COMPARING THE PERFORMANCE OF PHYSICAL, CHEMICAL AND BIOLOGICAL TREATMENT IN WASTE WATER REMEDIATION

ABSTRACT

The day-to-day activities of man is mainly water dependent and therefore discharge 'waste' into water. Some of the substances include body wastes (faeces and urine), hair shampoo, hair, food scraps, fat, laundry powder, fabric conditioners, toilet paper, chemicals, detergent, household cleaners, dirt, micro-organisms (germs) which can make people ill and damage the environment. It is known that much of water supplied ends up as wastewater which makes its treatment very important. Wastewater remediation involves treating contaminated water to remove pollutants before it will be reused. This process typically includes physical, chemical and biological methods. Physical method involves filtration, sedimentation and adsorption to separate solids from water. Chemical method uses coagulants, flocculants and disinfectants to neutralise contaminants. Biological method employs microorganisms to break down organic matter through processes like activated sludge or bio-filtration. This study is aimed at comparing the performance of physical, chemical and biological treatment in wastewater remediation using standard sampling methods of APHA (1999). Gray wastewater samples were collected from wastewater collection generated from the student's hostel at Chukwemeka Odumegwu Ojukwu University Uli, Anambra State. 100 ml of Stock Solutions was made using Moringa oleifera seed powder. The stock solution was screened for its potential to purify water. The wastewater sample was divided into two parts of 1 liter each. The stock solution was added to a 1-liter sample of gray wastewater, shaken for five minutes and allowed to stand for some hours to allow the coagulated particles to settle to the bottom which were later eliminated through the process of filtration using filter paper. The other 1-liter part was left to serve as control and for photocatalysis set up under low pressure high irradiation for 30 minutes. The supernatant was then subjected to physicochemical analysis. The physicochemical analysis carried out in the cause of this study includes; determination of temperature, pH and conductivity, determination of phosphate, determination of chloride, determination of dissolved oxygen, determination of chemical oxygen demand, determination of total dissolved solid, determination of total hardness of the water and colour determination. A thorough review of the purification processes been used in this study alongside literature, indicated that none of the treatment options can be used alone safely to treat wastewater to make them save for home use. It is therefore recommended that a combination of the performance of physical, chemical and biological treatment in wastewater remediation is needed to achieve a greater and better result.

KEYWORDS: Moringa Oleifera, Gray wastewater, Chemical oxygen demand (COD), Biological oxygen demand (BOD)

INTRODUCTION

Only 2.5% of the water on Earth is freshwater, 70% of this exists in solid form and 30% in liquid form, with less than 1% being usable for human consumption (Valverde et al., 2005). Water is an essential resource for life that is being threatened by pollution. Industrial, domestic, agricultural, commercial, or service related processes generate wastewater ladened with pollutants, including chemical substances and fecal matter. If left untreated, wastewater can affect environmental and human health (Manahan, 2007).

Wastewater treatment [4] involves physical, chemical and biological procedures, in order to remove pollutants and hazardous characteristics before final release into a body of water, without harming the environment or human health (Aguilar et al., 2002). Initial pretreatment (e.g., grease traps, sand traps, and roughing) consists of a physical process to remove large solids (López and Martin, 2015). The next step is primary treatment, which requires physical and chemical processes, such as decanting, clarification, and neutralization. In this stage of the treatment, the purpose of eliminating solids suspended in residual water (López and Martin, 2015, Manahan, 2007).

[5] Coagulation is a process in which colloidal particles are destabilized through addition of chemicals and agitation, which clarifies wastewater and reduces turbidity, color, and even the concentration of some pathogenic microorganisms. Factors such as pH, turbidity, agitation speed and time, coagulant dose, and the size of colloidal particles directly influence the size of the clot (Fúquene and Yate, 2018).

Secondary or biological wastewater treatment uses the metabolism of microorganisms to reduce pollutant load (Wiesmann et al., 2007). [1] Populations of bacteria, fungi, or other microorganisms in the wastewater use, in an isolated or synergistic manner, the pollutants present as a source of energy, carbon or electrons in their anabolic or catabolic routes (Fritsche and Hofrichter, 2008). However, these populations will also require adequate physical and chemical conditions for their metabolism and the genetic and enzymatic machinery to use these pollutants (Nielsen et al., 2014)

Finally, the tertiary treatment improves wastewater quality. [2] Depending on its use, different processes can be conducted, such as bleach disinfecting, nutrient reduction, or chemical precipitation (López and Marín, 2017). Wastewater remediation involves treating contaminated water to remove pollutants before it will be reused. This process typically includes physical, chemical and biological methods (Finley et al., 2019). Physical method involves filtration, sedimentation and adsorption to separate solids from water. Chemical method uses coagulants, flocculants and disinfectants to neutralise contaminants. Biological method employs microorganisms to break down organic matter through processes like activated sludge or bio-filtration. Advanced techniques like membrane filtration, reverse osmosis and UV disinfection are also utilised for more thorough treatment. Overall, wastewater remediation aims to protect ecosystem and public health same promoting water reuse and sustainability (Finley et al., 2019).

Wastewater is water whose physical, chemical or biological properties have been changed as a result of the introduction of certain substances which render it unsafe for some purposes such as drinking. The day-to-day activities of man is mainly water dependent and therefore discharge 'waste' into water. Some of the substances include body wastes (faeces and urine), hair shampoo, hair, food scraps, fat, laundry powder, fabric conditioners, toilet paper, chemicals, detergent, household cleaners, dirt, micro-organisms (germs) which can make people ill and damage the environment.

It is known that much of water supplied ends up as wastewater which makes its treatment very important. [4] Wastewater treatment is the process and technology that is used to remove most of the contaminants that are found in wastewater to ensure a sound environment and good public health. Wastewater Management therefore means handling wastewater to protect the environment to ensure public health, economic, social and political soundness (Metcalf and Eddy, 2021). Some objectives of wastewater management includes; Organic substances such as carbon, nitrogen, phosphorus, sulphur in organic matter needs to be broken down by oxidation into gases which is either released or remains in solution.

Nutrients such as nitrogen and phosphorous from wastewater in the environment enrich water bodies or render it eutrophic leading to the growth of algae and other aquatic plants. These plants deplete oxygen in water bodies and this hampers aquatic life.

Organisms that cause disease in plants, animals and humans are called pathogens. [3] They are also known as micro-organisms because they are very small to be seen with the naked eye. Examples of micro-organisms include bacteria (e.g. vibro cholerae), viruses (e.g. enterovirus, hepatits A and E virus), fungi (e.g. candida albicans), protozoa (e.g entamoeba hystolitica, giardia lamblia) and helminthes (e.g. schistosoma mansoni, asaris lumbricoides). These micro-organisms are excreted in large quantities in faeces of infected animals and humans (Awuah and Amankwaa-Kuffuor, 2002).

Water is a scarce and finite resource which is often taken for granted. In the last half of the 20th century, population has increased resulting in pressure on the already scarce water resources. Urbanization has also changed the agrarian nature of many areas. Population increase means more food has to be cultivated for the growing population and agriculture as we know is by far the largest user of available water which means that economic growth is placing new demands on available water supplies. The temporal and spatial distribution of water is also a major challenge with groundwater resources being overdrawn (National Academy, 2005). It is for these reasons that recycling and reuse is crucial for sustainability.

2. MATERIALS AND METHOD

2.1. Sample Collection

The gray wastewater samples were collected were collected from wastewater collection site, generated from the student's hostel at Chukwemeka Odumegwu Ojukwu University Uli, Anambra State. Standard sampling methods of APHA (2005) were adopted in the collection of the water samples. Water samples for physicochemical analyses were collected using transparent sterile containers of 10.0 L capacity. The plastic containers were thoroughly washed with 5 % nitric acid (HNO3) and rinsed with tap water (WHO, 2011). They were later rinsed thoroughly with deionized water and allowed to dry before use.

2.2 Preparation of Stock Solution

The powdered form of Moringa seed were sieved to remove the large particles. Then, 5 g of each powder was mixed with 100 ml distilled water to form 100 ml suspension. The suspension was then mixed thoroughly using a clean magnetic stirrer for 5 min to extract the active component, followed by filtration of the solution through a filter paper to remove solid materials. The obtained stock solutions preserved in a refrigerator at 3℃

2.3 Screening of Moringa Seed Powder Potential to Purify Water

In each treatment case, 100 ml of the stock solution were added into two 1L beaker containers each containing 900 mL of grey wastewater sample, made up to 1 liter, was shaken for five minutes and allowed to stand for some hours to allow the coagulated particles to settle to the bottom. The other two 1L beaker containers each containing 900 mL of grey wastewater sample serve as control and for photocatalysis set up under low pressure high irradiation for 30 minutes. After the incubation periods, the supernatant was poured through a filter paper to ensure that any suspended coagulant is trapped (Odeyemi et al., 2018). The supernatant was then subjected to physicochemical analysis.

2.4 Physiochemical Analysis

2.4.1 Determination of Temperature, pH and conductivity

The pH and temperature of the prepared samples was determined using Pocket – sized pH meter (HANNA instruments) while the conductivity of the liquid samples was determined using conductivity meter (DSS – 11A, China). The samples will be filtered and dispensed in beakers and triplicate readings were taken after calibrations of the instrument with buffer 7.0 and 1408 µS potassium chloride standards as instructed by the manufacturer (APHA, 2005).

2.4.2 Determination of Phosphate

The amount of phosphate was determined using molybdenum blue phosphorous method in conjunction with UV - Visible spectrophotometer according to APHA (2005) and as described by Aboulhassan et al. (2016). In order to prepare a calibration curve for the standard, 2 mL of the standard solution concentrations of 0.5, 1.0, 1.5, 2.0, 2.5, 3.0 and 3.5 ppm, respectively, 1 mL of ammonium molybdate and 0.4 mL of hydrazine sulphate were added and was made up to the mark with double distilled water in a 10 mL standard volumetric flask. The same procedure above was repeated but with 4 mL of the samples. These were kept for 30 min in a water bath for heating at 60 °C. On heating, a blue colour was observed due to the formation of phosphomolybdate complex and was cooled. The absorbance was measured using UV- Visible Spectrophotometer at 860 nm. Distilled water was used as experimental blank solution. The analysis was carried out in triplicate.

2.4.3 Determination of Chloride

Chloride was obtained using Argentometric titration method and as described by APHA (2005) and Aboulhassan et al. (2016). [18] Potassium chromate indicator solution will be prepared by dissolving 50 g K_2CrO_4 in a distilled water and $AgNO_3$ solution was added until a definite red precipitate was formed. This solution was allowed to stand for 12 h, filtered and diluted to 1 L with distilled water. Then, 2.395 g $AgNO_3$ was dissolved in distilled water and diluted to 1000 mL and stored in a brown bottle. This is the standard silver nitrate solution. Thereafter, 50 mL of the effluent sample was measured into 250 mL conical flask followed by addition of 1 mL K_2CrO_4 solution (indicator) and will be titrated with $AgNO_3$ (titrant) to a pinkish yellow end point. The process was repeated for blank using 50 mL of distilled water.

Calculation:

Where:

A = ml titration for sample,

B = ml titration for blank,

N = normality of $AgNO_3$

2.4.4 Determination of Dissolve Oxygen

The amount of dissolved oxygen demand was determined using Winkler's method according to the description of APHA (2005). [17] The samples were collected in a BOD bottle using D.O sampler. Then, 1 mL of $MnSO_4$ followed by 1 mL of alkali-iodide-azide reagent was added to a sample collected in 250 to 300 mL bottle up to the brim and mixed well by inverting the bottle 2 - 3 times and allowing the precipitate to settle down and leaving 150 mL clear supernatant. The precipitate is white if the sample is devoid of oxygen, and becomes increasingly brown with rising oxygen content. At this stage, 1 mL of concentrated H_2SO_4 was added and the stopper replaced and mixed well till the precipitate goes into solution. Thereafter, 201 mL of this solution was taken in a conical flask and titrated against standard $Na_2S_2O_3$ solution. Then, 2 drops of starch indicator were added and continued to titrate till the colour of the solution becomes either colourless or changes to its original sample color and the volume of 0.025N sodium thiosulfate consumed was noted down. As 1 mL of sodium thiosulfate of 0.025N equals to 1 mg/L dissolved oxygen. Therefore, dissolved oxygen (D.O.) (in mg/L) = mL of sodium thiosulfate (0.025N) consumed.

2.4.5 Determination of Chemical Oxygen Demand

The amount of chemical oxygen demand was determined according to APHA (2005). [6] The culture tubes and caps were washed with 20 % H_2SO_4 before using to prevent contamination. Then, 2.5 mL of the sample and 1.5 mL of $K_2Cr_2O_7$ digestion solution were placed in culture tube. Three point five (3.5 mL) of sulphuric acid reagent was carefully ran down inside of vessel so an acid layer is formed under the sample - digestion solution layer and tightly cap tubes or seal ampules and invert each several times to mix completely. The tubes were placed in water bath preheated to 100 °C and refluxed for 3 hr. The culture vessels were cooled to room temperature and vessels placed in test tube rack. One to two drops of Ferroin indicator were added and stir rapidly on magnetic stirrer while titrating with standardized 0.10 M ferrous ammonium sulphate (FAS). A sharp colour change from blue - green to reddish brown will appear as end - point, although the blue green may reappear within minutes. In the same manner, a blank containing the reagents and a volume of distilled water equal to that of the sample was refluxed and titrated. The COD is given by:

$$\text{COD (mg } O_2\text{ /L)} = [(A - B) \times M \times 8{,}000) / (V \text{ sample})$$

Where:

A = volume of FAS used for blank (mL);

B = volume of FAS used for sample (mL);

M = molarity of FAS;

8,000 = milli equivalent weight of oxygen (8) ×1,000 mL/L.

2.4.6 Total Dissolved Solid

The total dissolved solids content of the effluent sample was measured using the Gravimetric method and as described by APHA (2005). In this study, the weight of the dried filter paper was noted. The sample was homogenized and 50 mL measured using the sterile measuring cylinder, after which the sample will be filtered using dried filter paper. After the filtration, the filter paper with the residue was dried in the oven, cooled and the weight taken.

Calculation:

Total dissolved solid (mg/L) =

Where:

W1 represents weight of filter paper before use and

W2 represents weight of filter paper after use.

2.4.7 Total Hardness

By adopting the method of APHA (2005), 50 mL aliquot of water sample maximum was measured and placed in a 250 mL conical flask. Thereafter, 1 to 2 mL buffer solution was added to the sample solution so as to achieve pH of 10.0 to 10.1. Then, 2 mL Eriochrome black T indicator solution.The resultant was later titrated against standard EDTA solution stirring rapidly in the beginning and slowly towards the end till end point is reached when all the traces of red and purple color disappear and solution is clear sky blue in color.

Total hardness (as mg/L of $CaCO_3$ scale) =

2.4.8 Colour Determination

According to the method of Sanders, et al. (2012), the sample was centrifuged at 1,000 rpm for 30 min to remove all the suspended matter. The pH was adjusted to 7.6 with 2 M NaOH and then used for the measurement of absorbance at 465 mm. The absorbance values were transformed into colour unit (CU) using the following relationship:

Where:

A1 = Absorbance of 500 cu platinum cobalt standard solution and

A2 = Absorbance of the effluent sample.

3. RESULTS AND DISCUSSION

Table 1: pH Profile of the Grey Wastewater Treatment Setups

Gray Wastewater Samples	pH Profile
Gray Wastewater	7.45
Gray Wastewater + photocatalyst + Moringa Extract	6.94
Gray Wastewater + photocatalyst	7.08
Gray Wastewater + Moringa Extract	6.78

Results from table 1, showed the pH profile of the grey wastewater treatment set ups. From the result, raw waste water had the highest pH value of 7.45 while the grey wastewater plus moringa extract had the least pH value of 6.78, respectively.

The best temperature range for water to be absorbed and rehydrate effectively is between 10-22 degrees Celsius (50 - 72 degrees Fahrenheit). While people have different preferences for water temperature, room temperature or slightly cool water is considered ideal for consumption (FAO, 2006).

Table 1 shows pH variation of Gray wastewater when treated with Moringa extract in the presence and absent of photocatalyst

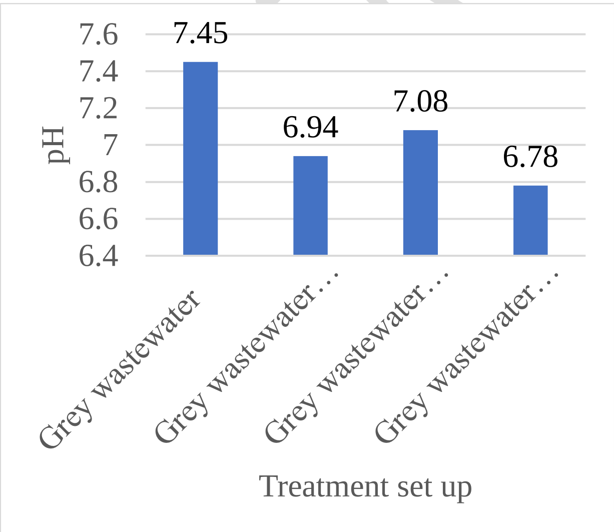

Figure 1 showed the pH profile of the grey wastewater treatment set ups. From the result, raw waste water had the highest pH value of 7.45 while the grey wastewater plus moringa extract had the least pH value of 6.78, respectively.

Table 2: Temperature Profile of the Grey Wastewater Treatment setups

Gray Wastewater Samples	pH Profile
Gray Wastewater	26.9
Gray Wastewater + photocatalyst + Moringa Extract	27.9
Gray Wastewater + photocatalyst	27.3
Gray Wastewater + Moringa Extract	25.3

Results from table 2, showed the temperature profile of the grey wastewater treatment set ups. From the result, the grey wastewater plus photocatalyst plus moringa extract had the highest temperature value of 27.90C while the grey wastewater plus moringa extract had the least temperature value of 25.30C, respectively. The conductivity of water is a measure of the capability of water to pass electrical flow. This ability directly depends on the concentration of conductive ions in the water. The conductivity of drinking water is 200 to 800 µS/cm (FAO, 2006).

Table 2 shows temperature variation of Gray wastewater when treated with Moringa extract in the presence and absent of photocatalyst.

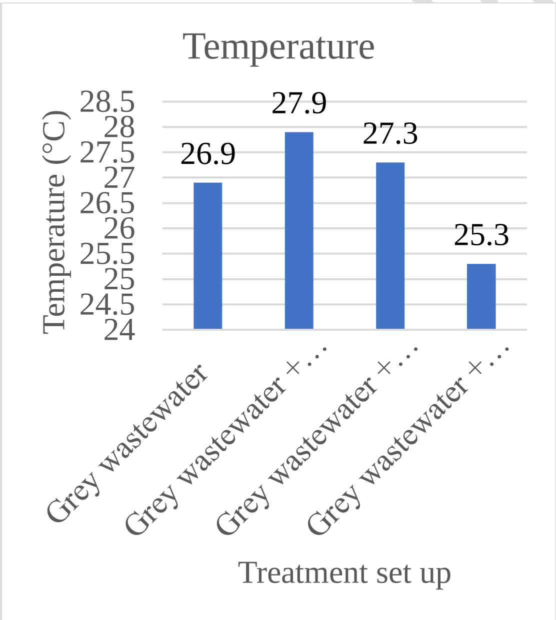

Figure 2 showed the temperature profile of the grey wastewater treatment set ups. From the result, the grey wastewater plus photocatalyst plus moringa extract had the highest temperature value of 27.9 while the grey wastewater plus moringa extract had the least temperature value of 25.3, respectively.

Table 3: Temperature Conductivity Variation of the Grey Wastewater Treatment setups

Gray Wastewater Samples	pH Profile
Gray Wastewater	133
Gray Wastewater + photocatalyst + Moringa Extract	418
Gray Wastewater + photocatalyst	380
Gray Wastewater + Moringa Extract	395

Results from table 3 showed the conductivity profile of the grey wastewater treatment set ups. From the results, the grey wastewater plus photocatalyst plus moringa extract had the highest conductivity value of 418 µS/cm while the grey wastewater had the least conductivity value of 133 µS/cm, respectively.

Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates. The WHO (World Health Organization), establishes that the turbidity of drinking water shouldn't be more than 5 NTU, and should ideally be below 1 NTU (FAO, 2006).

Table 3 shows conductivity variation of Gray wastewater when treated with Moringa extract in the presence and absent of photocatalyst.

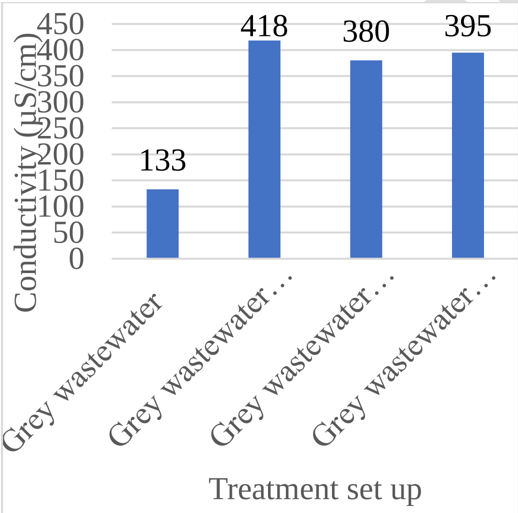

Figure 3 showed the conductivity profile of the grey wastewater treatment set ups. From the results, the grey wastewater plus photocatalyst plus moringa extract had the highest conductivity value of 418 µS/cm while the grey wastewater had the least conductivity value of 133 µS/cm, respectively.

Table 4: Turbidity profile of the Grey Wastewater Treatment setups

Gray Wastewater Samples	pH Profile

Gray Wastewater	356.79
Gray Wastewater + photocatalyst + Moringa Extract	327.54
Gray Wastewater + photocatalyst	268.69
Gray Wastewater + Moringa Extract	304.85

Results from table 4 showed the turbidity profile of the grey wastewater treatment set ups. From the results, the grey wastewater had the highest turbidity value of 356.79 NTU while the grey wastewater had the least turbidity value of 268.69 NTU, respectively.

Sodium chloride may impact a salty taste at 250 mg/l; however, calcium or magnesium chloride is usually detected by taste until levels of 1000 mg/l are reached. Public drinking water standards require chloride level not to exceed 250 mg/l (FAO, 2006).

Table 4 shows turbidity profile of Gray wastewater when treated with Moringa extract in the presence and absent of photocatalyst.

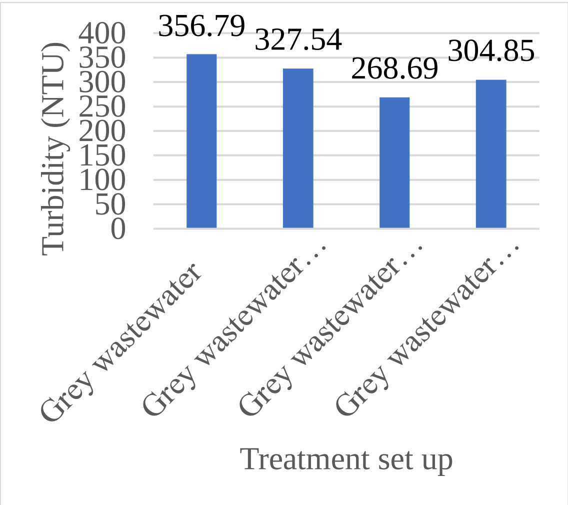

Figure 4 showed the turbidity profile of the grey wastewater treatment set ups. From the results, the grey wastewater had the highest turbidity value of 356.79 NTU while the grey wastewater had the least turbidity value of 268.69 NTU, respectively

Table 5: Chloride profile of the Grey Wastewater Treatment setups

Gray Wastewater Samples	**pH Profile**
Gray Wastewater	151.2
Gray Wastewater + photocatalyst + Moringa Extract	56.7
Gray Wastewater + photocatalyst	85.05
Gray Wastewater +	126

Moringa Extract

Results from table 5 showed the chloride profile of the grey wastewater treatment set ups. From the results, the grey wastewater had the highest chloride value of 151.2 mg/mL while the grey wastewater plus photocatalyst plus moringa extract had the least chloride value of 56.70 mg/mL, respectively.

According to the National Academy, (2005) secondary drinking water regulations, 500 ppm is the recommended maximum amount of TDS for your drinking water. Any measurement higher than 1000 ppm is an unsafe level of TDS. If the level exceeds 2000 ppm, then a filtration system may be unable to properly filter TDS.

Table 5 shows chloride profile of Gray wastewater when treated with Moringa extract in the presence and absent of photocatalyst.

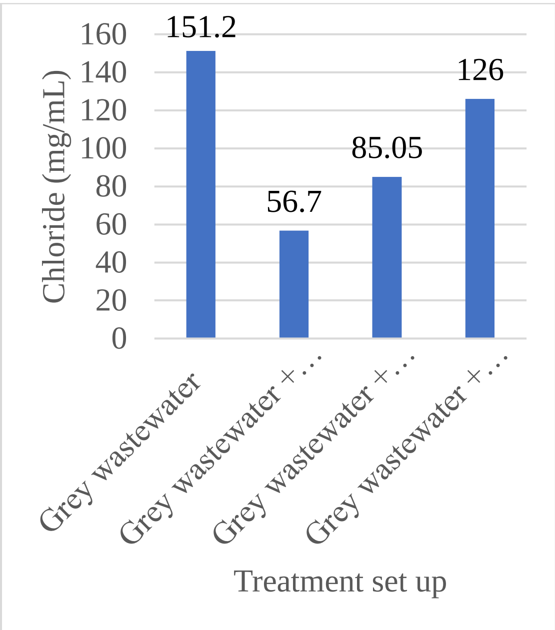

Figure 5 showed the chloride profile of the grey wastewater treatment set ups. From the results, the grey wastewater had the highest chloride value of 151.2 mg/mL while the grey wastewater plus photocatalyst plus moringa extract had the least chloride value of 56.70 mg/mL, respectively.

Table 6: Total dissolved solid profile of the Grey Wastewater Treatment setups

Gray Wastewater Samples	pH Profile
Gray Wastewater	99.75
Gray Wastewater + photocatalyst + Moringa Extract	313.5
Gray Wastewater + photocatalyst	213.75
Gray Wastewater + Moringa Extract	296.25

Results from table 6 showed the total dissolved solid profile of the grey wastewater treatment set ups. From the results, the grey wastewater plus photocatalyst plus moringa extract had the highest total dissolved solid value of 313.50 mg/mL while the grey wastewater had the least total dissolved solid value of 99.75 mg/mL, respectively.

The APHA color scale ranges from 0 to 500, with 0 as distilled white water and 500 as distinctly yellow water. Higher-purity liquids have less yellow and lower PtCo concentrations. (APHA, 2005)

Table 6 shows total dissolved solid profile of Gray wastewater when treated with Moringa extract in the presence and absent of photocatalyst.

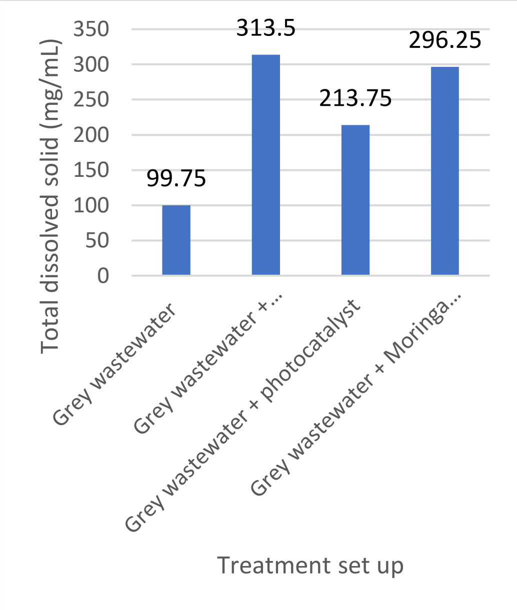

Figure 6 showed the total dissolved solid profile of the grey wastewater treatment set ups. From the results, the grey wastewater plus photocatalyst plus moringa extract had the highest total dissolved solid value of 313.50 mg/mL while the grey wastewater had the least total dissolved solid value of 99.75 mg/mL, respectively.

Table 7: Colour profile of the Grey Wastewater Treatment setups

Gray Wastewater Samples	**Colour Profile (CU)**
Gray Wastewater	77.28
Gray Wastewater + photocatalyst + Moringa Extract	38.98
Gray Wastewater + photocatalyst	70.21
Gray Wastewater + Moringa Extract	41.27

Results from table 7 showed the colour profile of the grey wastewater treatment set ups. From the results, the grey wastewater had the highest colour unit of 77.28 CU while the grey wastewater plus photocatalyst plus moringa extract had the least colour unit of 38.98 CU, respectively.

Hardness is most commonly expressed as milligrams of calcium carbonate equivalent per litre. Water containing calcium carbonate at concentrations below 60 mg/l is generally considered as soft; 60–120 mg/l, moderately hard; 120–180 mg/l, hard; and more than 180 mg/l, very hard (APHA, 2005).

Table 7: Colour profile of Gray wastewater when treated with Moringa extract in the presence and absent of photocatalyst.

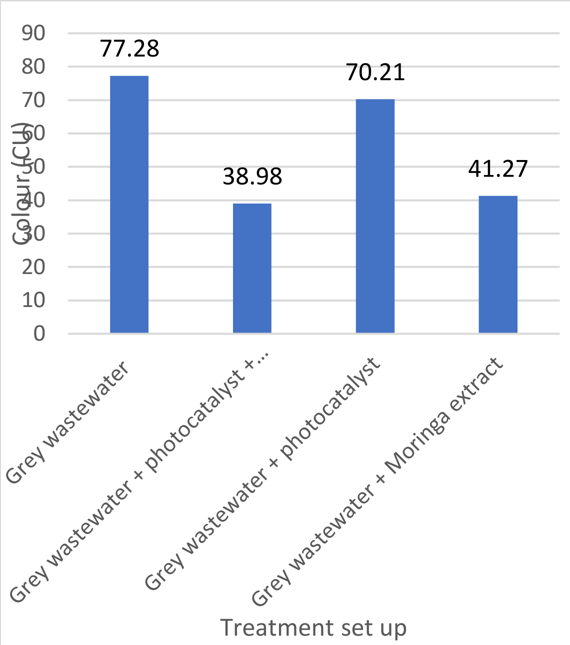

Figure 7 showed the colour profile of the grey wastewater treatment set ups. From the results, the grey wastewater had the highest colour unit of 77.28 CU while the grey wastewater plus photocatalyst plus moringa extract had the least colour unit of 38.98 CU, respectively.

Table 8: Total hardness profile of the Grey Wastewater Treatment setups

Gray Wastewater Samples	Total hardness Profile (mg/ml)
Gray Wastewater	500
Gray Wastewater + photocatalyst + Moringa Extract	230
Gray Wastewater + photocatalyst	290
Gray Wastewater + Moringa Extract	390

Results from table 8 showed the total hardness profile of the grey wastewater treatment set ups. From the results, the grey wastewater had the highest total hardness value of 500.00 mg/mL while the grey wastewater plus photocatalyst plus moringa extract had the least total hardness value of 230.00 mg/mL, respectively.

The COD content of 18.47 mg/L indicates that every litre of water contains 18.47 mg of organic material, while the maximum allowed is 10 mg. Like BOD, high levels of COD are caused by the accumulation of organic matter from livestock waste around water sources (FAO, 2006).

Table 8: Total hardness profile of Gray wastewater when treated with Moringa extract in the presence and absent of photocatalyst.

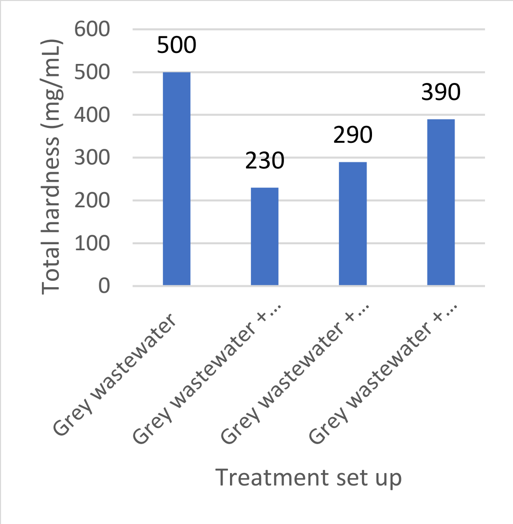

Figure 8 showed the total hardness profile of the grey wastewater treatment set ups. From the results, the grey wastewater had the highest total hardness value of 500.00 mg/mL while the grey wastewater plus photocatalyst plus moringa extract had the least total hardness value of 230.00 mg/mL, respectively.

Table 9: Total Chemical oxygen demand profile of the Grey Wastewater Treatment setups

Gray Wastewater Samples	Total Chemical oxygen demand Profile (mg/ml)
Gray Wastewater	500
Gray Wastewater + photocatalyst + Moringa Extract	230
Gray Wastewater + photocatalyst	290
Gray Wastewater + Moringa Extract	390

Results from table 9 showed the chemical oxygen demand profile of the grey wastewater treatment set ups. From the results, the grey wastewater had the highest chemical oxygen demand value of 960.00 mg/mL while the grey wastewater plus photocatalyst plus moringa extract had the least chemical oxygen demand value of 320.00 mg/mL, respectively (FAO, 2006).

In freshwater, DO reaches 14.6 mg/L at 0 °C and approximately 9.1, 8.3, and 7.0 mg/L at 20, 25, and 35 °C, respectively, and 1 atm pressure. At temperatures of 20 and 30 °C, the level of saturated DO is 9.0-7.0 mg/L. Low oxygen in water can kill fish and other organisms present in water.

Table 9: Total Chemical oxygen demand profile of Gray wastewater when treated with Moringa extract in the presence and absent of photocatalyst.

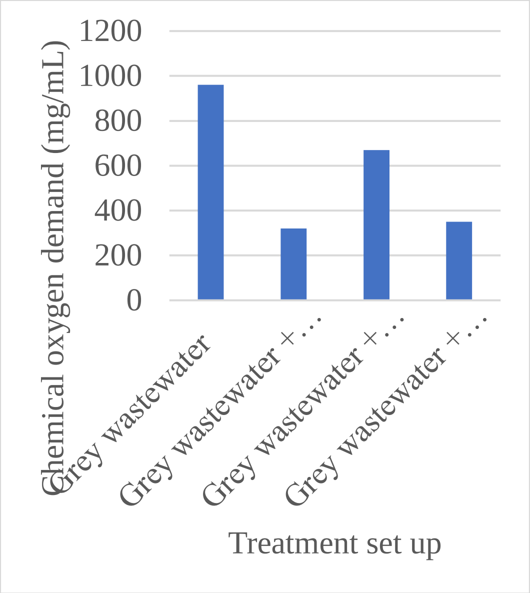

Figure 9 showed the chemical oxygen demand profile of the grey wastewater treatment set ups. From the results, the grey wastewater had the highest chemical oxygen demand value of 960.00 mg/mL while the grey wastewater plus photocatalyst plus moringa extract had the least chemical oxygen demand value of 320.00 mg/mL, respectively.

Table 10: Total Dissolved oxygen profile of the Grey Wastewater Treatment setups

Gray Wastewater Samples	**Total dissolved oxygen Profile (mg/ml)**
Gray Wastewater	3
Gray Wastewater + photocatalyst + Moringa Extract	25
Gray Wastewater + photocatalyst	15
Gray Wastewater + Moringa Extract	18

Results from table 10 showed the dissolved oxygen profile of the grey wastewater treatment set ups. From the results, the grey wastewater plus photocatalyst plus moringa extract had the highest dissolved oxygen value of 25.00 mg/mL while the grey wastewater had the least dissolved oxygen value of 3.00 mg/mL, respectively.

Table 10: Total dissolved oxygen profile of Gray wastewater when treated with Moringa extract in the presence and absent of photocatalyst.

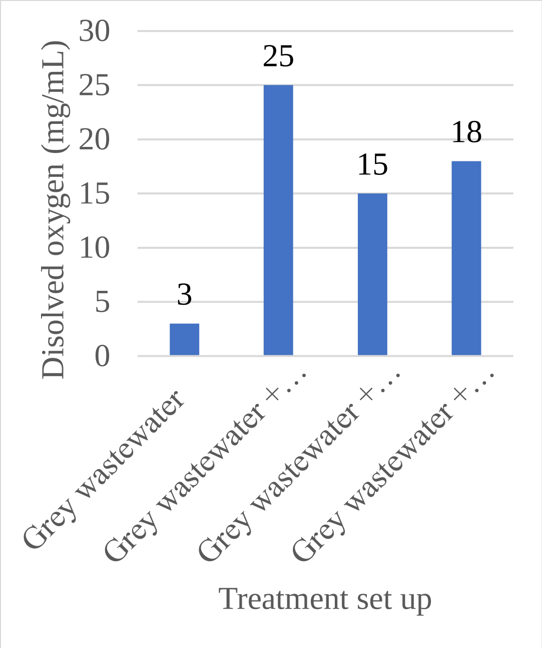

Figure 10 showed the dissolved oxygen profile of the grey wastewater treatment set ups. From the results, the grey wastewater plus photocatalyst plus moringa extract had the highest dissolved oxygen value of 25.00 mg/mL while the grey wastewater had the least dissolved oxygen value of 3.00 mg/mL, respectively.

Table 11: Phosphate profile of the Grey Wastewater Treatment setups

Gray Wastewater Samples	**Phosphate Profile (mg/ml)**
Gray Wastewater	50
Gray Wastewater + photocatalyst + Moringa Extract	15
Gray Wastewater + photocatalyst	24
Gray Wastewater + Moringa Extract	20

Results from table 11 showed the phosphate profile of the grey wastewater treatment set ups. From the results, the grey wastewater had the highest chemical oxygen demand value of 50.00 mg/mL while the grey wastewater plus photocatalyst plus moringa extract had the least chemical oxygen demand value of 15.00 mg/mL, respectively.

Table 11: Phosphate profile of Gray wastewater when treated with Moringa extract in the presence and absent of photocatalyst.

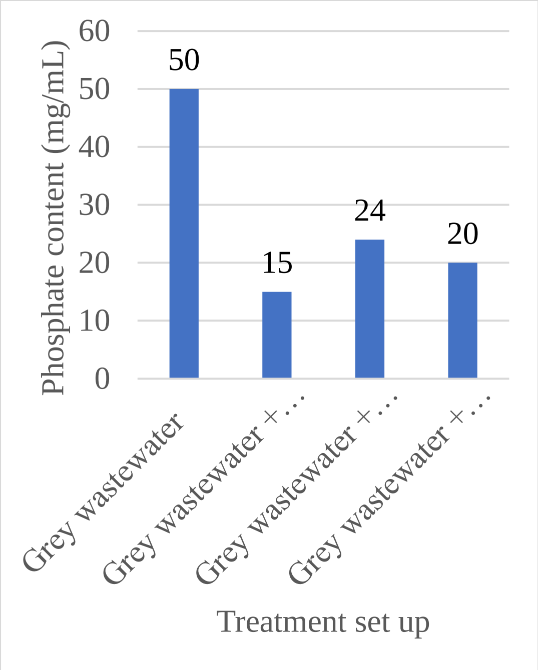

Figure 11 showed the phosphate profile of the grey wastewater treatment set ups. From the results, the grey wastewater had the highest chemical oxygen demand value of 50.00 mg/mL while the grey wastewater plus photocatalyst plus moringa extract had the least chemical oxygen demand value of 15.00 mg/mL, respectively.

4. CONCLUSION

4.1 Conclusion

Wastewater is and will always be with us because we cannot survive without water. When water supplied is used for the numerous human activities, it becomes contaminated or its characteristics is changed and therefore become wastewater. Wastewater can and must be treated to ensure a safe environment and foster public health. There are conventional and non-conventional methods of wastewater treatment and the choice of a particular method should be based on factors such as characteristics of wastewater whether it from a municipality or industry (chemical, textile, pharmaceutical etc.), technical expertise for operation and maintenance, cost implications, power requirements among others.

A thorough review of the purification processes been used in this study alongside literature, indicated that none of the treatment options can be used alone safely to treat wastewater to make them save for home use. It is therefore recommended that a combination of the performance of physical, chemical and biological treatment in wastewater remediation to achieve a greater and better result. However, chemical and biological treatments of wastewater should be accompanied by eco-toxicological assessment to ensure the protection of aquatic biota.

REFERENCES

1. Aboulhassan, M. A., Souabi, A., and Yaacoubi, M. B. (2016): Removal of surfactant from industrial wastewaters by coagulation flocculation process. International Journal of Environmental Science and Technology, **3**:327-332.

2. Aguilar, M.; Sáenz, J.; Llórens, M.; Soler, A. y Ortuño, J. (2002). Tratamiento físico-químico de aguas residuales, Coagulación floculación. Murcia, España. Universidad de Murcia, España.

3. American Public Health Association (APHA). (2005). Standard Methods for the Examination of Water and Wastewater, 21 (21). Washington, D. C, EE. UU. American Public Health Association.

4. Awuah, E. and Amankwaa-Kuffuor, R., (2002): "Characterisation of Wastewater, its sources and its Environmental Effects" I-Learning Seminar on Urban Wastewater Management

5. COOU (Anambra State) (2022): "Our History". Chukwuemeka Odumegwu Ojukwu University. Retrieved 27 June 2022.

6. Ezejiofor, Victoria Obianuju; Agim, Eliezer Chukwuyere; Ndanwu, Angela Ifeoma (2022). "Availability and utilization of information resources for igbo studies in Chukwuemeka Odumegwu Ojukwu University library, igbariam campus". Library Research Journal. **7**: 1–7.

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

8. FAO (2010) The wealth of waste. The economics of wastewater use in agriculture. FAO Water Reports 35. Food and Agri- culture Organization, Rome.

9. Fritsche, W., and Hofrichter, M. (2008). Aerobic Degradation by Microorganisms. Biotechnology: Second, Completely Revised Edition, 11-12, 144-167.

10. Finley, S., S. Barrington and D. Lyew. (2019): Reuse of domestic greywater for the irrigation of food crops. Water Air and Soil Pollution, **199**:235-245.

11. Fúquene, D. Y., and Yate, A. (2018). Ensayo de jarras para el control del proceso de coagulación en el tratamiento de aguas residuales industriales. Working papers, ECAPMA, 2:1.

12. López, S., and Marín, S. (2015). UF1666-Depuración de Aguas Residuales. Madrid, Spain. Editorial Elearning, S. L

13. López, S., and Marín, S. (2017). UF1666-Depuración de Aguas Residuales. Madrid, Spain. Editorial Elearning, S. L

14. Manahan, S. (2007). Introducción a la Química Ambiental. Barcelona, Spain. Editorial REVERTÉ, S.A.

15. Metcalf and Eddy, Inc. (2021) "Wastewater Engineering": Treatment Disposal and Reuse,third edition. New York: McGraw-Hill. pp. 11-19

16. National Academy (2005): "Water Conservation, Reuse, and Recycling": Proceedings of an Iranian-American Workshop National Academies Press, Washington

17. Obuobie, E., Keraita B. N., Danso, G., Amoah, P., Cofie, O. O. Raschid-Sally, L. and Dreschsel, P (2006) "Sanitation and Urban Wastewater Management" Book Chapter in Irrigated Urban Vegetable Farming in Ghana: Characteristics, Benefits and Risks http://www.cityfarmer.org/GhanaIrrigateVegis.html

18. Odeyemi O E, A A Adedeji, O J Odeyemi (2018) Effects of discharge from carwash on the physic-chemical parameters and zooplanktonic abundance of Odo-Ebo River, Ile-Ife, Nigeria. Agriculture and Environment, 10:83-96.

19. Otterpohl, R., M. Grottker and J. Lange. (2017): Sustainable water and waste management in urban areas. Water Science and Technology, **35**(9): 121-133.

20. Sanders, E. R. (2012). Aseptic Laboratory Techniques: Plating Methods. Journal of Visualized Experiments, (63), 1-18.

21. Valverde, T.; Meave, J.; Carabias, J. and Cano, Z. (2005). Ecología y medio ambiente. México. Pearson Education.

22. WHO (2011) WHO Guidelines for the Safe Use of Wastewater, excreta and greywater. World Health Organization, Geneva.

23. Wiesmann, U.; Choi, I. S. and Dombrowski, E.-M. (2007). Fundamentals of biological wastewater treatment. Weinheim, London, Wiley-VC.

24. MmonwubaNwannekaC. ,Agunwamba JC, and Onyekwere K.O: "comparative analysis of bioremediation of heavy metals using plants and microorganisms" INT J CURR SCI 2013, 6: E 153-160.

25. Ugwuanyi S.E, MmonwubaNwaneka C. and Adibe T.N: "Partial Replacement of Cement with Burnt rice Husk Ash for Low Strength Concrete Production" International Journal of Innovation Engineering, Technology and Science. IJIETS, Volume 2, No.2. April, 2018.

26. Ugwuanyi S.E, MmonwubaNwaneka C. and Adibe T.N : Challenges of Water Supply Sustainability in an Emerging Economy" IOSR Journal of Mechanical and Civil Engineering May, 2018. ISSN vol.15, 2278-1684,

27. Ugwuanyi, S.E. and Mmonwuba, N.C.:" Project Failure in Enugu State; Problems, Prospect and Perceived Solution". International J Journal of Innovation Engineering, Technology and Science.IJIETS, ISSN; 2533-7365 Vol. 2, No.2. March- 2019.

28. NwannekaMmonwuba .C.: "Effect of Soak-away on Ground Water Quality in Onitsha North Local Government Area of Anambra State" International J Journal of Innovation Engineering, Technology and Science. IJIETS, ISSN; 2533-7365 Vol. 3 No.2, Oct-2020

29. Agunwamba J. C. and Mmonwuba N. C.: Comparative Analysis of Some Existing Models for Estimating the Time of Concentration for watersheds in AnambraState.Journal of Engineering Research and Report. JERR.ISSN; 2582-2926.20(5); 64-75, 2021. Article no. JERR.65510.

30. NwannekaMmonwubaC. : "Comparative Analysis of Paving tiles Produced from Plastic Waste, Palm Karnel Shell and Normal Concrete" ". International J Journal of Innovation Engineering, Technology and Science.IJIETS, ISSN; 2533-77365 Vol. 2, No.1. March- 2018.

31. Dr. N.C Mmonwuba, Ezenwaka Patrick, ChukwuElochukwu Caleb. "The Design Of Sewage Treatmant Plant For Agulu Community, Nigeria"Journal of Engineering Research and Report. JERR.ISSN; 2582-2926.Vol 24; 1-7, 2023. Article no. JERR.95946https://doi.org/10.9734/jerr/2023/v24i4808.

32. N. C. MmonwubaAnaduakummaduabuchi, ChiamadikeAzubuike, NwekeNzubeTheophilius, and ChiokeChukwuemelie "The Effect of Industrial Waste Effluent on Water Quality: A Case Study of Atamiri River, Owerri, Imo State" Journal of Engineering Research and Report. JERR..Vol 24; 1-7, 2023. Article no. JERR.95943
https://doi.org/10.9734/jerr/2023/v24i48010

33. N.C. Mmonwuba, OkoyeOnyekachi Francis, OkpalaSomtochukwu, MaduegbunnaPatricChinweike, KizitoEzenwafor, EzeolisaIfunanya. G. "Effect of Solid Waste (Leachetes) on the Quality of Underground Water"Journal of Engineering Research and Report.JERR.Vol 24; 20-31, 2023. Article no. JERR.95945. https://doi.org/10.9734/jerr/2023/v24i38085.

34. N. C. Mmonwuba, Anene Walter, OnyirioforChibuike Maxwell, Adahor Lucy. “Hazardous Waste Management at Our Lady of Lourdes Hospital, Ihiala, Anambra State” American Journal of Innovation in Science and Engineering (AJISE). ISSN: 2158-7205, Vol. 2, Issue 1, 2023.https://journals.e-palli.com/home/index.php/ajise/article/view/1324/632

35. MmonwubaNwanneka C. D., Chekwube, O. D., Chibuzor, O. S.-M., & Anthony, A. chiemerie. (2023). Bioremidation and Phytoremdiation of Petroleum Contaminated Soil. Journal of Energineering Research and Report, 15(4), 34–44. https://doi.org/10.9734/jenrr/2023/v15i4322

36. Nwanneka, M., Sochima, M. E., Samuel, O. A., &Kizito, M. (2023). Analysis of Physical, Chemical and Biological Characteristics of Borehole Water in Awka, Awka-South LGA, Anambra State, Nigeria.Journal of Engineering Research and Reports, 25(12), 116–127.https://doi.org/10.9734/jerr/2023/v25i121046