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Effective Management of Wastewater Treatment Plant to Reduce the Effect of Effluent on Location Soil

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ABSTRACT: *In the process of the design of a Wastewater Treatment Plant (WWTP), it is important to investigate the problems in the design of a wastewater treatment plant (WWTP) and as such, the properties of the soil has to be studied extensively because, the entire load of the structure exerts so much pressure on the soil. Hence, the soil has to be capable of taking whatever load the structure exerts on it and so, it is important that there is a thorough study of soil properties before the construction starts in order to avoid failure of the structure for effective construction management. During the course of this project, questionnaires were distributed to ten (10) companies in the Niger Delta that have a wastewater treatment plant (WWTP). These questionnaires helped to extract relevant information like the basic data of the plant, the critical process parameters that may affect the efficiency of the wastewater treatment plant, how the sludge and effluent are being disposed of, etc. From the collation of results, it was observed that 10% of the companies use their discharged effluent to wash equipment, another 10% discharge their effluent to a saver pit and the remaining 80% discharge theirs to a river/ stream. It was revealed that 14% of the companies in Niger Delta that have a wastewater treatment plant (WWTP) dispose their sludge by incineration, 18% burn their sludge, 30% use their sludge as fertilizer and 40% dispose of their sludge at a landfill. Afterwards, Dufil Prima foods was used as the case study as it was discovered that they dispose their effluent to the water body which follows a path to choba, river. Soil samples were collected from Chobariver at radial distances of 1m, 2m, 3m, 4m and 5m. The soil tests performed were liquid limit, plastic limit, compaction test and triaxial compression test.*

KEYWORDS:*Wastewater, Sludge, Treatment plant.*

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I. INTRODUCTION

According to the World Health Organization informed that in Nigeria, over 80,000 is caused by poor water, sanitation and hygiene, whilst 28 in every hundred has access to enhanced sanitation facilities furthermore, 64 in every hundred to improved drinking water source which is pitiable.

Lack of working waste water treatment plants (WWTP) in Nigeria has left the populace prone to diseases such as cholera, diarrhea and typhoid which are to blame for epidemics that kill many and consume government revenue. In Nigeria, waste disposal management remains a chief concern despite the countless attempts by succeeding governments and private organizations. Little wonder it is a widespread sight across the country – beholding heaps of rotting waste dumps in almost every nook and cranny. For many households, residential buildings, markets, waterways, highways, streets and undeveloped plots of land are their waste dumps. Soil-waste interaction affects a large percentage of the soil properties. The consequences of pollutants on soil are complex, they become explicit if various factors are isolated and considered independently. Ions exchange or mature pore fluid influence soil properties (Leton, 2004). Water movement is adversely affected in some soils, while in scores of irrigated soils, water table is built up to set in great change in chemical and biological nature of underground soil and their role in ecological/ environmental imbalance is severely affected.

1.2 Statement of the Problem

In recent past, there has been a lot of infrastructure development in Niger Delta such as hospitals, dispensaries, schools, colleges. This has led to high population which has caused increased production of waste resulting to pollution and poor environmental health due to lack of proper sewerage system and a waste recycling plant. Poor sanitation and lack of sewerage system has increased health problems such as water borne diseases and malaria.

Several component of the waste are quite toxic to the environment particularly, the receiving water body. This effluent usually contains undesirable environmental pollutants. For example, aquatic ecosystems can assimilate certain amount of waste and still keep up near normal function. Nevertheless, when the wastes are excessively discharged, the river's natural cleansing process ceases; thereby causing damage and death to organisms.

Effluent discharge sometimes with high nitrogen and phosphorous in the receiving water body may lead to massive algal growth (referred to as eutrophication) which produces color, odor and unwholesome surface water. Accordingly, a huge gap between policy formulation, execution and implementation remains, which aggravate the problem of waste water management in companies in Rivers State and so, necessitates the need to evaluate these problems.

1.3 Aim and Objectives

1.3.1 Aim

The aim of this research is to examine the consequences of poor waste water management in Niger Delta and generate models for effective construction management in the design of a wastewater treatment plant in Niger Delta.

1.3.2 Objectives

The objectives include;

i. To evaluate problems associated with wastewater treatment in Rivers state.
ii. To investigate the effect of wastewater on the geotechnical properties of the soil in Rivers State.
iii. To generate models for future prediction of liquid limit, plastic limit, maximum dry density and optimum moisture content values at varying depths using Microsoft Excel.
iv. To remove heavy metals from effluent.

1.4 Scope of Work

This work recommends a number of practical options for optimizing the performance of wastewater treatment plants with regards to the aforesaid problems. In order to avoid and/or combat the problems during operation, this research would be based on proved practical experience and, therefore, may act as a flexible toolbox for an individually tailored design or operation of the plant.

The research undertaken is specifically formulated around the performance issues associated with the treatment of effluent discharged from wastewater treatment systems. The study is confined to Rivers State where the soils are highly weathered and representative of a subtropical coastal zone. It is narrowed down to Dufil Prima foods which disposes their effluent to the water body.

The research outcomes are applicable to comparable soils in similar geomorphologic climatic settings within Niger Delta.

1.5 Significance of Study

This study will present an educative platform for the general public, stakeholders in environmental management, students, the government and policy makers on the problems of waste water management with special interest in Niger Delta with a view of identifying management strategies to assuage the menace linked to poor waste water treatment plants and its management. It would also equip other scholars with the use of construction management which uses specialized project management techniques to manage the planning, design, and construction of a project, from start to finish.

II. LITERATURE REVIEW

Wastewater can be treated by direct discharge into surface water and this treatment is possible because surface water has a natural capacity to purify itself, so long as the assimilative capacity is not exceeded (Leton, 2004). However, in almost all cases, the prerequisite for directly discharging wastewater into surface water, dictated by water use, cannot be met without some form of treatment.

Leton (2004), reasoned that the basic theory in the treatment of wastewater is: separation of suspended/ colloidal particles then the conversion the soluble impurities into particulate bacteria, which becomes easily separable from the liquid. In so doing, bulky solids (sludge) are formed. Contained in the sludge are many of the original pollutants – pathogens, and toxic chemicals in more concentrated form, thus necessitating separate treatment and disposal measure.

These major operations are made up of unit operations (where removal of contaminants is achieved by physical processes) and/ or unit processes (where treatment occurs predominantly due to chemical or biological reactions). Not all the above treatment stages are required to treat wastes. Some industrial wastes are normally pre- treated before going through the main treatment stage. The degree of treatment necessary will be dictated by the use to which the treated effluent is to be put to and the available dilution in any receiving.

III. MATERIALS AND METHODS

3.1 Data Collection

A detailed questionnaire was developed and aimed at determining the problems associated with the design of a wastewater treatment plant so as to determine relevant geotechnical properties surrounding the nature of the soils subsurface and develop the a good construction management technique for a Waste Water Treatment Plant (WWTP). Ten (10) wastewater treatment plants in ten (10) companies located in Rivers State and environs were selected to serve as the focus of the investigation.

3.2 Experimental Analysis

The experimental analysis for liquid limit, plastic limit, undrained compression strength and compact test is described as; When sufficient water is added to a fine soil, it liquefies/ fluidizes; i.e, the soil acts like a liquid with no shear strength. However, when we reduce the water content of the soil gradually, the soil transforms from the liquid state to the plastic state. In the plastic state, the soil gains a lot of shear strength. The water content value at which there is a change of the soil from the liquid state to the plastic state is known as the liquid limit of the soil. In physical terms, it can be defined as that water content, at which the soil passes from zero shear strength to very small shear strength.

Liquid limit value of a soil is essential in the classification of fine grained (cohesive) soils. When the soil is classified from the plasticity chart, it poses very easy to comprehend its characteristics, thereby aiding in the selection of a suitable method, construction and maintenance of the structures made up of/ or/and resting on the soil.

The values of liquid limit are also used in obtaining the flow index, toughness index, and plasticity index, which are useful in giving an idea about the plasticity, cohesiveness, compressibility, shear strength, permeability, consistency and state of cohesive(fine grained) soils.

Liquid Limit = Moisture content at the 25th blow

Moisture content, $M_c = \frac{Mw - Md}{Md} * 100\%$ (3.1)

where;

M_w= Mass of wet soil

M_d = Mass of dry soil

Plastic Limit, PL

$PL = \frac{\Sigma(\text{Moisture content})}{N}$

where; Moisture content, $M_c = \frac{Mw - Md}{Md} * 100\%$ (3.2)

M_w= Mass of wet soil

M_d= Mass of dry soil

i. $q_u = \frac{Pf}{Af}$ (3.3)

where;

q_u= unconfined compressive strength

P_f = Load

Area, $A_f = \frac{\pi d^2}{4}$ (3.4)

d is the diameter

ii. Volume, V= Area * Height (3.5)

iii. Strain, $E = \frac{\Delta L}{L}$ where; (3.6)

ΔL= change in Length

L= Original length of the sample

iv. $\text{Stress} = \frac{P(1-\varepsilon)}{A}$ where; (3.7)

P= Pressure
A= Area
ε= Strain

3.3 Regression evaluation

Using the Analysis Tool Pack add-in in Microsoft Excel, regression analysis was employed to know if the data analyzed was an excellent fit, determine the error margin and verify the confidence level of the data. The following are methods the facts turned into interpreted using regression analysis

3.4 Remove heavy metals from effluent

Bamboo culms were selected as adsorbent for removal of cadmium ion in this study. The bamboo culms used for this research was a construction waste material which was used as reinforcement. They were collected from a construction site in Owipa, Choba, Port Harcourt.

IV. RESULTS & DISCUSSIONS

After the retrieval of the questionnaires distributed, the information obtained from the questionnaires were analysed and presented as tables and pie charts for better understanding. They are as shown below;

4.1 Treatment plant capacity

The Table 4.1 shows the capacity of the wastewater treatment plant visited in terms of the quantity, number of employees and the peak daily flow rate..

Table 4.1 Treatment Plant Capacity

TREATMENT PLANT CAPACITY										
Name of Company	A	B	C	D	E	F	G	H	I	J
Litres per day (mg/l)	7, 000	6,000	7,000	-	500,000	-	-	2,000	-	6,500
No. of employee in the unit	-	6	-	-	50	-	-	6	8	24
Peak Daily Flow Estimate (m^3/ hr)	-	-	-	-	25	-	-	150	-	-

4.1.2 Effluent discharge

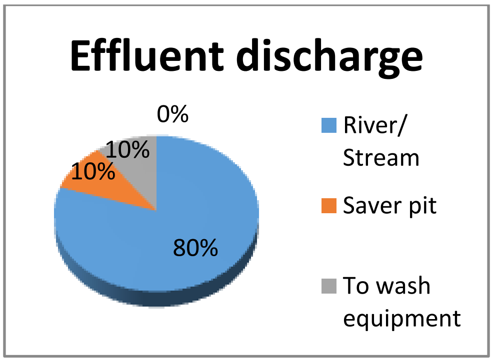

Figure 4.1. Effluent discharge

From the chart above, 10% of the companies said they use their discharged effluent to wash equipment, another 10% said they discharge their effluent to a saver pit and 80% said their effluent are normally discharged to a river/ stream as the case may be.

4.1.3 Disposal of sludge

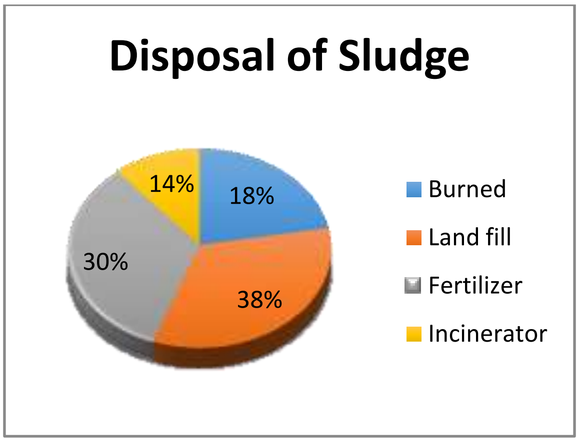

Figure 4.2. Disposal of sludge

The chart above reveals that 14% dispose their sludge by incineration, 18% burn their sludge, 30% use their sludge as fertilizer and 40% dispose of their sludge at a landfill.

4.1.4 Age of plant and modification

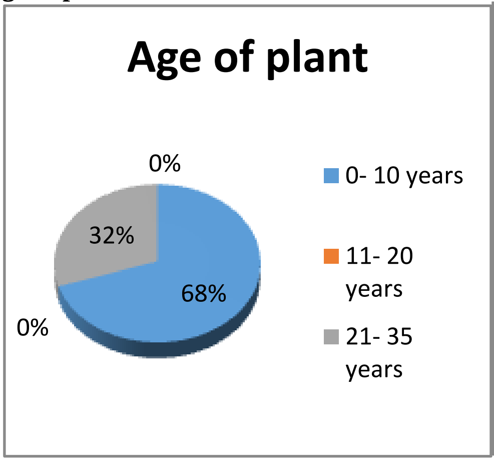

Figure 4.3. Age of plant

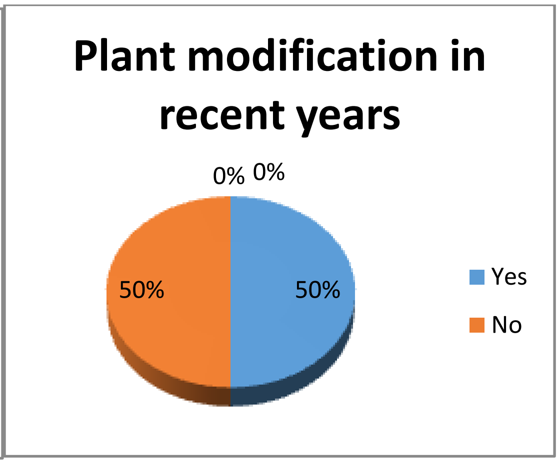

Figure 4.4. Plant modification in recent years

From the Figure 4.3, no company has their plant between the ages of 0 to 10 years. 32% has the age of their plant between 11 to 20 years while the remaining 68% has the age of their plant between 21 to 35 years. Figure 4.4 indicates that 50% of the plants have received modification in recent years and 50% have not received modifications yet.

4.1.5 Additional Improvements to the Plant

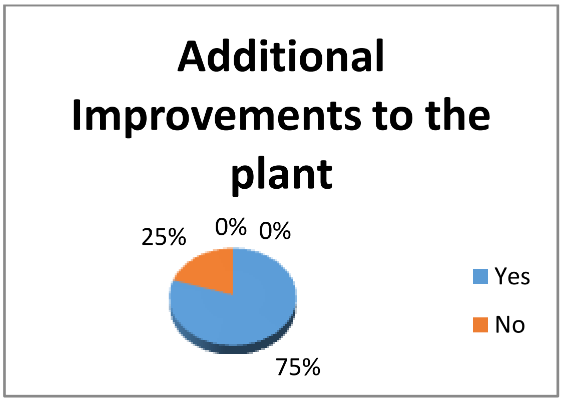

Figure 4.5. Additional improvements to the plant

Figure 4.5 shows that 75% of the companies visited have plans for additional improvements to the plant while 25% do not have plans for such.

4.2 Technical Features of the Project:

Number of samples collected : 3
Radial distance of the sample : 1m, 2m, 3m, 4m and 5m from the stream of liquid waste
Area covered: 6m * 6m = 36m^2
Depth of the soil sample extracted : 75 cm
Weight of each sample extracted : 15 kg
Number of tests performed on each sample : 4

4.3 Results Obtained from the Geotechnical Borings

Using Dufil Prima foods, choba as the case study, seeing that their effluent are being discharged to choba river, soil samples were obtained from choba river at a depth of 75cm and at radial distances of 1m, 2m, 3m, 4m and 5m. The results obtained during the geotechnical laboratory tests are tabulated as well as expressed in the graphs as follows.

4.3.1. Moisture Content Determination

The results below shows the moisture content results obtained from the soil analysis.

Table 4.3 Moisture Content Determination

SAMPLE NO	1m		1.5m		2m		2.5m		3m	
CONTAINER NO	A	B	C	D	E	F	G	H	I	J
WEIGHT OF CONTAINER (g)……W_1	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
WEIGHT OF CONTAINER AND WET SOIL (g)…… W_2	40.10	34.00	31.00	41.40	30.00	30.10	40.20	40.00	35.10	30.00
WEIGHT OF CONTAINER AND DRY SOIL (g)…… W_3	25.20	20.30	23.20	28.60	27.50	24.00	28.00	29.20	22.10	18.10
MASS OF WET SOIL (Mwet) = (W_2- W_1)	36.10	30.00	27.00	37.40	38.40	34.20	32.00	36.20	36.00	29.30
MASS OF DRY SOIL (M_D) = (W_3- W_1)	21.20	16.30	19.20	24.60	27.60	25.20	24.00	28.50	28.20	25.00

4.3.2. Liquid limit

Table 4.4 shows the moisture content and number of blows obtained at depths of 1m, 2m,3m, 4m and 5m.

Table 4.4 Liquid limit at 1m, 1.5m, 2m, 2.5m, and 3m depth

AT 1m DEPTH			
Moisture content (%)	21.15	34.00	36.22
Number of blows	37	22	13
AT 1.5m DEPTH			
Moisture content (%)	27.72	31.10	34.01
Number of blows	33	22	12
AT 2m DEPTH			
Moisture content (%)	29.57	29.21	32.10
Number of blows	30	21	11
AT 2.5m DEPTH			
Moisture content (%)	30.80	27.67	28.64
Number of blows	26	21	10
AT 3m DEPTH			
Moisture content (%)	33.33	25.37	26.40
Number of blows	23	19	9

4.2.3. Plastic Limit

Table 4.5 shows the result of the plastic limit obtained at 1m, 1.5m, 2m, 2.5m and 3m depth.

Table 4.5 Results of the Plastic Limit test

S/ No.	Name of the test	Sample 1 (1m)	Sample 2 (1.5m)	Sample 3 (2m)	Sample 4 (2.5m)	Sample 5 (3m)
1.	Plastic Limit (PL)	23.48	16.02	14.08	12.35	10.90

Table 4.6 shows the soil category and the plasticity index value to illustrate the degree of plasticity of the soil

Table 4.6 Soil category

Category	Soil	PI (percentage)	Degree of Plasticity
1.	Sand or silt	0-1	Non-plastic
	• Traces of clay	1-5	Slight plasticity
	• Little clay	5-10	Low plasticity
2.	Clay loam	10-20	Medium plasticity
3.	Silty clay	20-35	High plasticity
	clay	>35	Very high plasticity

AdaptedfromSoilconsistencyftp://ftp.fao.org/fi/cdrom/fao_training/FAO_Training/General/x6706e/x6706e08.htm (accessed on May 19, 2018)

4.2.4 Compaction test

Table 4.6a Moisture content and dry density values at 1m, 1.5m, 2m, 2.5m and 3m

AT 1m DEPTH					
Average Moisture content (%)	10.24	13.35	19.21	14.97	24.51
Soil dry density (N/mm^3)	1250	1611	1484	1781	1819
AT 1.5m DEPTH					
Average Moisture content (%)	9.87	7.14	10.21	14.12	20.53
Soil dry density (N/mm^3)	1421	1498	1642	1797	1991
AT 2m DEPTH					
Average Moisture content (%)	8.35	6.28	8.10	15.40	18.50
Soil dry density (N/mm^3)	1600	1310	1875	1850	2018
AT 2.5m DEPTH					
Average Moisture content (%)	6.46	5.50	14.00	10.75	16.30
Soil dry density (N/mm^3)	1768	1175	1989	1930	2263
AT 3m DEPTH					
Average Moisture content (%)	5.10	4.11	12.35	8.62	14.47
Soil dry density (N/mm^3)	1921	1008	2190	2090	2430

Table 4.7 Results of the Compaction test

S/ No.	Name of the test	Sample 1 (1m)	Sample 2 (1.5m)	Sample 3 (2m)	Sample 4 (2.5m)	Sample 5 (3m)
1.	Maximum Dry Density (kg/m^3)	1840	2100	2150	2350	2450
2.	Optimum Moisture Content (%)	22.50	17.50	15.00	15.00	13.50

Table 4.8 Results of the Triaxial compression test

S/ No.	Name of the test	Sample 1 (2.5m)	Sample 2 (3m)
1.	Undrained cohesion, C_u (KN/m^3)	66	80
2	Undrained angle of shearing resistance, ϕ_u (^{o})	6.52	3.18

The table above shows that the strength of the soil is low as it is lower than 100KN/m^3.

Table 4.8 below gives a summary of the mathematical models obtained from the various soil tests performed with their corresponding R^2 values.

Table 4.9 Summary of the Mathematical Models Derived

Soil Tests	Models Generated	Coefficient of regression, R^2
Moisture Content	**Y= - 0.035x + 3.4932** Where X= av. Moisture content (%) Y= Depth	88
Liquid Limit	**Y= 0.3365x – 8.3317** Where X = Liquid Limit (%) Y = Depth (m)	94
Plastic Limit	**Y= - 0.1487x + 4.2845** Where X= plastic limit (%) Y= Depth (m)	86
Compaction Test	**Maximum Dry Density** **Y= 0.0033x – 5.1249** Where X = Maximum Dry Density (kg/m^3) Y= Depth (m)	96
	Optimum Moisture Content **Y = -0.2038x + 5.4031** Where X= Optimum Moisture Content (&) Y= Depth (m)	84

V. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

From the collation of results in the questionnaire, it was observed that 10% of the companies use their discharged effluent to wash equipment, another 10% discharge their effluent to a saver pit and the remaining 80% discharge theirs to a river/ stream.

It was revealed that 14% of the companies in Niger Delta dispose their sludge by incineration, 18% burn their sludge, 30% use their sludge as fertilizer and 40% dispose of their sludge at a landfill.Also, no company has their plant between the ages of 0 to 10 years. However, 32% of the companies has the age of their plant between 11 to 20 years while the remaining 68% has the age of their plant between 21 to 35 years.

It was revealed that 50% of the plants have received modification in recent years and 50% have not received modifications yet. In addition to this, 75% of the companies visited have plans for additional improvements to the plant while 25% do not have plans for such.From the results of the soil analysis, the soil closer to the stream absorbs more amount of waste and permeates through the entire soil through its pores. As the liquid spreads, it loses its concentration compared to that of soil nearer to stream. Hence, we conclude from the results that the soil is badly affected near the river than it is away from the river.from wastewater.

5.2 Recommendation

Some of the recommendation of this work are as follows;

1. It is important to properlygrasp the accurate ground condition before the ground improvement so as to avoid placing wastewater treatment plants at the surface especially where there is an issue of fluctuation of the water table.
2. The use of compaction piles should be employed as a means of improving the soil before theerection of a wastewater treatment plant.
3. The location of any wastewater treatment plant should be as far as practical from dwellings, public places and any sites which will possibly be built on within the life of the plant. There should also be sufficient land set aside to allow for any future alterations and additions/extensions so that no offensive odors are detected at the property boundary.

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