International Journal of Engineering and Modern Technology (IJEMT) E-ISSN 2504-8848
P-ISSN 2695-2149 Vol 11. No. 4 2025 www.iiardjournals.org

Development Of Low-Cost Bio-Composite from Agricultural By-Products for Wastewater Treatment and Reuse

Mejeh Kingsley Ikechukwu[1], Nwadinobi, Chibundo Princewill[2*]
[1]Department of Mechanical Engineering, Abia State Polytechnic, Aba. Abia State.
[2]Department of Mechanical Engineering, Abia State University, Uturu, Abia State, Nigeria.
[*]Corresponding Author: chibundop@gmail.com, +2348063935655
DOI: 10.56201/ijemt.vol.11.no4.2025.pg242.251

Abstract
With the existing stages of industrial growth, it is quite challenging to stop organic pollutants and harmful heavy metals from tainting water. Therefore, treating polluted water and reusing it is a worldwide issue. This study showcases the use of a new combination of Moringa Oleifera seed powder and activated carbon made from corn cobs, which effectively eliminates a variety of organic and inorganic contaminants at the same time for the recycling of both industrial and household wastewater. In this research, a collection of innovative composite materials has been created and thoroughly analyzed. The cutting-edge uniqueness of these materials for the simultaneous removal of organic pollutants and inorganic heavy metals has been shown, with the new bio-based composite achieving a removal effectiveness of over 90% for each contaminant.

Keywords: *Bio-Composite, Wastewater Treatment, corn cobs activated carbon, Moringa Oleifera seed powder, pollutants*

Introduction

Wastewater refers to water whose chemical, biological, or physical properties have been changed due to the introduction of certain substances, making it unsuitable for particular uses like drinking. Water is essential for humans in their everyday lives. Wastewater can be seen as a type of water that has more harmful effects than beneficial ones on people. It is a by-product commonly generated from various domestic, industrial, commercial, or agricultural activities (Hoa and Hue, 2018). Wastewater may contain physical, chemical, and biological pollutants at different concentrations (Azad and Hassan, 2020). The physical features of wastewater include aspects like color, smell, temperature, and flow rate. When discussing the chemical features, topics such as organic matter, its measurement, inorganic substances, and gases are usually covered. To simplify, the chemical characteristics can be described by looking at alkalinity, biological oxygen demand (BOD), chemical oxygen demand (COD), dissolved gases, nitrogen compounds, pH levels, phosphorus, chloride, and various types of solids (both organic and inorganic, along with suspended and dissolved solids). The bacterial aspects of sewage result from the presence of bacteria and other microorganisms, including algae, fungi, and protozoa. It is widely recognized that a significant portion of the supplied water becomes wastewater, thus requiring treatment. Wastewater treatment involves technologies and methods aimed at removing most of the harmful substances found in wastewater to protect public health and the environment. Therefore, wastewater management is about managing this water to preserve the environment and ensure economic, social, public health, and political stability (Metcalf and Eddy, 1991).

As pointed out by Ghawi (2018), the treatment of domestic waste encompasses various methods for cleaning water, influenced by the types and levels of pollutants present. Wastewater is essentially water that has suffered a decline in quality due to contaminants. Most of the water is processed in large-scale treatment plants which may incorporate physical, chemical, and biological treatment methods. However, the use of septic tanks is common, employing aerobic treatment systems, while aerobic processes are generally used for industrial wastewater and biological sludge. Modern systems may even involve tertiary treatment using microfiltration or synthetic membranes. After passing through these membranes, the treated wastewater becomes nearly indistinguishable from naturally sourced drinking water, while requiring the addition of ozone bubbles that percolate through the tank (Idris-Nda *et al.*, 2013).

As noted by Idris-Nda *et al*, (2013), the treatment of household wastewater aims to alter its physical, chemical, or biological properties. This process helps to lessen the volume or toxicity of the wastewater, making it safer for disposal. Various treatment methods are utilized to transform both liquid and semi-solid waste into forms that are appropriate for disposal. One important aspect of wastewater treatment is reducing its volume. Wastewater that cannot be burned may be managed through techniques such as melting, evaporation, and incineration.

In some cases, treatment of domestic wastewater is necessary for radioactive, dangerous, and other types of waste. Certain solid waste from sanitary sources can be thrown away without treatment, while hazardous wastewater typically requires commercial treatment services. Mixed waste, which includes both hazardous and radioactive elements, presents unique management issues because they are hard to handle with current treatment technologies. Such wastewater cannot be disposed of unless they meet specific treatment standards (Ghawi, 2018). Traditional water treatment techniques consist of various clarification processes, including coagulation, flocculation, sedimentation, and disinfection. However, these techniques are often inappropriate due to the high costs and limited availability of necessary chemical coagulants and disinfectants. Additionally, the procedures and dosages can be too complex for many rural areas (Hoa and Hue, 2018). The use of alum as a coagulant at local levels can negatively impact the water quality (Bichi, 2013).

These challenges are recognized worldwide, prompting significant efforts from both governments and NGOs to address them over the years, yet the issues persist (Osarugue *et al*., 2020). To overcome these challenges, new methods are being introduced that prioritize sustainable water treatment systems characterized by low costs and durability, requiring little maintenance and operational expertise. Therefore, the objective of this research is to create innovative smart composite materials by combining Moringa Oleifera seeds and activated carbon derived from corn cobs, a combination that not only removes organic and inorganic contaminants from waste water but also has biodegradability.

MATERIALS AND METHODS

This section outlines the materials utilized in this research starting from the test materials. In addition to the test materials were the apparatus, reagents and other equipment that were used in the experimentation and analysis. They include: Dried corn cobs, Moringa Oleifera (MO) seed, distilled water, hydrochloric acid, and effluent water. An electrical weighing balance, a pH meter, an oven, filter paper, a stopper, a conical flask, a measuring cylinder, a spatula, a pipette, a burette, an atomic absorption spectrophotometer, and a mechanical shaker are among the instrument used. The domestic wastewater used for the analysis was collected from Waterside River, Aba and industrial wastewater was collected from 7up Bottling Company, Aba, Abia State. Dried corn cobs were purchased from Ubani market, Umuahia, Abia State.

In this section, the methods used in the preparation of the composite materials are described (Mejeh and Okpala, 2022; Mejeh and Okpala, 2023). In addition, the physicochemical properties test procedures were also outline, followed by the process optimization procedures.

Preparation of Treatment Samples and Experimental Procedure

For the preparation of treatment samples and the execution of the experimental process, a stock solution was generated by blending 100 ml of distilled water with moringa oleifera seed cake. This mixture formed a paste with inherent coagulant properties, following the methodology outlined by Ayerza, (2011). Wastewater samples for the experiments were obtained from the 7up Bottling Company in Aba, as well as from the municipal wastewater collected from Waterside River, which serves as the primary artificial drain for domestic wastewater in Aba. The initial qualities of the wastewater samples were analyzed and recorded. To prevent any alteration in their characteristics, all samples were stored in a refrigerator.

The PB-7006 Paddle Jar Test device was utilized to conduct the wastewater treatment procedure. A total of twelve labeled beakers were prepared, and roughly 500ml of each water sample was poured into their respective beakers. Subsequently, these beakers were placed within the Jar Test apparatus. Subsequent to this, the appropriate concentration of the previously prepared stock solution was introduced into each beaker. Initially, the apparatus was set to operate at a speed of 150 rpm for a span of 2 minutes. Subsequently, the speed was reduced to 50 rpm and sustained for 25 minutes. After this period, the paddles were brought to a halt, allowing the water to settle for a duration of 1 hour. To facilitate the filtration of the settled water, Whatman no. 4 filter paper was utilized, in accordance with the procedures delineated by Logsdoni *et al.*, (2004) and APHA (2005). After the hour had elapsed, the clear water samples were gathered in conical flasks and stored at 4°C. The filtrates from all the containers were analysed for their physiochemical properties and heavy metal concentration.

Physiochemical and Microbial Analysis

The collected samples underwent analysis for a range of physicochemical parameters, including pH, total alkalinity, electrical conductivity, turbidity, total dissolved solids (TDS), acidity, total hardness, total suspended solids (TSS), dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrate, phosphate, cadmium, iron, zinc, and chloride. The bacteriological parameteranalysed was total coliforms. The analyses were done according to APHA/AWWA/WEF (2005). The microbial analysis was done as described by Mejeh and Okpala, (2022).

Each experiment was repeated three times to confirm that the results are consistent. Each set of data is the average of three independent experiments, with standard deviations calculated at a 95% confidence level. Minitab software package version 21 was used for statistical analysis. The t-test was used to compare the data from the two wastewater sources. Statistical significance was set at $p < 0.05$ for t-test (t-test: Paired Two Sample for Means) analysis in the comparison of means of wastewater samples. Analysis of variance (ANOVA), with Tukey's test was alsocarried out to verify the significance of differences among the means.

RESULTS AND DISCUSSIONS

The results for the physiochemical properties of wastewater samples given various treatments using blends of Moringa Oleifera seed powder and activated carbon from corn cob are presented in tables 1 and 2.

Table 1: Physical Properties of Wastewater with MOSP-AC treatment

SAMPLE	pH	TA mg/l	TDS mg/l	TSS mg/l	EC µs/cm	Turbidity NTU	Acidity	TH Ppm
Untreated Industrial Wastewater	4.305	176.06	477.5	18.68	826	42.84	36	62.57
Treated Industrial Wastewater (ACM1)	6.48	86.14	454	23.43	739.5	9.2	23.95	35.605
Treated Industrial Wastewater (ACM2)	6.715	82.5	464	23.68	745	8.5	21.24	33.68
Treated Industrial Wastewater (ACM3)	6.27	85.35	434.5	34.04	721	8.7	25.69	38.72
Untreated Domestic Wastewater	5.74	96.19	85	17.625	620.04	39.65	22.825	50.275
Treated Domestic Wastewater (ACM1)	6.82	74	53.5	24.52	98	7.4	18.915	33.8
Treated Domestic Wastewater (ACM2)	6.5	75.6	59	24.05	105.5	7.7	19.915	34.375
Treated Domestic Wastewater (ACM3)	6.99	78.45	50	23.75	93.5	7.2	17.9	33.8

The pH of the wastewater samples showed significant ($p<0.05$) variations and were within the acidic to neutral level ranging from 4.30 to 6.99 with sample UIW (untreated industrial wastewater) recording the least pH while sample DACM3 had the highest pH. According to Rabbi *et al*., (2018), the pH of wastewater is an important parameter which reflects the acidityand alkalinity of the wastewater. According to Rabbi *et al*., (2018), most of the aquatic life suchas fish can only survive in a narrow pH range roughly pH 6 to 9.
The electrical conductivity (EC) of the wastewater samples varied from 93.5 to 826µs/cm and showed significant ($p<0.05$) differences with sample DACM3 recording the least value and sample UIW recording the highest value. EC is mainly attributed to the dissolved ions from the decomposed plant matter (Agoro *et al*., 2018). The EC of the surface water is a valuableindicator of salinity with total salt content. The higher EC values of some samples indicates a high amount of dissolved inorganic substances in ionized form (Agoro *et al*., 2018).
The highest concentration of total dissolved solids (TDS) was observed for sample UIW and it was found to be 477.5 mg/l while the least TDS was recorded in sample ACM3 as 50 mg/l. TheTDS values of all wastewater sample varied significantly ($p<0.05$) but the lower values recorded in the treated samples relative to that of the untreated sample is an indication that the treatments resulted to significant ($p<0.05$) decrease in TDS. The values obtained for TDS in this study was compliant

with target limit (<500 and 2000 mg/l) for TDS of sewage water (FAO, 1992; Abu- Zeid, 1998; WHO, 2006) and suggests that the wastewater samples were fit for application in agriculture in terms of environmental and public health concerns.

The total hardness (TH) of the treated wastewater samples ranged from 33.68 mg/l for sample IACM2 to 62.57 mg/l for sample UIW. These values were lower than the range (160 to 268 mg/l) reported for effluent water by Kushwah *et al*., (2019). It was clear that treatment of the wastewater resulted to a significant ($p<0.05$) decrease in total hardness especially treatmentusing IACM2 treatment. In addition, according to McGowan (2000), water containing calcium carbonate at concentrations below 60mg/l is generally considered as soft; 60 to 120mg/l, moderately hard; 120 to 180mg/l, hard; and more than 180mg/l, very hard. Therefore, the treatment given to the wastewater samples in this study made them soft. Also, the treatment of the wastewater on other stated physical properties resulted to a significant difference between the treated and untreated samples at ($p<0.05$) confidence level.

Table 2: Chemical Properties of Wastewater with MOSP-AC treatment

SAMPLE	Cd mg/l	Fe mg/l	Zn mg/l	BOD mg/l	COD mg/l	DO mg/l	Cl^- ppm	NO_3 ppm	PO_4
Untreated Industrial Wastewater	0.45	0.77	0.5	131.945	341.7	14.225	41.635	0.29	3.47
Treated Industrial Wastewater (ACM1)	0.2	0.325	0.35	59.7	120.425	5.5	19.45	0.06	2.32
Treated Industrial Wastewater (ACM2)	0.235	0.46	0.47	60.95	122.21	5.4	17.45	0.05	2.12
Treated Industrial Wastewater (ACM3)	0.175	0.305	0.28	59.7	114.345	5.6	20.13	0.09	2.65
Untreated Domestic Wastewater	0.215	0.895	0.31	210.64	469.64	16.975	59	0.39	4.04
Treated Domestic Wastewater (ACM1)	0.00	0.46	0.23	34.65	95.6	5.65	16.925	0.05	2.4
Treated Domestic Wastewater (ACM2)	0.00	0.5	0.265	36.55	88.53	5.275	18.745	0.05	2.885
Treated Domestic Wastewater (ACM3)	0.00	0.39	0.17	30.88	89.25	5.8	18.11	0.06	2.075

In addition, the concentration of chloride ions (Cl^-) ranged from 16.93 to 59.0 mg/l, the least concentration was observed for sample DACM1 while the highest concentration was recorded in sample UDW (untreated domestic wastewater). The lower level obtained in the treated effluents was due to the good efficacy of the treatment agents with regards to chloride. Also, the range (16.93 to 59.0mg/l) obtained for chloride in this work was within the limit of 100mg/l as stated by the Department of Water Resources and Forestry in South Africa. Chloride concentration is affected by treatment due to sodium chloride, a common component of humans and diet, which passes unchanged through the digestive system in wastewater (Agoro *et al*., 2018; Chigor *et al*., 2013).

The nitrate (NO_3^-) values obtained in this work ranged from 0.05 to 0.32 mg/l with treated samples recording the least values while untreated wastewater samples recorded the highest values. However, these values were quite lower than the recommended guidelines of 15 mg/l (Ewemoje & Ihuoma, 2014). Thus, it was evident that the different treatments given to the wastewater samples caused significant ($p<0.05$) reductions in the concentration of nitrates.

The level of phosphate (PO_4) in the wastewater samples ranged from 2.12 to 4.04mg/l with sample UDW (untreated domestic wastewater) recording the highest value while sample DACM3 had the least value. These values were similar to the range (0.02 to 5.12mg/l) reported for wastewater in three South African sewage by Agoro *et al*., (2018). Furthermore, the phosphate concentrations observed during this study complied with recommended limits for agriculture (<20 mg PO_4^{3-} P/l) but fell short of aquaculture target limits (0.005 mg PO_4^{3-}P/l) in terms of the risk of eutrophication (WHO, 2011). Hence, this observation suggests that the wastewater samples is suitable for agriculture but not for aquaculture with reference to orthophosphate, and in view of its environmental and public health significance. The values obtained for the determination of Chemical Oxygen Demand (COD) of the wastewater samples showed significant different ($P \leq 0.5$) in all the samples. The same applied to other chemical properties examined using the composite blend.

Table 3: Microbial load (cfu/ml) of wastewater samples given various treatments using blends of Moringa oleifera seed powder and activated carbon from corn cob

Sample	THBC	TFC	TCC
IACM1	8.9×10^7	9.3×10^5	5.6×10^4
IACM2	8.3×10^7	7.4×10^5	4.7×10^4
IACM3	3.4×10^7	1.5×10^5	4.1×10^4
DACM1	2.9×10^7	9.0×10^4	No Growth
DACM2	1.8×10^7	4.1×10^5	3.8×10^4
DACM3	3.2×10^7	1.9×10^5	No Growth

The microbial load of wastewater samples given various treatments using blends of Moringa Oleifera seed powder and activated carbon from maize cob were presented in Table 3. The total heterotrophic bacterial counts (THBC) of the treated wastewater samples ranged from 1.8 x 10^7 to 8.9 x 10^7 cfu/ml and were quite lower than that of the untreated wastewater which was observed to be 1.1 x 10^8 cfu/ml. However, these counts were quite higher than the limit (1.0 x10^2 cfu/ml) stated by World Health Organization. Generally, the results revealed that the various treatments given to the effluent samples resulted to a decrease in their THBC but they were not compliant with the World Health Organization limit for TBHC (1 x 10^2 cfu/ml).

The total counts of fungi (TFC) in the treated wastewater samples varied between 9.0 x 10^4 cfu/ml and 9.3 x 10^5 cfu/ml, which were notably lower than the TFC of the untreated wastewater sample, measuring at 1.03 x 10^6 cfu/ml. Although the treatments applied to the effluents resulted in a reduction of TFC compared to the untreated effluent, the TFC values remained relatively high, surpassing the World Health Organization's limit of 1 x 10^2 cfu/ml. This indicates the necessity for advanced water treatment methods.

Regarding the total coliform counts (TCC), the untreated wastewater exhibited a higher TCC of 7.2 x 10^4 cfu/ml in comparison to the treated effluents, which ranged from 3.8 x 10^4 to 5.6 x 10^4 cfu/ml, indicating the effectiveness of the treatments. However, these coliform counts were still higher than the range of 400 to 1100 MPN/100ml reported for Agege abattoir soil in Lagos state by Adesemoye *et al*.,(2006).

The bacterial isolates from the wastewater samples given various treatments using blends of Moringa Oleifera seed powder and activated carbon from maize cob are presented in Table 4.

These bacterial isolates include *Bacillus spp*, *Pseudomonas aeruginosa*, *Salmonella spp*, *Streptococcus spp* and *Micrococcus spp*. The isolation of *Salmonella spp* and *Micrococcus spp* was in agreement with the findings of Ogidi and Oyetayo (2012), they reported the presence of these bacteria in wastewater from restaurants in Akure, Ondo State, Nigeria. Similarly, the presence of *Bacillus spp* and *Pseudomonas aeruginosa* corroborates the findings of Adesomoye *et al*. (2006), they implicated these bacteria in abattoir wastewater in Lagos, Nigeria. Thepresence of these bacteria indicated the incidence of water contamination as some of these species are potential pathogens and their presence can pose severe health risks to the public in general and immune-compromised individuals in particular (Biyela *et al*., 2004).
Bacillus spp.in wastewater should be avoided since these bacteria have been reported to be associated with the production of toxin and diarrhea. Reduction in the number of bacteria in the treated wastewater could be due to the treatment process, when compared with the untreated wastewater. However, occurrence of bacteria in the wastewater after treatment could also harbour potential pathogens and the health risk caused by these should be taken intoconsideration when wastewater is discharged into water bodies.

Table 4: Colonial and Biochemical Characterization of Bacterial Isolates from Industrial wastewater samples given various treatments using the blends

Colonial morphology	Gram reaction	Cell shape	Catalase test	Indole reaction	Citrate utilization	H_2S production	Probable organism
Cream to white coloured, large, irregular-shaped colonies on nutrient agar plates	+ve	Rod	+ve	-ve	+ve	-ve	*Bacillus spp*.
Small, flat, wrinkled colonies with slight green pigmentation	-ve	Rod	-ve	-ve	-ve	-ve	*Pseudomonas aeruginosa*
Creamy, large and smooth colonies on nutrient agar plates	-ve	Rod	+ve	-ve	+ve	-ve	*Salmonella spp.*
Large, flat, creamy mucoid colonies on nutrient agar plates	+ve	Cocci in clusters	-ve	-ve	-ve	-ve	*Streptococcus spp.*
Tiny, yellow, irregular-shaped colonies on nutrient agar plates	+ve	Cocci	+ve	-ve	-ve	-ve	*Micrococcus spp.*

CONCLUSION

This work dwells on the utilization of natural composites as eco-friendly substitute for chemicals in water treatment. Therefore, the objective of this research is to create innovative smart composite materials by combining Moringa Oleifera seeds and activated carbon derived from corncob materials. This unique combination not only effectively eliminates both organic and inorganic pollutants from wastewater but also possesses the added advantage of being biodegradable. The composite was prepared, characterized, and assessed for the adsorption-coagulation efficiency of the resulting composite material. Samples were analyzed for necessary physicochemical parameters. Each set of data was the average of three independent experiments, with standard deviations calculated at a 95% confidence level. Minitab software package version 21was used for statistical analysis. The t-test was used to compare the data from two wastewater sources used. Statistical significance was set at $p < 0.05$ for t-test (t-test: Paired Two Sample for Means) analysis in the comparison of means of wastewater samples. Analysis of variance (ANOVA), with Tukey's test was also carried out to verify the significance of differences among the means. The results obtained showed that the treatment processes employed in this study for wastewater samples yielded samples of good quality by physicochemical standards.

REFERENCES

Abdullahi Idris-Nda , Humuani Kaka Aliyu, Musa Dalil (2013) The challenges of domestic wastewater management in Nigeria: A case study of Minna, central Nigeria; International Journal of Development and Sustainability; Volume 2 Number 2 (2013): Pages 1169-1182

Adesemoye, A.O., Opere, B.O. and Makinde, S.O. (2006) Microbial Content of Abattoir Wastewater and Its Contaminated Soil in Lagos, Nigeria. African Journal of Biotechnology, 8, 1963-1968.

Agoro Mojeed A., Omobola O. Okoh, Martins A. Adefisoye, Anthony I. Okoh Physicochemical Properties of Wastewater in Three Typical South African Sewage Works; Pol. J. Environ. Stud. Vol. 27, No. 2 (2018), 491-499; DOI: 10.15244/pjoes/74156

APHA (2005). *Standard Methods for the Examination of Water and Wastewater*. 21st Edition. American Public Health Association/American Water Works Association/Water Environment Federation, Washington DC.

Ayerza, R. (2011). Seed Yield Components, Oil Content, and Fatty Acid Composition of Two Cultivars of Moringa (Moringa Oleifera Lam.) Growing in the Arid Chaco of Argentina. Ind Crops Prod 33:389–394. doi:10.1016/j.indcrop.2010.11.003

Azad, M.S. and Hassan, M.S. (2020). "Importance of *Moringa oleifera* for Wastewater Treatment: A Review". *International Journal of Sustainable Energy Development (IJSED)*, *8*(1), 415-420.

Bichi, M.H. (2013). "A Review of the Applications of *Moringa oleifera* Seeds Extract in Water Treatment". *Civil and Environmental Research*, *3*, 1-11.

Biyela, P.T.J., Lin and C.C. Bezuidenhout, 2004.The role of aquatic ecosystem as reservoirs of antibiotic resistance bacteria and antibiotic resistance gene' Water Science and Technology, 50(1): 45-50.

Chigor Vincent N., Timothy Sibanda, Anthony I. Okoh (2013) Variations in the physicochemical characteristics of the Buffalo River in the Eastern Cape Province of South Africa; Environ Monit Assess; 185:8733–8747; DOI 10.1007/s10661-013-3208-1

Ewemoje Oluseyi and Ihuoma Samuel (2014) Physicochemical Changes in the Quality of Surface Water due to Sewage Discharge in Ibadan, South-Western Nigeria; Energy and Environment Research, 2014, vol. 4, issue 1, 55

FAO (1992) Food and Agriculture Organization of the United Nation. Rome, Italy, 391.

Food and Agricultural Organisation (FAO) (2006) Wastewater Treatment http://www.fao.org/docrep/t0551e/t0551e06.htm#TopOfPage

Ghawi Ali Hadi (2018) Study on the Development of Household Wastewater Treatment Unit; Journal of Ecological Engineering; Volume 19, Issue 2, March 2018, pages 63–71; https://doi.org/10.12911/22998993/81780

Hoa, N.T. and Hue, C.T. (2018). "Enhanced Water Treatment by *Moringa oleifera* Seeds Extract as the Bio-Coagulant: Role of the Extraction Method". *Journal of Water Supply: Research and Technology-Aqua*, *67*(7), 634-647.

Kushwah, S.; Dhir, A.; Sagar, M.; Gupta, B. Determinants of organic food consumption: A systematic literature review on motives and barriers. Appetite 2019, 143, 104402

Logsdonl, G. S., Freeman, S. D., Hulsey, R. A., and Veerapaneni, S. (2004). Cryptosporldlum and GilI, dltl Contamination and Removal. Advances in water and wastewater treatment, 487. Gottschalk, C., Libra, J. A., and Saupe, A. (2009). Ozonation of water and waste water: A practical guide to understanding ozone and its applications. John Wiley & Sons.

M. A. Abu-Zeid, (1998). Water and sustainable development: the vision for world water, life and the environment. Water Policy, vol. 1(1), 1998, pp. 9-19.

McGowan, W (2000). Water processing: residential, commercial, light-industrial, Lisle: Water Quality Association.

Mejeh, K. I and Opkala, A . N (2022). Application of Bio – Treatment Agent for Waste Water Remidiation using Moringa oleifera Seed Powder. J.Appl. Sci. Envirn. Manage. Vol. 26(12) 2025 – 2032.

Mejeh, K. I and Opkala, A . N (2023). Analysis of Wastewater Treatment using Corncob – Activated Charcoal. Int.J. Sci. Eng. Vol. 9 No. 3 2838 – 2847. E – ISSN: 2349 5359; P-ISSN:2454 - 9967

Metcalf and Eddy, Inc. (1991) Wastewater Engineering: Treatment, Disposal, and Reuse. 3rd Edition, McGraw-Hill, Inc., Singapore.

Ogidi, C. O. & Oyetayo, V. O. (2012) Assessment Of Microbiological and Physiochemical Properties of Wastewater from Restaurants in Akure, Nigeria; I.J.A.B.R., VOL. 2(4) 2012: 708-711

Osarugue, I.P., Omonigho, D.E., Frances, O.N. and Eseosa, U. (2020). "Effect of *Moringa oleifera* Seeds on the Microbiological and Physicochemical Parameters of Industrial and Kitchen Effluents". *PSM Biological Research, 5*(1), 1-13.

Rabbi M. A, Hossen J, Sarwar M. M, Roy P. K, Shaheed S. B, Hasan M. M. Investigation of Waste Water Quality Parameters Discharged from Textile Manufacturing Industries of Bangladesh. Curr World Environ 2018;13(2). DOI:http://dx.doi.org/10.12944/CWE.13.2.05

World Health Organisation, WHO (2011). Guidelines for drinking water quality (4 ed., Vol. 38 (4)). Geneva: World Health Organisation.