Open Journal of Engineering Science (OJES)
ISSN: 2734-2115
Article Details:
DOI: 10.52417/ojes.v4i2.498
Article Ref. No.: OJES0402001-445
Volume: 4; Issue: 2, Pages: 01–13 (2023)
Accepted Date: September 5th, 2023

CrossMark click for updates

Open Journals Nigeria (OJN)
Open Access | Bi-annual | Peer-reviewed
www.openjournalsnigeria.org.ng
editorial@openjournalsnigeria.org.ng

RESEARCH ARTICLE OJES0402001-445

CHARACTERISATION OF Moringa Oleifera FOR PURIFICATION OF TREATED WATER SLUDGE

***Nwokorie, I. C., Anyakora, V. N. & Abdulkarim, B. I.**

Department of Chemical Engineering, Faculty of Engineering, University of Abuja

***Corresponding Author's E-mail:** ijeomanwokorie3@gmail.com;* +2348055960944

ABSTRACT

Proper disposal of treated water sludge is one of the main challenges water treatment Plants are facing globally. This entails disposing of sludge in such a way that it will not be harmful to the environment due to the chemicals used during the treatment of the water. The disposal of sludge conditioned by chemical polymers has an adverse effect on health and the environment. The use of natural polymers (such as wool polymer) has been explored to reduce adverse effects that come from chemical polymers (polyurethane). Elemental compositions of *Moringa Oleifera* were distinctive using ultimate analysis, proximate Analysis, Fourier Transform Infrared Spectroscopy, and energy-dispersive X-ray fluoresce. Characterization was done to examine the composition, functional characteristics, and physico-chemical properties of *moringa oleifera* . The proximate result showed that *Moringa oleifera* contains 36.34% of crude lipids, 3.78% of moisture,4.08% of Ash, 4.70% of crude fibre, 29.56% of crude protein, and 21.54% of carbohydrate. The ultimate result showed that carbon contains 45.86% and hydrogen has 1.96%. FTIR Spectrum of *Moringa Oleifera* showed C≡N(carbon-nitrogen) C=N and S-S (Sulphur-Sulphur) stretching bond. FT-IR spectra showed the presence of protein and lipids components. The FTIR Spectrum of the dry sludge showed many vibrations indicating some functional groups like N-H in Amides, alcohols and amines O-H, (Oxygen-hydrogen) C≡C bond C=N, C-H(Carbon -Hydrogen)O-CH3, P-N-C, C-H in aldehydes and acids C=O in Carboxylic acids, and S-S bond ED-XRF showed the elemental composition of *Moringa Oleifera*; 0.018% Fe, 0.001% Cu, 0.003% Al 9.00%, 0.038% Mg etc. and that of the dry sludge as 9.22%, Fe_2O_3, 0.572% CuO, 9.63% Aluminum oxide, 29.96% Silicon Oxide, 2.57% magnesium oxide. Turbidity of the treated sample was reduced to the level of Nigerian standard (5NTU). *Moringa Oleifera* was discovered to be a viable and affordable alternative for conditioning of water treatment sludge.

Keywords: *Treated water sludge, Functional Group, Moringa Oleifera, Natural conditioner, purification, Polymer*.

INTRODUCTION

In numerous places, it is usual practice to dispose of sludge from water Treatment Plants with insufficient or no treatment at all. Disposal of untreated Sludge directly into the environment affects the recipient due to solid depositions and the chemical composition of the sludge. Therefore, strict waste discharge standards are imminent; hence there is a need for appropriate treatment of the sludge (Kaggwa *et al*., 2011).

Disposal of debris obtained from water Treatment Plants is one of the dominant problems most treatment plants appear not to overcome. This can be traced to the steady rise of waste, correspondingly to meet the need for water and treatment of water for human consumption. Waste from water treatment (Sludge) is made up of inorganic and organic compounds in gaseous, liquid, and solid states, which still differ in physical and chemical peculiarity relative to the treatment emissary used and the sources of raw water (*Odimegwu et al., 2018*).

In many countries, sludge is a very serious problem due to its high cost in treatment, and risk to human health and the entire environment. Sludge shows frequent difficult problems in cities of all dimensions due to the scarcity of proper disposal areas, increasing labour costs, and environmental concerns (Anyakora, 2013). The aforementioned (lower Usuma treated water sludge) waste needs to be disposed of appropriately following approved standards and regulations which stipulate the quantity of waste generated be reduced, reused, and recycled to minimize pollution (NESREA, 2009).

Hence Purification of treated water sludge becomes necessary. There are numerous available chemical conditioners especially utilized in the water industry, usually aluminum Sulphate, ferric chloride, lime/polymer, etc. Nevertheless, the shortcoming of chemical treatment of the sludge is the risk linked with using biofuels for terrestrial applications (Viera *et al*., 2010). Currently in Nigeria, most water treatment plants dispose of sludge by revolving it to the watercourse and stockpiling it in or thereabouts the treatment plants without further treatment whichever counter local and International best practices for environmental sustainability (Anyakora, 2013). Therefore, a natural conditioner can be useful for the treatment of water and wastewater. Utilizing greener processes to purify waste is becoming very popular because the processes are environmentally viable and offer a wide array of other advantages, including less cost, less generation of derivatives, higher biodegradability, and more environmentally friendly.

Many researchers have also identified the presence of an active anti-microbial agent in *Moringa Oleifera* (James, 1995) moreover, it is now evident that research in the study of the utilization of *Moringa Oleifera* in purifying water treatment sludge is yet to be fully harnessed. This inference also necessitated this research work which seeks to evaluate the potential of a natural conditioner and anti-microbial agent for the purifying water treatment sludge. Such is the case with *Moringa Oleifera* which is utilized as a conditioner in the purification of drinking water treatment sludge. This study aims to explore the potential utilization *Moringa Oleifera* in the purification of Lower Usuma Dam Water Treatment Sludge.

MATERIALS AND METHODS

This work employed the use of the Taguchi Design of Experiment for the Jar test of the sludge sample. The experimental design comprised three factors (Concentration, mixing time, and mixing speed) and Twenty-seven runs (27) represented in Taguchi array a s $3^3 = 27$. The responses are Turbidity, Conductivity, Biological Oxygen Demand, and Chemical Oxygen Demand. The materials used in this work are LUDWTP Sludge and Dried powder *Moringa Oleifera*. Sludge samples for the analysis were collected in clean plastic containers at different stages of the lower Usuma dam water treatment sludge located along Dutse-Bwari Road Abuja. The *Moringa Oleifera* were purchased at Bwari Market, Bwari FCT, shells were manually removed, dried at room temperature for 2 days, grounded in a household blender with steel blades, and stored in a container.

Figure 1: Deshelled *Moringa Oleifera* seed

Figure 2: *Moringa Oleifera* seed powder

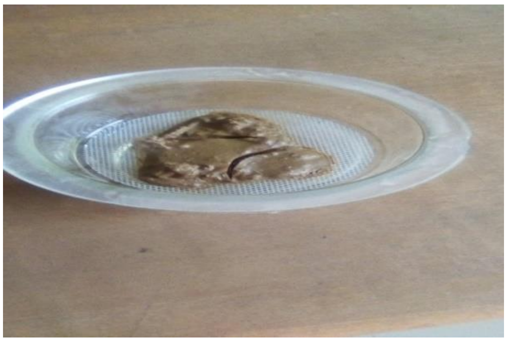

Figure 3: Dewatered sludge

Figure 4: Dried Sludge

Method

One litre of the supernatant of the sludge was poured into 3 beakers and placed under multiple stirrers. Prepared pure inoculum (0.1 ml) was added to each beaker before adding conditioner. The prepared seed extract; *Moringa Oleifera* seed powder (conditioner) was added at concentrations of 10, 20, and 30mg/l. The setup was mixed thoroughly at a speed of 200 rpm for 5 minutes to enable total dispersal of conditioner and 60 rpm for 30 minutes to aid in the effective flocculation of colloidal particles. After thorough mixing, the beakers were removed and placed on a workbench for an hour to allow the flocs to settle. Supernatants were decanted and the colour, Turbidity, BOD, COD, and conductivity were measured and recorded. The procedure was repeated with different mixing speeds and mixing times up to 27 times.

Proximate analyses were carried out according to the procedure of the Association of Official Analytical Chemists (AOAC, 1990). Fourier Transform Infra-red spectra of the samples were recorded using a Perkin-Elmer 2000 FTIR spectrometer fitted with a deuterated triglycine sulphate (DTGS) detector covering the frequency range of 500-4000 cm^{-1}. Ten milligrams (0.01 g) of samples of *Moringa Olefeira seed powder*, *dry sludge*, *dry Sludge with*

Moringa Olefeira, and Sludge without *Moringa Olefeira* were evenly dispersed in 200 mg of spectroscopic grade KBr to record the spectra. The sample spectra were recorded in 500 to 4000 cm^{-1} wavenumbers.

Ultimate analysis procedure, the powdered sample of *Moringa Oleifera* was introduced to CHN628 Series elemental determinator and CKIC 5E-S3200 Coulomb Sulphur Analyzer operated using S3200, and the following elemental composition was determined; the carbon (C), hydrogen (H), nitrogen (N) and the total sulphur (S) content; 0.10 mg of the sample was placed in a tin capsule, heated at 980°C with a constant flow of helium. Sludge characterization; Liquid sludge was collected from the water treatment sludge dewatered and dried. The following properties were analyzed; condition of sample, moisture content, Ph, colour, temperature, drying time, and settling rate.

RESULTS AND DISCUSSION

CHARACTERIZATION OF LOWER USUMA DAM WATER TREATMENT PLANT SLUDGE

Table 1: Characteristics of Lower Usuma Dam Water Treatment Plant Sludge.

Properties	**Result**
Condition of sample	Air dried
Moisture content	96.6%
Ph	7.4
Colour	Dark Brown
Temperature	28.7^{0}C
Drying Time	96 hrs
Settling rate	0.52m/hr

Table 1 shows the characteristics of the sludge sample. From Table 1 it is obvious that the sludge has high moisture content hence the need to condition it. Also, the pH is slightly alkaline indicating that it can work well with *Moringa Oleifera* since the pH was found to be 7.4 which means the sludge is alkaline.

PROXIMATE RESULT

Table 2: Proximate Composition of *Moringa Oleifera* Powder

S/N	**PARAMETERS**	**VALUES (%)**
1	Crude lipids (%)	36.34
2	Moisture (%)	3.78
3	Ash (%)	4.08
4	Crude fibre (%)	4.70
5	Crude Protein (%)	29.56
6	Carbohydrate (%)	21.54

Table 2 shows the result of the presence of nutrient percentage for the *Moringa Oleifera* seed. The result was compared with the result found by (Barakat and Ghazal, 2016) and some of the parameters such as Carbohydrate and Ash show an agreement.

ULTIMATE ANALYSIS

The elemental composition of *Moringa Oleifera* was determined and presented in Table 3 below.

Table 3: Elemental composition of *Moringa Oleifera*

s/n	Elements	Composition (%)
1	Carbon	45.86±0.16
2	Hydrogen	10.65±0.15
3	Nitrogen	1.96±0.22
4	Sulphur	3.31±0.25
5	Oxygen	38.24±0.13
6	Hydrocarbonate	0.21±0.02
7	Organic carbon	0.33±0.07

Table 3 represents the elemental composition of dry *Moringa Oleifera* the result shows that carbon has a higher composition than any other element present in the *Moringa Oleifera* this is due to the amount of Carbon dioxide that the Moringa tree absorbed. The result also shows that *Moringa Oleifera* has less percentage of Hydrocarbonate composition, the result shows in agreement with the result found by (Mahmet, 2019) on Nitrogen composition.

ENERGY DISPERSIVE X-RAY FLUORESCENCE (XRF) ANALYSIS

The elemental composition of dry sludge and dry sludge treated with Moringa Oleifera and Moringa Oleifera were determined and presented in Table 4 below.

Table 4: Energy Dispersive X-Ray Fluorescence concentration of dry sludge, dry sludge treated with *Moringa Oleifera* (MO) and *Moringa Oleifera*.

	Dry Sludge	***Dry Sludge treated* with *Moringa O.***		***Moringa Oleifera***
Oxides	**Concentration (%)**	**Concentration (%)**	**Elements**	**Concentration (%)**
Fe_2O_3	9.2287	8.3832	Fe	0.0178
SiO_2	29.9620	26.4140	Cu	0.000517
Al_2O_3	29.6800	25.2680	Ni	0.00312
MgO	2.5700	0.8900	Zn	0.007945
P_2O_5	0.1828	0.7302	Al	0.03811
SO_3	0.5404	1.7695	Mg	0.03837
TiO_2	0.6611	0.7964	Na	0.0169
MnO	0.9168	0.7801	S	2.1174
CaO	0.3410	0.3001	P	0.7301
K_2O	0.5721	0.7903	Ca	0.29277
CuO	0.1052	0.0116	K	0.6301
ZnO	0.0346	0.0390	Mn	0.003339
Cr_2O_3	0.00536	0.00597	Rb	0.00383
V_2O_5	0.01276	0.01222	Sr	0.001395
As_2O_3	0.0075	0.0106	Cl	0.01367
PbO	0.0270	0.0015	Cr	0.002184
Ga_2O_3	0.00561	0.00532	Bi	0.056
NiO	0.00667	0.00667	Nb	0.0067
Cl	0.0164	0.0165	Ta	0.00276

Table 4 shows the oxides concentration of the dry sludge before and after treatment with *Moringa Oleifera*. The results indicate that 42.9% of the concentration of the oxide decreased after the treatment with *Moringa Oleifera*, 30.9% of the concentration of the oxide increased and 26.2% remained unchanged some with zero value, furthermore, some of the concentration shows an agreement with the result found by (*Alexandre 2018*). The result shows that 31.7% were decreased, 68.3% was increased and 0% is unchanged. The results show that *Moringa Oleifera* seed powder is composed of elements only with Sulphur having the highest concentration and copper having the lowest concentration.

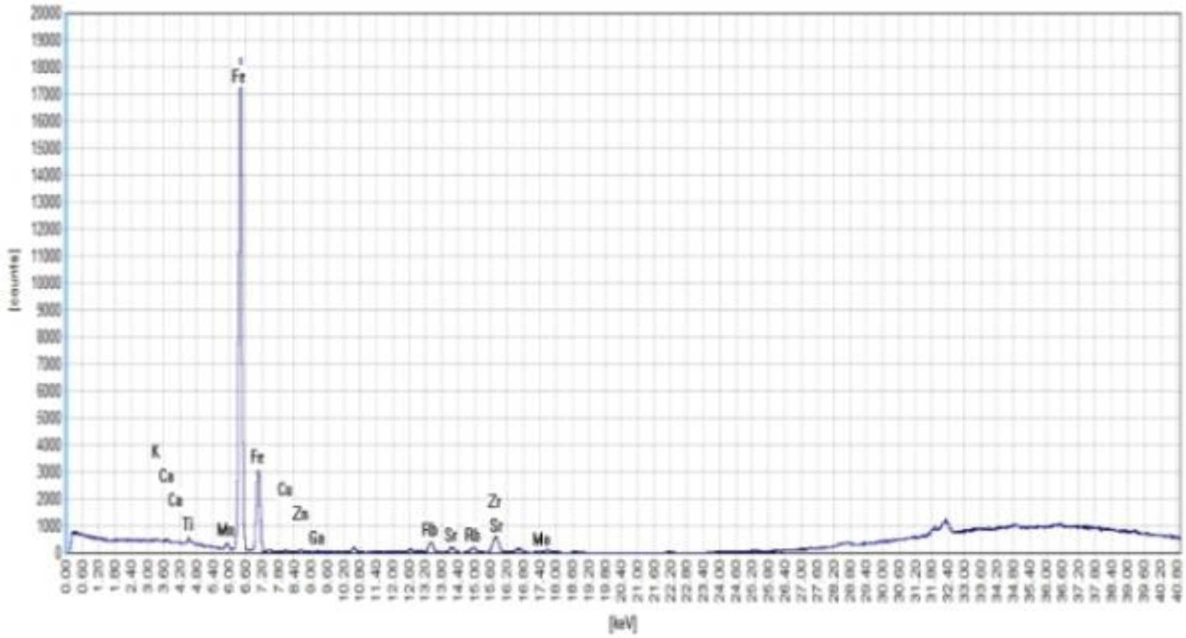

Figure 5: EDXRF Spectrum of Dry Sludge

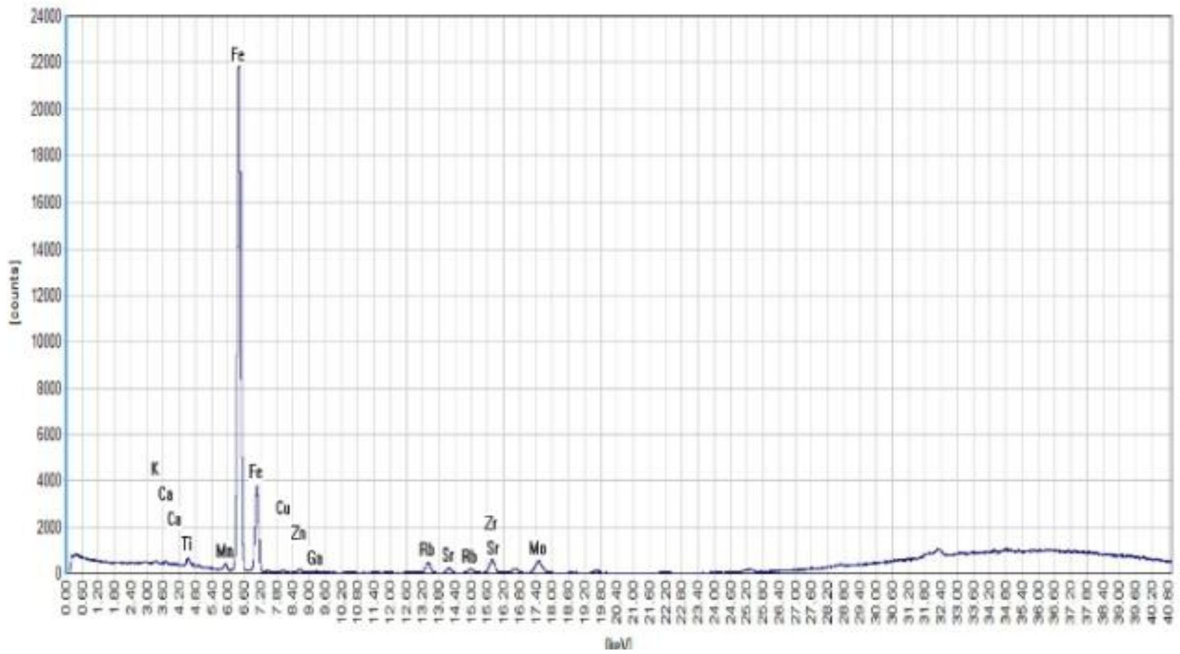

Figure 6: EDXRF Spectrum of Dry Sludge Treated with *Moringa Oleifera*

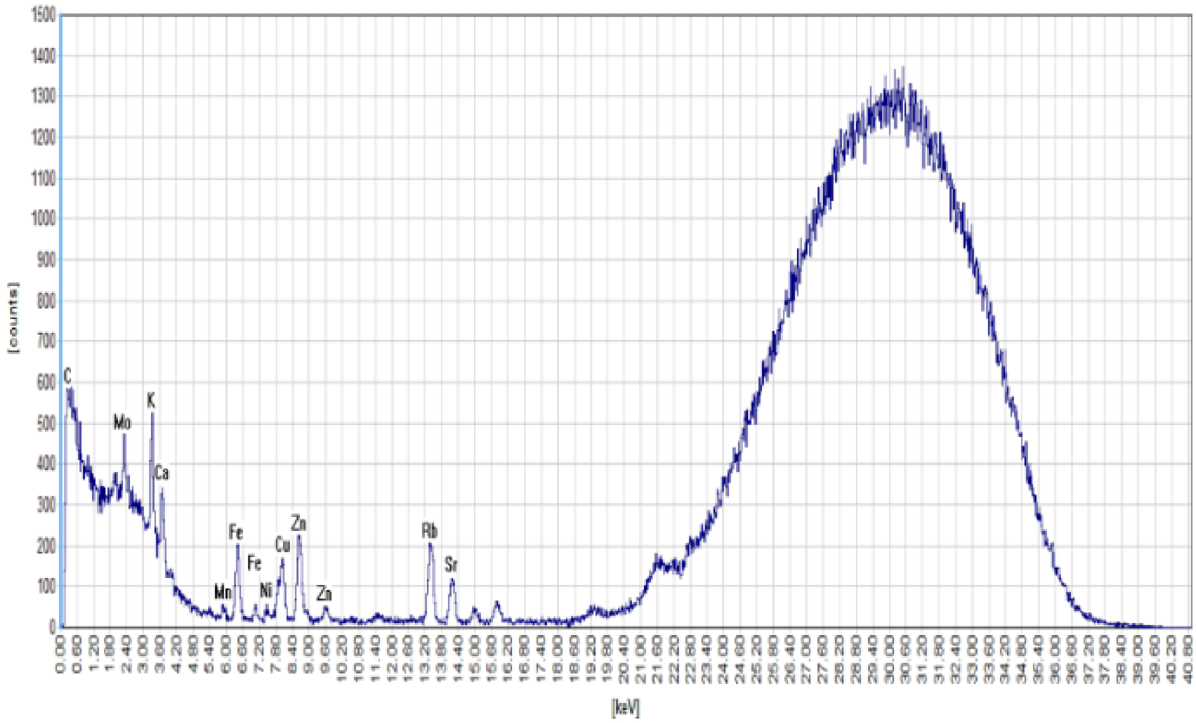

Figure 7: EDXRF Spectrum of *Moringa Oleifera*

The graphical representation for X-ray fluorescence of Dry Sludge, Dry Sludge treated with *Moringa Oleifera*, and *Moringa Oleifera* in Fig. 5, 6 & 7 EDXRF analyses was performed. During the EDXRF measurement, different areas were focused and the corresponding peaks at different element indications at the peaks are shown in Figures 5, 6 & 7 as follows K, Ca, Ti, Mn, Fe, Cu, Ga, Rb, Sr, Zr, Mo and AL can be seen in the synthesized structure in the EDXRF spectrum. In the EDXRF Spectrum Kilo electronvolt (KeV) of the Ti, Mn, Fe, Rb and Sr in fig.5 & 6 are viz 4.50, 6.00, 17.40, 6.30, 7.20, 13.5, 15.00, 14.10, 15.9 and 3.00, 3.90, 4.10, 6.00, 6.90, 7.80, 9.30, 14.25, 13.75, 16.00, 17.40 respectively. In Figure 7 the appearance Kev of the elements are as follows Mo-2.40, K- 3.00, Ca- 3.00, Mn- 6.00, Fe- 6.00, Ni- 7.20, Cu- 7.80, Zn- 6.40, Rb- 13.20, Sr- 14.40 respectively.

FOURIER TRANSFORM INFRARED SPECTROSCOPY (FT-IR)

The results of the FT-IR spectrum were presented in Figures 4 to 6 with many wavenumbers depending on the analyzed sample.

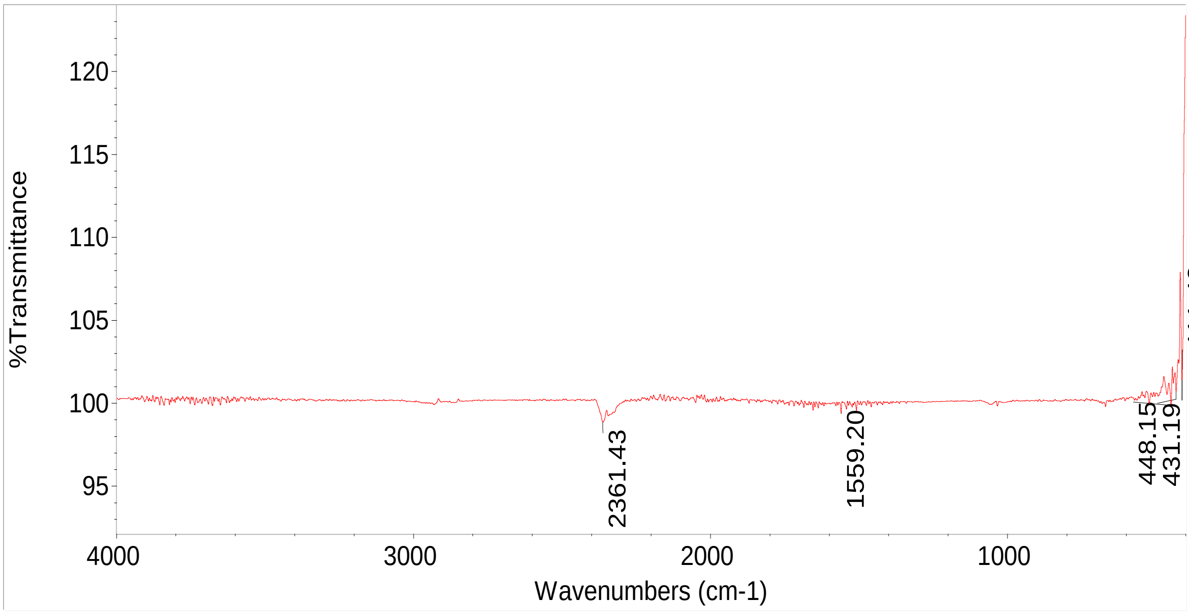

Figure 8: FT-IR Spectra of *Moringa Oleifera*

The FTIR Spectrum of *Moringa Oleifera* in Fig. 8 shows the five different positions and Intensity. The absorption peak at 2361.43 cm^{-1} is assigned to the stretching vibration of the Acetylene functional group (C≡N) bond with medium intensity, the absorption peak at 1559.20 cm^{-1} is colligated to the stretching vibration of the primary amine functional group (C=N) bond with weak medium intensity, the absorption peak of aryl disulfides functional group at 448.15, 431.19 and 411.43 cm^{-1} are S-S stretching bond.

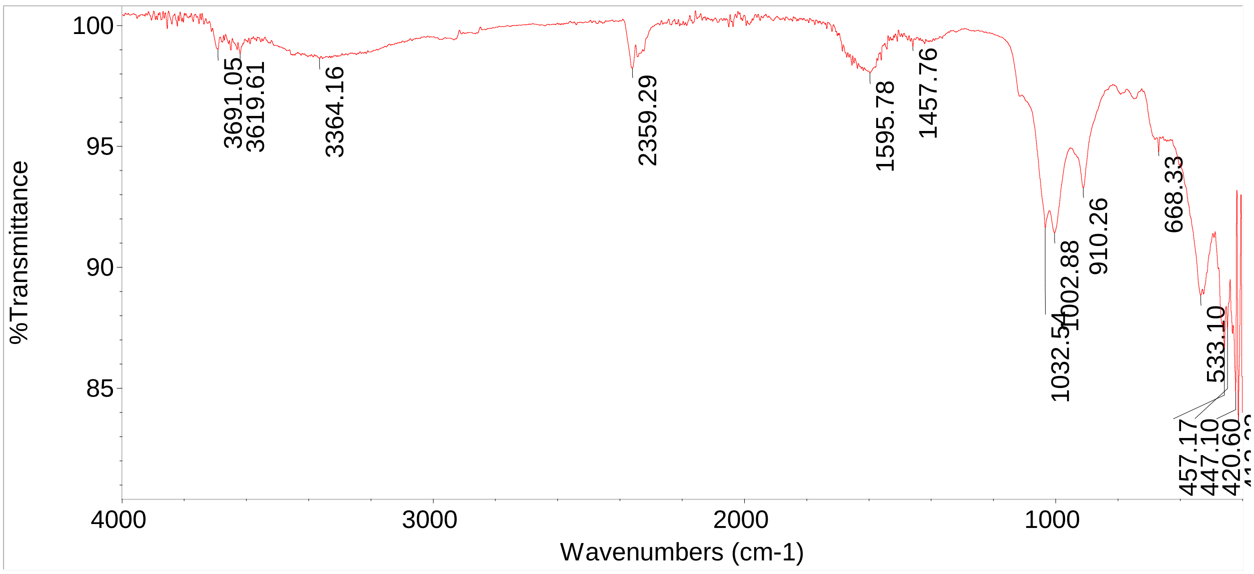

Figure 9: FT-IR Spectra of Dry Sludge

The FTIR Spectrum of Sludge without *Moringa Seed* in Fig. 9 shows many vibrational stretching, bending at absorption peaks, and their functional group bond as follows 3690.75, 3675.04, 3650.02, 3629.47 cm^{-1} bonded at Alcohol and hydroxy compound at O-H with narrow intensity, 2924.84 cm^{-1} at bond C-H that is Methyne functional group with medium intensity, 2360.40 & 2341.28 cm^{-1} associated at carbonyl amino group C≡C bond with medium intensity, 1654.07, 1636.79 & 1559.54 cm^{-1} stretched at simple hetero-oxy compound (C=N) bond with medium intensity, 1541.48 cm^{-1} stretched at N-O-C bond, 1457.96, 909.94 & 668.60 cm^{-1} bent at C-H bond, 1032.56 & 1003.36 cm^{-1} stretched at C-N bond, 522-73 cm^{-1} stretched at C-I bond, 461.67, 448.06, 435.73 cm^{-1} stretched at S-S bond at thiols and thio-substituted compounds and finally the result reveals that 420.60, 415.69 and 408.78 cm^{-1} are out of plane symmetry the result show similarity with the finding of (Coates, 2000).

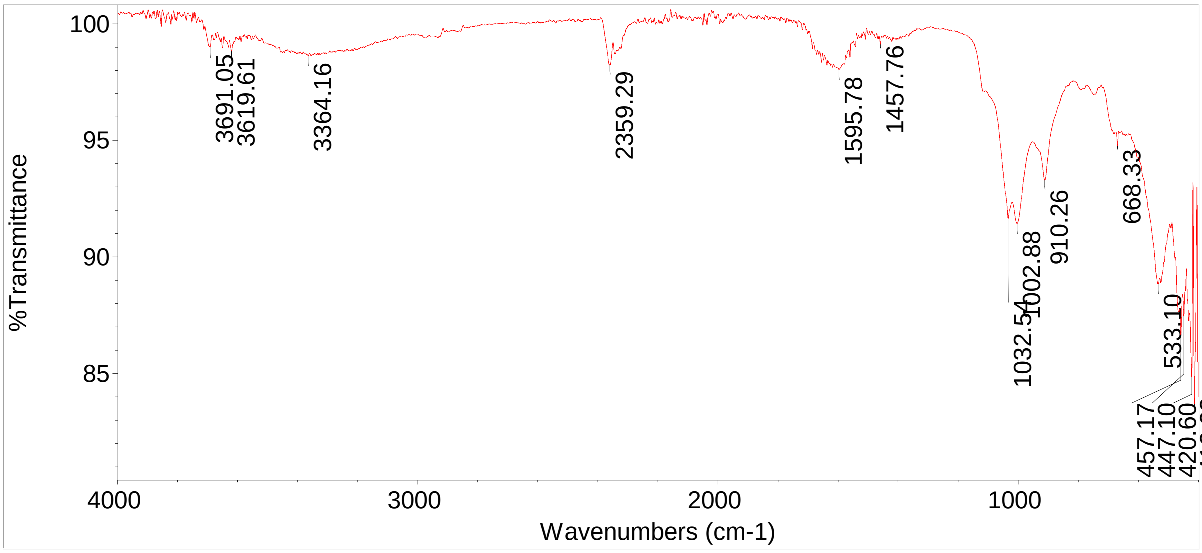

Figure 10: FT-IR Spectra of Dry Sludge treated with *Moringa Oleifera*

The FTIR Spectrum of Sludge with *Moringa Oleifera* in Fig. 10 shows fifteen absorptions at different intensities, the absorption at 3691.05 & 3619.61cm^{-1} stretched at hydroxy group (O-H) bond, 3364.16 cm^{-1} stretched at aliphatic secondary amine (N-H) bond with narrow intensity, 2359.29cm^{-1} peak stretched at carbonyl imino functional group (C≡C) bond, 1595.78cm^{-1} stretched at open chain imino functional group C=C-C bond, 1457.76cm^{-1} peak bend at C-H bond, 1032.54 & 1002.88cm^{-1} stretched at C-F bond, 910.26cm^{-1} peak stretched at P-O-C bond, 668.33cm^{-1} vibrational peak stretched at disulfides C-S bond, 533.10cm^{-1} absorption peak colligated at C-I bond, 457.17 & 447.10cm^{-1} peaks stretched at disulfides S-S bond and finally the graph shows that 420.60 and 412.23cm^{-1} are out of plane symmetry, the result compared with the experimental result by (Coates, 2000).

PHYSIOCHEMICAL PARAMETERS OF LUD TREATED WATER SLUDGE

Table 5: Physicochemical result of lower Usuma dam treated water sludge before and after treatment with *Moringa Oleifera*

SMP NO.	**Result before Treatment**				**Result after Treatment**				**% reduction Turbidity**
	Turbidity	**Cond**	**BOD**	**COD**	**Turbidity**	**Cond**	**BOD**	**COD**	**%Turbidity**
1	53.3	97.3	5.6	16.8	4.47	99.5	4.4	12.9	91.6
2	19.8	101.3	3.6	11.2	4.69	102.5	4.0	11.8	76.3
3	20.1	90.5	4.0	11.0	4.85	104.4	3.8	11.3	75.9
4	12.45	100.9	3.9	11.4	4.26	101.3	4.3	13.0	65.8
5	21.32	112.8	3.9	12.6	4.84	118.9	4.8	14.6	77.3
6	16.84	119.6	3.4	10.6	4.70	121.0	3.9	11.5	72.1
7	10.13	104.3	3.6	12.0	3.88	120.2	4.5	13.7	61.6
8	28.7	120.4	3.0	10.4	2.64	120.8	4.9	14.8	90.8
9	29.4	116.4	3.9	11.4	3.47	123.4	3.9	11.7	88.1
10	53.3	97.3	5.6	16.8	4.45	102.2	4.3	12.8	91.6
11	19.8	101.3	3.6	11.2	4.59	103.1	3.9	11.8	76.8
12	20.1	90.5	4.0	11.0	4.40	100.2	4.4	13.2	78.1
13	12.45	100.9	3.9	11.4	4.65	101.4	3.8	11.6	62.6
14	21.32	112.8	3.9	12.6	3.87	121.5	4.0	12.2	81.8
15	16.84	119.6	3.4	10.6	4.27	121.1	4.6	14.0	74.6
16	10.13	104.3	3.6	12.0	2.75	105.6	3.8	11.4	72.8
17	28.7	120.4	3.0	10.4	2.78	121.2	3.5	11.0	90.3
18	29.4	116.4	3.9	11.4	3.09	121.9	4.2	12.8	89.4
19	53.3	97.3	5.6	16.8	4.43	103.0	3.9	11.8	91.6
20	19.8	101.3	3.6	11.2	4.56	104.1	3.6	11.0	76.9
21	20.1	90.5	4.0	11.0	5.00	105.3	4.3	13.0	75.1
22	12.45	100.9	3.9	11.4	4.95	103.3	3.9	11.5	60.2
23	21.32	112.8	3.9	12.6	4.46	118.3	4.5	13.8	79.0
24	16.84	119.6	3.4	10.6	4.25	120.9	3.4	10.4	74.7
25	10.13	104.3	3.6	12.0	2.50	121.0	5.0	14.8	75.3
26	28.7	120.4	3.0	10.4	2.65	121.7	3.8	11.2	90.7
27	29.4	116.4	3.9	11.4	4.22	123.8	4.2	12.9	85.6
Mean	23.56	107.1	3.9	11.9	4.06	112.28	4.13	12.46	78.8

Table 5 shows the physicochemical result of the sludge treated with *Moringa Oleifera*, it observed that based on the percentage removal, *Moringa Oleifera* is effective for reduction of the treated sample to the level of Nigerian standard of Turbidity 5NTU (*NESREA 2009*).

CONCLUSION

The characterization of Moringa Oleifera seeds for the purification of treated water Sludge and compositions investigated in this work using ED-XRF, FTIR, proximate and ultimate analysis are adequate. The results of this work have demonstrated that *Moringa Oleifera* can be used in the purification of water treatment sludge and it is very effective in treating Turbidity to be within Nigeria standard of 5.0NTU.

ACKNOWLEDGEMENT

The Authors are grateful to the University of Abuja, Umaru Musa Yaradua University Kastina, Umanu Danfodiyo University Sokoto, Federal Capital Territory Water Board, Abuja, Sheda Science and Technology Complex (SHESTCO), Abuja, Nigeria for making use of their facilities.

REFERENCES

Vieira, A.M.S., Vieira, M.F., Silva, G.F., Araujo, A.A., Fagundes-Klen, M.R. Veit, M.T. and Bergamasco, R. (2009). "Use of MO seeds as a Natural Adsorbent wastewater Treatment'. *Journal of Water Air Soil Pollution* **206**:273-281. Doi: 10.1007/s11270-009-0104-y.

AOAC. (1990). Official Methods of Analysis. 4th Edition, Association of Official Analytical Chemists, Washington DC

Alexandre, H P. (2018). 'Portable X-Ray Fluorescence Spectrometry: Principles and Applications for Analysis of Mineralogical and Environmental Materials', February 2018 DOI: 10.31031/AMMS.2018.01.000506

Barakat, H. and Ghazal, G.A. (2016). 'Physicochemical Properties of *Moringa oleifera* Seeds and Their Edible Oil Cultivated at Different Regions in Egypt'. *Journal of food and Nutrition sciences*, **07**(06):472-484. Doi 10.4236/fns.2016.76049.

Coates, J. (2000). Interpretation of infrared spectra, a practical approach. *Encyclopedia of analytical chemistry,* **12**: 10815-10837.

Grabow, W.O.K., Slabert, J.L., Morgan, W.S.G, Jahn, S.A.A., 1985 "Toxicity and Genotoxicity valuation of water Coagulated with MO Seed preparations utilising fish,bacterial, ames Salmonella assays and protozoan" Water SA 11, pp. 9–14.

Mahmet, B. (2019) "Proximate and Ultimate Analysis before and after Physical & Chemical Demineralization" IOP conference Series Earth Environmental Science.

James, C. S., 1995. Analytical Chemistry of Food. Champman and Hall, London, pp: 64-65.

Kawamura, S., (1991) "Effectiveness of natural polyelectrolytes in water treatment". *Water works Association.* **83**(10): 88-91.

National Environmental Sanitation and Waste Control Regulations (2009), B1057-1102 Printed and Published by the Federal Government Printer, Abuja, Nigeria.

Anyakora, N.V. (2013). "Characterization and performance of water works sludge as brick materials" *International Journal and Engineering Applied Science,* **3**: 69-79.

R.C. Kaggwa, C.I. Mulalelo, P. Denny and T.O. Okurut, 2011, “The encroachment of Aluminium venting on a natural tropic wetland in Uganda, Water Resources, **35**(3): 795-807.

T.C. Odimegwu, I. Zakaria, M.M. Abood, C.B.K. Nketsiah and M. Ahmad (2018) “Review on different benefitcial shipway for Applying Alum sludge in a sustainable disposal Manner’’. *Journal of Civil Engineering*, **4**(9):2230. Doi:10.28991/cei-03091153.