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Comparing the Performance of Physical, Chemical and Biological Treatment in Waste Water Remediation

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study is aimed at comparing the performance of physical, chemical and biological treatment in wastewater remediation using standard sampling methods of APHA (1999). Grey wastewater samples were collected from wastewater collection generated from the student's hostel at Chukwemeka Odumegwu Ojukwu University Uli, Anambra State. Wastewater remediation involves treating contaminated water to remove pollutants before it will be reused. This process typically

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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. 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, which from the result obtained it was discovered that grey waste water has the highest values in pH (7.45), turbidity (356.79 NTU), chloride (151.2 mg/mL), colour unit (77.28 CU), total hardness (500 mg/mL), COD(500 mg/mL) and phosphate (50.0 mg/mL). While grey wastewater plus photocatalyst plus moringa extract has the highest value in temperature (279ºC), Conductivity (418 µS/cm), TDS (313.50 mg/mL), and TDO (25.00 mg/mL) respectively. 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).

1. 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 (Awuah & Amankwaa-Kuffuor 2002) 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 & 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).

(COOU. 2022) 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). (Aboulhassan et al., 2016) 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 & 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. (Aguilar et al., 2002) 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" (Agunwamba et al., 2021).

"Environmental conditions arising from inadequate or non-existing wastewater management pose significant threats to human health, well-being and economic activity. Efforts to secure access to safe drinking-water and basic sanitation, have been partly hindered by this" (Mmonwuba, N.C. 2018). It should therefore be recognized as a challenge in the progressive realization of the human right to water and sanitation. All of these can cause health and environmental problems and can have economic/financial impacts (e.g. increased treatment costs to make water usable for certain purposes) when improperly or untreated wastewater is released into the environment. “Wastewater Management is therefore necessary in handling wastewater to protect the environment to ensure public health, economic, social and soundness” (Otterpohl et al., 2017)

2. MATERIALS AND METHODS

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" (Mmonwuba, N. C. et al., 2023). 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" (Mmonwuba, N. C. et al., 2023).

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℃" (Mmonwuba, N. C. et al., 2023).

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" (Nwanneka, M.et al.,2023). 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" (Mmonwuba, N. C. 2020).

2.4.3 Determination of chloride

Chloride was obtained using Argentometric titration method and as described by APHA (2005) and Aboulhassan et al. (2016). (Odeyemi et al., 2018) 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" (Mmonwuba, N. C. et al., 2023).

Calculation:

$$MgCl/L = (A-B) \times N \times 35 \times 450 / mL \text{ of samples}$$

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). (Obuobie et al., 2006)."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" (Mmonwuba, N. C., Okoye O. F.et al., 2023). "The precipitate is white if the sample is devoid of oxygen, and becomes increasingly brown with rising oxygen content" (Ugwuanyi, S.E. et al., 2018). 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). (Ezejiofor et al., 2022) 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" (Ugwuanyi, S.E. & Mmonwuba, N.C., 2019). The COD is given by:

COD (mg O_2 /L) = [(A - B) × M × 8,000) / (V 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" (Mmonwuba, N. C. et al., 2013).

Calculation:

Total dissolved solid (mg/L) = (W2 - W1)/ Volume of sample x 100

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"(Ugwuanyi, S.E.et al., 2018)

Total hardness (as mg/L of $CaCO_3$ scale) = 1000 Mililitre of EDTA used (unboiled sample)/ Mililitre of sample x 10^3

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:

CU= 500 x A_1/A_2

Where:

A_1 = Absorbance of 500 cu platinum cobalt standard solution and
A_2 = Absorbance of the effluent sample.

3. RESULTS AND DISCUSSION

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).

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

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 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

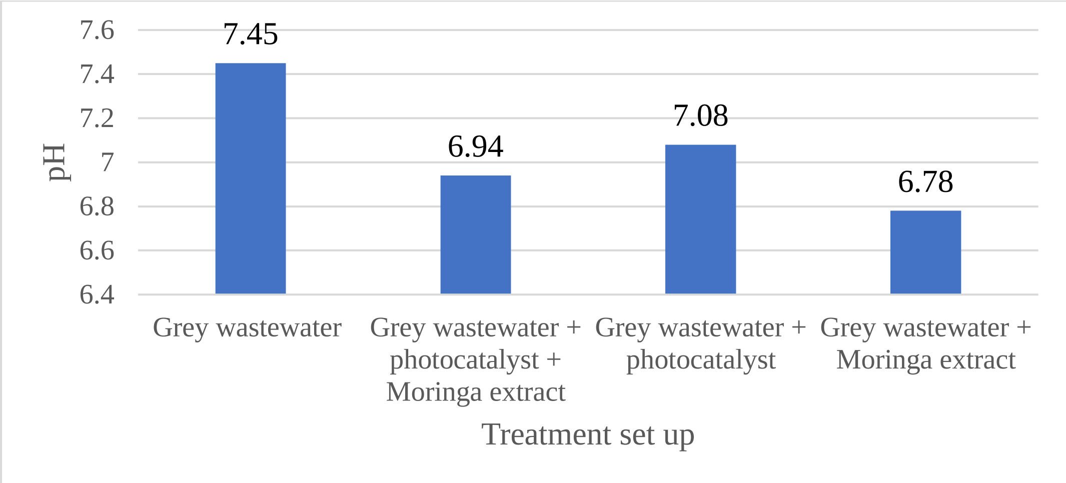

Fig. 1. The pH profile of the grey wastewater treatment set ups. From the result, raw waste water had the highest pH value of 7.45 while the grey wastewater plus moringa extract had the least pH value of 6.78, respectively

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

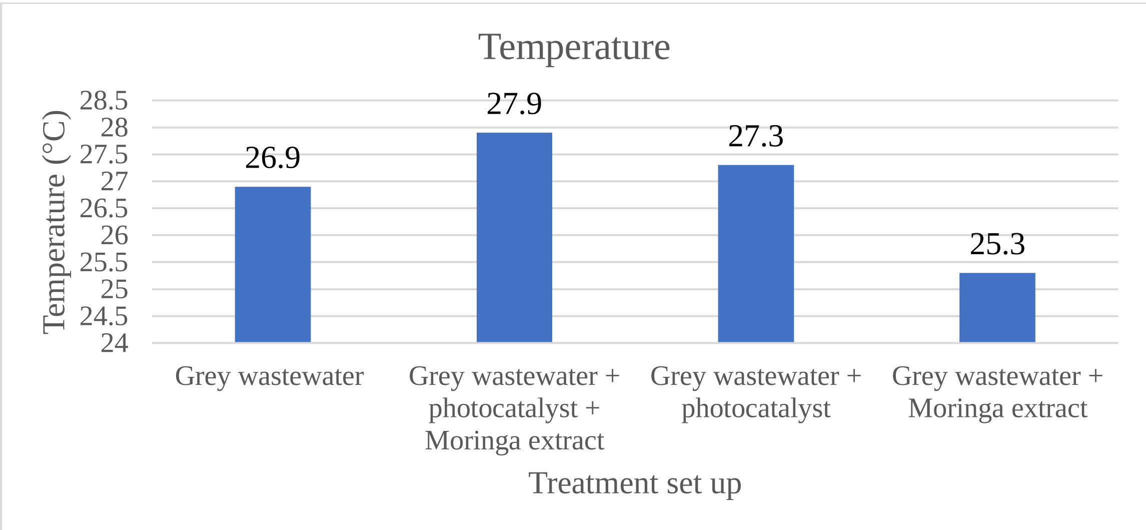

Fig. 2. The temperature profile of the grey wastewater treatment set ups. From the result, the grey wastewater plus photocatalyst plus moringa extract had the highest temperature value of 27.9 while the grey wastewater plus moringa extract had the least temperature value of 25.3, respectively

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

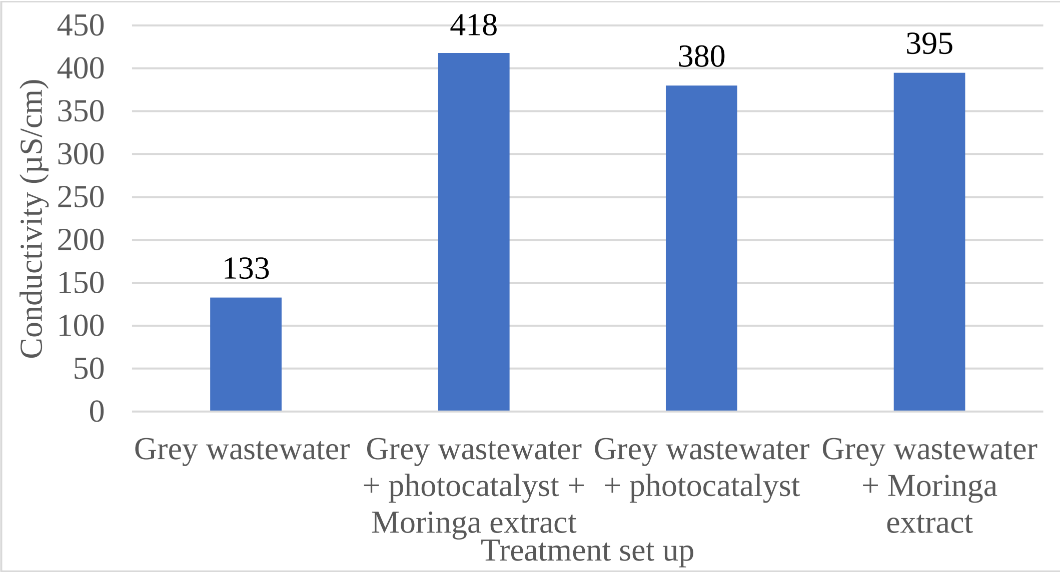

Fig. 3. The conductivity profile of the grey wastewater treatment set ups. From the results, the grey wastewater plus photocatalyst plus moringa extract had the highest conductivity value of 418 µS/cm while the grey wastewater had the least conductivity value of 133 µS/cm, respectively

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

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

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).

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

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.

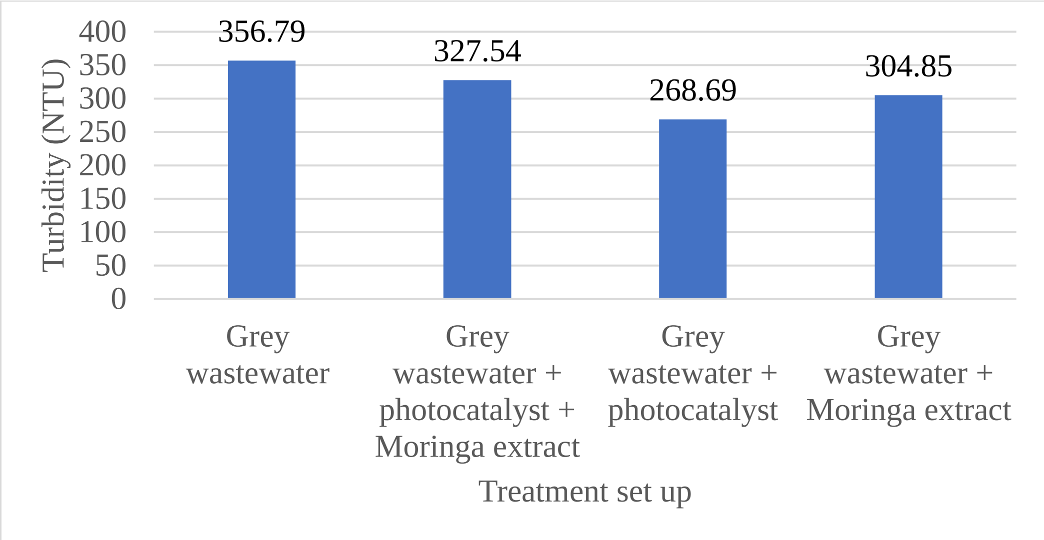

Fig. 4. The turbidity profile of the grey wastewater treatment set ups. From the results, the grey wastewater had the highest turbidity value of 356.79 NTU while the grey wastewater had the least turbidity value of 268.69 NTU, respectively

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 + Moringa Extract	126

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).

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

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.

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

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).

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

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).

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

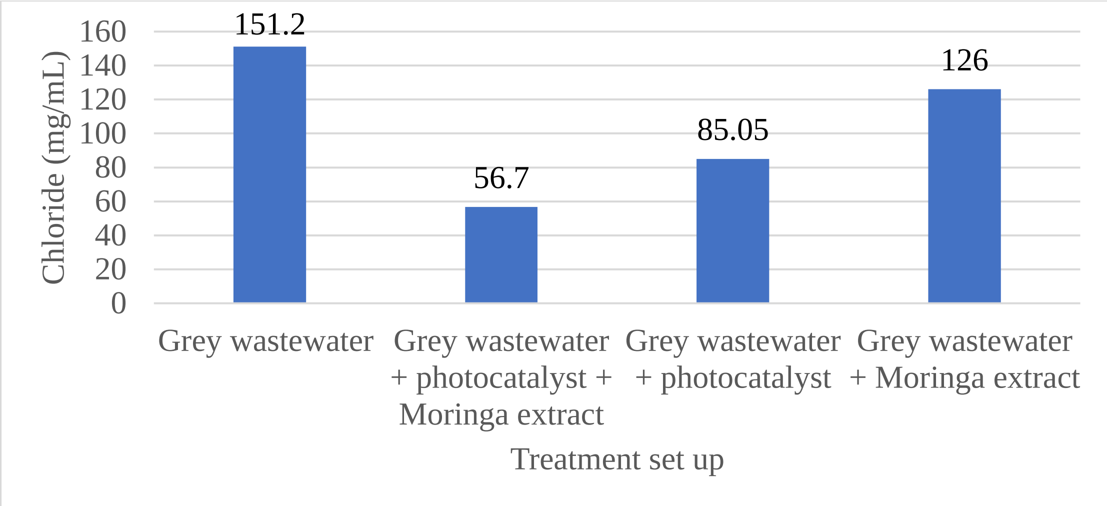

Fig. 5. The chloride profile of the grey wastewater treatment set ups. From the results, the grey wastewater had the highest chloride value of 151.2 mg/mL while the grey wastewater plus photocatalyst plus moringa extract had the least chloride value of 56.70 mg/mL, respectively

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

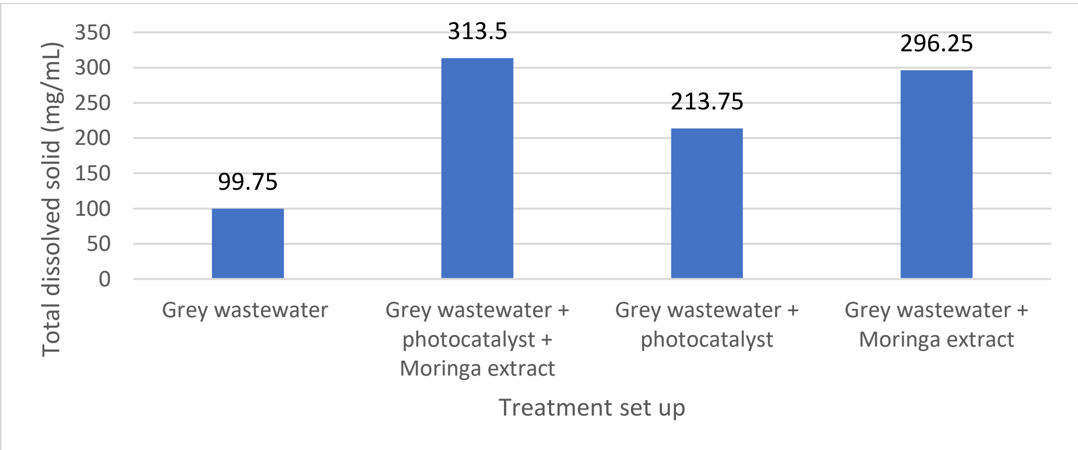

Fig. 6. The total dissolved solid profile of the grey wastewater treatment set ups. From the results, the grey wastewater plus photocatalyst plus moringa extract had the highest total dissolved solid value of 313.50 mg/mL while the grey wastewater had the least total dissolved solid value of 99.75 mg/mL,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

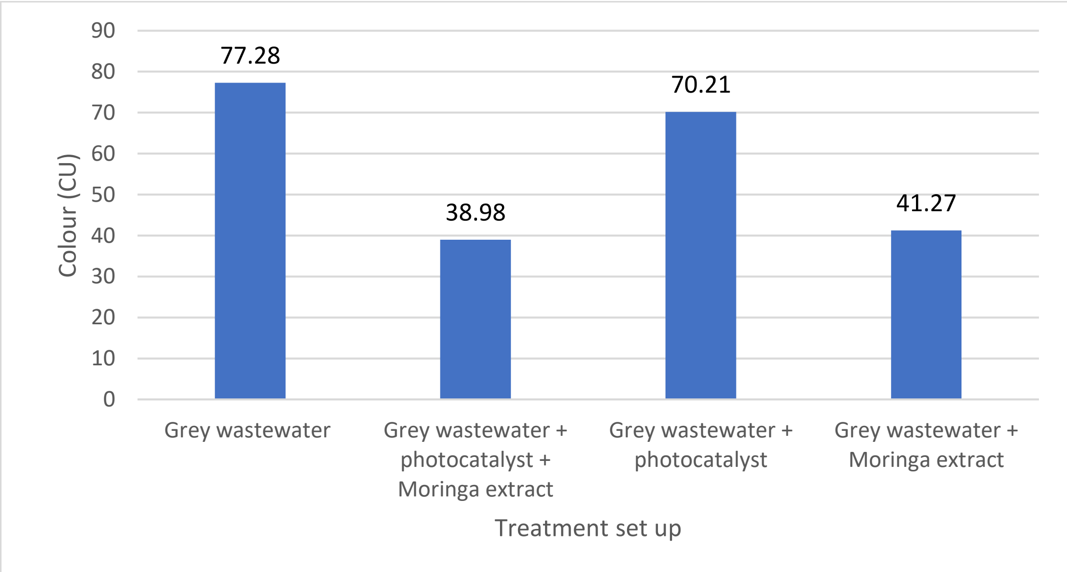

Fig. 7. The colour profile of the grey wastewater treatment set ups. From the results, the grey wastewater had the highest colour unit of 77.28 CU while the grey wastewater plus photocatalyst plus moringa extract had the least colour unit of 38.98 CU, respectively

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).

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

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 500.00 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.

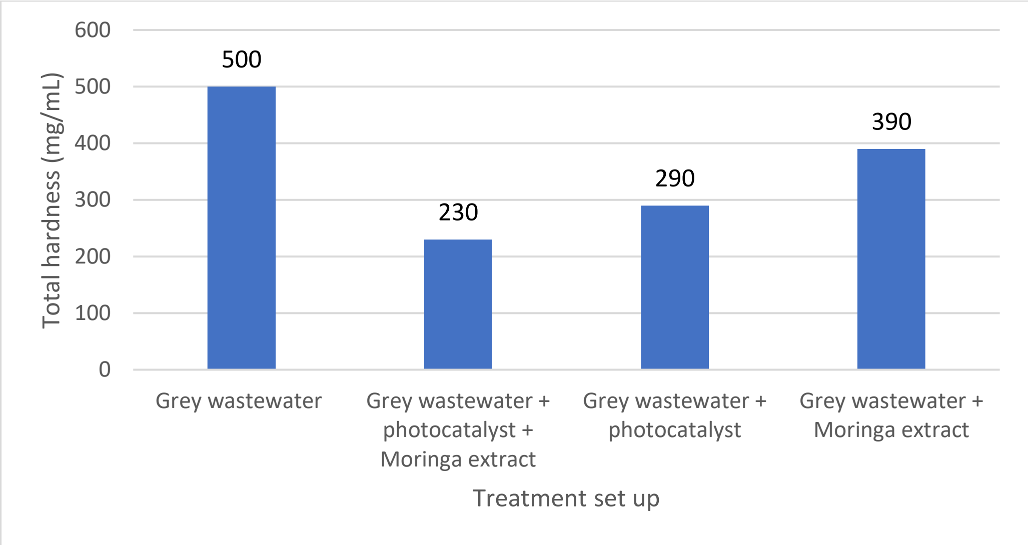

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Table 9. Total Chemical oxygen demand profile of the Grey Wastewater Treatment setups

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

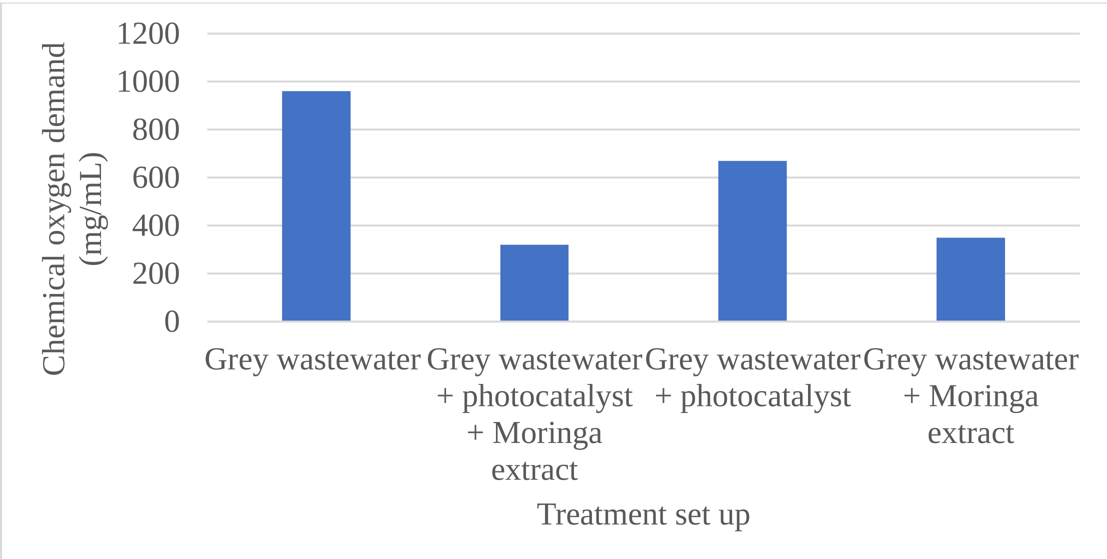

Fig. 9. The chemical oxygen demand profile of the grey wastewater treatment set ups. From the results, the grey wastewater had the highest chemical oxygen demand value of 960.00 mg/mL while the grey wastewater plus photocatalyst plus moringa extract had the least chemical oxygen demand value of 320.00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

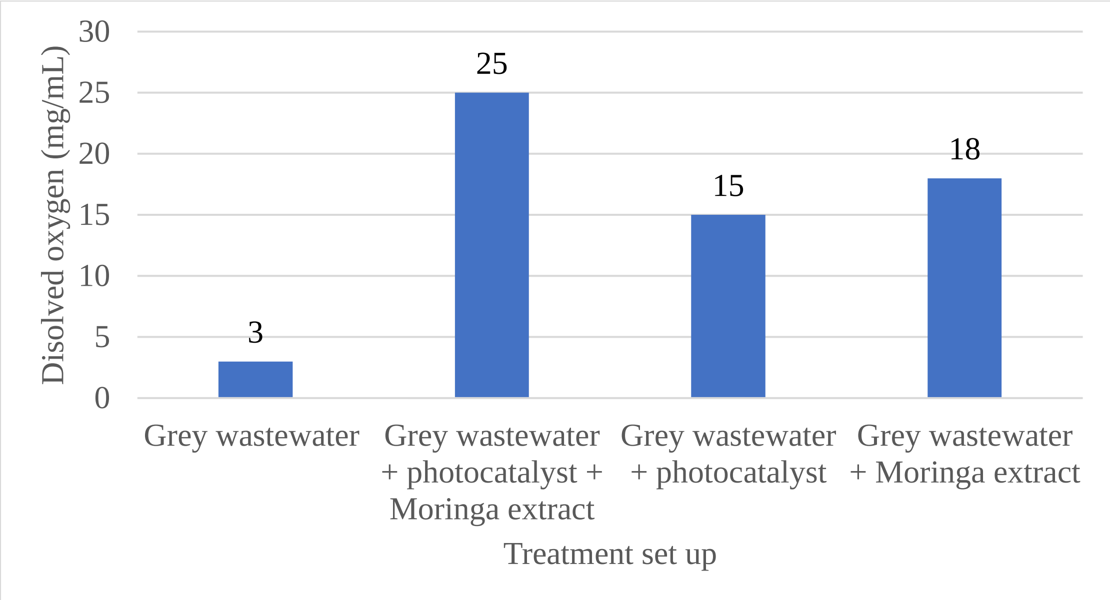

Fig. 10. The dissolved oxygen profile of the grey wastewater treatment set ups. From the results, the grey wastewater plus photocatalyst plus moringa extract had the highest dissolved oxygen value of 25.00 mg/mL while the grey wastewater had the least dissolved oxygen value of 3.00 mg/mL, respectively

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

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

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.

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

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

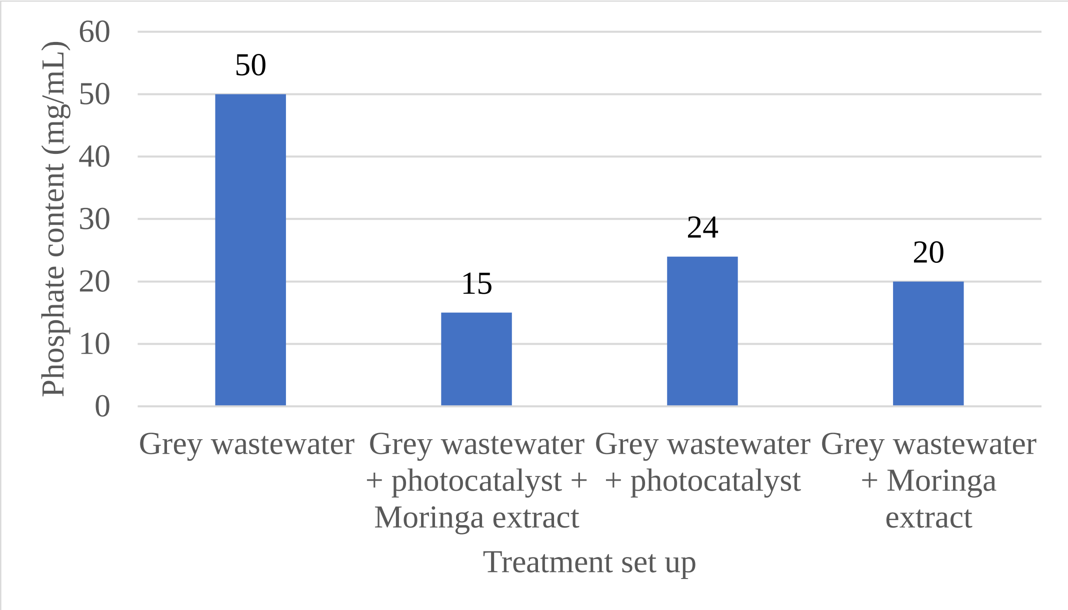

Fig. 11. The phosphate profile of the grey wastewater treatment set ups. From the results, the grey wastewater had the highest phosphate value of 50.00 mg/mL while the grey wastewater plus photocatalyst plus moringa extract had the least chemical phosphate value of 15.00 mg/mL, respectively.

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

4. 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.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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