IJAAR PUBLISHING®

Engineering Research Journal | ISSN: 2782-8212
Vol. 5, Issue 4 (2025) | www.ijaar.org/erj

PERFORMANCE EVALUATION AND OPTIMIZATION OF *MORINGA OLEIFERA* SEED POWDER AS BIO-COAGULANT FOR WATER PURIFICATION IN JOS MINING POND

Dangyang Bulus Sunday*, Ibrahim Hassan, Sani Aliyu
Civil Engineering Department, Abubakar Tafawa Balewa University Bauchi, Nigeria

ABSTRACT

Mining in Jos Plateau has flourished for decades but left behind post mining environment scarred by numerous abandon mining ponds and dams surrounded by heaps of mine dumps and devastated landscape. Coagulants play a vital role in water treatment for both human and animal consumption. Aluminium sulphate is the most common and effective chemical coagulant for water treatment but are cost-ineffective, toxic and they are not eco-friendly. Its continuous usage in water purification may cause severe health issues like cancers and neurologic disorders. Therefore, natural and greener methods of water purification are crucial for safe and effective water treatment. This study evaluates and optimize Moringa oleifera seeds powder (MOSP) as bio-coagulant to remove turbidity in water at abandoned mining pond in Rayfield, Jos. Water samples were collected by careful immersion of the sample containers in the pond water and the containers were sealed with tight fitting corks and stoppers to avoid air bubbles. Samples were immediately transferred to a refrigerator (4°C) prior to analysis. The samples collected were analyzed for pH, Turbidity, Total dissolved solids, electrical conductivity. The quality of water in the abandoned ponds for drinking and irrigation purposes in this study was determined by Kelly's index and sodium adsorption ratio. The physico-chemical parameters of raw water and treated water with Moringa Oleifera seed powder shows temperature of 31.7^{O}C for control and 29.8^{O}C for optimum. TDS of 13 mg/L for control while 10 mg/L for control. COD of 23.2 mg/L for control while 14.9 mg/L was recorded at optimum replacement. The Turbidity, Sodium Adsorption Ratio and Kelly's index obtained for raw water were 17NTU, 1.07 and 0.228 respectively while the treated water with optimum coagulant dosage of 0.03 mg/L of Moringa Oleifera seed powder gave 5NTU, 4.42 and 1.89 respectively. The properties of water such as MOSP, turbidity, TDS and COD were modeled and optimized using central composite design (CCD). The optimization result showed 0.03 mg/L of MOSP, 60mins contact time, 5 NTU for turbidity, 10 mg/L for TDS and finally 14.9 mg/L for COD. At the end of the analysis, the optimum dosage and C.T (0.03 mg/L at 60 mins C.T) of MOSP as a natural coagulant in water purification was determined. This study recommends the use of 0.03 mg/L of Moringa oleifera seed powder for purification of water in abandoned mining pond.

KEYWORDS: Optimization, Moringa Oleifera Seed Powder, Bio-Coagulant, Water Purification, Mining Pond

Sunday, D. B., Hassan, I. & Aliyu, S. (2025). Performance Evaluation and Optimization of *Moringa Oleifera* Seed Powder as Bio-Coagulant for Water Purification in Jos Mining Pond. *Engineering Research Journal. 5*(4), 81-99. DOI: https://doi.org/10.5281/zenodo.17982980

1.0 INTRODUCTION

United Nations (UN) set seventeen sustainable development goals (SDGs) to replace the millennium development goals in year 2019 and the particular interest in this review is the SDG no. 6: Ensuring availability and sustainable management of water and sanitation for all (UN, 2020).

In 2019, the United Nations reported that "billions of people" are without access to safe drinking water, most of whom are in developing countries including Nigeria (UN, 2019). This put into perspective, Nigeria's progress so far in achieving SDG no. 6 judging by 2 of its major indicators, thus: To achieve equitable and universal access to affordable and safe drinking water for all by 2030; To improve water quality by reducing all forms of pollution, eliminating, dumping and minimizing release of hazardous chemicals and materials (including heavy metals), halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally by 2030 (UN, 2020).

The sources of water available for man include rivers, streams, and springs, hand dug wells, boreholes and other freshwater bodies (Kalip *et al.*, 2020). The uniqueness of water to human existence cannot be over emphasized. In fact, human survival on earth without water is impossible.

Water is an essential resource for the global economy as well as for sustaining life. However, because of the combined effects of anthropogenic and natural factors, the quality of drinking water worldwide has been worsening for decades (Vadde *et al.,* 2018). Studies carried out on drinking water samples from Jos South and Pankshin local government areas showed that they were gradually contaminated with E-coli, total coliforms, and some physicochemical parameters from various sources (Anthoina *et al.*, 2024). The amount of the impact that human activities have on the quality of the water can vary greatly from one location to the next. Alterations in the physical, chemical, and biological features of water have a deleterious impact, not only on human health but also on the health of ecosystems. In the process of penetrating the subterranean aquifer, effluents from industry/miners, home waste, dump sites, and fertilizers all contribute to the contamination of water and constitute a possible threat to the receptors (Zacchaeus *et al*., 2020). All the diseases which claim lives in the third world countries are directly related to poor drinking water quality. Every day, almost 4,000 people die from diseases attributable to inadequate water, sanitation and hygiene (UNICEF, 2023).

2.0 LITERATURE REVIEW

2.1 Water Quality Assessment

Water quality assessment provides the baseline information on water safety. Since water quality in any source of water and at the point of use, can change with time and other factors, continuous monitoring of water is essential.

According to United Nations Children Fund (2010), it was stated that world health organization guidelines provide values for 96 substances (out of 128 chemicals initially reviewed). It is very expensive, time consuming, difficult and largely unnecessary to test for all these parameters. The list of parameters to be selected from the guidelines and included in any water assessment and monitoring program will vary according to the local conditions.

UNICEF (2010) provided parameters that are basic and generally considered priorities in any water quality assessment programme. They are: microbiological parameters such as thermo-tolerant coliforms (a group of bacteria that grow at 44°C) and faecal streptococci. In addition, physical and chemical parameters, such as disinfectant residuals, pH and turbidity, conductivity, colour, taste and odour might cause rejection of water and harmful chemicals such as nitrate, iron, arsenic, fluoride, lead, cyanide, metals (aluminium, cadmium, chromium, copper, manganese, mercury), selenium, organics (including pesticides and disinfectant by-products), alkalinity and corrosively.

2.3. 1 W.H. OStandard for Water Quality Assessment

According to W.H.O (2010) Standard, pH of drinking water should be 6.5 to 8.5. The standard maximum permissible limit for conductivity is 1200us/cm^{-1}. The parameters are presented in Table 1.

Table 1: W.H.O Standard for Water Quality Assessment

S/N	Parameters	WHO Standard (Maximum Permissible Limits)
1	pH	6.50-8.50
2	Conductivity (us/cm^{-1})	1200
3	Turbidity (NTU)	5.0
4	Total Alkalinity (mg/L)	100
5	Iron (mg/L)	3
6	Total Dissolved Solids (mg/L)	1000
7	Total Hardness (mg/L)	500
8	Calcium (mg/L)	NS
9	Magnesium (mg/L)	20
10	Sulphate (mg/L)	500
11	Chromium (mg/L)	0.05
12	Fluoride (mg/L)	1.5
13	Chloride (mg/L)	250
14	Nitrate (mg/L)	50
15	Potassium (mg/L)	NS
17	Total Coli form	Must not be detected in any 100ml sample.

Source: Daramola and Akindureni, (2017)

2.3.2 NAFDAC Guidelines for Water Quality Assessment

NAFDAC (2001) Standard for parameters in water assessment are presented in Table 2.

Table 2: NAFDAC Maximum Permitted Levels for Parameters in Water

S/N	Parameters	NAFDAC Maximum Allowed Limits
1	Ph	6.50-8.50
2	Conductivity (us/cm^{-1})	1000
3	Turbidity (NTU)	5.0
4	Total Alkalinity (mg/L)	100
5	Iron (mg/L)	0.3
6	Total Dissolved Solids (mg/L)	500
7	Total Hardness (mg/L)	100
8	Calcium (mg/L)	75
9	Magnesium (mg/L)	20
10	Sulphate (mg/L)	100
11	Chromium (mg/L)	0.05
12	Fluoride (mg/L)	1.0
13	Chloride (mg/L)	100
14	Nitrate (mg/L)	10
15	Potassium (mg/L)	10

Source: Daramola and Akindureni, (2017)

2.8 Assessment of Water Quality in Nigeria

Godwin and Oborakpororo (2019) used the WA-WQI to study the quality of the surface water of the river around the Nigerian city of Warri. Numerous physicochemical elements were used to calculate the WQI. These elements are pH, temperature, dissolved oxygen, electrical conductivity, total dissolved solids, total suspended particles, sulphate, nitrates, phosphates, chlorides, turbidity, and biochemical oxygen demand. The obtained values for the water quality index ranged widely from 110.12 to 821.5. The high value of WQI is related to the high levels of total suspended solids (124 mg/l) and turbidity (119 mg/L).

Daramola and Akindureni (2017) analyzed the quality of drinking water supplied to Akure metropolis. Samples from these different sources were collected, physical, chemical and bacteriological tests were carried out on each sample and the values compared with NAFDAC and World health organization (WHO) guidelines for drinking water. The physical parameters showed that the PH ranges from 4.5 to 6.3 which are slightly acidic. Turbidity value ranges from (0.11 NTU to 1.44 NTU), Electrical conductivity (142 to 412us/cm^{-1}). Total Dissolved Solids (89 to 276mg/l), Total hardness (22-120mg/L), Nitrate (2.10to 23.5 mg/L), Total alkalinity (0 to 44 mg/l), Chlorides (0.0 to 0.3 mg/L), Chromium (0.01 to 0.03 mg/L), Fluoride (0.06-0.23 mg/L), Iron (0.00 to 0.06 mg/L). The results of chemical parameters for all the samples conform to WHO standard.

Ikhuoriah and Onajite (2024), evaluated the physicochemical properties and bacteriological quality of four (4) outdoor swimming pools in Ovia North East, Local Council of Edo State, Nigeria. Results of physicochemical analysis showed that water temperature (25.75 - 26.38°C), pH (3.78 - 6.1), electrical conductivity (37.5 - 72.5 mg/L), total dissolved solids (14.58

- 38.43mg/L), turbidity (0.75 – 4 NTU), dissolve oxygen (6.03 - 7.43 mg/L), residual chlorine (0.03 - 0.13 mg/L), alkalinity(7 - 26.5 mg/L), hardness (6 – 36 mg/L), were within the World Health Organisation and Environmental Protection Agency stipulated maximum permissible limit for recreational waters except for pH and residual chlorine levels. The presence of pathogenic microorganisms in all the studied pools are total bacteria count (1 – 3 CFU/100mL), total coliform count (1 – 5 CFU/100 mL) and E. coli count (1 – 2 CFU/100 mL) predisposes the users of these facilities to microbial infection. The findings demonstrated that the swimming pools did not meet the required standards, particularly in terms of pH levels, residual chlorine, and microbial parameters.

Toko *et al.* (2020) collected and studied thirty (30) samples of groundwater in Port Harcourt, Nigeria. Laboratory results were used to develop weighted arithmetic water quality index (WAWQI) and water quality map of the study area. The analysed results revealed that 93.3% of the samples fell under excellent and good categories of WAWQI as their values ranged from 5.70 to 38.36 while 6.7% of the samples fell under poor and unsuitable categories with values ranging from 66.74 to 415.40. However, it was noted that the groundwater quality improved during the rainy season for the entire study area but deteriorated towards the southern part of the study area irrespective of season.

Waida *et al*. (2022) evaluated the extent to which the water, soil and plants in parts of Plateau State are polluted through a factor known as pollution load index. The results revealed that, the contamination factor for heavy metals in Bassa, Jos South, Barkin Ladi, Mangu and Jos East have their values in trend with Cr (0.04) > As (0.013) >Pb (0.006) > Ni (0.005) > Cd (0.003) for water, Cr (75.2) >Pb (74.8) > Ni (43.6) > As (24.4) > Cd (3.58) for soil and Ni (5.4) >Pb (1.72) > Cr (0.71) > Cd (0.03) > As (0.028) for plant. It can therefore be concluded that the soil, water and plants in the study area are seriously polluted and call for serious concern and regulatory control.

3.0 MATERIALS AND METHODS

3.1 Materials

The biocoagulants used for the study was *Moringa Oleifera* seed powder as shown in Plate I and distilled water. The Equipments used in this study include the following: Laboratory Mill or Grinder, Weighing Balance, Beakers and Glassware, Stirrer or Magnetic Stirrer, pH Meter, Turbidimeter, Spectrophotometer, Microscope, Pipettes and Burettes.



Plate I: Moringa Seed Powder

3.2 Methods

3.2.1 Sample Collection from Study Area

Abandoned pond location for the study is located at Rayfield Resort, Jos south, plateau state at coordinate latitude 9^{o} 51'57.0924" and longitude 8^{o} 54'3.2682". The Geographical Information System of the study area is presented in Figure I.

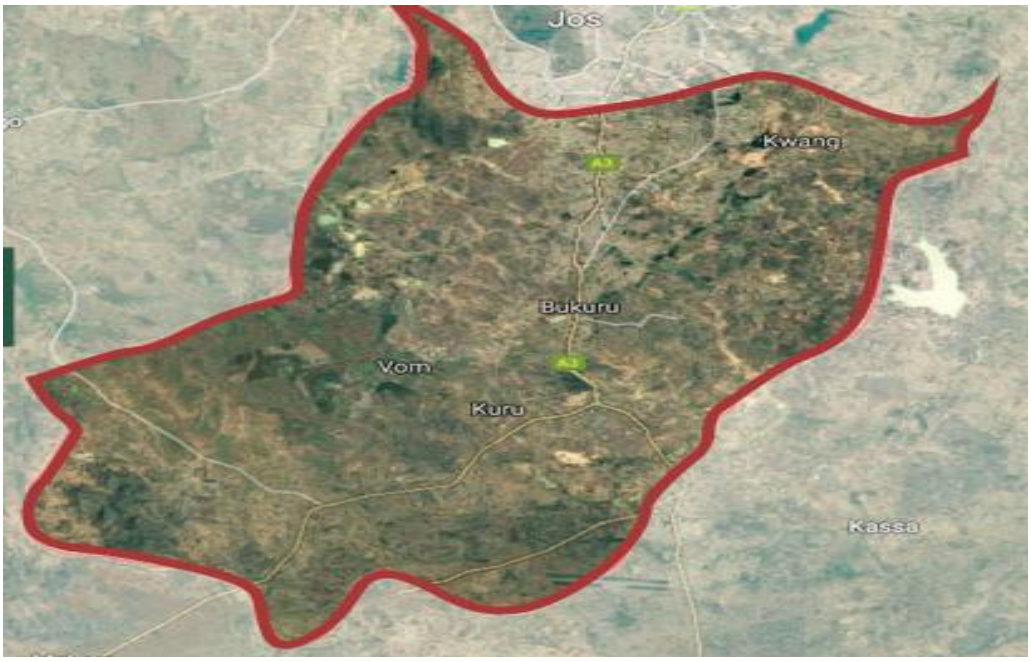


Figure I: GIS Map of the Research Area in Jos

The water samples were collected from the abandoned mining ponds in Jos. Sample was collected by careful immersion of the sample containers in the pond water and the containers were sealed with tight fitting corks and stoppers after collection, in order to prevent air bubbles. Samples were immediately transferred to a refrigerator (4°C) prior to analysis.

3.2.2 Physicochemical Analysis

The samples collected was analyzed for pH, Turbidity, Total dissolved solids, COD, and Presence of sodium, calcium, and magnesium.

Turbidity was determined using a standardized Hanna H198703 Turbidimeter. The samples were poured into the measuring bottle and the surface or the bottle was wiped with silicon oil. The bottle was inserted into the Turbidimeter and the reading obtained.

A portion of water was filtered out and 10mL of the filtrate measured into a reweighed evaporating dish. Following the procedure for the determination of total solids above, the total dissolved solids content of the water was calculated using equation 1.

$$\text{Total dissolved solids (mg/L)} = \frac{(W2-W1)mg\ x\ 1000}{mL\ of\ Filterate\ \ Used} \quad \ldots (1)$$

Where
W_1 = initial weight of evaporating dish
W_2 = Final weight of the dish (evaporating dish + residue).

3.2.3 Assessment by Water Quality Index for Irrigation

The quality of water used for drinking and irrigation purposes in this study was determined by sodium adsorption ratio. The acceptable water for use in irrigation depends on some main components such as Na, Ca, Mg, etc in the water. The popular indices for water use in irrigation include sodium adsorption ratio (SAR). The SAR refers to sodium content (alkali risk), which has a significant indication to figure out whether irrigation water is suitable for usage (Shil *et al.*, 2019). SAR measures sodium hazard and can be estimated using Equation 5. The Table 7 shows the categories of water used in irrigation according to the SAR readings.

3.2.4 Preparation and Treatment of Water Using MOSP

Matured seeds of *Moringa oleifera* were obtained in Jos. The seeds were harvested when they were fully matured shown through cracked pods on the plants. The pods were cracked to obtain the seeds which were air-dried for two days. The shells surrounding the seed kernels were removed using knife and the kernels were pounded using laboratory mortar and pestle into powder and sieved by 0.8 mm mesh. The seed powder was mixed with a small amount of clean water to form a paste. The insoluble material was filtered out. The milky white suspension was added to the turbid water and stirred fast. Then the water must be slowly and regularly stirred. After stirring, the treated water was covered and left to settle for clarification to take place.

3.2.5 Experimental Design for Jar Test

Central Composite Design (CCD) of design expert 13 software was adopted in the design of experimental combinations. It was used to quantify the relationship between the controllable input parameters and the obtained response surfaces. CCD was used to optimise the results of Turbidity, TDS, and COD. The software was used to generate a mathematical model. Table 10 shows the factor level of mixture.

Table 3: Factor and Factor Levels of Mixture

Name	Units	Low	Middle	High
Dosage	(g/L)	0.03	0.05	0.07
Contact Time	(mins)	20	40	60

Where
CD = Coagulant dosage
C.T = Contact time

The coagulation mechanism is dependent upon the coagulant dosage. In the charge neutralization, the positive charged of protein from plant-based natural coagulant *Moringa oleifera* seed powder is attracted to the negative charge colloid via electrostatic interaction. The dosage of the plant-based natural coagulant has significant effect on the optimum capacity of turbidity removal. Moreover, insufficient dosage will not effectively destabilize the particles in the water while excessive dosage of plant-based natural coagulant can result in detrimental impact. This experiment was conducted to determine the effect of dosage on the turbidity removal rate. The dosage of MOSP extract as plant-based natural coagulants to be added into the raw water were chosen as 0.03g/L, 0.05g/L, and 0.07g/L.

Contact time is a parameter for determining the equilibrium time required for the coagulation and flocculation processes in the jar test experiment. The jar test was performed to evaluate the contact time effect on the water turbidity removal rate by the MO extract. The variables were decided to be 3 sets in which contact time was 20 mins, 40 mins and 60 mins for coagulation and flocculation processes. Optimum contact time for the formation of floc was determined. The effect of contact time on turbidity was evaluated.

4.0 RESULTS AND DISCUSSION

4.1 Raw Water Characteristics

The results of physico-chemical quality of the raw water used in the study are presented in Table 4. The source of the raw water is prone to pollution from mining, and dumping of domestic waste as well as pollution from surface runoff. Most of the parameters were within the permissible limits specified by NAFDAC except for Turbidity.

Table 4: Result of Raw Water Characteristics

S/N	Parameter	Control sample	NAFDAC Maximum Allowed Limits
1	Temperature	31.7	_
2	pH	7.6	6.5 to 8.5
3	Colour (pt-co)	107	_
4	Total Dissolved Solid mg/L	13	500
5	E/Conductivity (us/cm^{-1})	0.00	1200
6	Turbidity NTU	17	5.0
7	Sodium(Na) mg/L	2.53	_
8	Calcium(Ca) mg/L	8.5	75
9	Magnesium(Mg) mg/L	2.59	20
12	COD mg/L	23.2	_

From Table 4, the pH value plays important role in the coagulation of both organic and inorganic particles/molecules. The pH result before treatment is 7.6 which is within NAFDAC allowable specified limit of 6.5 to 8.5. The NAFDAC and WHO allowable specified limit for turbidity is 5 NTU while the result of the turbidity test conducted on the raw water showed 17 NTU. This shows that the water is not fit for drinking purpose.

The value of sodium, calcium and magnesium present in the raw water are 2.53, 8.5 and 2.59 mg/L respectively. Computing the SAR, using equation 5. The value is 1.07meq/L. SAR value less than 10meq/L shows that the water is good for irrigation in its raw form.

The value of COD for the raw water is 23.2mg/L. EU sets a maximum allowable concentration of 125 mg/L for COD in surface water while No specific guideline value for COD recommended by WHO but recommends that drinking water should not contain substances that can cause harm to human health.

4.2 Performance Evaluation of *Moringa Oleifera* Seed Powder in Pond Water

The raw water was treated using Moringa Oleifera Seed powder. The effects of coagulant dosage and contact time on parameters such as turbidity, TDS and COD were studied.

4.2.1 Influence of *Moringa Oleifera* Seed Powder on Turbidity

Measurement of Turbidity reflects the transparency in water. It is caused by the substances present in water in suspension. In natural water i.e. pond water, it is caused by clay, silt, organic matter and other microscopic organisms. The prescribed limit of Turbidity for drinking water is 5 NTU (WHO standard). The effect of MOSP on turbidity of raw water at varied contact time is shown in Figure 2.

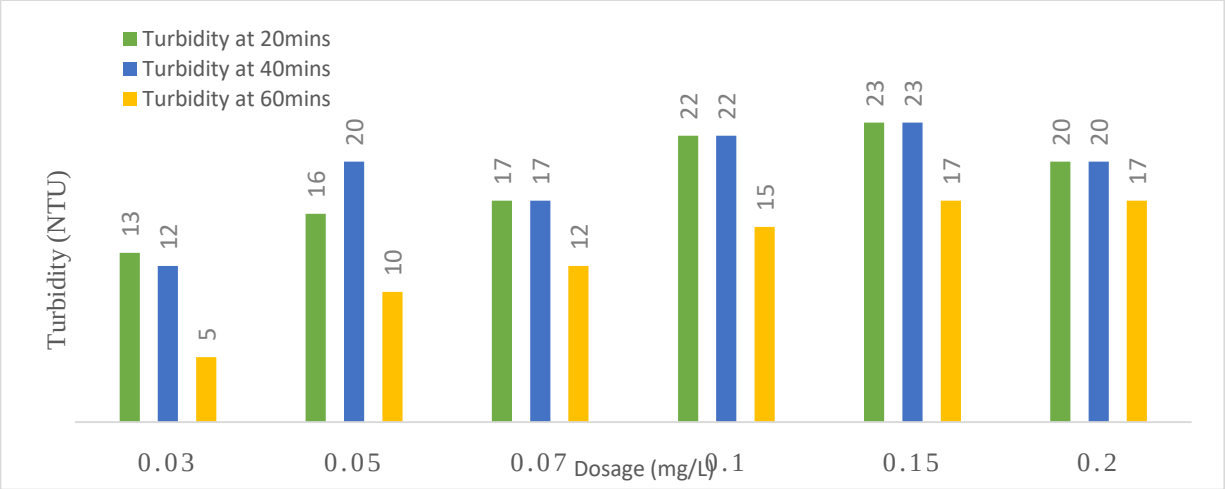


Figure 2: Turbidity Result with Moringa Seed Powder Dosage

From the result in Figure 2, the higher the dosage of *Moringa Seed* Powder, the higher the turbidity. Excessive coagulant addition will not cause turbidity to disappear until the lower limit. The best turbidity reduction at 5 NTU was achieved with optimum dose of 0.03 mg/L MOSP at 60mins contact time. This result shows 71% turbidity removal from the raw water and the 5 NTU is within the permissible limit. Determination of optimum dose was done by the lab-scale Jar Test method. MOSP was also used to treat waste water by Nhut *et al*. (2020) and 88%

of turbidity removal was achieved. Nkurunziza *et al*. (2009) recorded almost 99% of turbidity in their research.

4.2.2 Influence of *moringa oleifera* seed powder on TDS

The effect of MOSP on TDS of raw water at varied contact time is shown in Figure 3.

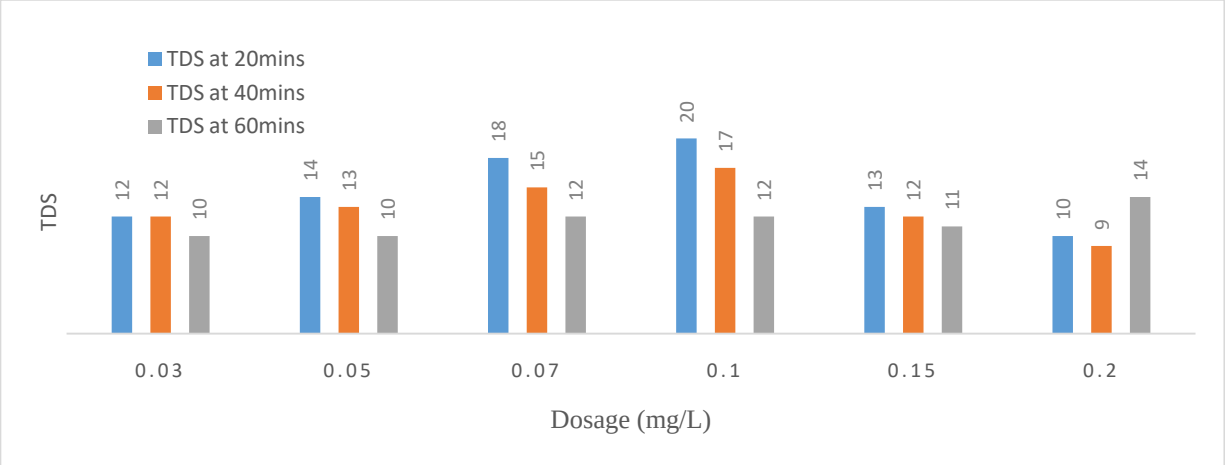


Figure 3: Effect of Coagulant Dosage and Contact Time on TDS

Influence of coagulant dosage and contact time on TDS is shown in Figure 2. The higher the coagulant dosage from 0.03 to 0.1mg/L, the higher the TDS but after 0.1mg/L, there is visible reduction in the TDS. All the values of TDS are within the WHO and NAFDAC allowable specification.

4.2.3 Influence of *moringa oleifera* seed powder on COD

The effect of MOSP on COD of raw water at varied contact time is shown in Figure 4.

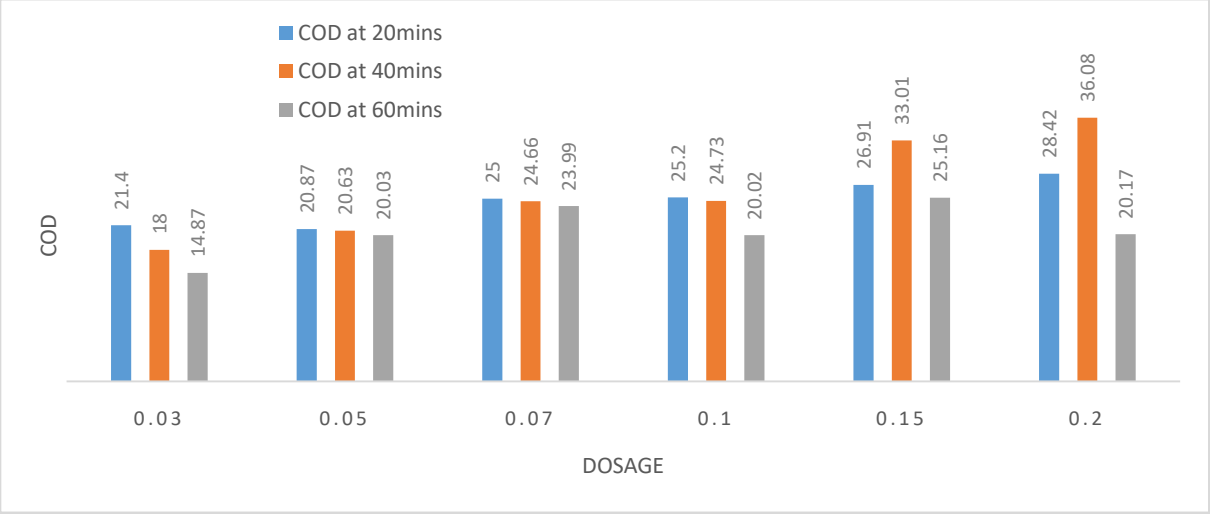


Figure 4: Effect of Coagulant Dosage and Contact Time on COD

Influence of coagulant dosage and contact time on COD is shows an increase with increase in coagulant dosage. The higher the coagulant dosage from 0.03 to 0.2mg/L, the higher

the COD. All the values at different dosage and contact time are within EU maximum allowable concentration of 125 mg/L for COD in surface water.

4.3 Optimization by Central Composite Design

Optimization strategies delve into refining treatment parameters such as dosage and contact time for *Moringa oleifera* seed powder using central composite design. This includes exploring variations in dosage based on pond water compositions and environmental conditions to achieve optimal and consistent results.

4.3.1 Turbidity by CCD

The result of the turbidity test at 0.03 to 0.07 mg/L dosage is shown in Table 5 and the analysis of variance is presented in Table 6 and Fit statistics in Table 7.

Table 5: Turbidity Result

Run	Factor 1 A: Dosage mg/L	Factor 2 B: Contact time mins	Response 1 Turbidity NTU
1	0.05	40	15
2	0.05	40	15
3	0.03	60	5
4	0.07	60	12
5	0.05	40	15
6	0.05	20	16
7	0.07	40	17
8	0.03	20	13
9	0.05	40	15
10	0.07	20	17
11	0.05	60	10
12	0.05	40	15
13	0.03	40	9

Table 6: ANOVA for Turbidity

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	146.52	5	29.30	80.30	< 0.0001
A-Dosage	60.17	1	60.17	164.87	< 0.0001
B-Contact time	60.17	1	60.17	164.87	< 0.0001
AB	2.25	1	2.25	6.17	0.0420
A^2	7.41	1	7.41	20.30	0.0028
B^2	7.41	1	7.41	20.30	0.0028
Residual	2.55	7	0.3649		
Lack of Fit	2.55	3	0.8515		
Pure Error	0.0000	4	0.0000		
Cor Total	149.08	12			

The Model F-value of 80.30 implies the model is significant. P-values less than 0.05 indicate model terms are significant. In this case A, B, AB, A^2, B^2 are significant model terms.

Table 7: Fit Statistics for Turbidity

Parameters	Values
Std. Dev.	0.6041
Mean	13.38
C.V. %	4.51
R^2	0.9829
Adjusted R^2	0.9706
Predicted R^2	0.8343
Adeq Precision	30.8636

It is seen from the analysis of variance result, R^2 is 0.9829 showing that the correlation between the actual and predicted values is very good and the regression model coincides with the test data. The Predicted R^2 of 0.8343 is in reasonable agreement with the Adjusted R^2 of 0.9706. Adeq Precision measures the signal to noise ratio. A ratio of 30.86 indicates adequate signal. The model equation for Turbidity is shown in Equation 1. The effect of contact time and coagulant dosage on turbidity of raw water is presented in Figure 5.

$$Turbidity = 0.274 + 493A + 0.076B + 1.875AB - 4094A^2 - 0.0041 * B^2 \ldots (1)$$

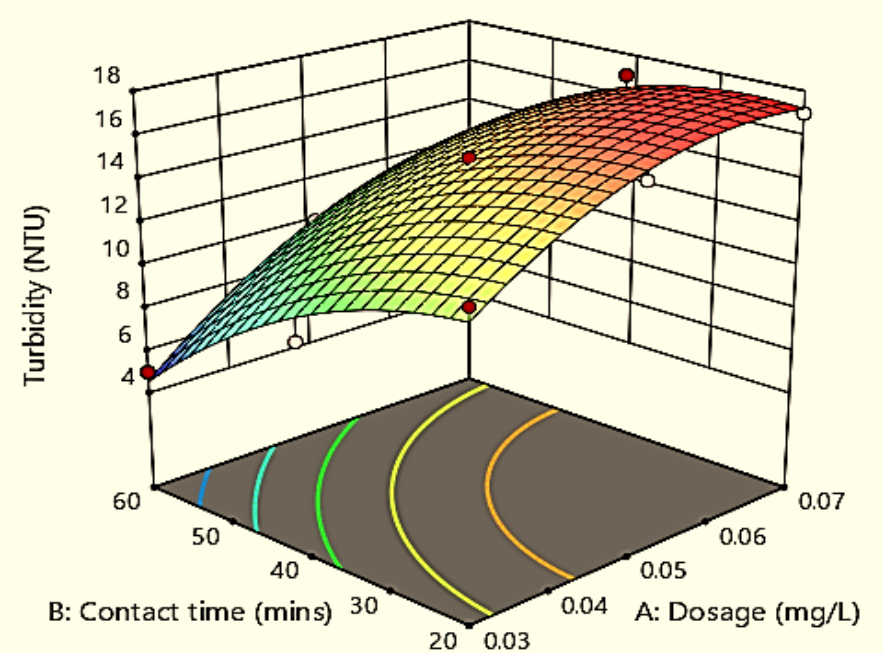


Figure 5: Response Surface Graph Showing the Effect of C.T and CD on Turbidity

4.3.2 Total dissolved solid by CCD

The result of the TDS test at 0.03 to 0.07 mg/L dosage is shown in Table 8 and the analysis of variance is presented in Table 9.

Table 8: TDS Result

Run	Factor 1 A:Dosage mg/L	Factor 2 B:Contact time mins	Response 2 TDS mg/L
1	0.05	40	13
2	0.05	40	13
3	0.03	60	10
4	0.07	60	12
5	0.05	40	13
6	0.05	20	14
7	0.07	40	15
8	0.03	20	12
9	0.05	40	13
10	0.07	20	18
11	0.05	60	10
12	0.05	40	13
13	0.03	40	12

Table 9: ANOVA for TDS

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	50.42	5	10.08	139.56	< 0.0001
A-Dosage	20.17	1	20.17	279.12	< 0.0001
B-Contact time	24.00	1	24.00	332.18	< 0.0001
AB	4.00	1	4.00	55.36	0.0001
A^2	1.52	1	1.52	21.01	0.0025
B^2	1.59	1	1.59	22.00	0.0022
Residual	0.5057	7	0.0722		
Lack of Fit	0.5057	3	0.1686		
Pure Error	0.0000	4	0.0000		
Cor Total	50.92	12			

The Model F-value of 139.56 implies the model is significant. P-values less than 0.05 indicate model terms are significant. In this case A, B, AB, A^2, B^2 are significant model terms. Values greater than 0.1 indicate the model terms are not significant. The Fit-statistics for TDS is shown in Table 10.

Table 10: Fit Statistics for TDS

Parameter	Value
Std. Dev.	0.2688
Mean	12.92
C.V. %	2.08
R^2	0.9901
Adjusted R^2	0.9830
Predicted R^2	0.9103
Adeq Precision	41.9841

The Predicted R^2 of 0.9103 is in reasonable agreement with the Adjusted R^2 of 0.9830; i.e. the difference is less than 0.2. The Adeq precision ratio of 41.984 indicates an adequate signal. The model equation for TDS is shown in Equation 2. The response surface graph on the effect of contact time and coagulant dosage on TDS of raw water is presented in Figure 6.

$$TDS = 8.95 + 6.32A + 0.177B - 2.5\,AB + 1853\,A^2 - 0.0019B^2 \quad \ldots (2)$$

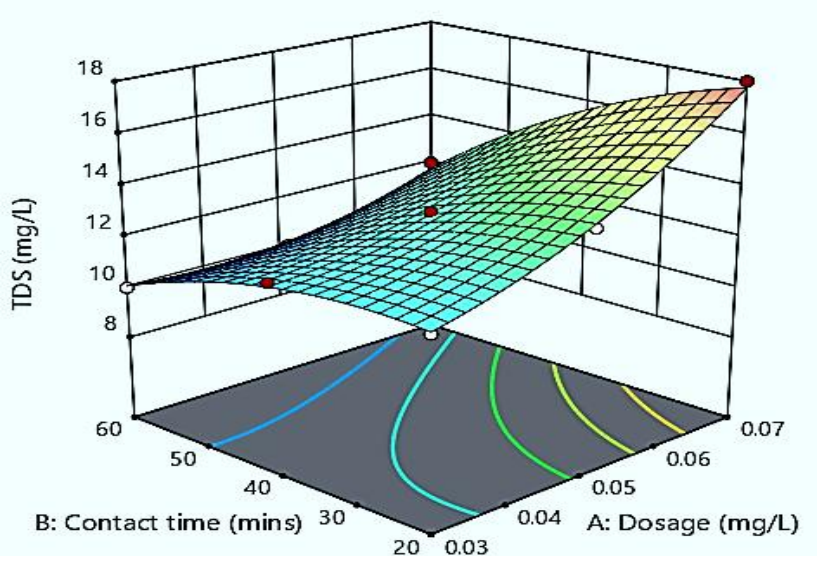


Figure 6: Response Surface Graph Showing the Effect of C.T and CD on TDS

4.3.3 Chemical oxygen demand by CCD

The result of COD test at 0.03 to 0.07 mg/L dosage is shown in Table 11 and the analysis of variance is presented in Table 12.

Table 11: COD Results

Run	Factor 1 A:Dosage mg/L	Factor 2 B:Contact time mins	Response 3 COD mg/L
1	0.05	40	20.63
2	0.05	40	20.63
3	0.03	60	14.87
4	0.07	60	23.99
5	0.05	40	20.63
6	0.05	20	20.87
7	0.07	40	24.66
8	0.03	20	21.4
9	0.05	40	20.63
10	0.07	20	25.00
11	0.05	60	20.03
12	0.05	40	20.63
13	0.03	40	18.00

Table 12: ANOVA for COD

Source	Sum of Squares	df	Mean Square	F-value	p-value
Model	81.92	3	27.31	52.13	< 0.0001
A-Dosage	62.60	1	62.60	119.51	< 0.0001
B-Contact time	11.70	1	11.70	22.34	0.0011
AB	7.62	1	7.62	14.54	0.0041
Residual	4.71	9	0.5238		
Lack of Fit	4.71	5	0.9428		
Pure Error	0.0000	4	0.0000		
Cor Total	86.63	12			

The Model F-value of 52.13 implies the model is significant. P-values less than 0.05 indicate model terms are significant. In this case A, B, AB are significant model terms. Values greater than 0.1 indicate the model terms are not significant. The Fit-statistics for COD is shown in Table 13.

Table 13: Fit Statistics for COD

Parameter	Value
Std. Dev.	0.7237
Mean	20.92
C.V. %	3.46
R^2	0.9456
Adjusted R^2	0.9274
Predicted R^2	0.7811
Adeq Precision	23.0492

The Predicted R^2 of 0.7811 is in reasonable agreement with the Adjusted R^2 of 0.9274. The difference is less than 0.2. Adeq Precision measures the signal to noise ratio. A ratio greater than 4 is desirable. The ratio of 23.049 indicates an adequate signal. The model equation for COD is shown in Equation 3. The response surface graph on the effect of contact time and coagulant dosage on COD of raw water is presented in Figure 7.

$$COD = 22.5391 + 23.5\,A - 0.2423\,B + 3.45\,AB \quad \ldots (3)$$

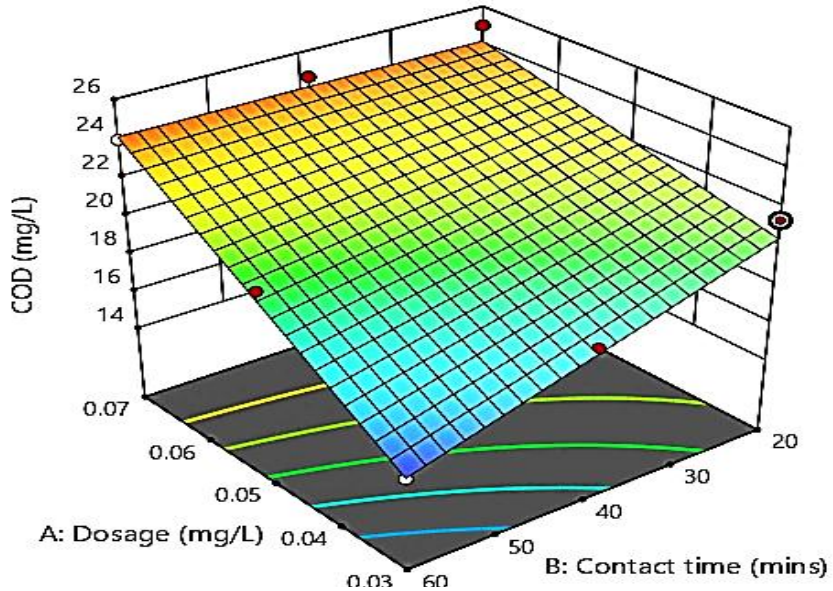


Figure 7: Effect of Contact time and Coagulant Dosage on COD

4.4 Optimization by Numerical Method

The goals set for responses in numerical optimization are presented in Table 14.

Table 14: Goals for Numerical Optimization of Pond Water

Name	Goal	Lower Limit	Upper Limit
A: Dosage	is in range	0.03	0.07
B: Contact time	is in range	20	60
Turbidity	minimize	5	17
TDS	minimize	10	18
COD	minimize	14.87	25

The automatic optimization function of Design-Expert software version 13 indicates that the optimal values of the factors and responses are presented in Figure 8.

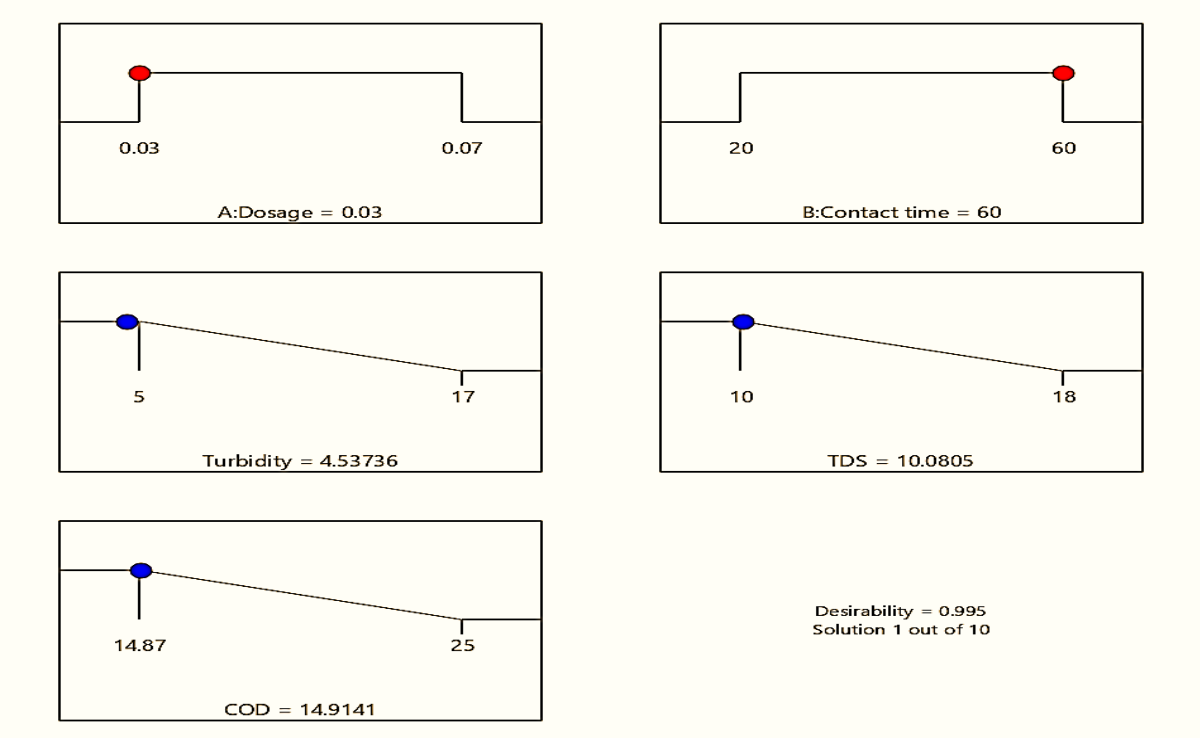


Figure 8: Ramp Plot Showing the Optimal Values for Factors and Responses

4.5 Comparison Between Control and Optimum Dosage

The results from analysis carried out on raw water and treated water using optimum dose (0.03mg/L) of *Moringa oleifera* seed powder is tabulated in Table 15.

Table 15: Comparison of Control and Optimum Dosage

S/N	Parameter	Control sample	Optimum Dosage
1	Temperature	31.7	29.8
2	pH	7.6	7.1
3	Colour (pt-co)	107	92
4	Total Dissolved Solid mg/L	13	10
5	E/Conductivity	0.00	0.00
6	Turbidity NTU	17	5
7	Sodium(Na) mg/L	2.53	2.75
8	Calcium(Ca) mg/L	8.5	1.28
9	Magnesium(Mg) mg/L	2.59	0.18
10	SAR	1.07	4.42
11	Kellys Index	0.228	1.89
12	COD mg/L	23.2	14.9

5.0 CONCLUSIONS

(i) The physico-chemical parameters of raw water and treated water with *Moringa Oleifera* seed powder shows temperature of 31.7^{O}C for control and 29.8^{O}C for optimum. TDS of 13 mg/L for control while 10 mg/L for control. COD of 23.2 mg/L for control while 14.9 was recorded at optimum replacement.

(ii) The turbidity, sodium adsorption ratio and Kelly's index obtained for raw water were 17NTU, 1.07 and 0.228 respectively while the treated water with optimum coagulant dosage of 0.03 mg/L of *Moringa Oleifera* seed powder gave 5NTU, 4.42 and 1.89 respectively.

(iii) The properties of water such as turbidity, TDS and COD were modeled and optimized using numerical optimization. The optimization result showed 0.03 mg/L of MOSP, 60 minutes' contact time, 5 NTU for Turbidity, 10 mg/L for TDS and finally 14.9 mg/L for COD.

(iv) At the end of the analysis, the optimum dosage and C.T (0.03 mg/L at 60 mins C.T) of MOSP as a natural coagulant in water purification was determined.

REFERENCES

Anthoina C.C., Duguryil, Z.P., Gambo, N.N., Lubis, S. and Kitka B.D. (2024). Physicochemical Parameters and Bacteriological Quality Assessment of Some Domestic Water Sources in Pankshin LGA of Plateau State Nigeria. *Asian journal of chemical science* 14(2), 74-82

Daramola, A.S. and Akindureni, Y. (2017). Water Quality Analysis of Akure Metropolis, Ondo State, Nigeria. *American Journal of Engineering Research (AJER).*Volume-6, Issue-3, pp-28-31

Godwin, A., Oborakpororo, O. (2019). Surface water quality assessment of warri metropolis using Water Quality Index. *International Letters of Natural Sciences*, 74, 18–25. http://dx.doi.org/10.18052/www. scipress.com/ILNS.74.18

Ikhuoriah, S.O and Onajite, I.E., (2024): Water Quality Assessment of Outdoor Public Swimming Pools in Ovia North East, Edo State, *Nigeria. Journal of Materials & Environmental Sustainability Research* (2024), 4(2): 16-27 p-ISSN: 2811-1338; e-ISSN: 2811-132X DOI: https://doi.org/10.55455/jmesr.2024.004

Kalip, A., James, Y. and Aremu, S. O (2020): Assessment of Radon (222RN) and Heavy Metals in Groundwater Sources from Kaduna and Environs, Nigeria. *International Journal of Innovative Science, Engineering & Technology*. 7: 2348 – 7968

NAFDAC (2001). National Agency for Food and Drug Administration and Control, Ministry Safety Bulletin, Volume 1. Recommendation, National Agency Food, Drugs, Administration and control. Lagos, Nigeria

Nhut, H.T.; Hung, N.T.Q.; Lap, B.Q.; Han, L.T.N.; Tri, T.Q.; Bang, N.H.K.; Hiep, N.T. and Ky, N.M. (2020) Use of *Moringa oleifera* seed powder as bio-coagulants for the surface water treatment. International Journal of Environmental Science and Technology, 1-8.

Nigerian Industrial Standard (NIS) (2015), Nigerian Standard for drinking water quality, NIS Publication, Abuja, Nigeria, 2015, pp. 20-21.

Nkurunziza, T.; Nduwayezu, J.B.; Banadda, E.N. and Nhapi, I. (2009) The effect of turbidity levels and *Moringa oleifera* concentration on the effectiveness of coagulation in water treatment. Water science and technology, 59(8):1551-1558.

Shil, S., Singh, U.K., Mehta, P. (2019). Water quality assessment of a tropical river using water quality index (WQI), multivariate statistical techniques and GIS. *Applied water science*, 9, 1–21. https://doi. org/10.1007/s13201-019-1045-2

Toko, M.A., Shaibu-Imodagbe, E.M., Okuofu, C.A. and Giwa, A. (2020). Assessment of Groundwater Quality in Port Harcourt, Nigeria using Weighted Arithmetic Water Quality Index. *Nigerian Research Journal of Engineering and Environmental Sciences* 5(2) 2020 pp. 894-900.

United Nations (2019). Progress on Sustainable Development Goal 6. http://www.undp.org

United Nations Children's Fund (UNICEF), (2023). Triple Threat How disease, climate risks, and unsafe water, sanitation and hygiene create a deadly combination for children. New York. ISBN: 978-92-806-5438-7 © United Nations Children's Fund (UNICEF), March 2023

United Nations Children's Fund, (2010). Water Quality Assessment and Monitoring. Technical Bulletin No.6. Supply Division, May 2010. danwash@unicef.org

United Nations. (2020). Sustainable Development Goals. http://www.undp.org

Vadde, K. K., Jianjun, W., Long, C., Tianma, Y., Alan, J. & Raju, S. (2018). Assessment of water quality and identification of pollution risk locations in Tiaoxi River (Taihu watershed) China. Water10. 183.

Waida J., Rilwan U., Olanyi W., Yusuff I.M and Sunday, B.I (2022). Pollution Load Index of Heavy Metals Resulting from Mining Activities in Plateau State, Nigeria. *J. Rad. Nucl. Appl*. 7 No 3. http://dx.doi.org/10.18576/jrna/07031