www.cenresinpub.org
ISSN 2277-0054

THE USE OF CLAYS IN WASTEWATER TREATMENT

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ABSTRACT

Two Nigerian clays were studied using Atomic Absorption Spectrophotometer and X-ray diffractometer. They were coded OT and BB obtained from Delta State, Nigeria. Mineralogical analysis revealed the presence of kaolinite in the two clays. Illite and Quartz in OT, smectite illite, mixed layer and Quartz in BB. Pebble:Clay ratio of 1:2 was adopted and percolation rate studies showed that BB had lower rate than OT. One and three flow through methods were adopted. This was used in treating effluent from the wood factory. 3 flow through gave outstanding performance on the pollution characteristic measured for they were below WHO standard. This showed that clays have high potentials for pollutants removal.

Keywords: *Clays, Pebbles, Fortified, effluent.*

INTRODUCTION

Water is vital to life. It is a fundamental requirement for the survival, well being and social-economic development of all humanity. Safe drinking water is a birthright of every human. It is a solvent medium, transport and catalyst in nearly all chemical reactions occurring in the environment [1]. The mammoth demand for clean water has always been met by tapping water from the aquifers. One of the earth's main deposits of fresh water, but the sudden realization that the supply is not inexhaustible has awakened the interest of researchers to devise sustainable means of water/wastewater treatment for reuse. Two distinctive properties of clay render them technologically useful; plasticity when wet and extremely fine crystals often colloid in size and platy in shape. The flattened (platy) shape of clay particles together with peculiarities of the crystal structure give opportunity for adsorbing ions in a variety of ways.

Theoretical Basis of the Study

Clays are phyllosilicate minerals. They have a unique structure of alternating layers of two sheets;

i. One sheet consist of the ions Al^{3+}, O^{2-} and OH^{-}; the negative ions forming octahedron around Al^{3+}, the relative numbers of 02^{-} and $0H^{-}$ are shared between adjacent octahedron, so that the structure is continuous in two dimensions. This is similar to $Al_2(OH)_6$ gibbite sheet which is octahedral sheet.

ii. The second type of sheet is made up of Si^{4+}, O^{2-} and OH^{-} ions. Each Si^{4+} is at the centre of a tetrahedron of oxygen ions, all the tetrahedral facing the same direction and the oxygen at their bases are linked forming hexagonal rings. This is the silica or tetrahedral sheet. Its complete structure is that of one of the several possible combinations of the octahedral and tetrahedral sheets

Four Mechanisms can be Identified for Cation Exchange Capacity.

i. Cations are held in exchangeable form on or near the surface of clay minerals by electrostatic forces, resulting from the net negative charge on the structure arising from ionic substitution.

ii. At edges and corners there are 'broken bonds or unsatisfied valencies to which exchange ions can become attached. The numbers of such sites increases as the clay particles decreases.

iii. Exposed hydroxyl groups may dissociate with the hydrogen ions being replaced by cations.

iv. Under certain conditions, cations from within the clay structure may become exchangeable e.g. ion acidic environment aluminium ions move from within the silicate structure of clay minerals into exchange position. These reactions depends on the kind of ions and the kind of clay mineral present [2].

This paper aim at designing a technologically simple, low energy consuming, low cost and reliably simple wastewater treatment (purification) using different clay minerals fortified with smooth stone pebbles to overcome clay impermeability to water.

MATERIALS AND METHODS

Clays were collected from Otorho (OT) and Abbi (BB) Delta State, air-dried, pulverized with wooden mortar and sieved with 0.05nm size filter. Stone pebbles were collected from sharp sand dug from Ethiope River, washed thoroughly under tap water and air dried.

Wood Factory (Wastewater)

The wastewater used was obtained from wood factories located along Ogulahai/Forcados axis located in the Niger Delta area located between longitudes 06^0 17' to 06^0 21'E and Latitude 05^0 01' to 05^0 05'N respectively. The colour produced was brown, foaming and displayed a tendency towards putrefication. All the effluents were discharged from the wood industries producing logs and timber woods for electrical poles and domestic consumptions, washing of plants and equipment washing process. The amount of waste generated daily was about 21.2×10^4 litres (51×10^3 gallons). They were collected in 10 litres plastic containers at 2 hrs interval over a period of 12 hrs starting at 6.00am in the morning and ending at 6.00pm. A composite sample was taken. pH determinations were carried out on the field using an orion digital pH/millivolt meter 611. Conductivity using a thermo orion conductimeter after calibrating the instrument with 0.01N and 0.1N KCl. Turbidity, Suspended Solids, Total Solids, Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand Ammonia-Nitrogen, Total Kjeldahl Nitrogen, Nitrate-Nitrogen, total bacteria and heavy metals as recommended by Standard Methods [3] and APHA[4]. Mineralogical Analysis using x-ray Diffractometer and Cation Exchange Capacity (C.E.C) using Blacky (1968) and Performance efficiency and percolation studies[5]. Combination ratio of 1:2 on a weight of 3kg for pebble/clay mixtures were measured out, carefully packed in a column of length 100cm and diameter 20cm, but the packing length was maintained within 80cm for uniformity.

It was flushed several times with distilled water to wash off organic impurities and allow for maximum swelling to occur.

RESULTS AND DISCUSSION

The kaolin group is the predominant in the clay minerals OT 58.2% and BB 38.4%.

Table 1: Mineralogical Analysis of Clay Minerals

Clay Minerals	OT	BB
Saponite	Nil	Nil
Smectite	Nil	8.3
Chlorite	Nil	Nil
Illite	10.1	12.4
Mixed layer Illite-Monthromonillonite	Nil	15.4
Kaolinite	58.2	38.4
Quartz	27.5	24.5
Hematite	4.3	Nil

KEY: OT – Otorho; BB – Abbi

Table 2: Results of Geochemical Analysis

Metal oxide %	OT	BB
SiO_2	43.37	44.44
Al_2O_3	38.60	38.80
Fe_2O_3	6.61	7.67
Na_2O	1.97	0.89
MgO	1.93	1.82
K_2O	2.69	1.68
TiO_2	0.99	0.98
CaO	0.31	0.21

Table 3: Cation Exchange Capacity

ClaySample	CEC (m/kg)
OT	71.00
BB	62.00

Table 4: Results of Raw and Treated Wood Factories Wastewater (Using Single Column)

Parameter	Units	Raw Sample Mean Values	Results after Treatment	
			OT	BB
pH	-	6.5	7.00	7.20
Turbidity	NTU	190.00	1.20	1.00
TS	mg/L	280.00	7.00	6.90
DS	"	100.00	6.00	5.00
SS	"	180.00	0.82	0.81
DO	"	0.61	4.70	4.60
COD	"	710.00	48.00	40.30
BOD	"	240.00	14.00	13.80

TKN	"	15.50	3.20	3.00
NH_4^+-N	"	15.00	1.00	1.02
NO_3-N	"	4.00	1.20	1.48
Total Bacteria	Count/ 100ml	4.0 x 10^8	2.0 x 10^6	1.0 x 10^6

Table 5: Results of Raw and Treated Wood Factory (effluent) (Using three Columns)

Parameters	**Units**	**Raw Sample**	**Results after Treatment**		**WHO Standard for Drinking Water**
			OT	**BB**	
pH at 20^0C	-	6.3	8.0	8.20	6.5-8.5
Turbidity	NTU	200.00	ND	ND	10
TS	mg/L	300.00	1.9	1.8	500
DS	"	101.00	2.00	1.90	
SS	"	190.01	ND	ND	
DO	"	0.60	9.00	8.50	
COD	"	710	9.20	9.10	30.0
BOD	"	240.00	6.00	5.32	6.0
TKN	"	17.50	0.10	0.11	
NH_4^+-N	"	16.20	0.06	0.03	10.0
NO_3-N	"	4.20	0.50	0.41	0.02
Total Bacteria	Count/ 100ml	4.0x10^8	7.2x10^4	6.9x10^4	

Table 6: Results of percolation studies

Sample	**Time to obtain first drop (m^3/s)**	**Time to obtain 100ml (m^3/s)**
OT	1.7 x 10^{-6}	1.5 x 10^{-6}
BB	2.4 x 10^{-6}	1.8 x 10^{-6}

Table 7: Metal Ion Adsorption

Metal Ions	**Units**	**Raw Sample**	**Results after Treatment**		**WHO Standard**
			OT	**BB**	
Cr	mg/l	0.10	ND	ND	0.05
Hg	"	ND	ND	ND	0.001
Pb	"	0.21	ND	ND	0.01
Cd	"	<0.001	ND	ND	0.003
Fe	"	1.40	0.32	0.10	0.3

The pH from each media was slightly alkaline due to cation removal from clay structures. Total solid reduction was about 86% with clay acting as inert medium for a fixed surface for microbial attachment and growth, reducing total solid content[6]. The Biological

Oxygen Demand and Chemical Oxygen Demand which are indicators of pollution shows above 90% reduction using the three columns. The results of Nitrogen removal were about 60% removal in line with Kamppi[7]. Total Bacteria removal was above 90%[8]. The mineralogical composition, chemical co-ordination characteristics and high surface contributes to their adsorptive power[9, 10].

Figure : OTORHO (OT)

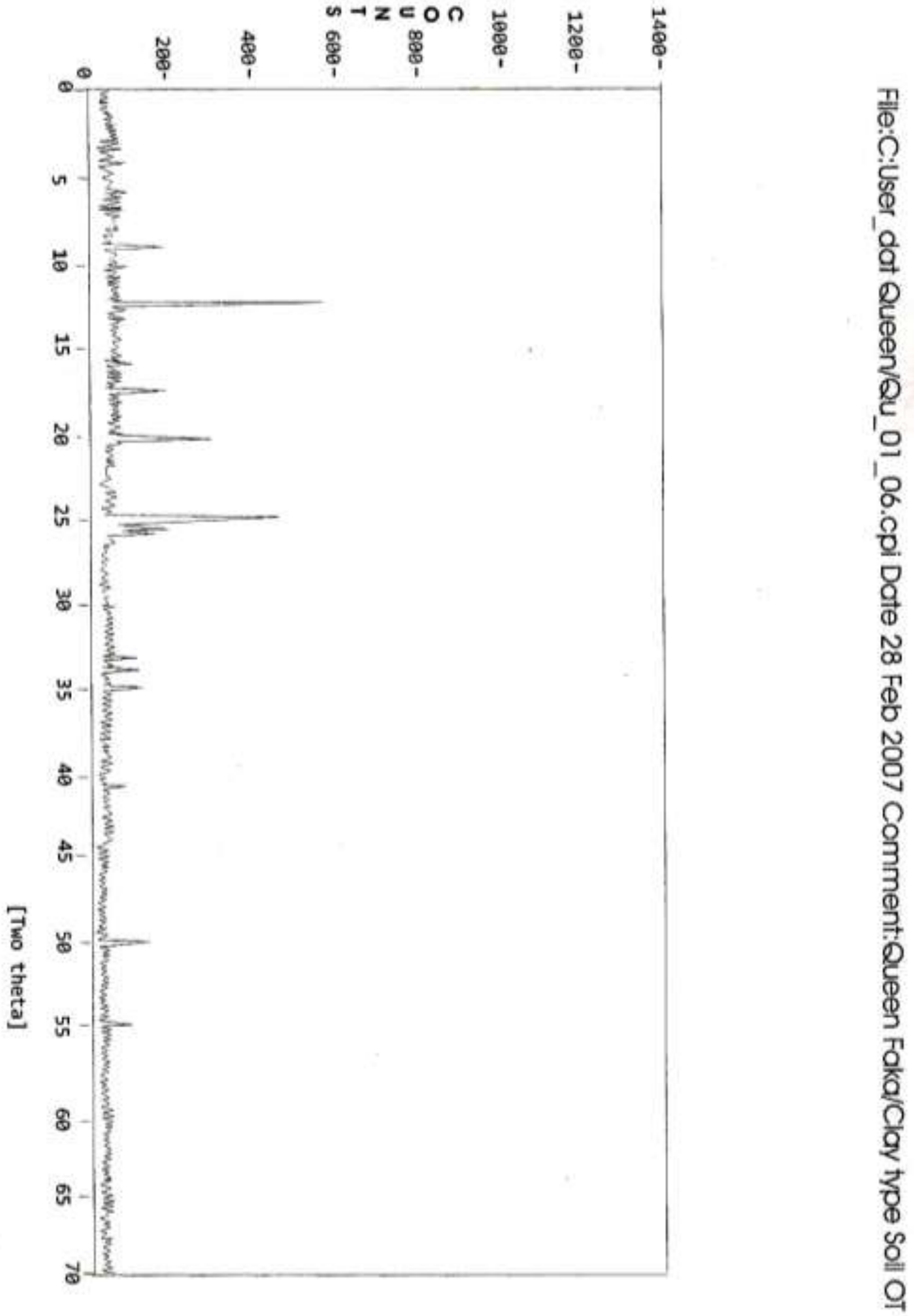
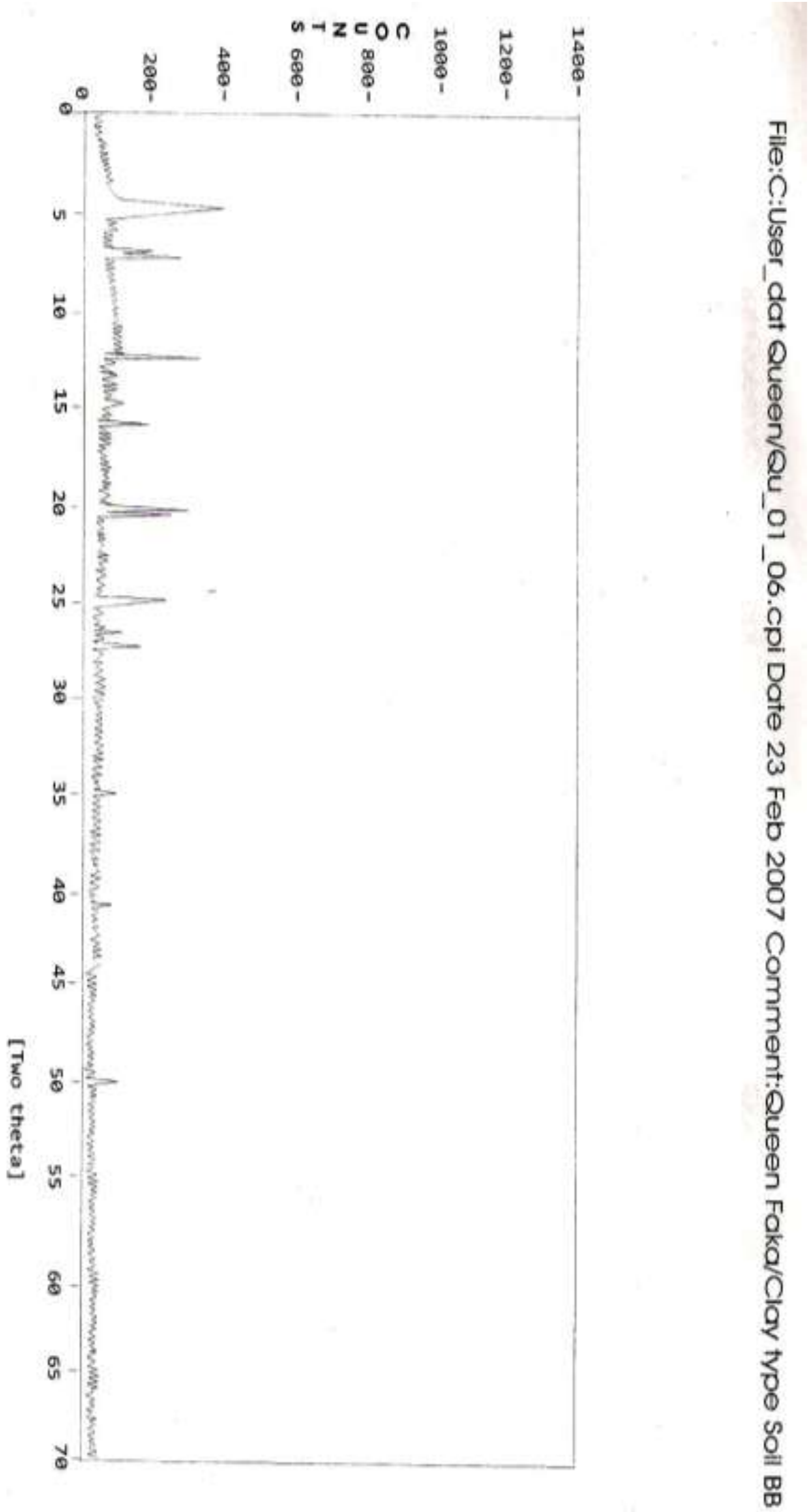


FIG. 2: ABBI (BB)


File:C:User_dat Queen/Qu_01_06.cpi Date 23 Feb 2007 Comment:Queen Faka/Clay type Soil BB
COUNTS
0
200
400
600
800
1000
1200
1400
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
[Two theta]

CONCLUSION

The three (3) columns method gave a significant reduction of the pollution characteristics studied and the treatment efficiency of clays is directly related to their mineralogical assemblage. The longer the residence time of wastewater in the media, the more efficient the media in the purifying process. It could be deduced that clays have varying purifying power in wastewater treatment.

REFERENCES

Ademoroti, C.M.A. (1996). Environmental Chemistry and Toxicology. Foludex Press Ltd., Ibadan, Nigeria.

Grimms, R. E. (1968). Applied Clay Mineralogy: 2nd Edition: McGraw-Hill, N.Y.

Lonore, S.C., Arnold, E.G. and Andrew, D.E. (2009). Standard Methods for Examination of Water and Wastewater (17th ed.). Washington, D.C.: American Public Health Association, Pp. 134.

APHA (1995). Standard Methods for the Examination of Water and Wastewater. 17th Edition, J. Wiley and Sons, NY U.S.A.

Blacky, C. A. (1968). Methods of Soil Analysis. Agronomy No. 9. *Amer. Soc. Agronomy*. Madison, Wisconsin.

Dinges, R. (1978). Upgrading Stabilization Pond Effluent by Water Hyacinth Culture. *Journal of Water Pollution* 50:833 – 845.

Kamppi, A. (1971). Studies of Wastewater Disposal on Reatland Forest Basin System which were in effect in Finland. Reg. A4.

Brown, J. L. (1972). Advanced Wastewater Treatment using Organic and Inorganic Materials. Part 1. Use of peat and peat sand filtration media. 4th Int. Peat. Congr. Otaniemi, Finland IV.

Oladoja, N. A. (2003). Fortified clay in wastewater Treatment. Ph.D Thesis, Chemistry Department, University of Benin, Benin-City, Edo State.

Adock. P. (1999). Reed bed take on Industrial wastewater **2**(1) 50 – 52.