OPEN ACCESS
Saudi Journal of Engineering and Technology
Abbreviated Key Title: Saudi J Eng Technol
ISSN 2415-6272 (Print) |ISSN 2415-6264 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com/sjeat

Original Research Article

Effect of Fish Pond Sludge Waste Materials on the Geotechnical Properties of Soils

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DOI: 10.36348/sjet.2020.v05i03.001 | **Received:** 22.02.2020 | **Accepted:** 01.03.2020 | **Published:** 07.03.2020

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Abstract

The research work investigated the effect of leachate sludge waste materials from fish rearing pond on the geotechnical properties of soils from dumpsites. Results of investigations conducted on the control sites at 30m away from each dumpsite of bulk unit weight have incremental percentage values over control sites. Percentage (%) passing BS sieve #200 is higher in dumpsites over control with percentile value increase. Obtained results showed the presence of leachate material affects the physical properties of soil as percentages passing sieve #200 are higher in dumpsite materials. The consistency limits of the control sites of Liquid over plastic limits are summarized into the plastic index (LL-PL=PI), the obtained results indicated reductions values over dumpsites, this indicated that dumpsites leachate materials affected consistency limits of soils with higher values recorded in dumpsites. The entire results of grain size distribution showed that leachate percolation from waste materials affected the distribution properties of soil with dumpsites samples in dominants over control sites. Results indicated reductions in Unconfined compressive strength of control sites, these results showed that the presence of leachate materials has a great effect on soil properties of tested. The California bearing ration results of unsoaked and soaked of dumpsites have higher values over control sites. Results of California bearing ratio obtained showed that the presence of contaminants from waste dumpsites affected the geotechnical properties of tested soil with higher percentage values of dumpsites over control sites. The entire results showed that the presence of fish pond waste sludge has great negative effects on the geotechnical properties of soil.

Keywords: Waste Materials, Geotechnical, soils, dumpsites.

INTRODUCTION

The rearing of fishes in diverse cultural media or a confined controlled environment such as ponds made of concrete or earthen, plastics or wooden has alarming numbers[1].Among these cultured systems, concrete and earthen ponds are widely used [2] and all to meet the daily human population and challenges. Sludge generated from these practices is made up of various organic materials that end up at the bottom of ponds mixed with some of the various inorganic resulting from artificial feeds. The precise makeup of sludge depends greatly on what's in and around the pond, of course. Lately, the earthen ponding system was the conventional method, but of recent, reinforced concrete and concrete block tanks have dominated the fish rearing culture. Sewage sludge is that the suspension residue derived from wastewater treatment processes. Tons of exacting controls on the quality of effluent discharges have given rise to larger volumes of the sludge for disposal. Principal disposal routes embody agricultural employment and land restoration or sludge-to-landfill operations, either co--disposal at municipal landfills or mono disposal at dedicated sites. The sludge ought to be adequately dried or dewatered to engineer, as associate degree example, the economical handling and trafficability by machine plant, optimum compaction, associated degree adequate issue of safety against slope instability for the sludge-to-landfill route. The dewatered sludge is also a soil-like material, and, as such, its performance at intervals the lowland area unit usually modeled victimization soil mechanics theory and knowledge of the drying, shear strength, and consolidation properties of the compacted material. Geotechnical properties unit of measurement presented that, once applied to the planning of a sludge mono-fill, will facilitate minimize potential environmental hazards by increasing lowland stability and dominant leachate and biogas generation at intervals the strategy, these procedures will maximize the storage capability and, hence, the operational life of a given sludge monofil. The lowland trend ought to realize the implications of digestion on the engineering properties of the sludge material once determining the semi-permanent issue of safety against the instability of the lowland slopes.

Researches revealed that fish farmers preferred concrete method and 73% of ponds in Port Harcourt is made of concrete while 27% are of earthen ponds[3, 4].

Fish harvested from the controlled concrete tanks have high deposits of sludge [5], reported on contamination resulting from water quality and high stocking densities. The feed consumed by the fishes contained organic materials with varieties of microorganisms into the ponds [6].

Due to the number of ponds present, the generation of sludge is high which has resulted in indiscriminate dumping. The waste (sludge), as a result of lack of proper environmental planning, have contact with the soil, decomposed and reacts to the soil and thereby contaminating the soil and affecting the geoenvironmental and geotechnical properties of the soil. The result of the contaminative nature affects the geotechnical properties of the soil which makes the soil becomes plastic, shrinkage, compressible and low shear strength and low California Bearing Ratio. When soils are to be used for engineering activities such as foundation support for roads, building, and structural elements, it is very viable to develop economical and technically feasible solutions to reinforce/stabilized the poorest type of soil.

MATERIALS AND METHODS

Study Area Description and Sampling Locality

The study areas are in Obio/Akpor Local Government Areas of Rivers, namely; Rukpoku dumpsite laying between Longitudes 7^{o}.00 ’15" E and latitudes 4°.90’ 36" N, Igwuruta between Longitudes 7^{o}.01 ’36" E and latitudes 4°.95’ 64" N, and Rumuokoro between Longitudes 6o.98 ’80" E and latitudes 4°.86’ 51" N in the Niger Delta of South-South of Nigeria.

Sample Collections

Collection of soil sample

Soil samples were collected from the dumpsites using hand-dug agar, sampled on 150 mm farmland before sampling, sealed in plastic bags and placed in plastics to prevent moisture loss during transport. Samples collected at a depth of 1800 mm, and after 7 days of air drying, the optimal capacity of the deltaic soil can be assessed [7-9].

Geotechnical laboratory analysis of soil properties was performed to determine the physical properties; New and clean cellophane bags with specific gravity, humidity, fine particle percentage, liquid limit, plastic limit, plasticity index, optimum humidity, maximum dry density and heavy metal levels in individual profiles. Samples were immediately sent to the laboratory for analysis

Conducted tests included (1) Moisture Content Determination (2) Atterberg limits test (3) Particle size distribution (sieve analysis) and (4) Standard Proctor Compaction test, (5) California Bearing Ratio test (CBR) and (6) Unconfined compressive strength (UCS) tests.

Moisture Content Determination

The natural moisture content of the soil obtained from the site was determined by BS 1377 (1990) Part 2. The freshly assembled sample was laminated and kept loose in the container, and the containers containing the specimens were weighted together. 0.01g.

Grain Size Analysis (Sieve Analysis)

This test is done to determine the percentage of different grain sizes present in the soil. Mechanical or sieve analysis is performed to determine the distribution of coarse, large-sized particles larger-sized particles.

Atterberg Limits

This test is performed to determine the plastic and liquid boundaries of fine-grained soil. Liquid limit (LL) is defined as arbitrary water content, in which a portion of the soil in a standard cup and a standard measuring groove is cut because a distance of 13 mm flows simultaneously into the canal (1/2 in.) with two shocks per second, 25 mm from the cup. Plastic restriction (PL) is the amount of water, in percentage, that cannot hold soil without breaking it into pieces with a diameter of 3.2 mm (1/8 inch).

Moisture – Density (Compaction) Test

This laboratory test is performed to determine the relationship between moisture and soil dry density for the specified compact effort. Compact effort means mechanical force applied to the mass of the soil. There are many different techniques used to compact the soil in the field, and some examples are tamping, kneading, and static load capture. In 1933, the lab at the RK The type and method of equipment developed by R. Proctor uses the tamping or impact condensation method, therefore, the test is also called the proctor test.

Unconfined Compression (UC) Test

The primary objective of this test is to determine unconfined compressive strength, which is then used to calculate the uniform shear strength of the soil under exceptional conditions. According to the ASTM standard, unconfined compressive strength is defined as compressive stress in which unrefined cylindrical clay fails the normal compression test. Also, in this test method, the unconfined compressive strength is taken as the maximum load attained per unit area, or the load per unit area at 15% axial strain, whichever occurs first during the performance of a test.

California Bearing Ratio (CBR) Test

The California Bearing Ratio (CBR) test was developed by the California Division of Highways as a method of classifying and evaluating soil- subgrade and base course materials for flexible pavements. CBR is a measure of the resistance of a material to penetration.

RESULTS OF INVESTIGATION

Results of investigations conducted on the control sites, 30m away from each dumpsite of Bulk Unit Weight have incremental percentile values of 63.24466%, 63.09872% and 50.78086% over control sites 36.75534%, 36.90128%, and 49.21914%. The results indicated a rise in bulk densities due to the presence of leachate materials percolation into the soil.

Percentages (%) passing BS sieve #200 are higher in dumpsites over control with percentile value increase of 100.9165%, 64.84465% and 74.77857% over -0.9165%, 35.15535& and 25.22143, obtained results showed the presence of leachate material affects the physical properties of soil as percentages passing sieve #200 are higher in dumpsite materials.

The specific gravity percentile values decreases in dumpsites with percentage values of -54.282%, -23.9206% and -11.0517% against 154.282%, 123.9206% and 111.0517%. This showed the influence of leachate materials does not affect the specific gravity of soils.

The natural moisture content (%) of soils as affected by leachate waste with percentage differences of 71.22015%, 57.94135% and 75.06732% over-controlled samples of 28.77985%, 42.05865%, and 24.93268%.

The consistency limits of the control sites of Liquid over plastic limits are summarized into plastic index (LL-PL=PI) are percentage values of -30.6681%, -47.5502% and -44.439% against 130.6681%, 147.5502% and 144.439% of controlled sites, obtained results indicated reductions values over dumpsites, this indicated that dumpsites leachate materials affected consistency limits of soils with higher values recorded in dumpsites. The Compaction Characteristics of dumpsites are not affected.

The Grain Size Distribution of analyzed samples was affected by leachate material percolation with higher distributions in dumpsites of gravel; 152.8444%, 152.2619%, 141.5673% over control sites of -52.8444%, -52.2619%, -41.5673. Sand distributions are; 141.7795%, 145.6778%, 163.6071% over control sites of -41.7795%, -45.6778%, -63.6071%. Silt distributions are; 154.8001%, 181.898%, 210.139% over control sites of -54.8001%, -81.898%, -110.139%. Clay size distributions are 136.7024%, 134.179%, 130.7075% over control sites of -36.7024%, -34.179% and -30.7075%.

The entire results of grain size distribution showed that leachate percolation from waste materials affected the distribution properties of soil with dumpsites samples in dominants over control sites. The Unconfined compressive strength of sampled soils from dumpsites is 155.4973%, 120.3358%, 121.7354% over control sites of -55.4973%, -20.3358% and -21.7354%.

Results indicated reductions in unconfined compressive strength of control sites, these results showed that the presence of leachate materials has a great effect on soil properties of tested.

The California bearing ration results of unsoaked of dumpsites are 280.556%, 352.161%, 299.385% over control sites of -180.556%, -252.161% and -199.385 while soaked CBR for dumpsites are 273.19%, 305.717%, 195.3577% and control sites are -173.19%, -205.717%, -95.3577%. Results of California bearing ratio obtained showed that the presence of contaminants from waste dumpsites affected the geotechnical properties of tested soil with higher percentage values of dumpsites over control sites.

Table-3.1: Engineering Physical Analysis of Soil Samples at the Dumpsite

Description	Rukpoku (Laterite Soil) Site 1		Igwuruta Dumpsite (Laterite Soil) Site 2		Rumuokoro Dumpsite (Laterite Soil) Site3	
	Control	**Dumpsite**	**Control**	**Dumpsite**	**Control**	**Dumpsite**
Depth of sampling (m)	1.8	1.8	1.8	1.8	1.8	1.8
Bulk Unit Weight (kN/m^3)	13.9	16.2.4	13.1	15.3	12.7	14.4
(%) passing BS sieve #200	33.5	42.7	35.3	41.4	31.9	38.3
Color	**Reddish**		**Reddish**		**Reddish**	
Specific gravity	2.55	2.23	2.59	2.44	2.57	2.50
Natural moisture content (%)	29.9	35.6	33.2	38.3	27.8	33.4
Consistency Limits						
Liquid limit (%)	35.9	31.4	42.7	38.4	39.3	34.6
Plastic limit (%)	22.3	18.8	29.2	26.4	27.8	24.3
Plasticity Index	13.6	12.6	13.5	12.0	11.5	10.3

AASHTO soil classification	A-2-6	A-2-6	A-2-6	A-2-6	A-2-6	A-2-6
Compaction Characteristics						
Optimum moisture content (%)	15.8	13.8	17.7	14.5	14.7	11.3
Maximum dry density (kN/m^3)	1.72	1.57	1.84	1.69	1.63	1.51
Grain Size Distribution						
Gravel (%)	4.9	4.3	6.6	5.8	5.1	4.6
Sand (%)	33.5	30.2	38.3	34.2	43.5	37.2
Silt (%)	37.1	39.5	27.7	29.8	17.6	21.5
Clay (%)	24.5	26.6	27.4	30.2	33.8	36.7
	Unconfined compressive strength					
Unconfined compressive strength (kPa)	147.6	128.7	155.6	147.9	168.6	159.7
California Bearing Capacity (CBR)						
Unsoaked (%) CBR	13.2	8.8	14.4	8.5	14.9	9.6
Soaked (%) CBR	10.8	7.3	11.3	7.2	10.7	8.5

Table-3.2: Control and Dumpsites Obtained Values Difference and Percentile Value

	Control and Dumpsites Obtained Values Difference						**Control and Dumpsite Percentile Value**					
	Site 1		**Site 2**		**Site 3**		**Site 1**	**Site 2**	**Site 3**	**Site 1**	**Site 2**	**Site 3**
	Control	**Dumpsite**	**Control**	**Dumpsite**	**Control**	**Dumpsite**	**Control**	**Dumpsite**	**Control**	**Dumpsite**	**Control**	**Dumpsite**
Bulk Unit Weight (kN/m3)	0.856	1.168	0.856	1.168	0.882	1.134	85.591	116.835	85.621	116.794	88.194	113.386
Percentage(%) passing BS sieve #200	0.785	1.275	0.853	1.173	0.833	1.201	78.454	127.463	85.266	117.281	83.290	120.063
Specific gravity	1.143	0.875	1.061	0.942	1.028	0.973	114.350	87.451	106.148	94.208	102.800	97.276
Natural moisture content (%)	0.840	1.191	0.867	1.154	0.832	1.201	83.989	119.064	86.684	115.361	83.234	120.144
	Consistency Limits											
Liquid limits (%)	1.143	0.875	1.112	0.899	1.136	0.880	114.331	87.465	111.198	89.930	113.584	88.041
Plastic limits (%)	1.186	0.843	1.106	0.904	1.144	0.874	118.617	84.305	110.606	90.411	114.403	87.410
Plasticity limits (%)	1.079	0.926	1.125	0.889	1.117	0.896	107.937	92.647	112.500	88.889	111.651	89.565
	Compaction Characteristics											
Optimum moisture content (%)	1.145	0.873	1.221	0.819	1.301	0.769	114.493	87.342	122.069	81.921	130.089	76.871
Maximum dry density (kN/m3)	1.096	0.913	1.089	0.918	1.079	0.926	109.554	91.279	108.876	91.848	107.947	92.638
	Grain Size Distribution											
Gravel (%)	1.140	0.878	1.138	0.879	1.109	0.902	113.954	87.755	113.793	87.879	110.870	90.196
Sand (%)	1.109	0.901	1.120	0.893	1.169	0.855	110.927	90.149	111.988	89.295	116.936	85.517
Silt (%)	0.939	1.065	0.930	1.076	0.819	1.222	93.924	106.469	92.953	107.581	81.860	122.159
Clay (%)	0.921	1.086	0.907	1.102	0.921	1.086	92.105	108.571	90.728	110.219	92.098	108.580
	Unconfined compressive strength											
Unconfined compressive strength (kPa	1.147	0.872	1.052	0.951	1.056	0.947	114.685	87.195	105.206	95.051	105.573	94.721
	California Bearing Capacity (CBR)											
Unsoaked (%) CBR	1.500	0.667	1.694	0.590	1.552	0.644	150.000	66.667	169.412	59.028	155.208	64.430
Soaked (%) CBR	1.479	0.676	1.569	0.637	1.259	0.794	147.945	67.593	156.944	63.717	125.882	79.439

Table-3.3: Control and Dumpsites Obtained Values Difference and Percentile Value Difference

	Control and Dumpsites Obtained Values Difference						Control and Dumpsite Percentile Value Difference					
	Site 1		Site 2		Site 3		Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
	Control	Dumpsite	Control	Dumpsite	Control	Dumpsite	Control	Dumpsite	Control	Dumpsite	Control	Dumpsite
Bulk Unit Weight (kN/m3)	0.856	1.168	0.856	1.168	0.882	1.134	63.245	36.755	63.099	36.901	50.781	49.219
Percentage(%) passing BS sieve #200	0.785	1.275	0.853	1.173	0.833	1.201	100.917	-0.917	64.845	35.155	74.779	25.221
Specific gravity	1.143	0.875	1.061	0.942	1.028	0.973	-54.282	154.282	- 23.921	123.921	-11.052	111.052
Natural moisture content (%)	0.840	1.191	0.867	1.154	0.832	1.201	71.220	28.780	57.941	42.059	75.067	24.933
	Consistency Limits											
Liquid limits (%)	1.143	0.875	1.112	0.899	1.136	0.880	-54.215	154.215	- 42.776	142.776	-51.501	151.501
Plastic limits (%)	1.186	0.843	1.106	0.904	1.144	0.874	-69.627	169.627	- 40.596	140.596	-54.476	154.476
Plasticity limits (%)	1.079	0.926	1.125	0.889	1.117	0.896	-30.668	130.668	- 47.550	147.550	-44.439	144.439
	Compaction Characteristics											
Optimum moisture content (%)	1.145	0.873	1.221	0.819	1.301	0.769	-54.800	154.800	- 81.898	181.898	-110.139	210.139
Maximum dry density (kN/m3)	1.096	0.913	1.089	0.918	1.079	0.926	-36.702	136.702	- 34.179	134.179	-30.708	130.708
	Grain Size Distribution											
Gravel (%)	1.140	0.878	1.138	0.879	1.109	0.902	-52.844	152.844	- 52.262	152.262	-41.567	141.567
Sand (%)	1.109	0.901	1.120	0.893	1.169	0.855	-41.780	141.780	- 45.678	145.678	-63.607	163.607
Silt (%)	0.939	1.065	0.930	1.076	0.819	1.222	25.139	74.861	29.335	70.665	82.217	17.783
Clay (%)	0.921	1.086	0.907	1.102	0.921	1.086	33.044	66.956	39.166	60.834	33.075	66.925
	Unconfined compressive strength											
Unconfined compressive strength (kPa	1.147	0.872	1.052	0.951	1.056	0.947	-55.497	155.497	- 20.336	120.336	-21.735	121.735
	California Bearing Capacity (CBR)											
Unsoaked (%) CBR	1.500	0.667	1.694	0.590	1.552	0.644	-180.55	280.556	- 252.16	352.161	-199.385	299.385
Soaked (%) CBR	1.479	0.676	1.569	0.637	1.259	0.794	-173.19	273.190	- 205.71	305.717	-95.358	195.358

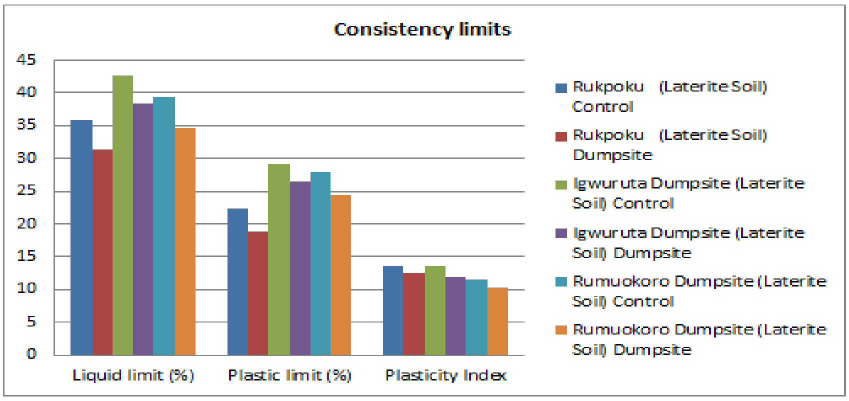

Fig-3.1: Consistency Limits of Control and Dumpsites

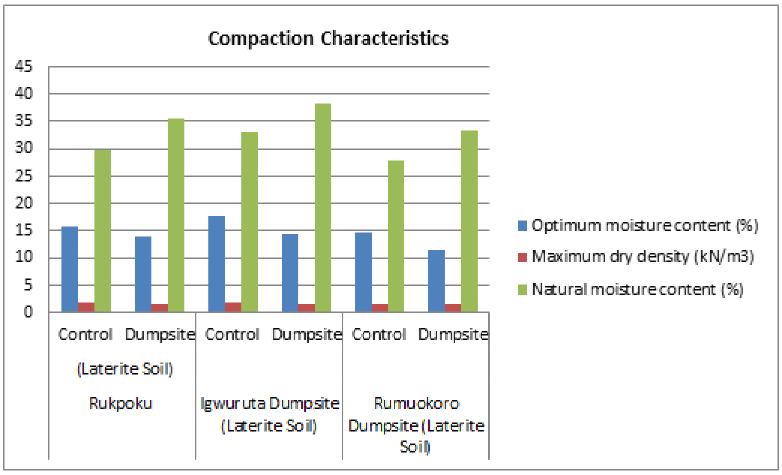

Fig-3.2: Compaction of Control and Dumpsites

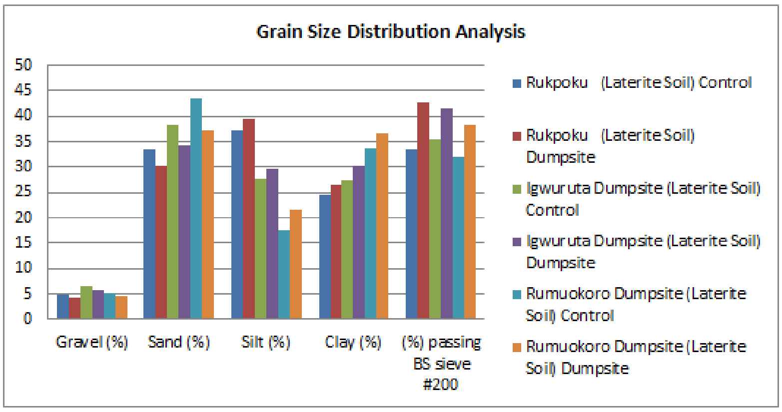

Fig-3. 3: Grain Size Distribution Analysis of Control and Dumpsites

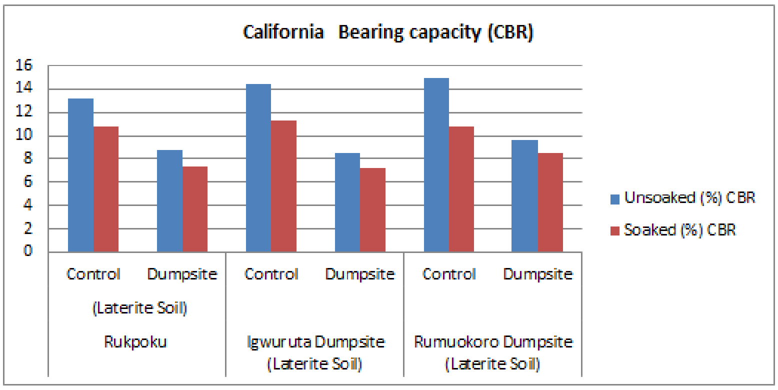

Fig-3.4: California bearing ratio of Control and Dumpsites

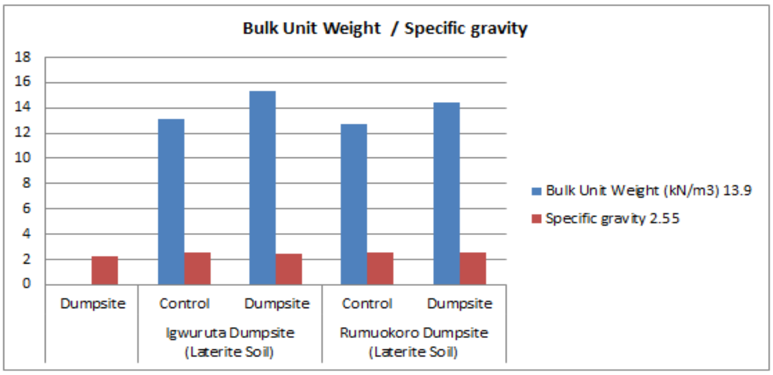

Fig-3.5: Bulk Unit Weight / Specific gravity of Control and Dumpsites

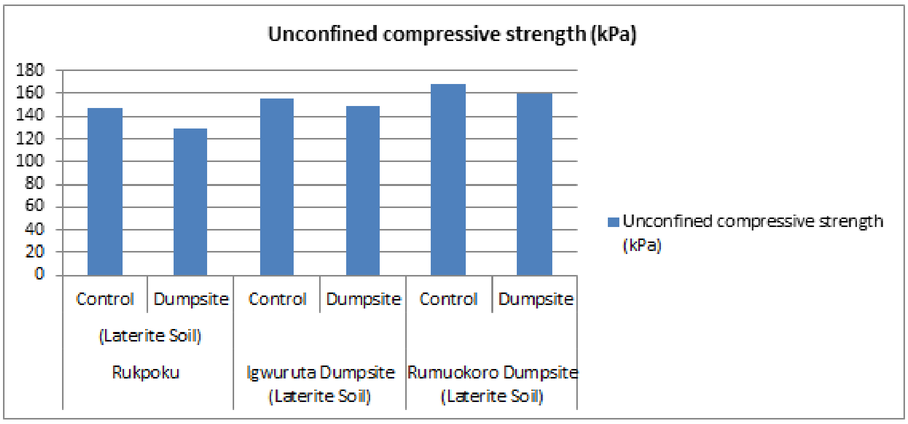

Fig-3.6: Unconfined compressive strength (kPa) of Control and Dumpsites

CONCLUSION

The below conclusions were drawn from the research results

1. The results indicated a rise in bulk densities due to the presence of leachate materials percolation.
2. Obtained results showed the presence of leachate material affects the physical properties of soil as percentages passing sieve #200 are higher in dumpsite materials.
3. This showed the influence of leachate materials does not affect the specific gravity of soils.
4. Obtained results indicated reductions values over dumpsites; this indicated that dumpsites leachate materials affected consistency limits of soils with higher values recorded in dumpsites.
5. The entire results of grain size distribution showed that leachate percolation from waste materials affected the distribution properties of soil with dumpsites samples in dominants over control sites.
6. Results indicated reductions in Unconfined compressive strength of control sites, these results showed that the presence of leachate materials has a great effect on soil properties of tested.
7. Results of California bearing ratio obtained showed that the presence of contaminants from waste dumpsites affected the geotechnical properties of tested soil with higher percentage values of dumpsites over control sites.

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