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Characterization of Wastewater and Evaluation of Recycling Technologies Using Analytical Hierarchical Process for a University Community

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ABSTRACT

Characterization and treatment of greywater are major environmental issues in most nations of the world. The research aims to characterize and evaluate recycling technologies using an analytical hierarchical process for Afe Babalola University Ado-Ekiti (ABUAD) community. A survey was conducted around ABUAD to determine the number of functioning boreholes and active water systems in the area, the total population of students was derived from the total head count of each room and student in each hostel, and a population projection for the next 3 years was conducted to determine the rate at which the student body will grow in terms of future water demands, and daily water volume and questionnaires were used to collect data. Before developing the small-scale model of the greywater filter system (consisting of activated carbon, shaft sand, pebbles, cotton fiber, and gravel), water grey samples were gathered from several ABUAD locations to evaluate the pollution level of each greywater source. A total of 88 students (43 males and 45 females) replied to the survey, revealing their high need for clean water and their dissatisfaction with the water supply in their respective hostels. The water quality tests conducted in the various locations of ABUAD reveal high levels of total dissolved solids (TDS) and turbidity, particularly in the girl's hostels, and the water was discovered to be predominantly alkaline. After passing a sample of greywater through the small-scale greywater filtering device, it was determined to be effective, since it produced clear, reusable water and a greywater filtration system in ABUAD will yield favorable outcomes.

INTRODUCTION

Greywater is any effluent generated in homes or offices from streams or outlet pipes that is free of feces. Greywater, by definition, is wastewater from showers, baths, basins, and washing machines. Greywater treatment is simpler and less expensive than municipal wastewater treatment, which has sparked a lot of interest and a lot of focus on its use and recycling methods. Greywater re-use and reuse are commonly used in restroom flushing, washing, and other non-potable applications. Water shortages caused by poor rainfall or high demand, as well as environmental and economic drivers, are all recycling reasons. It's also true that recycling is an emotional issue that grows in proportion to the public's proximity to the recycling application. Water pollution is caused by the influx of foreign material that can degrade a body of water's water quality, endangering human life and health in the process. One particular point source of water pollution is industrial effluents (Mathurin et al. 2022; Awomeso et al. 2010). Industrial effluents that include harmful substances can harm both people and animals and deteriorate the quality of the water (WHO 2008).

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As a result, public perception difficulties can often exceed technical issues as impediments to adoption, resulting in the cancellation of otherwise viable economic reuse programs. Water recycling in the urban setting is one of the four generic water recycling strategies available for water resource management and use that is likely the least well-developed. Utilizing recycled greywater lessens the pressure on the water supply system and the sewage treatment process. It also reduces the quantity of downstream wastewater infrastructure required (collection, treatment, and disposal). One of the most prevalent applications of reusable greywater is the lowering of sewage effluent into surface water, which is environmentally advantageous. This research concentrates on greywater water quality metrics such as BOD, COD, turbidity, heavy metals, salinity, conductivity in mg.L^{-1}, pH, and microbiological content values, as well as a decentralized viable treatment process to bring these parameters to the appropriate quality to meet the reusable water quality requirements.

PAST STUDIES

Water is composed of the chemical components hydrogen and oxygen, and water exists in gaseous, liquid, and solid states (Fernández et al. 2022). It is one of the most abundant and indispensable. At room temperature, it is a tasteless, odorless liquid with the ability to dissolve a wide variety of other compounds. Water's versatility as a solvent is essential for the survival of all living things. It is necessary for all known forms of life despite lacking caloric or biological ingredients. Surface water and subterranean water are the two primary sources of water. Water is one of the most essential elements for human survival among those that are necessary for the survival of humans, animals, and plants. Man can survive for days without food, but not without water. It is believed that life began in the aqueous solutions of the world's oceans, and biological activities such as blood and digestive juices are dependent on aqueous solutions. Water exists on planets and moons outside and within the solar system. Small amounts of water appear colorless, but a slight absorption of light at red wavelengths imparts a blue hue to the substance. Although water molecules (H_2O) have a simple structure, the physical and chemical properties of the compound are exceedingly complicated and not typical of most substances on Earth. Water occurs as a liquid on the Earth's surface under normal conditions, making it invaluable for transportation, leisure, and as a habitat for a variety of plants and animals. The ability of water to readily transform into a vapor (gas) enables it to be transported from the oceans to inland places, where it condenses and nourishes plant and animal life like rain. The majority of the water on the Earth's surface is found in the oceans (97.25 percent) and polar ice caps and glaciers (2.05 percent), with the remaining distributed among freshwater lakes, rivers, and groundwater. As the global population and demand for freshwater rise, water filtration, and recycling are becoming increasingly important. Surprisingly, industrial water purity standards are frequently greater than those for human use. For example, the water used in high-pressure boilers must be at least 99.999998 percent pure. Because it includes significant levels of dissolved salts, seawater must be desalinated for most uses, including human consumption.

To reuse greywater for toilet flushing, bathing, cleaning, and washing, the primary objective of this study is to analyze various treatment methods, characterize them, and develop a water recycling process. Because flushing, bathing, cleaning and washing account for 25-35 percent of total household freshwater usage, reusing wastewater for toilet flushing, bathing, cleaning, and washing can save up to 25%-35% of total household freshwater demand. Petroleum hydrocarbon pollution is one of the most serious problems affecting the globe today since it is one of the most hazardous pollutants in aquatic and land habitats (Imron et al. 2019, Khalid et al. 2021). Oil spills, whether they are caused naturally or artificially, can contaminate the oceans with petroleum compounds. Natural spills include those caused by volcanic eruptions and natural leaks from underwater reservoirs. Synthetic spills include those caused by a variety of processes, such as oil extraction and transportation spills, oil loading operations, and transportation accidents. The poor management of medical waste and environmental pollution are two key issues that emerging nations must address to improve public health, natural ecosystems, and the environment (Oyebode & Otoko, 2022, Andarge 2019). The absence of water treatment technologies has led to substantial pollution in emerging and rapidly developing countries. Increasing aquatic pollution puts aquatic life in jeopardy and encourages water scarcity (Dey et al. 2021, Tse-Lun et al. 2021). One of the most economical and environmentally responsible wastewater treatment techniques to be developed in recent years is adsorption. Academic interest has been drawn to several adsorbent materials because of their effectiveness in removing ammonium ions from wastewater (Chopin et al. 2012, Neori et al. 1998). Local geology, land use/management techniques, climate, and human activities can all have an impact on groundwater quality (Ogarekpe et al. 2023, Oyebode 2022a). In transdisciplinary educational research, biomedical engineering (BME) is becoming more important because of technological advancements, a lack of equipment, difficulties in medical practice, and better healthcare-related causes. The question of whether the building materials used are of high quality and whether the design techniques utilized are of high standards has always been essential to sustainability (Oyebodeb 2022). To reduce agricultural non-point-source pollution, numerous technologies have been created (ANPSP). Instead of treating an entire region with numerous pollution sources as a control unit, the majority, however, simply reduce pollution from a single source. To safeguard the environment and promote agricultural sustainability, a regional pollutant reduction system for regulating ANPSP might be constructed by combining technology and the reuse of treated wastewater (TWR) and nutrients (NR) (Sun et al. 2019).

One of the most urgent problems at hand is the possible impact that poor water quality could have on soil, plants, and people. On the other hand, untreated water has a diverse microbial population and can include dangerous species in it. When human or animal excrement enters greywater from washing hands, clothes, or produce, as well as surface water sources, pathogens, which are microscopic organisms that can cause illness or disease, are frequently linked to these sources. A bathroom leak, washing vegetables, or washing hands and contaminated clothing can all introduce people to harmful germs found in greywater (Rose et al. 1991, Birks et al. 2004, Jefferson et al. 2004). Many operations that use freshwater produce wastewater (Tchobanoglous 2003). Typically, these procedures flush or wash away waste materials and nutrients that have been introduced to the water supply. Wastewater needs to be cleaned of pollutants to produce effluent that can be recycled. Effluent can be recycled or used again in the water cycle (Nathanson 2020). Nigeria's population is growing as a result of urban techno-economic growth, changing production and consumption patterns, and increased waste generation. Due to their detrimental effects on the environment and public health, colored pollutants in wastewater must be eliminated before discharge. The quality of groundwater is a deeply held issue for people since it is crucial to preserving water resources and is directly tied to human welfare (Oyebode 2019). Environmental deterioration has existed ever since man first began to live in cities. In the early nomadic hunting societies, the tribe group would move on when their present location's food supply ran out and the area around their camp became polluted or unclean (Oyebode 2018). Wastewater has a wide variety of connotations that might mean different things to different people. Wastewater treatment's main objective is normally to enable the disposal of industrial and human effluents without harming public health or creating an unacceptable risk to the environment (Aderomose & Oyebode 2022).

NEEDS AND IMPORTANCE OF WATER CONSERVATION

Water is a necessity for every life on Earth, including our own. Many human activities rely on the usage of water. These include food preparation (drinking), cleaning (washing), and energy production (producing). Even though 70% of Earth's surface is covered with water, just a little quantity of it may be used for drinking and cooking. Water that has been exposed to salt is unsafe for human consumption in 97% of the world's water. Only 1% of the world's freshwater is fit for human use, making up only 3% of total water. Glaciers and ice caps cover the remaining 2% of the planet's surface. 70% of the water supply is polluted in some way or another. We can only use the water that is available to us at this time. It may seem like a small amount of water, but with an ever-growing population and dwindling water supplies, there is a growing concern that there will one day be insufficient water sources to meet even the most basic demands of the people. Since it is unsuitable for human consumption or industrial use, even for power generation, extremely salty seawater cannot be used. Because of the high salt content, using this water in factories and power plants can lead to salt buildup on machinery, which can be extremely hazardous and even cause major industrial disasters. Seawater does not provide any benefit to humans as a result. Because freshwater supplies are limited and just 3% of the planet's total water supply is available to us, it is only logical that we must protect and conserve our water if we are to continue to exist as a species. There will be no water left in the world if this does not occur.

Source: (Gutiérrez-Ramírez et al. 2018)

BASIC GREYWATER GUIDELINES

Greywater is different from fresh water and requires different guidelines for it to be reused.

i. The storage of greywater is not recommended (more than 24 hours). During storage, the nutrients in greywater begin to degrade and produce an unpleasant stench.
ii. Reduce your exposure to greywater. A disease may enter the water if an infected individual excreted in the water, thus your system should be set up so that water is absorbed into the ground rather than accessible to humans or animals.
iii. Understanding how well water drains into the soil (or the earth's percolation rate) will aid in the right design of a greywater treatment system. A mosquito breeding ground, as well as a site where people can come into touch with greywater, can be found in a greywater pool.
iv. Avoid pumps and filters that require regular maintenance and keep your system as basic as possible. Simple systems last longer, consume less energy, and cost less to maintain.
v. Make switching between the greywater and sewer/septic systems easier by installing a 3-way valve.
vi. Match the amount of greywater to the amount of irrigation water your plants need.

MATERIALS AND METHODS

The methodology adopted includes a survey of borehole functionality in ABUAD. The total population of students was derived from the total head count of each room and student in each hostel, a population projection for the next 20 years was conducted to determine the rate at which the student body will grow in terms of future water demands, and daily water volume and questionnaires were used to collect data. People, businesses, community groups, or even individuals can provide water through a network of pipes via a pumping system. For communities to function correctly, they must have access to clean water.

Uses of Water in a University Environment

1. Personal Hygiene
2. Sanitary
3. Lab Work
4. Industrial Functions

Procedures for Determination of Data

- Obtaining the number of pumps

  The authors went around the different structures and areas in ABUAD, counting the pumps to obtain the number of functioning pumps on the ABAUD campus. In doing that they also looked out for signs that indicated the functionality of each.

- Obtaining population data

Table 1: Interpretation of functionality of water systems in ABUAD.

S/N	Location	Number of Boreholes	Status
1.	New guesthouse	1	Yet to be connected
2.	Front of college 1	1	Dormant
3.	Back in college 1	1	Dormant
4.	Left-back of college 1	1	Dormant
5.	Right-back of college 1	3	Dormant
6.	Back of college 2	2	Functioning
7.	The back of the boys hostel	2	Regulated
8.	Sport complex	1	Yet to be connected
9.	Towards the second adjacent	1	Regulated
10.	The left side towards the anatomy building	1	Yet to be connected
11.	Abuad female hostel	3	Very Good
12.	Back of Abuad female hostel	1	Regulated
13.	Back of Abuad female hostel (behind A and D wing	1	Functioning
14.	Central hall of residence	2	Dormant
15.	Beside Alfa Balgore hall	2	Dormant
16.	Ventures Local kitchen (cafeteria 1)	2	Dormant
17.	Front of kitchen	2	Pumping to capacity
18.	Beside Water plant	2	Pumping to capacity
19.	In front of the laundry	2	Pumping to capacity but not satisfying the users
20.	Back of the water plant	1	Pumping to capacity but not connected
21.	Old Abuad quarters (front of block C)	2	Pumping to capacity
22.	Front of block f	1	Working to capacity
23.	Back of block I	2	It is regulated because of its low yield, also low recharging strength
24.	Front of block	1	Defective
25.	White Rock	1	Very Good
26.	Inside ABUAD teaching hospital	2	Good
27.	ABUAD medical hostel 1	1	Working to capacity
28.	ABUAD medical hostel 2	1	Working to capacity
29.	Beside Caf 1	1	Yet to be connected
30.	Behind Captain Cook	2	Pumping to capacity
31.	Behind NFH1	1	Pumping to capacity but not satisfying the users
32.	Behind PTCF	1	Pumping to capacity
Total		48	

Table 2: Population data:

Name of hostel	4 bedded rooms	2 bedded rooms	1 bedded room
Hostel 1	128	184	16
Hostel 2	128	184	16
4 man deluxe	48		
2 man deluxe		160	24
Freshers' Hostel	192	8	
Med. Hostel		112	
Total Rooms	496	648	56
Total Students	1984	1296	56
Total Boys	**3336**		
Name of hostel	4 bedded rooms	2 bedded rooms	1 bedded room
Abuad Hostel	425	2	17
Wema Hostel	400	5	4
NFH 1	96	260	13
NFH 2	96	14	
Med. Hostel		112	
Total Rooms	1017	393	34
Total Students	4068	786	34
Total Girls	**4888**		
Grand Total (students):	**8224**		

Source: (Field Study, 2022)

To obtain the number of students on campus, the authors went to all hostels and determined their capacity by counting the number of rooms and multiplying by the room capacity. They also obtained population data for previous years from the school registry.

- Daily water volume

  Using the data provided from obtaining the student population, they calculated the total volume of water used in each hostel by multiplying the value by the average volume of water used daily by an ABUAD student

- Population projection data

  The authors projected the future population of ABUAD using the different population forecasting formulas

- Obtaining survey data

  They created a google form containing questions to gather data on the student's interactions with ABAUD water supply facilities and how they perceive the current situation of water supply on campus. Table 1 indicates the functionality of water systems in ABUAD while Table 2 presented information on population data.

Water Consumption

The population of students is 8500 (Wikipedia)

Assumed Consumption per head = 141litres

Total Consumption (water needed) = 1,198,500 litres/day

Breakdown:

- Bathing twice (2) a day at 20 liters = 40 liters
- Flushing of toilets twice (2) per day at 20 liters = 40 liters
- Washing (laundry) at 20 liters (3 buckets) = 60 liters
- Brushing twice (2) a day 0.5 liters = 1.0 liter

Total 141 liters

Water Demands in the hostel = (8500*141) litres

= 1,198,500 liters/day

$$\text{Average water consumed hourly} = \frac{1,198,500\, litres/day}{24\, hrs}$$

= 49,938 liters/hr.

Water Savings

The population of students is 8500 (Wikipedia)

Assumed Consumption per head = 141 liters

Total Consumption = 1,198,500 litres/day

So, if the consumption of water was saved.

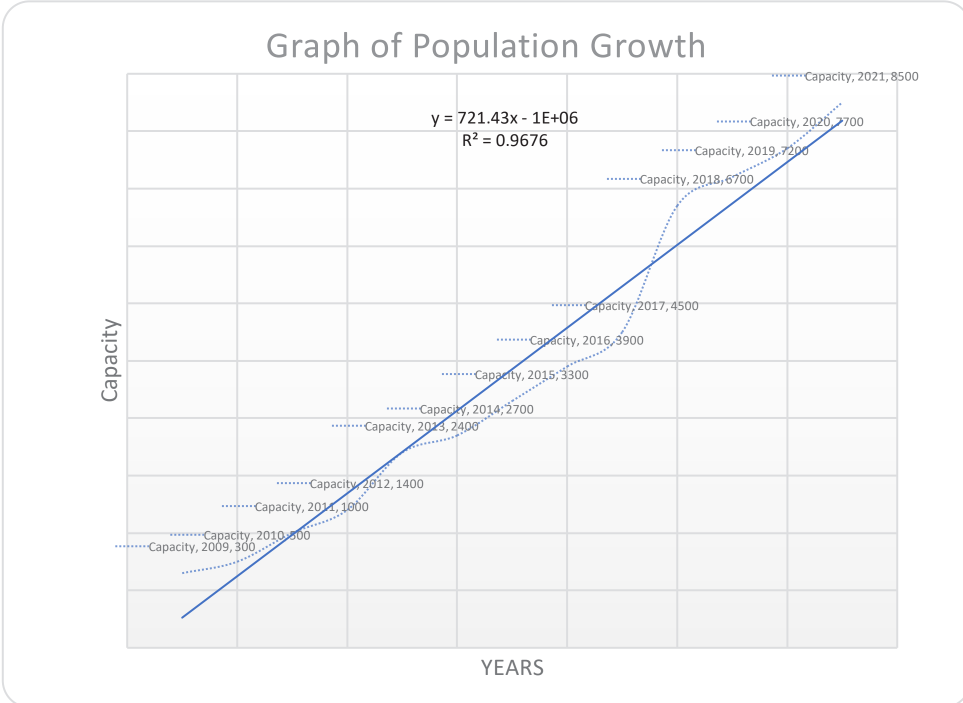


Fig. 1: Population growth between 2010 to 2022.

- Bathing = 40 liters
- Flushing = 20 liters
- Washing = 40 liters

Total 100 liters

100 litres × 8500 people = 850000 liters/day

If Greywater recycling is implemented, 50% of the water used in the ABUAD hostels would save up to 425000 litres/day. Fig. 1 presented the population growth between 2010 to 2022.

Table 3: Capacity forecast.

Years	Capacity
2009	300
2010	500
2011	1000
2012	1400
2013	2400
2014	2700
2015	3300
2016	3900
2017	4500
2018	6700
2019	7200
2020	7700
2021	8500

So, the volume of freshwater that would be needed to be supplied to the hostel would be Freshwater = total consumption – Recycled water

=1,198,500 – 425000

= 773,500 liters/day

Table 3 presented information on the capacity.

Methods for predicting future population growth use both current and historical demographic data. The value of a particular area's current and historical populations can be found in local census records. Population Growth data from 2009-2021:

Total population = 8500

Forecasting for 3 years, that means in 2023, the population will be estimated to be based on the Exponential Increase Method;

$$P_0 = P_n \times e^{k(t_2 - t_1)}$$

$$P_{2023} = 8500 \times e^{0.1(2023-2021)}$$

= 10,382 students (for the year 2023)

Water Consumed in 2023 = 10,382 student × 141 litres = 1,463,862 litres/day

Water saved with greywater system = 50% = 731,931 litres/day saved

As the population grows the water demand also increases over time to prevent water stress within ABUAD, a greywater filtration system should be implemented within the residential areas.

Design of the Greywater Filtration System

Greywater would enter the tank via 762 mm (30 inches) PVC piping from the structure. Scum accumulates on the surface of each tank as greywater runs through it, while solids or heavier particles fall at the bottom. The greywater is then filtered using a greywater filtering system that includes;

1. The gravel and pebbles filter out larger sediments.
2. The sand filters out the fine impurities.
3. The Activated carbon removes contaminants and impurities by absorption through the pores of the activated carbon.

Note: - Water from the filter is still unsafe to drink unless it is purified further for human consumption. Significant suspended particles, biochemical oxygen demand (BOD), turbidity, chemical oxygen demand (COD), and other water parameters are predicted to be reduced at the tank's final exit.

Calculations for Male Hostels Only

For Male Hostels, total population is 3336 boys

Water Consumption for Boys

= 141 liters/day (as previously calculated) * 3336 boys

= 470,376 liters/day

Therefore, the water consumption will be approximated to 500,000 litres/day for design safety.

If 1 m^3 = 1000 litres

Then 500,000 liters = 500 m^3 (Capacity of Sedimentation Tank)

500 m^3 (3.05 m × 14.63 m)

Height × Diameter

Area of tank

= 3.05 m × 14.63 m

= 44.6215 m^2

Water Pipe Sizing

Diameter of pipe = 30 inches

Diameter = 0.762 m

Volume Flow rate =?

Flowrate = Area × Velocity

$$\text{Area (A)} = \frac{\pi}{4} D^2$$

$$A = \frac{3.14}{4}(0.762)^2$$

A = 0.4558 m^2

Velocity

Average Velocity = Length of pipe × Time Taken to flow

= 1.8228 m × 2.4 sec

= 4.4 m/s

For 30 inches pipe, an average velocity will be 4.4 m/s

Now; - Flowrate= Area × Velocity

Q = 0.4558 × 4.4

Q = 2.0 m/s

Q = 2.0 × 3600

Q = 7220 m^3/h

For Sedimentation Tank

Capacity of tank = 500 m^2 (3.05 m × 14.63 m)

The volume of tank = 44.6215 m^2

$$\text{Detention period} = \frac{Volume\ of\ tank}{Rate\ of\ Flow}$$

$$= \frac{44.6215}{\left(\frac{500*10^3}{24}*10^{-3}\right)}$$

= 2.14 h

$$\text{Average flow velocity} = \frac{length}{Detenton\ time}$$

$$= \frac{3.05m}{2.14hrs} = \frac{305cm}{(2.14*60)} = 2.375 \text{ cm/min} = 1.425 \text{ m/h}$$

Flowrate = Area × Velocity

Q = VA

$$A = 2\pi r(r+h)$$

$$= 2 \times 3.14 \times \left(\frac{14.63}{2}\right) \times [\left(\frac{14.63}{2}\right) + 3.05]$$

A = 476.4 m

Q = 1.425 m/h × 476.4

= 678.87 m^2/h = 0.188575 m^2/s

Sand Filter and Carbon filter

Following the septic tank, a sand filter and carbon filter will be used to reduce BOD, COD, TSS, and fecal coliform. Sand filter medium supplemented by gravel and activated carbon would be utilized in a 500 m^3 tank.

The surface area required for the filters will be calculated using a greywater flow rate of 7220 m^3/hr. and a sand media filtration rate of 15 m^3/m^2.hr. The surface area = 476.4 m^2

Filtration Velocity =

$$\frac{Flow\ rate\ from\ the\ pipe}{Surface\ Area} = \frac{7220m^3/h}{476.4m^2} = 15.16\ m^3/m^2/h$$

Since this tank's area is larger than the required filtration area it should be sufficient for use.

Like the septic tank system, the sand filer would be placed in a trench with backfilled gravel and activated carbon at a depth of 3/4 the height of the tank.

Disinfection Tank

The disinfection tank will contain chlorine, which will be used to disinfect the water after it has been filtered. This will ensure that the water is not contaminated. Therefore, the chlorine dosage for the water will be 130 mg/L if the desired chlorine residual is 60 mg/L

Chlorine demand, mg/L = Chlorine dose, mg/L - Chlorine residual, mg/L

= 130 mg/L – 60 mg/L = 70 mg/L

Storage Tank

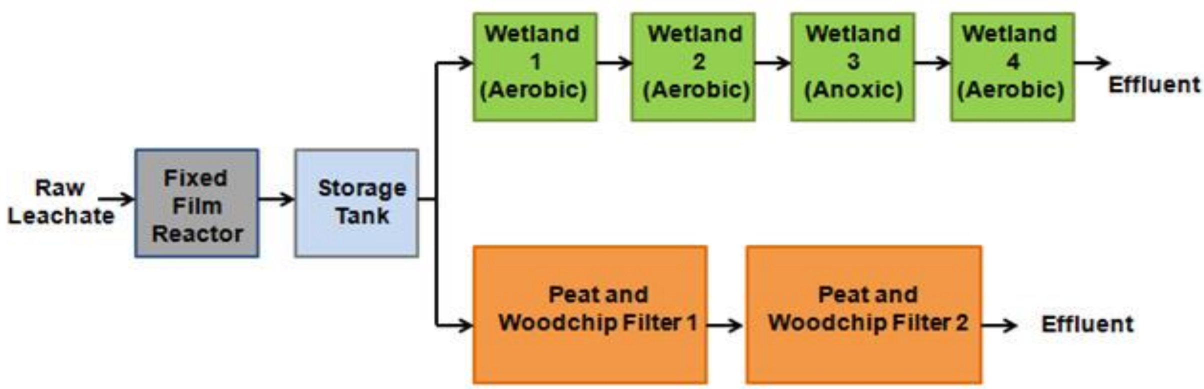
The sand, carbon, and gravel filter-treated greywater will be stored in the storage tank. A 500 m^3 storage tank would be used since the capacity is the nearest size that is available locally. The efficacy of the filter calculated above was tested using a small-scale model, which was then used to filter the wastewater. All water that has come into touch with rubbish contained in a landfill is considered landfill leachate. Continuous confined animal operations, such as milk and egg production, necessitate agricultural wastewater treatment. With mechanical treatment devices that are equivalent to those used in industrial waste disposal, it can be done as long as the property is easily accessible, seasonal use circumstances such as breeding or harvesting may necessitate lower operational expenditures. Anaerobic lagoons are frequently used to store animal slurries before they are sprayed or dripped onto grassland. Occasionally, manmade wetlands are used to dispose of animal feces. Fig. 1 presented leachate sewage treatment flow chart. Fig. 2 presented the membrane Bioreactor design, while Fig. 3 presented a hydrological map of Nigeria showing the major inland waters.

Membrane bioreactors join microfiltration (MF) or ultrafiltration (UF) with a biological process, such as a suspended growth bioreactor, for wastewater treatment (WWT). The membranes act as a filter, removing particles that form during the biological process and producing a clean, pathogen-free product. Fig. 3 presented a typical Membrane Bioreactor design.

The hydrological map of Nigeria depicts the country's most important inland waterways. Fig. 4 presented the hydrological map of Nigeria.

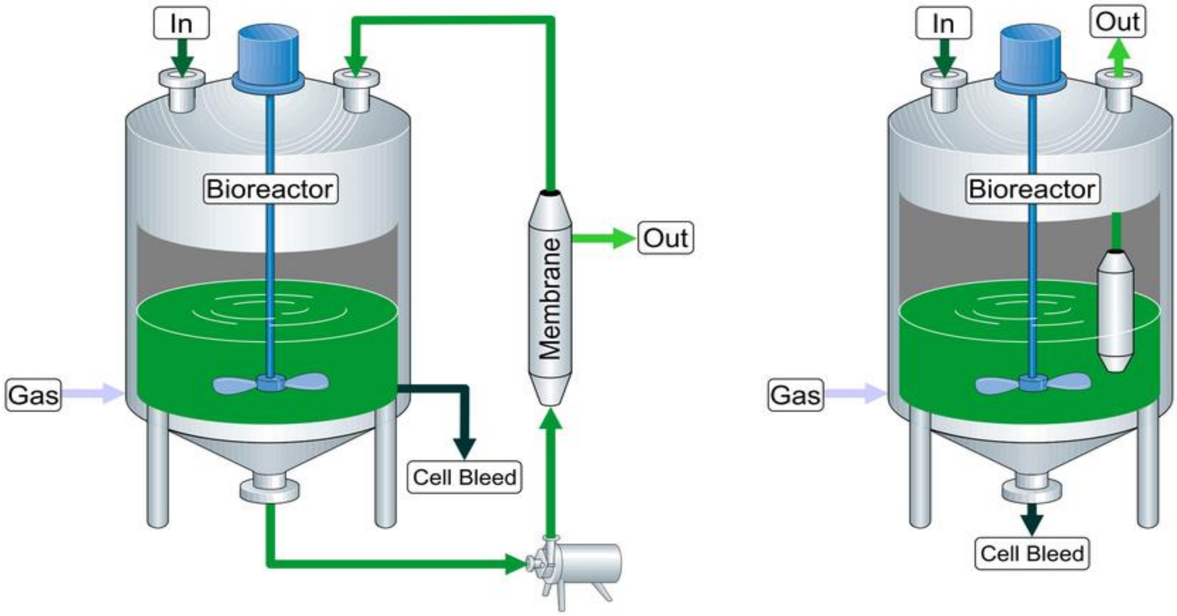
RESULTS AND DISCUSSION

A questionnaire was prepared to measure the daily water usage in the ABUAD Community's male and female hostels and to determine whether the water supply in ABUAD is enough. It comprises everything that must be assessed to determine the study's viability.



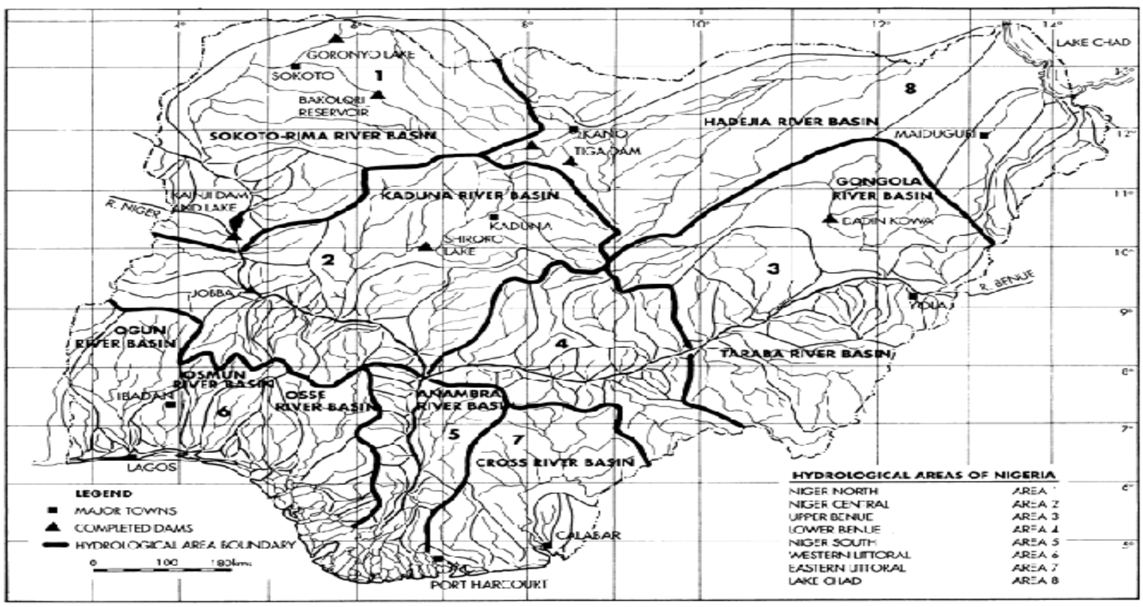
Source: (Lugowski et al. 2014)

Fig. 2: Leachate sewage treatment flow chart.



Source: (Sárvári Horváth 2016)

Fig. 3: Membrane bioreactor design.



Source: (Oladimeji 2018)

Fig. 4: Hydrological map of Nigeria showing the major inland waters.

Fig. 6 presented information on the daily use of water in the hostel while Fig. 7 presented a statistical analysis of various use of water in the hostel.

The above survey results reflect the numerous responses received from both male and female students in their hostels, demonstrating their various water usage and satisfaction

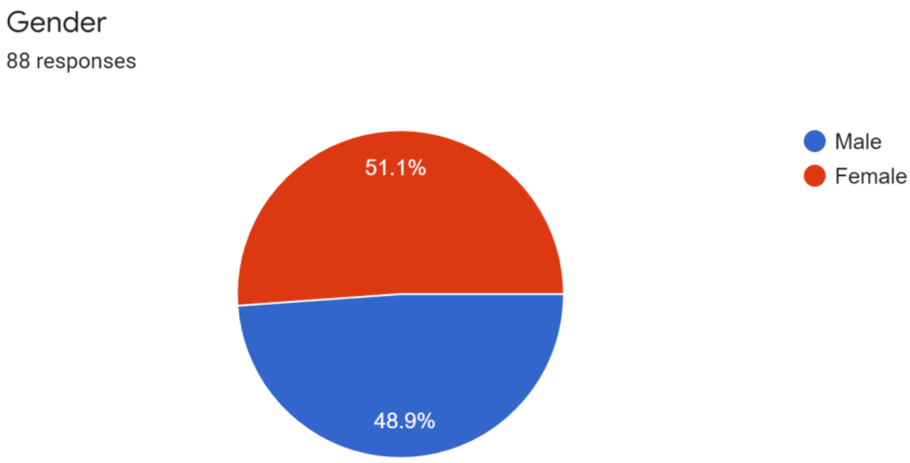


Fig. 5: Results from Google Form Questionnaire.

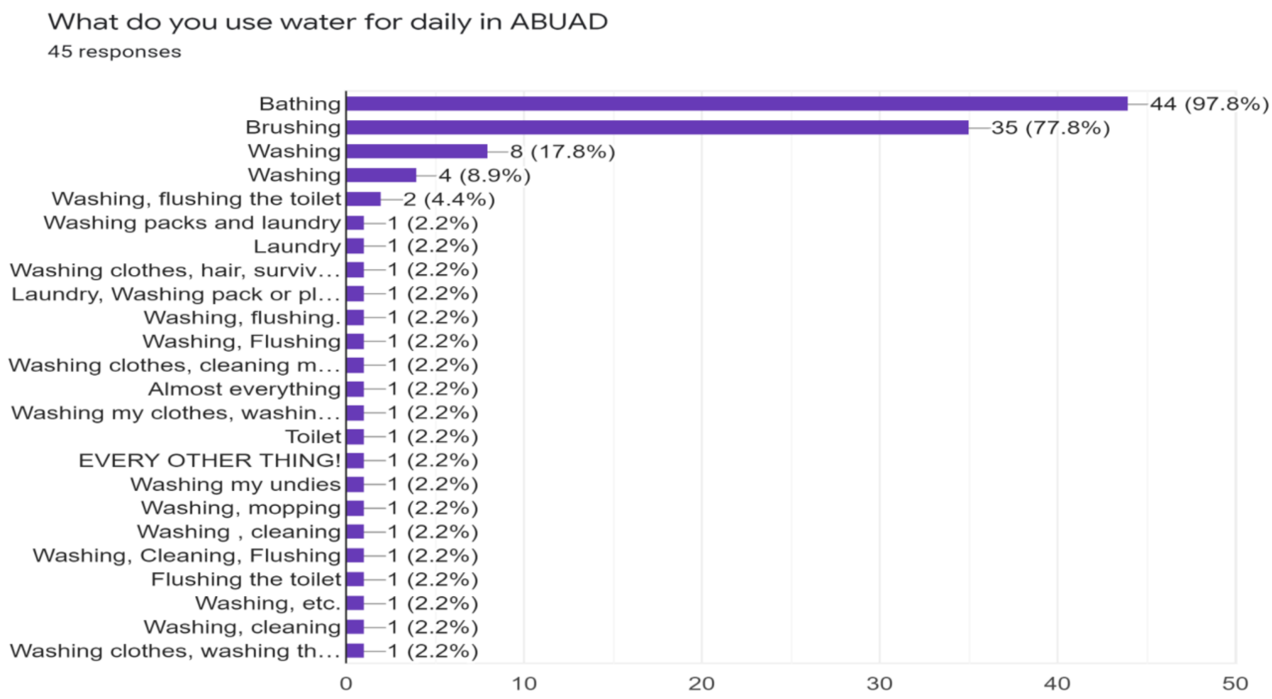


Fig. 6: Daily use of water in the hostel.

levels with the water supply. The results of the survey reflect their discontent with the water supply in their hostel, as shown in the survey form above, which received 88 replies (43 responses from boys and 45 responses from ladies).

Results for the Water Quality test done before and after Filtration

Table 4 presents the results of the water quality test carried out before treatment.

The water qualities in Table 5 demonstrate the various qualities and metrics of wastewater collected from several locations in ABUAD. Table 5 presented heavy Metals present in the greywater sample and Table 6 presents the results of the water quality test carried out after treatment and their comparison to the required water quality standard. It also presented the water qualities of the sample collected after they have been passed through the filtration system and their comparison to NDW standards.

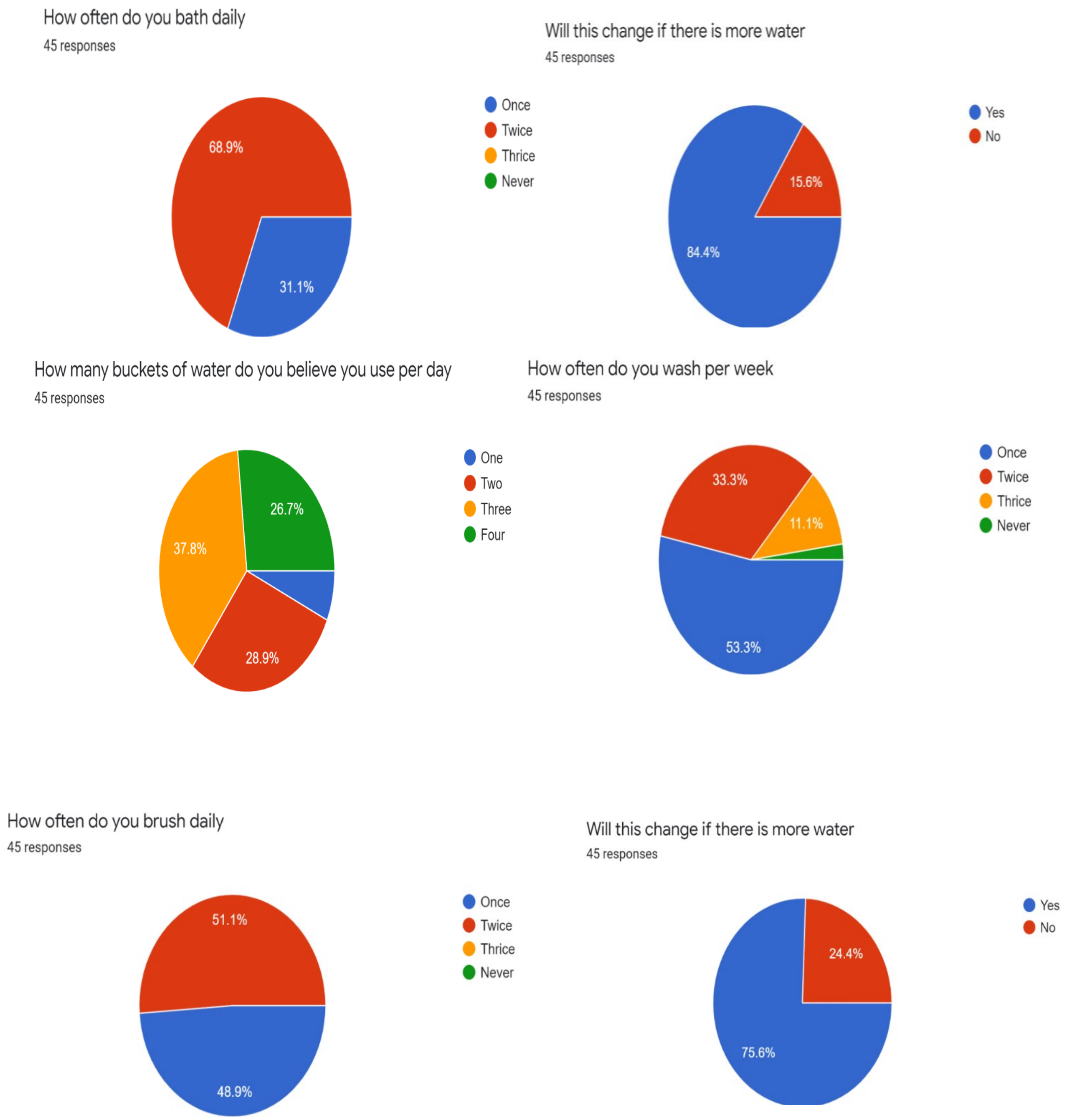


Fig. 7: Statistical analysis of various use of water in the hostel.

Results and values for the calculations are presented in Table 7.

CONCLUSIONS

Although a greywater system can provide an alternative source of water and so reduce demand for main water supplies, it does not reduce overall water consumption; rather, it recycles water that has already been consumed. Residential non-profit water recycling for washing and toilet flushing has been demonstrated to significantly reduce the amount of potable water used. The system has been demonstrated to be a technically viable water delivery solution, especially in long-established institutions such as ABUAD. The

Table 4: Results of the water quality test carried out before treatment.

S/N	TEST	Unit	Boys Hostel 2	Laundry	Cafeteria	Girls Hostel 1	Boys Hostel 2
1.	Ph	TCU	8.4	10.94	7.3	8.5	10.2
2.	Total dissolved solids (TDS)	mg/L	9.63	12.71	1424	1232	681
3.	Turbidity	NTU	516	854	88.7	697	270
4.	Calcium Hardness	mg/L	184	180	194	189	174
5.	Conductivity	µs/cm	19.28	25.4	12.87	12.46	13.79
6.	Dissolved Oxygen	mg/L	5.68	4.22	5.87	5.88	5.71
7.	Biochemical Oxygen Demand (COD)	mg/L	30	22	48	46	41
8.	Chemical Oxygen Demand (COD)	mg/L	96	113	164	128	124

Table 5: Heavy metals present in the greywater sample.

		Sample #1		Sample #2	
S/N	Metals	Absorbance	Concentration (mg/L)	Absorbance	Concentration
1.	Pb	0.035	1.570	0.052	9.667
2.	Cd	0.140	1.950	0.167	2.360
3.	As	0.004	0.036	0.013	0.199
4.	Cr	0.160	3.260	0.102	2.044
5.	Mn	0.206	2.270	0.174	2.476
6.	Fe	0.145	2.618	0.156	2.817
7.	Cu	0.230	3.245	0.476	6.774
8.	Zn	0.107	1.361	0.239	3.137

Table 6: Results for the water quality test carried out after treatment and their comparison to the required water quality standard.

S/N	TEST	Unit	Boys Hostel 2	Laundry	Cafeteria	Girls Hostel 1	Boys Hostel 2	Nigeria Drinking Water Standard
1.	pH	TCU	7.43	7.31	7.46	8.11	7.61	6.5-8.5
2.	(TDS)	mg/L	360	288	12.2	10	234	500
3.	Turbidity	NTU	4.68	4.35	5.68	4.85	4.42	5
4.	Calcium Hardness	mg/L	85	85	123	136	112	150
5.	Conductivity	µs/cm	178	182	184	188	174	1000
6.	Dissolved Oxygen	mg/L	3.86	3.65	3.78	3.64	3.52	6.5-8
7.	Biochemical Oxygen Demand (BOD)	mg/L	2.57	3.6	3.9	3.96	2.87	1
8.	Chemical Oxygen Demand (COD)	mg/L	16.5	16.8	27	22	17.8	-

Table 7: Results for population forecast and water demand.

Total current population of ABUAD 2021	8500 people
Future Design period	3 years
Total Population in 2023	10,382 students
Water Consumption per student	141 liters
Water Demand in the hostel daily	1,198,500 liters/day
Water Recycled (50%)	425,000 liters/day
Freshwater Saved	773,500 liters/day

fundamental objective of this research is to investigate the viability of implementing greywater recycling systems in ABUAD residential areas, characterize wastewater in the ABUAD community, and evaluate recycling technologies using Analytical Hierarchy methodologies. The amount of water that was calculated to be saved daily with the use of a greywater recycling system was demonstrated to be effective if it was implemented in ABUAD residential area. There are numerous options for water treatment, recovery, and reuse. For best efficiency, many low-tech greywater recycling solutions can be combined. As a result, you can't compare treatment methods because the treatment method we choose is determined by the rate of pollution of recycled wastewater. Each recycling method has its own characteristics.

RECOMMENDATIONS

Since recycling wastewater has been shown to offer financial benefits and reduce the quantity of freshwater consumption, these practices ought to be made more widespread shortly. There is not enough knowledge among the general people. As a result, it is recommended that the importance of recycling wastewater is brought to the attention of more people, as well as that awareness be raised. It is possible to explain the significance of wastewater, as well as support the dependability and high quality of reclaimed water. Demonstration projects need to receive more focus, and members of the general public should be invited to see urban water reuse facilities. A facility for recycling greywater should be designed or built at ABUAD so that it may be used to facilitate the reuse of greywater, which in turn will help save freshwater and improve the quality of the environment. Communities and educational institutions should implement a greywater recycling system within their residential areas in other to save costs and increase the shelf life of the environment. Storage of greywater should not be kept for more than 24 hours in other for it not to develop a foul odor. When recycling greywater it should always undergo biological treatment to prevent microorganisms like bacteria, fungi, worms, etc., so it may be consumable for humans.

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