TREATMENT AND CHARACTERIZATION OF DOMESTIC GREYWATER USING SIMPLE TECHNIQUES FOR HOME-GARDEN IRRIGATION IN SAMARU-ZARIA, NIGERIA

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Abstract

In the face of growing global water scarcity, greywater irrigation emerges as an innovative solution to conserve freshwater resources. This study assessed the suitability of reusing domestic wastewater for home-garden irrigation. Five water sources; borehole, bathroom, washing machine, kitchen sink and floor cleaning; and five locally available treatment media; coconut shell, sand, pebble, activated charcoal and sawdust were used in a completely randomized design experiment making twenty-five treatments. Treatment of greywater was based on a simple physical filtration using disposable plastic bottles (with cut base). The ion concentrations analyzed include Ca^{2+}, Mg^{2+}, K^{+} and Na^{2+} while the indices used are pH, Electrical Conductivity and Sodium Absorption Ratio (SAR). Bathroom water had lower values of SAR ranging from 7.6 – 13. The least SAR value was attained from the greywater treated with Pebbles. Sodium has the highest concentration in all the greywater samples compared to other ions in the order of $Na^{2+} > Ca^{2+} > K^{+} > Mg^{2+}$. The percentages of sodium removal after treatment were found to be within the range of 1.4 to 38.4%, with highest removal in the bathroom greywater treated with sand and the least in kitchen sink greywater treated with coconut shell. These imply that, the simple treatment techniques employed performed better for greywater with lower ion concentrations. The techniques adopted though simple and cost-effective, an advanced technique is required for effective greywater treatment for irrigation. Nevertheless, where the advanced technique is not accessible, bathroom water could be treated with pebbles or sand for use in home-garden irrigation.

Keywords: Greywater, Treatment media, Simple techniques, Home-garden irrigation

Introduction

As the world grapples with water scarcity and the increasing demand for freshwater resources, the concept of sustainable water management has gained significant attention. One innovative approach to mitigate water shortages and reduce reliance on potable water for non-potable purposes is the use of greywater for irrigation. The treatment and reuse of greywater from various household can serve as a local solution to the emerging problems of water supply needed to irrigate crops (Gorgich *et al.*, 2020). Greywater refers to the used water from sources such as sinks, showers, bathtubs and washing machines, which can be collected, treated and reused for various purposes. As global water resource supplies are worsening, water shortage is already affecting about 2.7 billion people (in the year 2025), resulting in poverty and famine. This means the water shortages affect 1 out of every 3 people in the world (Eriksson *et al*., 2002; Ghaly *et al*., 2021).

Greywater irrigation holds immense potential for conserving precious freshwater resources and promoting sustainable residential, commercial, and agricultural practices. Repurposing greywater, this practice minimizes the strain on traditional water supplies and alleviates the burden on wastewater treatment systems. Delving into the benefits, challenges and considerations surrounding the use of greywater for irrigation, shedding light on the emerging trend that holds promise in addressing our ever-growing water challenges is worthwhile and timely (Van de Walle *et al*., 2023).

One of the primary advantages of greywater irrigation is its ability to conserve freshwater resources. By diverting greywater from entering sewage systems and reusing it for irrigation, significant amounts of potable water could be saved. Considering that a substantial portion of household water use is non-potable, harnessing greywater for irrigation reduces the strain on municipal water supplies, particularly during times of drought or water scarcity (Pachkor and Parbat, 2017).

Greywater irrigation also contributes to a reduction in wastewater discharge into rivers, lakes, and oceans. Rather than mixing with other forms of wastewater and undergoing complex treatment processes, greywater can be captured and treated on-site, preventing it from overwhelming municipal treatment facilities. This diversion of greywater from traditional wastewater streams helps in maintaining the ecological balance of water bodies and mitigates the environmental impact associated with conventional wastewater disposal (Fikri *et al*., 2023; Shqerat and Al-Tabbal, 2025; Stejskalová *et al*., 2021).

Greywater contains essential nutrients such as nitrogen and phosphorus, derived from organic soaps, shampoos, and other cleaning products. When used for irrigation, these nutrients can be beneficial for plant growth, thus promoting natural fertilization and reducing the need for chemical fertilizers. Consequently, greywater irrigation contributes to soil enrichment and improves overall plant health, making it an environmentally friendly option for agricultural and landscaping purposes (Shqerat and Al-Tabbal, 2025).

By utilizing greywater for irrigation, significant cost savings can be achieved. As greywater reduces reliance on potable water sources, homeowners, businesses, and farmers can considerably decrease water bills. Additionally, the installation of greywater collection and treatment systems may qualify for various incentives, grants, or rebates offered by local authorities or water management organizations, further offsetting the initial investment costs (Karnapa, 2016; Lahlou *et al*., 2022; Prashanna Rangan and Heenalisha, 2019)

While greywater irrigation offers several benefits, it is crucial to consider certain environmental aspects. Proper treatment and management of greywater are essential to ensure its safe use and prevent any potential health risks associated with microbial contamination. Appropriate system design, regular maintenance, and adherence to relevant guidelines and regulations are necessary to safeguard public health and protect the environment (Garzon and Paterlini, 2018)

The use of greywater for irrigation presents a sustainable solution to address water scarcity, conserve freshwater resources, and promote responsible water management practices. By harnessing greywater's potential, we can reduce the strain on traditional water supplies, decrease wastewater discharge, recycle nutrients, and realize significant cost savings. However, it is crucial to approach greywater use with care, implementing appropriate treatment and adhering to established guidelines to ensure safety and environmental sustainability. As we navigate the challenges posed by water scarcity, greywater irrigation emerges as an innovative and practical approach to create a more water-efficient and resilient future (Lahlou *et al*., 2022). Several studies were conducted to treat greywater for various purposes and using different techniques, the challenges remain in their complexity and costs among others, especially for small scale usage like home-garden irrigation. Therefore, this study attempts to use locally available materials as the treatment media using a simple physical technique.

Materials and methods

Water Sample Collection

The Household Wastewater (HWC) sample was collected daily from four different water sources: rinsing water from a washing machine, kitchen sink, bathroom, and floor cleaning water. Water from these sources was collected in a 20-liter container to form a Greywater Raw Sample (GWS) for irrigation.

Greywater Characterization

The collected greywater from the various sources were characterized to determine their chemical properties. This characterization was repeated three times for every 20 liters of GWS collected for each source before treatment. Borehole water was used as a control in this study.

Treatment of Greywater

Treatment of household greywater was based on a simple physical treatment, mainly filtration, as suggested by Pangarkar *et al*. (2010) using various treatment media such as coconut shells, sawdust, pebbles, activated charcoal and sand. These materials are widely available within the community at low cost or freely at open sites. The filtration system was simple and could be installed in the home garden with no energy source and little maintenance requirement (Pangarkar *et al*., 2010).

Experimental Setup

Five (5) water sources, namely borehole (BH, control), bathroom (BR), washing machine (WM), kitchen sink (KS) and floor cleaning (FC) water; and five (5) locally available treatment media namely coconut shell (CS), sand (SA), pebble (PE), activated charcoal (AC), and sawdust (SD), were used in a completely randomized design experiment making twenty (25) treatments repeated twice making a total of fifty (50) combinations as presented in Table 1.

Table 1: Treatments description

S/No	Treatment Combination	Description
1	BHCS	Treated water from Borehole using Coconut Shell
2	BHSD	Treated water from Borehole using sawdust
3	BHSA	Treated water from Borehole using sand
4	BHAC	Treated water from Borehole using activated carbon
5	BHPE	Treated water from Borehole using pebbles
6	BRCS	Treated water from Bathroom using Coconut Shell
7	BRSD	Treated water from Bathroom using sawdust
8	BRSA	Treated water from Bathroom using sand
9	BRAC	Treated water from Bathroom using activated carbon
10	BRPE	Treated water from Bathroom using pebbles
11	WMCS	Treated water from washing machine using Coconut Shell
12	WMSD	Treated water from washing machine using sawdust
13	WMSA	Treated water from washing machine using sand
14	WMAC	Treated water from washing machine using activated carbon
15	WMPE	Treated water from washing machine using pebbles
16	KSCS	Treated water from the kitchen sink using Coconut Shell
17	KSSD	Treated water from the kitchen sink using sawdust
18	KSSA	Treating water from the kitchen sink using sand
19	KSAC	Treated water from the kitchen sink using activated carbon
20	KSPE	Treated water from the kitchen sink using pebbles
21	FCCS	Treated water from the floor cleaning using Coconut Shell
22	FCSD	Treated water from the floor cleaning using sawdust
23	FCSA	Treated water from the floor cleaning using sand
24	FCAC	Treated water from the floor cleaning using activated carbon
25	FCPE	Treated water from the floor cleaning using pebbles

The setup involved the use of disposable plastic bottles (with cut base) to obtain twenty (20) sample bottles. The Sample bottles were labeled according to the combinations as presented in Table 1. The treatment media - CS, SA (Quartz), SD, and PE were initially washed thoroughly with distilled water to remove external contaminants and color which can discolor the filtrates. The treatment media were all arranged into a filter bed in each plastic bottle and a cotton material was placed beneath each filter bed as shown in Plate 1. Water was passed through the various media and collected as filtrate. The treated water was taken to the laboratory for characterization.

Laboratory Analysis of Water Sample

Firstly, the greywater collected from the five (5) sources, namely borehole (BH, Control), bathroom (BR), washing machine (WM), kitchen sink (KS) and floor cleaning (FC) water was analyzed in the laboratory and thereafter, the treated greywater using the various treatment media were also analyzed to assess the rate of water treatment by each medium and also their possible usage for irrigating vegetables mainly cultivated at home-garden. The ion concentrations analyzed include Ca^{2+}, Mg^{2+}, K^+ and Na^{2+} while the indices used are pH, Electrical Conductivity (EC) and Sodium Absorption Ratio (SAR). Exchangeable base of Ca and Mg were determined using Atomic Absorption Spectrophotometer (ASS), while Na and K were determined with Flame emission photometry. The pH and EC were determined using pH meter and conductivity meter, respectively. The SAR for each sample was then determined using equation 1.

$$SAR = \frac{N_a^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}} \quad (1)$$

Data Analysis

The treatments were analyzed statistically using analysis of variance (ANOVA) in a statistical analysis software (SAS) and the means were separated using Duncan's Multiple Range Test (DMRT). The result was compared with the water from the borehole as a control.

Results and discussion

Analysis of Borehole Water (Control)

The chemical characterization for Borehole Water (BW) from the study location is presented in Tables 2 and 3. The ion concentrations analyzed include Ca^{2+}, Mg^{2+}, K^+ and Na^{2+} while the indices used are pH, Electrical Conductivity (EC) and Sodium Absorption Ratio (SAR).

Ion Concentration

Several elements found in water can affect its suitability for irrigation. Calcium (Ca^{2+}), Magnesium, Potassium, and Sodium were investigated in this study. These elements are important because they have significance in determining the sodicity of agricultural soil. Ca^{2+} found in groundwater has its source in limestone ($CaCO_3$) rocks. From Table 2, a lower value of Ca^{2+} is of great concern to irrigation, this is because Ca^{2+} is known to serve as pH buffer and promote flocculation in soil. Flocculation is the aggregation of soil into lumps to enhance soil structure and aeration, making it easier for plants to penetrate the soil to access water and nutrients. Values above 50 mg/L but less than 100 mg/L are acceptable for irrigation purposes (Baye *et al*., 2022). The assessment of borehole water shows that Ca^{2+} concentration (50.29 mg/L) is just above the level of concern and, hence could be suitable for irrigation but with cautions and monitoring.

Table 2 indicates a lower value of Mg^{2+} (3.74 mg/L) which falls below the level of concern (25 mg/L). Magnesium (Mg^{2+}) is another important macronutrient whose deficiency could be detrimental to plant growth. Mg^{2+} is central to photosynthesis in plants and is a component of chlorophyll. On the flip side, lower values mean reduced photosynthesis and interference with nutrient uptake.

Potassium (K^+) is another macronutrient required by plants for their physiological processes. In low values, it can have an adverse effect on plant growth and yield. Bryan (2000) states that no high levels of concern for plant growth. The assessment of borehole water showed 15 mg/L concentration of K^+.

The sodium (Na^+) assessment of borehole water conducted revealed a value of 110 mg/L, which is above the threshold of 50 mg/L (Baye *et al*., 2022). Sodium at a low level is considered beneficial to irrigation. However, sodium at high levels is problematic leading to sodium toxicity and soil salinity.

pH

The assessment of borehole water showed that the pH is 7.00, which indicates that it falls within the acceptable range (6.50 – 8.40) for irrigation (da Silva *et al*., 2018). The pH of water is crucial in determining the health of plants and the availability of nutrients. This is an important parameter in water suitability for irrigation because it measures the acidity or alkalinity of the water. It is typically measured on a scale of 0 to 14, where 7 is considered neutral. Values above 7 are alkaline (basic), while values below 7 are acidic.

Electrical Conductivity

The EC obtained from the assessment of borehole water as presented in Table 3 was found to be 0.90 dS/m. The reported values of 0.70 – 3.0 by da Silva *et al*. (2018) considered it as slight and can have a little impact on plants. Notably, investigating the electrical conductivity (EC) of water for irrigation purposes is important to prevent soil and crop damage. EC of water can be simply put as measuring the degree to which water conducts electricity. This degree of conduction is relative to the presence of dissolved ions in the water. The high presence of dissolved ions means high conductivity and at the same time high salinity. Irrigation water with high salinity is toxic to plants and causes salinity hazards. EC requires regular tests and monitoring to understand the variability and the potential for high salinity.

Sodium Absorption Ratio (SAR)

The SAR of borehole water was found to be 4.03 while EC was 0.9. From Table 1, it can be said to be moderate and suitable for irrigation purposes. SAR is a dimensionless ratio that relates the concentration of ions of Sodium, Calcium, and Magnesium to assess the suitability of water for irrigation purposes. High values of SAR in water can cause clay swelling which makes soil impermeable to water and consequently hinder plant growth.

The treated greywater using the various treatment media was analyzed for the major water quality parameters and indices for assessment of its suitability for the home-garden irrigation. The indices considered in this study include ion concentrations, SAR, EC and pH of the water samples. While greywater irrigation offers several benefits, it is crucial to consider certain environmental aspects. Proper treatment and management of greywater are essential to ensure its safe use and prevent any potential health risks associated with microbial contamination. Appropriate system design, regular maintenance, and adherence to relevant guidelines and regulations are necessary to safeguard public health and protect the environment (Garzon and Paterlini, 2018)

Table 2: Ion concentration of the borehole water used in the experiment

Ion	Concentration (mg/L)	Level of Concern	Source
Ca^{2+} (mg/L)	50.29	Below 40 mg/L (plant deficiency), above 100 (may cause P and Mg deficiency)	
Mg^{2+}(mg/L)	3.74	Below 25 mg/L (plant deficiency)	(Baye *et al*., 2022)
K^{+} (mg/L)	15	No high level of concern for plant growth.	
Na^{2+} (mg/L)	110	Above 50 mg/L	

Table 3: Chemical characteristics of the borehole water used in the experiment

Indices	Result of Borehole water	USEPA Reuse Standard for Irrigation			
			None	Slight to Moderate	Severe
pH	7.00	Normal range: 6.50 – 8.40			
Electrical Conductivity, EC (dS/m)	0.90		<0.70	0.70 – 3.0	> 3.0
		SAR		EC	
Sodium Absorption Ratio (meq/L)	4.03	0-3	>0.7	0.7 – 0.2	< 0.2
		3-6	>1.2	1.2 - 0.3	< 0.3
		6-12	>1.9	1.9 – 0.3	< 1.5
		12-20	>2.9	2.9 – 1.3	< 1.3
		20-40	>5.0	5.0 – 2.9	< 2.9

Analysis of Treated Greywater

Effect of Treatment Media on Ion Concentrations

The concentrations of ions of Ca, Mg, K, and Na were determined across the different media that were used for treatment and the profiles of removal are shown in Figure 1. The concentration of ions in the control sample as indicated in band A (CTRL) was found to be lower than the concentrations found in all greywater samples of bands B, C and D (BRRW, WMRW, KSRW, and FCRW) that were collected for treatment. Band B shows the removal efficiency of Coconut shells, Sawdust, Sand, Activated Carbon and Pebbles in bathroom water. Concentration ions were found to be in the order of Na^{2+} > Ca^{2+} >K^{+} > Mg^{2+}. The removal capacity of all treatment media was significant on Na^{2+} while other ions had minimal removal. In B and C, the removal efficiency of Coconut shell, Sawdust, Sand, Activated Carbon, and Pebbles in Washing Machine water was observed. The result showed that the concentration of ions was in the order of Na^{2+} > Ca^{2+} >K^{+} > Mg^{2+}. The removal capacity was moderate in all the treatment media used. However, Band D showed a slight difference in the order (Na^{2+} >K^{+} > Ca^{2+} > Mg^{2+}) of ion concentrations in the Kitchen Sink water and Floor cleaning water. The removal capacity can be said to be moderate in all the treatment media used. Sodium has the highest concentration in all the greywater samples compared to other ions in the order of Na^{2+} > Ca^{2+} >K^{+} > Mg^{2+}. The control has a lower sodium concentration (110 mg/liter) followed by BRRW (318 mg/liter) and WMRW (342 mg/liter) then FCRW (415 mg/liter). The highest concentration was in the KSRW (421 mg/liter). This is probably due to the high waste materials especially dissolved foods and oils spills in the water from the kitchen sink (KSRW). Radingoana *et al*. (2020) in their study found elevated levels of salt concentrations in greywater, with exceptions from laundry water. The sodium concentrations in the treated greywater from various sources range from 196 to 415 mg/liter. These values even after the treatment are far above the threshold level of 50 mg/liter (Baye *et al*., 2022). The percentages of sodium removal after treatment with various media (coconut shells, sawdust, sand, activated carbon, and pebbles) were found to be within the range of 1.4 to 38.4%, with highest removal (38.4%) in the bathroom greywater treated with sand, and the least percentage removal (1.4%) was in kitchen sink greywater treated with coconut shell. These imply that, the simple treatment techniques employed in this study perform better for greywater with lower ion concentrations, which suggest the use of more advanced techniques such as laboratory scale gray water treatment plant (Pangarkar *et al*., 2010) and a non-conventional system for accumulating and filtering of greywater (Garzon and Paterlini, 2018), etc., for the treatment of greywater of higher ion concentrations.

In general, Bands B and C showed improved removal of sodium ions from the greywater while calcium and magnesium ions remained relatively stable. This could have a significant impact on the sodium absorption ratio. While Band D showed higher values of sodium ions while the calcium and magnesium ions remained relatively stable, this could portend danger of sodium toxicity.

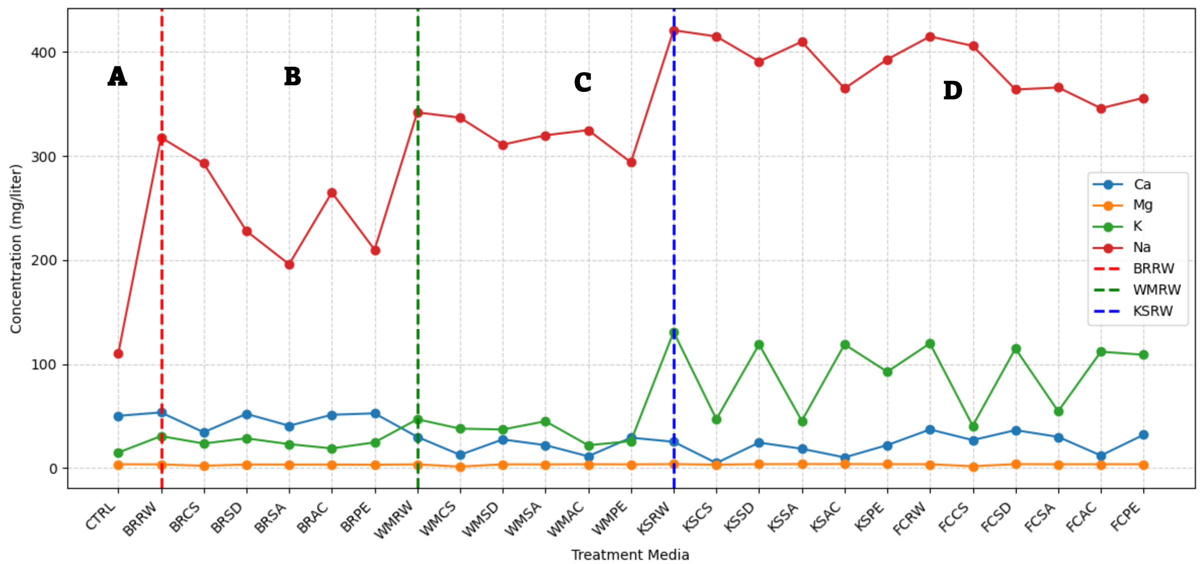

Figure 1: Ion concentrations across different Treatment Media

Effect of Treatment Media on Sodium Absorption Ratio and Electrical Conductivity

The comparison of SAR and EC gives good information on the quality of greywater for irrigation. Figure 2 showed that Band B (Bathroom water) had lower values of SAR ranging from 7.6 – 13. The least SAR value (7.6) was attained from the greywater treated with Pebbles. These values can be attributed to the reduction of Na^{2+} ions after treatment. However, Bands C, D and E for the treated greywater sourced from washing machine, kitchen sink and floor cleaning, respectively showed high trends of SAR ranging between 13.6 – 35.3. The high values of SAR (35.3) could be attributed to the higher concentrations of the ions in the mentioned water sources and also poor sodium reduction after treatment thereby resulting in high SAR in the greywater even before the treatment. This implies that, the techniques adopted in this study though simple and cost-effective for greywater treatment, an advanced technique is required for effective treatment of greywater (especially from washing machine, kitchen sink and floor cleaning) for irrigation. However, where the advanced technique is not accessible, bathroom water could be treated with pebbles for use in home-garden irrigation.

The electrical conductivity (EC) in all the treated greywater using different media (coconut shells, sawdust, sand, activated carbon, and pebbles) ranges between 0.75 to 2.8 dS/m. The highest value (2.8 dS/m) was in treated greywater from the floor cleaning using sawdust and the lowest (0.75 dS/m) was in the bathroom water treated with Pebbles. These values are within the acceptable range (0.70 – 3.0) recommended for irrigation water (Zaman *et al*., 2018).

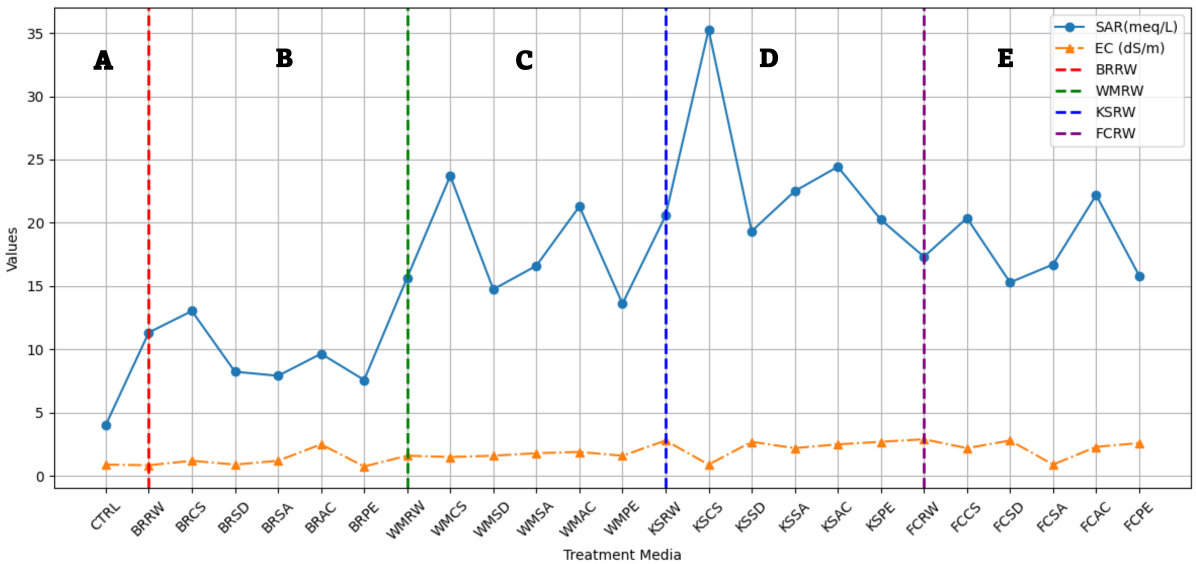

Figure 2: Comparison of SAR and EC for Control and Treated Greywater using different Treatment Media

Effect of Treatment Media on pH

Variability in the pH of treated samples is depicted in Figure 3. The assessment of pH levels in the various water samples revealed that the average pH values for borehole water and treated greywater from BR, MW, and FC all fell within the acceptable range (6.50 – 8.40) for irrigation purposes (Zaman *et al*., 2018). However, only KS did not meet the specified standard, both before and after treatment using different treatment methods. Bakare *et al*. (2017) observed a similar trend, noting that the greywater originating from the kitchen had the lowest pH value. This lower pH was attributed to the rapid degradation of contaminated food particles and oils, particularly in an anoxic (oxygen-depleted) environment. This phenomenon was distinct from greywater from other sources.

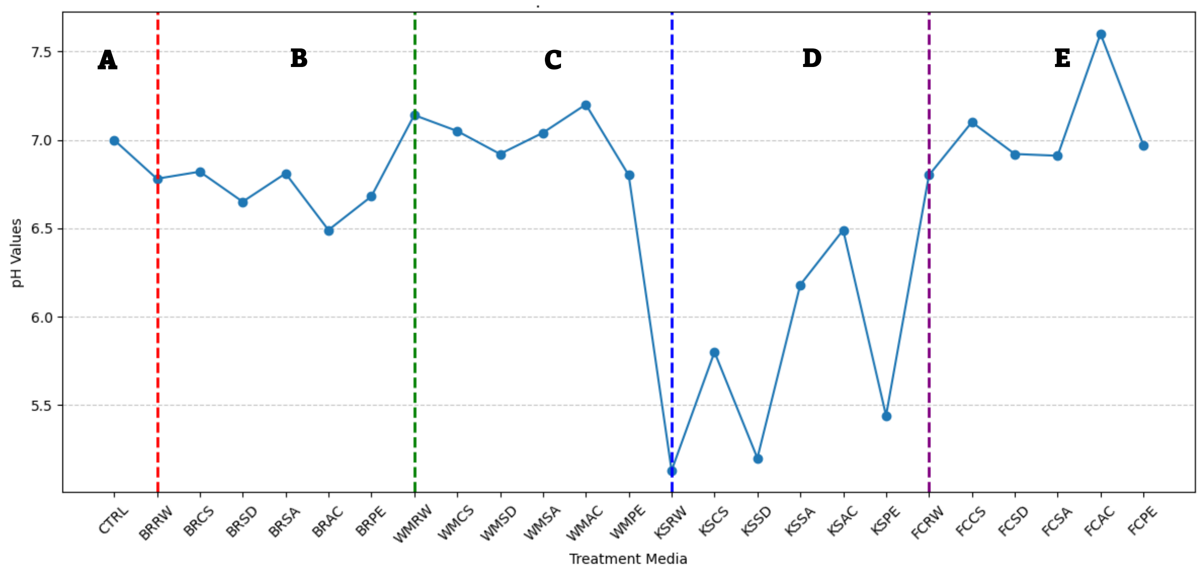

Figure 3: Variation of pH values for different Treatment Media

Statistical Analysis of Treated Borehole and Wastewater using Various Treatment Media

Table 4 presents the statistical means of Na, SAR, EC and pH as affected by water sources and treatment media. The sodium concentration and sodium absorption ratio are significantly higher in wastewater from kitchen sink (KS) followed by floor cleaning (FC) and washing machine (WM) then bathroom. The least concentration was from borehole water. The higher concentration of sodium will result in soil toxicity and salinity problems. The treated water with pebbles has the least sodium concentration and SAR followed by sand and sawdust then activated carbon (for sodium concentration). Coconut shell resulted in higher concentration of sodium and SAR. This indicates pebbles has higher ability to remove sodium from wastewater compare to other treatment media considered in this study.

The EC in wastewater from kitchen sink (KS) and floor cleaning (FC) (which are statistically similar) are significantly higher followed by washing machine (WM) then bathroom (BR). The least value was from borehole water (BH). In addition, the treated water with coconut shell has the least EC value followed by sand and pebbles then sawdust. The least value was from activated carbon.

Tables 5 and 6 present the effects of water sources and treatment media interactions on sodium and sodium absorption ratio. Borehole water reported the least sodium concentration with all the treatment media particularly when treated with activated carbon. The highest concentrations were in kitchen sink water treated with coconut shell and sand. When treated wastewater were considered, bathroom water treated with sand has the least sodium concentration. This value is much higher than the threshold of 50 mg/L (Baye *et al*., 2022) for irrigation water. And therefore, suggests for the application of advanced wastewater treatment techniques.

Table 4: Statistical means of indices as affected by water sources and treatment media

Indices	Na	SAR	EC	pH
Water Sources				
BH	97.236e	3.74e	0.983d	6.912b
BR	238.44d	9.23d	1.331c	6.750c
WM	317.44c	17.93c	1.575b	6.987a
KS	394.84a	24.31a	2.137a	5.765d
FC	367.64b	18.03b	2.265a	7.045a
SE±	0.018	0.022	0.047	0.021
Treatment Media				
CS	311.756a	19.23a	1.357d	6.756b
SA	277.800d	13.45c	1.419c	6.735b
PE	269.450e	12.15e	1.725b	6.557c
AC	278.500b	16.19b	1.995a	6.915a
SD	278.090c	12.22d	1.795b	6.496d

Note: Borehole (BH), Bathroom (BR), washing machine (WM), kitchen sink (KS), floor cleaning (FC), coconut shell (CS), sand (SA), pebble (PE), activated charcoal (AC), sawdust (SD), Sodium (Na), Sodium absorption ratio (SAR), Electrical conductivity (EC).

Table 5: Effects of water sources and treatment media interactions on Sodium

	Na				
	Treatment Media				
Water Sources	CS	SD	SA	AC	PE
BH	107.66v	96.33x	96.88w	91.38z	94.13y
BR	293.04q	228.04s	196.08u	265.08r	210.08t
WM	337.04k	311.04n	320.04m	325.04l	294.04p
KS	415.04a	391.04e	410.04b	365.08g	393.04d
FC	406.04c	364.04h	366.08f	346.04j	356.08i
SE±	0.04				
pr > F	<.0001				

Note: Borehole (BH), Bathroom (BR), washing machine (WM), kitchen sink (KS), floor cleaning (FC), coconut shell (CS), sand (SA), pebble (PE), activated charcoal (AC), sawdust (SD), Sodium (Na).

Table 6: Effects of water sources and treatment media interactions on sodium absorption ratio

	SAR				
	Treatment Media				
Water Sources	CS	SD	SA	AC	PE
BH	3.95r	3.80s	3.75st	3.55u	3.65tu
BR	12.95l	8.15n	7.85p	9.65m	7.55q
WM	23.65c	14.65k	16.55h	21.25f	13.55k
KS	35.25a	19.25g	22.45d	24.35b	20.25g
FC	20.35g	15.25j	16.65h	22.15e	15.75i
SE±	0.049				
pr > F	<.0001				

Note: Borehole (BH), Bathroom (BR), washing machine (WM), kitchen sink (KS), floor cleaning (FC), coconut shell (CS), sand (SA), pebble (PE), activated charcoal (AC), sawdust (SD), Sodium absorption ratio (SAR).

Table 7: Effects of water sources and treatment media interactions on electrical conductivity

	EC				
	Treatment Media				
Water Sources	CS	SD	SA	AC	PE
BH	0.985i	0.975i	0.995hi	0.985i	0.975i
BR	1.305fg	1.005ghi	1.305fg	2.395bc	0.645k
WM	1.395ef	1.495def	1.695de	1.795d	1.495def
KS	0.795ik	2.595b	2.095cd	2.395bc	2.805ab
FC	2.305bc	2.905a	1.005ghi	2.405b	2.705ab
SE±	0.105				
pr > F	<.0001				

Note: Borehole (BH), Bathroom (BR), washing machine (WM), kitchen sink (KS), floor cleaning (FC), coconut shell (CS), sand (SA), pebble (PE), activated charcoal (AC), sawdust (SD), Electrical conductivity (EC).

Table 8: Effects of water sources and treatment media interactions on pH

	pH				
	Treatment Media				
Water Sources	CS	SD	SA	AC	PE
BH	6.99cd	6.79ef	6.89de	6.89de	7.00cd
BR	6.85ef	6.75ef	6.85ef	6.55g	6.75ef
WM	7.15b	6.95cde	6.945cde	7.145b	6.745f
KS	5.745i	5.145k	6.145h	6.445g	5.345j
FC	7.045bc	6.845ef	6.845ef	7.545a	6.945cde
SE±	0.0478				
pr > F	<.0001				

Note: Borehole (BH), Bathroom (BR), washing machine (WM), kitchen sink (KS), floor cleaning (FC), coconut shell (CS), sand (SA), pebble (PE), activated charcoal (AC), sawdust (SD).

Conclusion

Sodium has the highest concentration in all the greywater samples namely Bathroom (BR), washing machine (WM), kitchen sink (KS) and floor cleaning (FC) water compared to other ions in the order of $Na^{2+} > Ca^{2+} > K^{+} > Mg^{2+}$. The percentages of sodium removal after treatment with various media (coconut shells, sawdust, sand, activated carbon, and pebbles) were found to be within the range of 1.4 to 38.4%, with highest removal (38.4%) in the bathroom greywater treated with sand and the least percentage removal (1.4%) in kitchen sink greywater treated with coconut shell. These imply that, the simple treatment techniques employed in this study performed better for greywater with lower ion concentrations. In addition, the techniques adopted in this study though simple and cost-effective for greywater treatment, an advanced technique is required for effective treatment of greywater (especially from washing machine, kitchen sink and floor cleaning) for irrigation. Nevertheless, where the advanced technique is not readily available, bathroom water could be treated with pebbles or sand for use in home-garden irrigation.

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a. Treatment setup using plastic bottles

b. Treatment setup containing media and treated sample

c. Graywater before treatment

d. Graywater after treatment

Plate 1: Experimental setup, treatment media, greywater, and treated samples