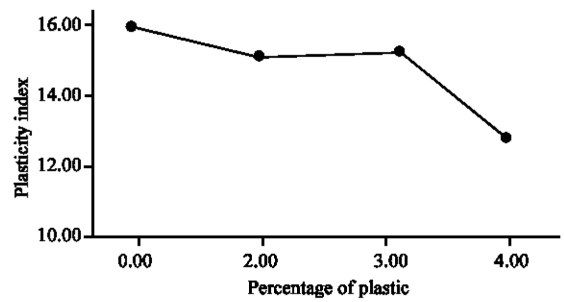

Fig. 13: Relationship between plasticity index and percentage plastic inclusion of aspect ratio = 2.7

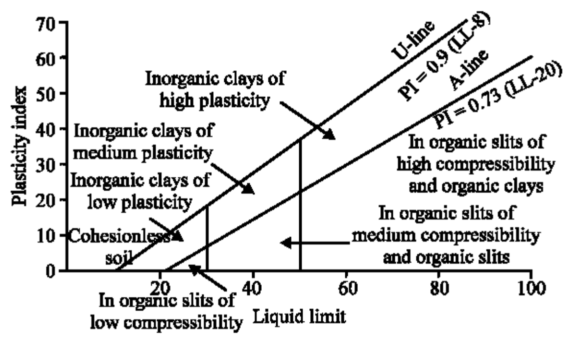

Fig. 14: Plasticity chart

Table 6: Triaxial test result with different percentage of plastics inclusion (aspect ratio = 2)

Compressive strength (kN/m^2)	Angle of friction (°)	Percentage of plastic
33	8.5	0
33.5	10	2
35	13	3
36	14.5	4

Table 7: Triaxial test result with different percentage of plastics inclusion (aspect ratio = 2.7)

Compressive strength (kN/m^2)	Percenage plastic	Angle of friction (°)
33	0	8.5
34.5	2	10.5
36	3	14
37	4	16.5

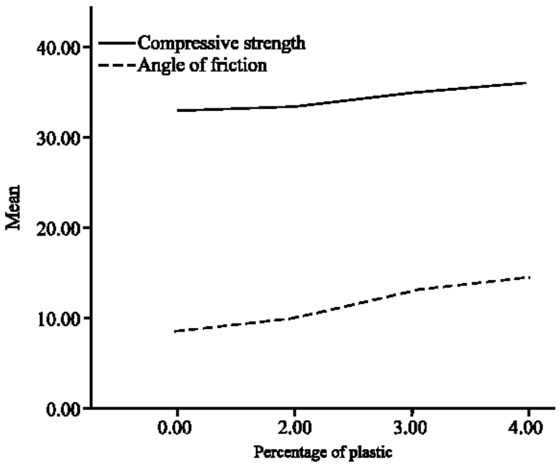

Fig. 15: Relationship between cohesion internal angle of friction and percentage plastic of aspect ratio = 2

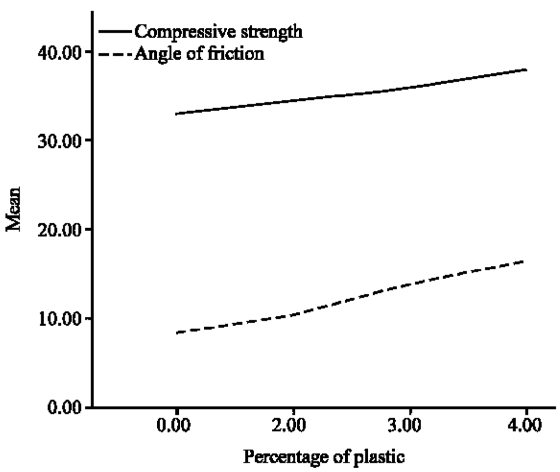

Fig. 16: Relationship between cohesion internal angle of friction and percentage plastic of aspect ratio = 2.7

CONCLUSION

This research has shown that polyethene plastic wastes (which is one of the global threatening wastes in our environment in this 21st century) have both positive and negative impact on soil. Polyethene plastic waste has claimed a large land space as a dumping site and hence, causing ecological hazards. The predominant effect is found in reducing the aesthetic of our environment, decreases the bearing capacity of the soil and increases the overall construction cost of project in the sense that extra money is needed for removing the polyethene plastic waste and possibly stabilizing that area occupied by the waste.

Sustainable management of polyethene plastic waste is the positive impact. This is possible because this plastic waste can be utilized in soil improvement and stabilization. Several soil tests like liquid and plastic limits, compaction and triaxial compression tests were carried out to verify the potential impact of polyethene plastic waste to improve the geotechnical properties of the soil. The inclusion of shredded waste polyethene plastic in the clay soil decreases both Maximum Dry Density (MDD) and Optimum Moisture Content (OMC). The variation between MDD, OMC and the shredded pieces of polyethene plastic waste is linear

Polyethene plastic waste shredded into rectangular pieces make the clay soil to move from a soil of medium plasticity to a clay soil of low plasticity. The classification of the soil is from a clay soil of Medium Compressibility (CM) to a clay soil of Low Compressibility (CL). The shear parameters of the clay soil are improved by the addition of shredded ployethene plastic waste. Angle of internal friction was increased by the addition of different percentage of polyethene plastic waste cut into 2 different aspect ratio. Geotechnical properties of the clay soil increases as the aspect ratio of the polyethene plastic pieces.

RECOMMENDATIONS

We recommend the following: every engineering solution should be implemented within the boundary of sustainability. That every engineering construction should be environmental friendly to be able to conserve the habitats of the biodiversities of the earth for optimum human performance. That further research should be conducted towards finding out influence of different aspect ratio in the stability of structures built on a soil stabilized by shredded waste polyethene plastic. Also, the effect of shredded plastic on the void ratio of the soil should be investigated. This aspect of managing polyethene waste should be practically and physically implemented in real world construction processes.

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