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CHARACTERISTICS OF SLUDGE FROM DIFFERENT WATER TREATMENT PLANTS

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Abstract

Sludge is water that contains suspended solids from the source water and the reaction products of chemicals added in the treatment process. And in order to treat and dispose of the solids produced from treatment plants in the most effective manner, it is important to know the characteristics of the solids that will be processed. This study is an investigation into the engineering and chemical properties of sludge collected from different water treatment plants in South-Western Nigeria. After determining the engineering and physical properties of the sludge samples, the sludge samples were also subjected to XRF analysis. It was found out that the sludge which was an alkaline silty-sandy material possessed four major oxides present in a Portland cement which include those of Lime (CaO), Silica (SiO_2), Alumina (Al_2O_3) and Iron (Fe_2O_3) were also present at an appreciable quantity in the sludge ashes and this feature suggests a possible application of the sludge ash in place of cement only that the sludge remained a non-plastic material.

KEYWORDS: Moisture Content, Sieve Analysis, Sludge, Treatment Plant, XRF analysis

INTRODUCTION

A water treatment plant produces large quantities of sludge as a result of treatment processes of raw water such as flocculation, filtration and coagulation (Townsend et al. 2001). Sludges are water that contains suspended solids from the source water and the reaction products of chemicals added in the treatment process (Tech Brief, 1998). And the composition and properties of water treatment sludge depends on the quality of raw water and the type of treatment chemical used in the treatment process. Water treatment plants produce large quantities of sludge as a result of treatment processes of raw water such as coagulation, flocculation and filtration. Knocke and Wakeland (1983) affirmed that water plant sludges are often characterized by high water content (low suspended solids concentration), high resistance to mechanical or gravity dewatering and other problems associated with their handling and ultimate disposal. And in order to facilitate the design of sludge treatment systems, it is imperative that fundamental sludge properties be investigated to determine why water plant sludge possesses these particular characteristics. Studies by Sales et al. (2011) concluded that Aluminum salts (e.g. $Al_2(SO_4)_3.18H_2O$) or Iron salts (e.g. $FeCl_3.6H_2O$, $FeCl_2$, $FeSO_4.7H_2O$) are commonly used as coagulants. These salts get hydrolyzed in water to form their respective hydroxide precipitates. Colloidal and suspended impurities such as sand, silt, clay, humic particles present in the crude water are removed by charge neutralization, sweep floc mechanism and adsorption onto hydroxide precipitates according to Trinh and Kang, (2011). The hydroxide precipitate along with sand, silt, clay and humic particles removed from the raw water mainly constitute the solids present in the sludge. The moisture content of the wet sludge is generally above 80 wt%. (Tantawy et al. 2015).

Typically, waterworks sludge can be classified into coagulant, natural, groundwater or softening, and Manganese sludge but coagulant's sludge constitutes the vast majority of water treatment plants residues. Coagulant sludge is commonly Aluminum or Iron-based salts. They occur mostly in particulate or gelatinous form, consisting of varying concentrations of micro-organisms, organic and suspended matter, coagulant products and chemical elements. Mimoza (2016) submitted that in order to treat and dispose of the solids produced from treatment plants in the most effective manner, it is important to know the characteristics of the solids that will be processed. The thrust of this study is to investigate the engineering and chemical properties of sludge collected from different water treatment plants in South-Western Nigeria.

MATERIALS AND METHODS

Materials used for the Study

Sludge samples were collected from three different water treatment plants.

Experimental Procedure

The sludge used in this work were the coagulant sludge collected from the clarifier of the three plants, the sludge were dewatered by gravity thickening method and subsequently air-dried on a drying bed to achieve moisture of about 20%. Samples of the sludge were oven-dried at 110^0C for 24 hours while some were air-dried for 7 days, after which their end-product was compared. It was found that the sample that was oven-dried turned to dark brown and the other sample air-dried turned reddish brown. The colour change probably denotes the presence of atmospheric oxygen present during air-drying but absent during oven-drying. And the sludge was also subjected to chemical analysis (XRF analysis).

RESULTS AND DISCUSSION

The sludge collected from the three different water treatment plants were found to have the following engineering/physical properties as shown in Table 1.

Table 1:Engineering Properties of the Collected Sludge

Property	Value/Remark		
	Sludge A	Sludge B	Sludge C
Moisture Content	0.28	0.25	0.29
Specific Gravity	2.44	2.40	2.52
Bulk Specific Gravity	1.27	1.25	1.3
Plasticity Index	Non-Plastic	Non-Plastic	Non-Plastic

The sludge ash from the three plants was found to be silty-sandy material, the sludge particle size was well graded, a relatively large fraction of the particles (up to 85 percent) were found to be less than 0.075mm (No. 200 Sieve) in size (as shown in Table 2). The sludge samples have a relatively low organic and moisture content and their permeability and bulk specific gravity properties are not unlike those of natural inorganic silt. The sludge samples were found to be non-plastic materials. Trace metal concentrations (e.g. Lead, Cadmium, Zinc, and Copper) found in the sludge samples (as shown in Table 3) are typically higher than concentrations found in natural fillers or aggregates.

Table 2: Sieve Analysis of the Dry Sludge

Sieve No.	Diameter (mm)	Sludge A		Sludge B		Sludge C	
		% Retained	% Passing	% Retained	% Passing	% Retained	% Passing
4	4.75	4.2	95.8	5.6	94.4	3.9	96.1
10	2	4.4	91.4	4.8	89.6	4.2	91.9
20	0.84	1.2	90.2	1.5	88.1	1.0	90.9
60	0.25	27	63.2	29	59.1	26	64.9
140	0.106	15.6	47.6	16.7	42.4	14.4	50.5
200	0.075	35.3	12.3	31.7	10.7	34.8	15.7
Pan		12.3	0	10.7	0	15.7	0

Table 3: Metal Concentrations in the Collected Raw Sludge

Metal	Concentration (mg/L)		
	Sludge A	Sludge B	Sludge C
Cd	<0.008	<0.008	<0.008
Cr	<0.01	<0.01	<0.01
Cu	<0.01	<0.01	<0.01
Fe	2.68	2.75	2.62
Pb	<0.01	<0.01	<0.01
Mn	<0.05	<0.05	<0.05
Ni	<0.03	<0.03	<0.03
Zn	0.35	0.38	0.32

The sludge samples consist primarily of Silica, Iron and Calcium (as shown in Table 4). The composition of the raw sludge can vary significantly. The pH of the sludge was found to range between 8.9 and 9.7 (as shown in Table 5), which shows that the sludge samples were slightly alkaline.

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Table 4: Elemental and Oxides Concentration in the Sludge Ash

Element	Oxide	Sludge A		Sludge B		Sludge C	
		Elemental Concentration (%)	Oxides Concentration (%)	Elemental Concentration (%)	Oxides Concentration (%)	Elemental Concentration (%)	Oxides Concentration (%)
Silicon	SiO_2	20	27	17	25	21	29
Calcium	CaO	8	21	9	22	7	22
Iron	Fe_2O_3	4	8.2	6	7.4	3	6.2
Aluminium	Al_2O_3	7	14.4	6.5	15.2	7	14.7
Magnessium	MgO	2	3.2	2	3.6	1.5	3.0
Sodium	Na_2O	0.3	0.5	0.5	0.6	0.4	0.5
Potassium	K_2O	0.5	0.6	0.5	0.7	0.4	0.6
Phosphorus	P_2O_3	6	20.2	7	19.3	5	18.6
Sulphur	SO_3	0.3-1.2	0.9	0.3-1.2	0.8	0.3-1.2	0.8
Carbon	-	0.6-2.2		0.6-2.2		0.6-2.2	

Table 5: pH Value of the Collected Raw Sludge

	Sludge A	**Sludge B**	**Sludge C**
pH	9.2	8.9	9.7

CONCLUSION AND RECOMMENDATIONS

Based on this experimental study, the sludge ash from the three plants was an alkaline silty-sandy material; this can help to reduce the exploration of sand and can contribute to reduce sludge disposal areas as this was also pointed out by Jamshidi et al. (2016). Likewise, the four major oxides present in a Portland cement which include those of Lime (CaO), Silica (SiO_2), Alumina (Al_2O_3) and Iron (Fe_2O_3) were also present at an appreciable quantity in the sludge ashes and this feature suggests a possible application of the sludge ash in place of cement only that the sludge remained a non-plastic material. Quite a number of factors are responsible for the quality of water treatment plant, some of the factors are the type and strength of the hardness of raw water, type and quality of water, amount and type of chemical added, the treatment process, type of treatment plant, the season etc. The specific gravity is low when compared with clay, according to Jamshidi et al. (2016) the addition of chemicals in a water treatment plant may increase the specific gravity especially the presence of iron and the high organic content. Generally the raw water iron content is high when compared with other metals. The plasticity limit of water treatment plant residuals are believed to be strongly influenced by the floc structure of the residuals. As the material ages, floc water escapes and a different floc structure develops along with some cementation, decreasing plasticity. The results of the elemental and oxide concentration indicated that there is great variation of concentration of different metals in different sludge type.

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