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Evaluation of Modified Clay in Storm Water Treatment

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Abstract

Storm water from South western Nigeria was collected using composite sampling. The Storm water was then analyzed according to the standard methods for the examination of wastewater using COD, BOD, DO etc. The characterized water was treated using raw and Hexadecyltrimethyl-ammonium bromide, HDTMA-Br clay. The research was aimed at the effectiveness of clay sample in storm water treatment. The results of both the treated and untreated storm water were recorded. Raw clay was modified by ion-exchange reactions using HDTMA-Br. The reaction process was carried out at a temperature of 50°C at various times using a mechanical stirrer at a speed of 300rpm. The physicochemical properties of raw clay samples A and B were determined: pH 5.42 and 5.32, Ca 3.00 and 1.50cmol/kg, silt 20.00 and 22.00% respectively.

Keywords: Storm Water, Modified Clay, Hexadecyltrimethyl-Ammonium Bromide.

Introduction

Clay material is one of the most used adsorbent due to its availability and high adsorption capacity. In recent times, there has been considerable interest in the use of low cost adsorbents, thus the search for cheaper and effective adsorbent materials such as clay. Clay due to its chemical and mechanical properties fits into this laudable scheme for efficient and effective adsorbent due to its high cation exchange capability and surface area. Hence the need to source for adsorbent material that can remove both inorganic and organic contaminants from water and wastewater. Yuh Shan Ho and Ofomaja(2004) gave the ideal of adsorbent and how biosorbents have been used to treat water. Ordinarily, raw clay materials are negatively charged but with a lot of cations like Na^+ , K^+, Ca^{2+} , Mg^{2+}, Fe^{3+}, etc on the surface, which are ion exchangeable. When these ions are exchanged, it leads to clay surfaced modification as this can be exchanged for cation (2,3).

Cation Exchange Capacity, CEC measures the exchangeable cations. The size of various cations determine how readily they are exchanged and how tightly it is held once replaced. The larger the non-hydrated size of the cation the more easily it drives out the existing cation. In addition the smaller the hydrated size of the ion is, the more strongly it holds onto its position in the clay matrix. CEC ranges from 3-15 meq /100gram. Untreated clay materials have very low sorption capacity for non- polar organic compounds as raw clay is hydrophilic (water loving) as adhering water films repels the hydrophobic, non-polar organic compound.(2) The early works of many chemists suggested that organic compounds with polar active groups and non-ionic molecules of positive character could be adsorbed by the clay mineral through cation exchange. Studies on clay minerals have it that through chemosorption or physiosorption, surfactant can adhere to the clay surface which can make the clay organophilic and enhance its ability and capacity to adsorbs both organic and inorganic contaminants in water. In a nut shell, the metal ion (cation) on the clay surface can be exchanged for positive charged organic surfactant to make the native clay organophilic. (4,5).

This research is aimed at the certainty use of modified clay sample as adsorbent or coagulant aid to purify water sample, using APHA[American Public Health Analyst] 2005, and Ademoroti[1996] standard for effluent and waste water determination.

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Method

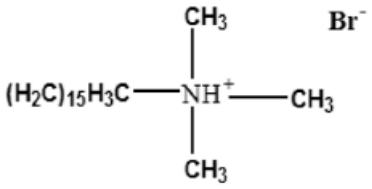
The collected clay sample from Preston International school Akure , Ondo State was using method described by (8); and its physico chemical compositions were determined using Alther 2002 method. Preston International School is located in Oba-Ile Akure, North Local Government Area of Ondo State Nigeria, Its headquarters is in town of Iju/ Itaogbolu. Oba-Ile is popularly known as Oba-Ile -Akure, and it shares boundary with Akure City. As a matter of fact, it is located in the extreme end of Akure. Akure is between latitude 7°15' and longitude 5° 11' in South Western

Nigeria.

Sampling

Storm water collection was done using composite technique within the period of June when the raining season is at its peak. At each sampling storm water was collected at time interval of an hour. Collected sample was kept and transferred into a refrigerator after taken pH and temperature. Sample was then analysed using standard method as described by Ademoroti, 1996 and APHA, 2005.

Structure of HDTMA-Br



Results and Discussion

Table 1

Physicochemical analysis of modified clay sample

PH	Kcmol/kg	Na cmol/kg	Ca cmol/kg	Mg cmol/k	CEC cmol/kg
5.32 ±0.01	0.17±0.01	0.28±0.01	1.50± 0.01	0.60± 0.01	13.26±0.01

Sand%	Clay%	Silt%	WHC%	$A1^{3+}$ cmol/kg	Fe%	
8.80 ± 0.01	69.20± 0.01	22.00 ±1.00	60.82± 0.01	2.40±0.10	0.46±0.01	

Mn%	Base Saturation%	Bulk density	Colour	Surface area m /g
0.16±0.01	19.23 ±0.01	1.29 ±0.01	Yellow 8/4	324.00± 0.01

Values: Mean+ Standard deviation

Table 2

Triplicate result of raw and treated water showing the mean and the standard deviation

Parameter	Storm water	Raw sample	Modified	WHO std
pH at 20°C	6.79^{a}±0.00	7.80^{c}±0.10	7.40^{b}±0.10	6.50-8.50
Temp ^{0}C	29.70^{a}±0.10	28.90^{a}±0.10	28.95^{a}±1.00	^{0}C ambient
Colour	10.10^{a}+0.01	8.00^{a}±0.01	1.10^{b}±0.01	
Turbidity	17.50^{a}±0.01	10.00^{b}+1.00	5.50^{a}±0.01	5.0 NTU
Conductivity	14.7^{a}±1.00	8.80^{d}±1.00	3.14^{a}±1.00	1000µs/cm^{-1}
TOC	2.20^{a}±0.00	2.34^{a}±0.01	2.90^{b}±0.10	5.0mg/l
TDS	74.00^{c}±4.00	1.57^{b}±1.00	1.16^{c}±1.00	200.0mg/l

DO	2.90^{a}O±.50	4.10^{b}±0.01	3.60^{a}±0.10	5.0mg/l
BOD_5	8.00^{e}±0.01	7.80^{d}±0.10	3.20^{a}±0.10	5.0mg/l
COD	200.00^{a}±0.10	30.00^{e}±1.00	3.41^{d}±1.00	5.0mg/l
NH_4^+ -N	19.98^{c}±1.00	8.79^{c}±0.01	7.11^{b}±0.01	
NO_3^- -N	21.79^{c}±1.00	17.89^{b}±0.01	9.98^{a}±0.01	
Parameter	Storm water	Raw sample	Modified	
THC	0.80^{c}+0.01	0.06^{b}±0.01	BDL	
Oil &Grease	10.02^{a}±0.01	0.89^{b}±0.10	0.03^{a}±0.01	
Phenol	0.92^{c}±0.01	0.07^{b}±0.01	BDL	
Iron	0.89^{e}±0.02	0.61^{a}±.01	0.56^{b}±0.01	0.3mg/l
Zinc	2.26^{a}±0.01	0.47^{c}±0.01	0.28^{b}±0.01	5.0mg/l
Lead	0.53^{a}±0.02	0.04^{c}±0.01	0.16^{b}±0.01	0.01mg/1
Cadmium	0.05^{b}+0.01	0.02^{a}±0.00	BDL	0.03mg/l

Key:
Values: Mean and standard deviation.
Values with different superscript shows significant difference
Values with the same superscript shows no significant difference.
Treatment was with Raw and Modified clay sample
BDL- Below Detectable limit
NTU- Nephelometric Turbidity Unit
WHO- World Health Organisation
Mg/L- milligram per liter
$\mu s/cm^{-1}$- siemen per unit centimeter

Discussion

There was a change in pH from acidic to alkaline for both raw and modified clay. This can be attributed to the cation exchange capacity of the clay samples. Temperature affects most chemical reactions occurring in natural system like solubility of gases (Akinyele, 2001). The temperature for raw sample was 28.90°C compared to modified sample at 28.95°C. The increase in temperature for modified samples is an indicative of the trend in Dissolved Oxygen. The lower the temperature, the higher the dissolved oxygen and vice versa. Bio-chemical reactions of aquatic organisms are temperature dependent. Increase in temperature of water body will promote chemical reactions in the water.

The TOC result for effluent and other treatment above showed that is below the permissible limit which shows a high level of treatment. Low TOC confirms the absence of potentially harmful organic chemicals in water used to manufacture pharmaceutical products. All the clay samples show significant reduction of TOC (2.23 and 2.9mg/L) for raw and modified clay respectively, but the attendant increase in the storm water treated with modified clay as the surfactant used is organic in nature (5). The implication of this may be due to the fact that the modified clay could not pick the organic matter compared to the raw clay samples. As the total dissolved solid [TDS] value increase, the conductivity values also increase. TDS is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular suspended form. The values for raw and modified samples were 1.57 and 1.16 respectively. .

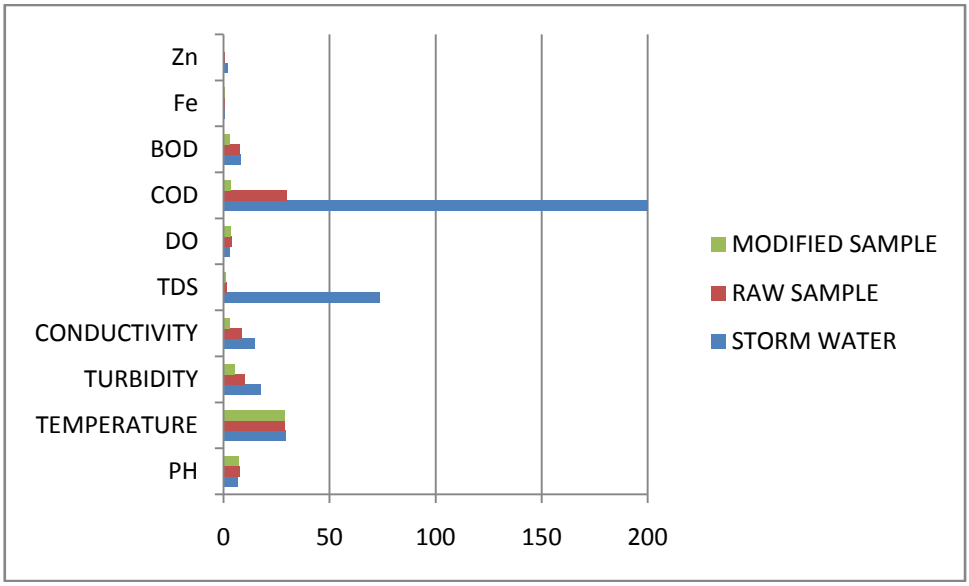
DO according to the result slightly reduced with the modified clay. This suggests that the effluent is capable of causing death of some fish and micro-invertebrates because the oxygen required by these

aquatic habitats will be consumed by micro-organisms(6). DO is an important environmental parameter for the survival of aquatic life (10). The amount of Oxygen dissolved in water is measured in milligram per liter. The ability of water to hold oxygen in solution is inversely proportional to the temperature of water, the cooler the water, the more dissolved oxygen it can contain(11)

There was a noticeable reduction in the BOD value of the raw and modified clay and it follows the trend of increase in DO to decreases in COD/BOD ratio. Similar reductions were observed Nitrogen-Nitrates, ammonia-nitrates, heavy metals, Oil and grease, respectively. The result also showed a high decrease of COD in treated storm water compared to the effluent. (8) reported that a high level of performance reduction can be due to the presence of some organic pollutants in their ionized form (anionic and cationic) or as neutral molecule. There was a drastic reduction in the COD level from 200 in the storm water to 30 in the raw clay and 3.41 in the modified clay, this can be attributed to a very good level of improvement in clay as adsorbent in storm water treatment.

There were noticeable reduction in turbidity after treatment with raw clay and more reduction with modified clay, i.e from 10.00 to 5.50NTU. Tubidity in water is related to or affects many other indicators of drinking water quality, the presence of turbidity can have a significance effect on the microbiological quality of drinking water. The detection of bacteria and viruses in drinking water may be complicated by the presence of turbidity. Excessive turbidity can protect micro-organism from effect of disinfection and stimulate the growth of bacteria in water.(12)

Figure I
Percentage reduction of some parameters



Conclusion

Clay is an effective coagullant especially when modified with Hexydecyltrimethyl ammonium bromide. From the research above , it is good in removing both organic and inorganic contaminant from storm water.

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