FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 8 No. 4, August, 2024, pp 261 - 265
DOI: https://doi.org/10.33003/fjs-2024-0804-2601

IMPROVING FISH POND WATER QUALITY THROUGH CLAY-FILTRATION AND BIOLOGICAL TREATMENT METHOD

***[1]Umudi, E. Q., [2]Umudi, O. P., [3]Asabor, B. M. and [1]Igere, O. F.**

[1]Department of Chemical Sciences, Faculty of Science, University of Delta, Agbor, PMB 2090, Delta State, Nigeria.
[2]Department of Biotechnology, Faculty of Science, Delta State University, Abraka, PMB 1, Delta State, Nigeria.
[3]Departement of Science Education (Biology Unit), Faculty of Education, University of Delta, Agbor, PMB 2090, Delta State, Nigeria.

*Corresponding authors' email: queenumudi@unidel.edu.ng

ABSTRACT

This study sought to evaluate the physical, chemical and bacterial parameters of fish pond wastewater after treatment using clay filtration and biological treatment methods. Appropriate parameters were analyzed in other to determine the quality of the wastewater before and after treatment with clay, using standard methods. The clay sample used, which was obtained from Ossiomo Edo State was also analyzed by measuring its mineralogical and geochemical composition using x-ray diffractometer and atomic absorption spectrophotometer respectively. The clay was found to be composed mainly of kaolinite and alumino-silicates. From the result obtained from the treatment of the fish pond wastewater showed significant percentage reduction in the relevant pollution parameters (electrical conductivity - 54.39% reduction, biochemical oxygen demand - 95.94% reduction, total dissolved solids - 40.25% reduction, chloride - 89.40% reduction, ammonia-nitrogen - 92.27% reduction, phosphate - 23.24% reduction, turbidity 94.11% reduction, total bacteria count - 92.57% reduction). The values obtained after treatment were lower than WHO and FEPA limit values and favoured quality production of fish and other non-potable usage, indicating that clay filtration is a cost-effective and eco-friendly method which can be employed in the treatment of fish pond wastewater.

Keywords: Fish pond, Wastewater, Clay, Treatment, Physico-chemical

INTRODUCTION

Water quality is important to fish, since it is its home. The water quality is biological, chemical and physical which determines its usage in fish cultivation. It is needed for growth of aquatic organisms generally which depends on the physico-chemical parameters of body water (Akpotayire *et al*., 2018). Pollution from the environment has reduced the level of oxygen and added nutrient, which have led to a destabilized ecosystem. When water with nutrients, high suspended solid, agricultural materials, chemicals it may become acidic, or basic and described as poor quality of water, this result in fish being exposed to diseases. Fish is of vital importance in supplying protein to human population which is preferable to meet consumption (Orobator *et al*., 2020).

Improving the quality of fish pond water is of vital importance for a healthy aquatic environment for fishes. The use of clay particles in removing toxins from water to improve its purity and possible clarity involving microorganisms in breaking down organic molecules (matter), as it percolates through it thereby enhancing a balanced ecosystem in the pond (Egbeki *et al*., 2024) combining this method can reduce pollutants, control algae growth and create optimal conditions for fish growth and health, minimize the need for chemicals for eco-friendly solution and suitable pond management. Improving fish pond water quality is also very crucial for maintaining a healthy aquatic environment. Clay filtration makes use of natural clay as bentonites, kaolin, in removing impurities and particles from water because of its absorptive nature, can trap pollutants as excess nutrients, suspended solids improving the clarity and quality of water. While biological uses micro-organisms to degrade organic matter and nutrient in water.

Recycling of wastewater is necessary since fresh water demand exceeds the quantity requirement of human usage (Salahuddin, 2023). It is the major need of man for his daily activities and survival but fresh water supply has been a long time problem and only few has access to it resulting in water related diseases and general increase in death rate (Uwidia, 2020) due to mismanagement over use of resources of water, growth in population and change in climate, we are left with no option but to re-treat. Fish pond wastewater is spent water from the fish pond without contaminants from human excrement with variation from different ponds depends on the activities. It contains organic components, chemicals from medications, nutrient, bacteria, viruses, and parasites which can degrade, it is better to recycle, treat so as to reuse the water. Since such water can harm aquatic ecosystem and biodiversity, contaminate drinking water and even affect human health. Recycling wastewater helps in water conservation in limited supply of clean water. Several agricultural products have been previously used in treating wastewater including sugarcane bagasse, orange peel and onion peel (Aliyu *et al*., 2022)

This study is aimed to analyze fish pond wastewater for pollution characteristics and treating it with clay material as described by (Umudi and Awatefe, 2018) to reduce pollutants so that water can be reused for other purposes but not for drinking and become environmentally friendly. The study shows that clay filtered pond wastewater can be used for non-potable usage.

MATERIALS AND METHODS

Collection and Sample Description

The fish pond effluent (wastewater) was collected from Code Farms, located at Ekakpamre in Ughelli South Local Government Area in Delta State, Nigeria. The wastewater was mainly from fish pond channel. Collection of samples was done at two hours interval in well-labeled 5 litres jerricans starting at 7:00am ending at 4:00pm, sample were thoroughly homogenized to get a composite with determination of pH on site. Sample were stored in ice-cooled boxes and taken to the laboratory for other analysis. Small stones were collected from the bank of Udu bridge river from dredgers in Delta State, Nigeria.

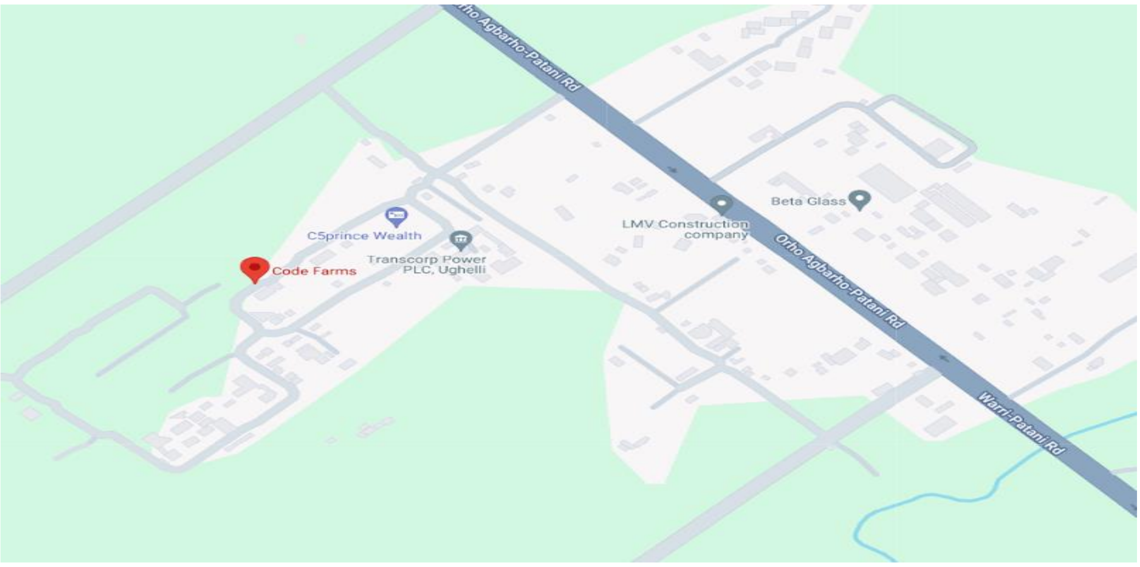

Figure 1: Map showing Code Farms

Preparation of Sample

Clay was collected with a plastic shovel, dried, pulverized with mortar and pestle and sieved with a 2 µm sieve. About 2.0 g clay was mixed with sodium-based coagulant and smeared into the x-ray diffractometer. Samples were tested and showed prominent peaks, which were cross-matched and mineral constituents came out using XSPEX version 5.61.

Vats of plastics with length 130 cm and 65 cm diameter, graduated in cm apart was made. Glass wool was well packed to 5 cm depth at the base and mixed quantities of clay/stones were carefully packed to 70 cm mark. This was used as the column for percolation.

Physico-chemical Analysis

Physicochemical analysis was carried out as described by Ehiagbonare and Ogunrinde (2010); and Keremah *et al*. (2014). The determination of pH, electrical conductivity, turbidity and total dissolved solids was done by electrometric method using batch aquaculture kits for analyzing water samples HACH DR FF+5 aquatic test calibration and after stabilization (APHA, 1998) after calibration with cell diffed into the solution. Total hardness was measured by titration colourmetrically with EDTA solution using HA-7IA model, dissolved oxygen and biochemical oxygen demand by Azide modification of Winklers method, electrical conductivity with conductivity meter EQ-660 model. Total alkalinity by titration method, chloride with chloridometer model 3500 Elitech was used, nitrates by phenol disulphonic acid method, phosphate was done with ethylenediaminetetraacetic acid titration method using standard methods (APHA, 1998). Clay was collected from Ossiomo in Edo state and characterized by measuring their geochemical and mineralogical analysis using Atomic Absorption Spectrophotometer (AAS-spetral10 model) and X-ray Diffractometer (Phillips 180WR model) respectively.

Biological Treatment

Biological treatment with little modifications as described by (Uwidia, 2020). Two 50 litres were filled with pond wastewater. 50 ml of phosphate solution was added, 10 ml each of calcium chloride, iron chloride and magnesium sulphate were added for adequate nutrient to the bacteria population (Uwidia, 2020). Aeration was carried out at 4 hours daily intervals and pH-monitored. The resulting wastewater was filtered through the clay packed in plastic vats forming column of clay and small stone of various sizes for easy percolation, these were previously washed to remove impurities. The filtrates were finally analyzed for microbiological and physiochemical characteristics.

RESULTS AND DISCUSSION

The percentage mineralogical composition of the clay sample is presented in Table 1.

Table 1: Results of percentage mineralogical composition of the clay

Clay Mineral	Mineral Composition (%)
Kaolinite	48.00
Smectite	18.01
Montmorillonites/illite	10.30
Illite	13.00
Dolomite	1.00
Hematite	1.50
Saponite	2.00
Quartz	6.19

The result in above showed the mineral composition to be composed mainly of kaolinite (48.00%). Other minerals present in the clay include smectite (18.01%), montmorillonites/illite (10.30%) and illite (13.00%). The percentage composition of quartz was 6.19%, while minerals such as saponite (2.00%), hematite (1.50%) and dolomite (1.00%) were found in minute quantities.

The result obtained from the geochemical analysis of the clay (in percentage) is presented in Table 2.

Table 2: Geochemical analysis of percentage oxides in clay

Oxide of Metal	Geochemical Composition (%)
SiO_2	48.04
Al_2O_3	26.11
Fe_2O_3	3.00
MgO	1.00
CaO	5.00
Na_2O	1.23
K_2O	1.70
T_1O_2	1.76
P_2O_5	0.06
MnO	0.10
H_2O	12.00

A significant impurity present was Fe_2O_3 (3%) which is traceable to its mineralogical composition, Others impurities present are Na_2O (1.23%) and K_2O (1.70%). The presence of MgO and CaO was also low (1.00% and 5.00%) due to the presence of dolomite which is salt of Mg and Ca.

Results of the analysis for raw and treated pond wastewater is shown in Table 3.

Table 3: Summary of results obtained from raw and treated sample fish pond wastewater of with clay, with WHO and FEPA limits

Parameters	Raw fish pond water	Treated fish pond water	WHO	FEPA	Desired range
Temperature (℃)	29.30±0.002	27.00±0.000	<35	27.0	20-30
pH	8.00±0.004	8.9±0.000	6.5-8.5	6-9	6.5-9.0
Electrical Conductivity (μs/cm)	239.00±7.11	109.01±3.00	-	200	20-500
Total Dissolved solid (mg/L)	400.00	239.00	-	500	500
Dissolved oxygen (mg/L)	2.11±0.02	8.70±0.43	8-10	8-10	5.00
Biochemical oxygen demand (mg/L)	73.41±2.63	2.98±0.53	10	10	0.29
Total alkalinity (mg/L)	73.41±2.63	98.32±4.53	1.0	-	50-400
Total hardness (mg/L)	39.83±1.63	52.18±0.01	200	-	50-400
Chloride (mg/L)	4.81±0.12	0.51±0.001	-	-	-
Ammonia nitrogen (mg/L)	5.43±0.02	0.42±0.000	-	-	0.75
Phosphate (mg/L)	3.40±0.001	2.61±0.001	0.033-2.00	-	
Turbidity (NTU)	340.00±2.80	20.41±2.80	5.00	1.00	-
Total bacteria count (cfu)	323×10^{-5}	24×10^{-5}	-	-	-

cfu = colony forming unit

The result obtained from the analysis of the physico-chemical parameters as presented in Table 2, reveal that the pH of the fish pond wastewater was 8.0, indicating slight alkalinity. This is in contrast with the works of Keremah *et al.*, (2014) and Ehiagbonare and Ogunrinde (2010), in which fish pond wastewater from Bayelsa and Okada were slightly acidic to neutral (6.412 and 6.75-7.10 respectively). The temperature recorded (29.30℃) was somewhat similar to that recorded by Keremah *et al*. (2014) (25.8℃), while the dissolved oxygen level (2.11 mg/L) was lower than those observed by Keremah *et al.*, (2014) (4.96 mg/L) and Ehiagbonare and Ogunrinde (2010) (9.3-16.2 mg/L). The turbidity (340 NTU), total dissolved solids (400 mg/L), and electrical conductivity (239 μs/cm) recorded in this study were higher than the values recorded by Keremah *et al*. (2014) (37.14 NTU, 74.70 mg/L and 118.22 μs/cm respectively). Total alkalinity (73.41 mg/L) and total dissolved solids (400 mg/L) obtained in this study fell within the range of that observed by Ehiagbonare and Ogunrinde (2010), who recorded 35-135 mg/L and 22-906 mg/L respectively.

The percentage reduction of parameters analyzed in samples of raw and treated fish pond wastewater is shown in Table 4.

Table 4: Changes in composition of raw and treated samples of fish pond wastewater with clay

Parameters	Raw Fish Pond Water	Treated Fish Pond Water	% Reduction After Treatment
Electrical Conductivity (μs/cm)	239.00±7.11	109.01±3.00	54.39
Total Dissolved Solids (mg/L)	400	239	40.25
Biochemical Oxygen Demand (mg/L)	73.41±2.63	2.98±0.53	95.94
Chloride (mg/L)	4.81±0.12	0.51±0.001	89.40
Ammonia nitrogen (mg/L)	5.43±0.02	0.42±0.000	92.27
Phosphate (mg/L)	3.40±0.001	2.61±0.001	23.24
Turbidity (NTU)	340.00±2.80	20.41±2.80	94.00
Total Bacteria Count (cfu)	323×10^{-5}	24×10^{-5}	92.57

cfu = colony forming unit

The physicochemical parameters are crucial for optimal fish production. Temperature dictates aquatic growth in vegetation and fish reproduction. A body of water holds smaller amount of oxygen when there is increase in temperature caused by increase in respiration. The temperature is caused by increased fish production (WHO, 2022).

pH is a vital component in the survival of fish and aquatic species. The pH was 8.90 which is good for fisheries (Airsang and Laskshman, 2013) and microbes. For fish. The pH is slightly alkaline, pH<6.5 limits the growth of fish and <5 ceases reproduction and death of fry. The value for electrical conductivity for pre-treated and post-treated wastewater was 239 µs/cm and 109 µs/cm respectively, with a 54% reduction. It shows the dissolved solid contain in the fish pond. Electrical conductivity between 20-1500 µs/cm is good for hydrophonic (Salahuddin, 2023). These values are within acceptable standard limits of WHO (2022) for water quality of fish culture.

Dissolved oxygen was 2.11 for raw and 8.9 in treated samples. Dissolved oxygen of more than 5 mg/L is regarded as good for fish culture. There was increase in DO after treatment as oxygen is needed for growth of fish. COD is a measure of total dissolved oxygen consumed by microorganism for breaking down organic materials. BOD levels >5 mg/L indicate serious pollution, 2 mg/L is clean, 3 mg/L fairly clean, 5 mg/L doubtful and 10 mg/L polluted (Bhatnagar and Devi, 2013). The chemical state of nitrogen compound facilitates its removal from water (Kububa *et al.*, 2022). The performance of clay in removal of these pollutants is traceable to their mineralogical composition, their high surface area for absorption. They are removed either as anionic, cationic or neutral pollutants according to these equations:

$R\text{-}NH_4 + H_2O + \text{clay OH} \longrightarrow RNH_3.Clay.H_2O$ (1)
Cation Organic

$H_2O.C + M^+.Clay \longrightarrow M^+.Clay.C + H_2O$ (2)
Anionic
Inorganic
Substance

$H_2O.RNH_2 + [Clay\ H]^+ \longrightarrow [RNH_2^+ - Clay]\ H_2O$ (3)
Neutral organic

The clay filtration and biological treatment was a low-cost value, locally sourced material, abundant environmentally friendly and easily to operate system.

CONCLUSION

The combination of clay filtration and biological treatment method is a promising approach to improving fish pond water quality for re-use. This is as a result of the properties of clay which reduced pollution biomarkers to acceptable standards. The pollution parameters of the end-product obtained from the treatment of the fish pond wastewater being within regulatory standard is an evidence that the combination of clay filtration and biological treatment method is an effective treatment process which can generate water of desired quality which can be re-utilized for various purposes.

REFERENCES

Airsang, R.V. and Lakshman, H.C. (2013). Diversity of Chlorophyceae related to physico-chemical parameters in Shetter lake of Navalgund, Dharwad District in Karnataka-India. *Science Research Reporter*, **3**(2): 129-134.

Akpotayire, S.I., Miikue-Yobe, T.F.B., Kalagbor, I.A., Okpabi, D.A., Nwoha, N. and Needom, I. (2018). Assessment of the physicochemical characteristics of artificial fish pond water in Ogoni: A case study of Ka-Gwara community. *Academia Journal of Scientific Research*, **6**(6): 216-221. https://doi.org/10.15413/ajsr.2018.0112

Aliyu, A.O., Musa, F.K., Faruruwa, M.D. and Okunola, O.J. (2022). Evaluation of the potential of onion peel composite as an adsorbent for the removal of cations in fish pond wastewater. *FUDMA Journal of Sciences*, **6**(4): 266-273.

APHA (1998). Standard for the Examination of Water and Wastewater. APHA. AWWA. WPCF. Washington DC. 1998.

Bhatnagar, A., and Devi, P. (2013). Water quality guidelines for the management of pond fish culture. *International Journal on Environmental Sciences, 3(6)*: 1980-2009. https://doi.org/10.6088/ijes.2013030600019

Egbeki, O.C., Odion, N.S. and Obomese, F. (2023). Characterization and preparation of light weight porous clay ceramic filter pellets for fish wastewater management. *Journal of Engineering for Development*, **15**(1): 96-110.

Ehiagbonare J.E. and Ogunrinde, Y.O. (2010). Physico–chemical analysis of fish pond waters in Okada and its environs, Nigeria. *African Journal of Biotechnology*, **9**(36): 5922-5928.

FEPA (1991). Guidelines and Standard for Environmental Pollution Control. Federal Environmental Protection Agency (FEPA), 27 pp. 20.

Keremah, R.I., Davies, O.A. and Abezi, I.D. (2014). Physico-chemical analysis of fish pond water in freshwater areas Bayelsa State, Nigeria. *Greener Journal of Biological Sciences*, **4**(2): 033-036 https://doi.org/10.15580/GJBS.2014.2.042313583.

Kububa, J., Lephallo, J. and Rutto, H. (2022). Comparison of various technologies used to eliminate nitrogen from wastewater: a review. *Journal of Water Process Engineering*, **48**:102885. https://doi.org/1016/j.jwpe.2022.102885.

Orobator, P.O., Akiri-Obaroakpo, T.M. and Orowa, R. (2020). Water quality evaluation from selected aquaculture ponds in Benin City, Nigeria. *Journal of Research in Forestry, Wildlife and Environment*, **12**(1): 24-33.

Salahuddin, S. (2023). Analysis of fish productivity in Mohabala Lake, Bhadravati, Maharashtra, India. *Oriental*

Journal of Chemistry **39**(4): 1076-1081. http://dx.doi.org/10.13005/ojc/390436.

Umudi, E.Q. and Awatefe K.J. (2018). Leachate treatment using clay/stone filters. *Journal of Chemical Society of Nigeria*, **43**(1): 178-183.

Uwidia, I. (2020). Treatment of kitchen wastewater using aerobic biological method and sand-bed filtration. *International Journal of Chemistry*, **12**(2): 12-18. https://doi.org/10.5539/ijc.v12n2p12.

WHO (2022). World Health Organisation Standard for drinking water (3rd Edition), World Health Organization (WHO). p. 148.