

Design and Construction of Bio-Sand Filtration System for Treatment of Influent Obtained from a Well and Stream

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ABSTRACT

This study used Bio-Sand Filter (BSF) to treat influent from well and stream. BSF was made of plastic container of average diameter 30.60 cm (33.6, 31.4, 30.30, 27) and 40cm length. Filter media were sand (0.425mm – 0.850mm, depth = 7cm), activated charcoal (4cm depth) and gravel (1.18mm – 2.36mm, depth = 9cm). Particle size distribution and specific gravity analyses were done for aggregates using Federal Ministry of Works and Housing Standard. Physico-chemical analyses were done for influent and effluent using American Public Health Association Standard, after 48hours retention. Mass lost in particle size distribution for gravel and sand were; 2.97g and 7.28g respectively, while specific gravity results for gravel and sand were 2.62 and 2.58. Physico-chemical analyses results for influent and effluent of well and stream were; pH [8.1, 7.6], [8.79, 8.0]; Electrical Conductivity [0.78, 0.73], [1.02, 0.89]; Turbidity [2.59, 1.43], [2.65, 2.51]; Nitrate [1.53, 1.10], [1.99, 1.91]; Phosphate [0.09, 0.04], [0.12, 0.08]; Calcium [0.08, 0.04], [0.15, 0.11]; Magnesium [0.27, 0.2], [0.31, 0.29]; Potassium [0.19, 0.1], [0.25, 0.22]; Hardness [120, 114, [106, 104]; Colour 1.29, 1.2], [2.0, 1.8]; Sodium [1.3, 1.0], [2.3, 2.2]; Manganese[0.02, 0.01],

[0.48, 0.29]; Lead [0.04, 0.03], [0.06, 0.06]; Aluminium [0.03, 0.01], [0.05, 0.04]; Biochemical Oxygen Demand [0.4, 0.3], [0.5, 0.47]; Iron [0.011, 0.009], [0.006, 0.04]; Total Dissolved Solids [65, 62], [102, 96] in mg/l respectively. Well effluent results satisfied drinking water quality standards by World Health Organization. This work is applicable in sustainable water treatment for environmental protection.

KEYWORDS: Bio-sand filter, Influent, Effluent, Well, Stream, Treatment

1. INTRODUCTION

According to the World Health Organization (WHO) (2014) [1], water is very critical for human survival and therefore, potable water must be free from any pollutant capable of adversely affecting human health. Furthermore, the WHO reiterated that when humans consume polluted water, waterborne diseases become unavoidable. As such, in the event of waterborne diseases such as diarrhea, dysentery and typhoid fever, children usually suffer the biggest health eventualities. In a previous study, the WHO/UNICEF (2006) [2] concluded that nearly 2 million people die yearly because of waterborne diseases, with a significant

number being children who are not up to 5 years. Furthermore, Sridhar and Oloruntoba (2008) [3], reported that the other waterborne diseases recorded in Nigeria for many years are; encephalitis, ancylostomiasis, trichuriasis, schistosomiasis, trachoma and ascariasis. Thus, communities where these diseases are prevalent have residents spending a huge chunk of their scarce resources on therapeutics.

Also, Ayandiran and Dahunsi (2017) [4] reported that when clean water is consumed regularly and in adequate proportions, this can help expel body wastes and toxins, guarantee easy digestion, optimize body metabolism, cushion body joints and even prevent organs and tissues from damage and or shock. Consequently, Elliot *et al.*, (2018) [5] recommended that every adult human being should have access to a minimum of 150 liters of water daily, in order to meet their sanitary, domestic and even bodily requirements. More so, the study further recommended that an adult male weighing about 70 kg should consume around 35 liters of water daily so as to maintain good health and optimal body functions. However, the continued depletion of water resources in the planet as one of the consequences of climate change has made this WHO recommendation nearly impossible (Olanipekun and Oladejo, 2022) [6].

In order to remedy this serious environmental challenge, scientists and researchers the world over have developed a number of environmentally friendly and affordable treatment mechanisms for the purpose of recycling and or treating used, spent or

unclean water for further use. According to Lynch *et al.*, (2015) [7], some of the treatment approaches that have been adopted globally are; artificially constructed wetlands for wastewater treatment, natural wetlands, rapid sand filtration system, slow sand filtration system and a variant of the slow sand filtration system, known as the bio-sand filtration system. According to the Standards Organization of Nigeria (SON) (2007) [8], the bio-sand filter (BSF) was first developed by Dr. Manz in the University of Calgary, Alberta Canada. The BSF is renowned for its capacity to allow for filtration of water intermittently at the domestic level and has been found to efficiently remove sulfur, manganese and iron from influent samples.

Similarly, the BSF has performed significantly well in the treatment of pathogenic viruses and bacteria present in water, while also helping to remove turbidity in large amounts. Furthermore, Oladejo *et al.*, (2015) [9] reported that another advantage that the BSF has over the slow sand filter is that it can combine different functions such as filtration, straining and settlement into one unit. This therefore, helps in the treatment and remediation of physical, chemical and even biological pollutants that may be present in a water sample. However, suffice to mention that the most critical function of the BSF is carried out in the Shmutzdecke. According to Oladejo (2018) [10], the Shmutzdecke is a hypogeal biological layer, otherwise called biofilm which becomes developed on the surface of the sand in the presence of atmospheric oxygen. This hypogeal biological layer helps to remove deleterious microorganisms present in water.

However, as the influent travel downwards into the filtration system, the oxygen present is used up through the microbial activities occurring within the Shmutzdecke. Subsequently, the downward movement of the influent through the different layers of filter media such as sand and gravel help to remove contaminants present in the influent (Oladejo and Olanipekun, 2018) [11]. This treatment mechanism (BSF) has been reported to be efficient, affordable and reliable in providing solution to the recurring problem of unclean/unsafe water in developing countries like Nigeria (Kubare and Haarhoff, 2010) [12], (Baker and Duke, 2006) [13], Stauber *et al.*, 2006) [14]. To this end, this study embarked on the design, construction and implementation of BSF for the treatment of water samples obtained from a hand-dug well and a stream, in order to provide clean water to the residents of Ijako-Ota community, Ado Odo Ota local government area, Ogun State.

This study is essential because the continued consumption of polluted and unclean water by the residents of Ijako-Ota predisposes them to waterborne diseases and poor living conditions, especially seeing as the community is mostly peopled by low-income earners. This is even more imperative because there is no government provided pipe-borne and potable water in the community – a feature that can be found in all the communities present in the local government. As such, the provision of affordable BSFs in each household in Ijako-Ota can significantly reduce the huge burden of costs accruable to the residents every time

they come down with waterborne diseases. To this end this study is justified. The objectives of this study were; the design and construction of the BSF, the particle size distribution and specific gravity analyses of the aggregates used, the physico-chemical analyses of the influent samples before treatment and the physico-chemical analyses of the effluent samples after treatment.

2. MATERIALS AND METHODS

2.1 Materials Sourcing and Preparation

The materials used for construction of the BSF according to Oladejo (2014) [15] were; locally sourced river sand obtained from a stream in the community and which was subjected to particle size distribution and specific gravity analyses before use; a plastic container bought from Atajere market in Ijako-Ota community; influent samples (fresh water) obtained from a hand-dug well (belonging to a resident) and Atajere market stream both located in the community as shown in Figure 1 and Figure 2 respectively; and activated carbon which was a by-product of charcoal. The charcoal samples were subjected to preparation process outlined by Ekpete *et al.*, (2017) [16]. This procedure was carried out at the central research laboratory, Covenant university, Ota, Ogun State, Nigeria.

Furthermore, the BSF was adopted for this study for the following reasons according to Oladejo *et al.*, (2015) [9]; its efficiency in the removal of pathogenic organisms is very high, through the actions of coagulation and

flocculation it removes suspended particles significantly, it is very affordable to design and build because all the materials required for construction are locally available, the materials used are not prone to corrosion because of the chemical processes of water, and it is very easy to operate and own even for moderately educated or illiterate residents, and it is very convenient to maintain through the backwashing method.

2.2 Design and Construction of the Bio-Sand Filter

For this study, a plastic container having an unequal cross-sectional area was adopted according to Stauber *et al.*, (2006) [14], although, the average diameter of the container used (33.6, 31.4, 30.30, and 27) was 30.60cm. The total length of the plastic container was 40cm, while the topmost part of the contained was fitted with an improvised plastic diffusion pan, in order to allow for easy removal during maintenance. Immediately after the diffusion pan, the filter media were placed which consisted of different grades of gravel (coarse aggregates) and sand (fine aggregates), with the activated carbon as well. Subsequently, the first layer of the BSF consisted of fine aggregates which ranged from 0.425mm to 0.850mm and having a depth of 7cm.

Furthermore, the second layer consisted of the activated carbon, having a depth of 4cm, while the third layer consisted of coarse aggregates which ranged from 1.18mm to 2.36mm and having a depth of 9cm. Similarly, the fourth layer consisted of gravel materials which ranged from 30mm to

40mm. Suffice to mention that every layer in the BSF was separated from each other by a perforated net in order to allow for easy maintenance of the system. Finally, an outlet tap was fitted to the lowest part of the BSF so as to receive the filtered water sample (effluent) as shown in Figure 3 accordingly. Suffice to mention that the retention time adopted for this work was 48 hours according to Tiwari *et al.*, (2009) [17].

However, the general maintenance operations adopted for the BSF after the 48 hours of retention period for the influent from the hand-dug well had elapsed and it was time to introduce the influent from the stream were; the topmost part of the BSF was removed and washed; the layers of the filter bed were gently removed; the lowest part of the BSF were washed with clean water; new layers of clean gravel and sand were rearranged, while activated charcoal was also placed on the filter bed.

2.3 Particle Size Distribution Analysis

The particle size distribution analysis was carried out according to Federal Ministry of Works and Housing (F.M.W H) Specification Requirements (2017) [18] in order to determine the relative sizes of the aggregates and their suitability for use in this study. Usually, the data obtained from particle size distribution analysis can also be adopted for the design of earth dams and water filters.



Figure 1: Hand-dug Well where Influent Sample was Obtained



Figure 2: Flowing Stream where Influent Sample was Obtained

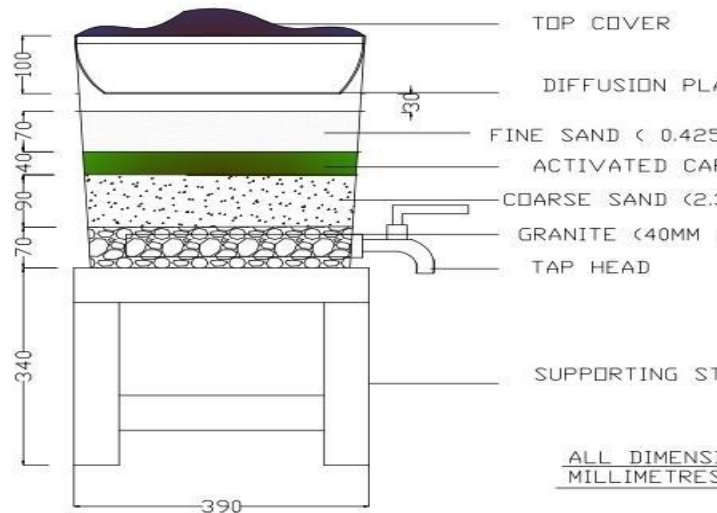


Figure 3: Cross Section of the Designed and Constructed Bio-Sand Filter

The data could also be used in conjunction with permeability data for the prediction of soil and water movement in the ground. The apparatus used were laboratory oven, set of sieves with pan and cover, mechanical sieve shaker, rubber mortar and pestle, receiver, iron cleaning brush and laboratory weighing balance. After oven-drying a measured aggregate sample of 400g, the samples that were lumped together after the oven-drying were ground with the mortar and pestle accordingly.

The weight of the aggregates was measured again in grams and the set of sieves were arranged sequentially from 4.75mm, 3.35mm, 1.18mm, 500um, 425um, 300um, 212um, to 75um). After the sieves have been cleaned with the iron brush, the pan was then positioned beneath the #200 sieve and the soil sample was carefully poured into the top sieve before covering it with the cover. The sieve stack was then shaken for 10 minutes in the mechanical shaker and each sieve's weight was meticulously weighed, to ensure its actual retained soil was noted. The

observed weights were recorded for the lower pan holding the fine soil accordingly.

2.4 Specific Gravity Analysis

This test is often performed for the determination of the phase relationship of solids, water and air, in a given volume of soil. The apparatus used for this study were; pycnometer, funnel, spoon, vacuum pump, weighing balance and water. The initial weight of the clean, empty and dry pycnometer was measured and recorded, labeled W1 while a 50g of an oven-dried soil sample was put in the pycnometer. Furthermore, the weight of the pycnometer after the dry soil has been poured into it was measured and recorded, labeled W2. Thereafter, measured distilled water of half to three-fourth was poured into the pycnometer and the soil sample was left to soak considerably for a period of 10 minutes.

After the 10 minutes were completed, the soaked soil sample was then thoroughly shaken for about 10 minutes in order to expel the entrapped air. The pycnometer was then filled with the distilled water up to the marked portion, while the outer surface of the pycnometer was cleaned with a dry and clean cloth. Thereafter, the weight of the pycnometer and its contents were measured and recorded, labeled W3. When this was completed, the pycnometer was emptied out and cleaned again. Finally, the weight of the distilled water labeled W and that of the pycnometer labeled W4 were measured and recorded accordingly. Consequently, the specific gravity of the soil solids was

obtained using the mathematical relationship in Equation 1;

$$\text{Specific Gravity, } G_s = \frac{(W_2 - W_1)}{(W_4 - W_1) - (W_3 - W_2)}$$

(1)

Where;

W1 = weight of empty pycnometer, g

W2 = weight of pycnometer filled with dry soil sample

W3 = weight of pycnometer filled with water and soil

W4 = weight of pycnometer and distilled water

2.5 Physico-Chemical Analyses

The laboratory apparatus used for the physico-chemical analyses were; porcelain evaporating dishes of 150 – 200 mL capacity, Erlenmeyer flask, steam bath, drying oven, dessicators, pipette, burette, beaker, weighing balance, thermometer, electrical muffle furnace, filter paper, cuvettes, measuring cylinder, colour comparator with discs, atomic absorption spectrophotometer (AAS), nephelometer, pH meter, turbidity meter and Nessler tubes. The procedures followed in the laboratory for carrying out the physico-chemical analyses are in line with the American Public Health Association (APHA) (2019) [18] and are outlined accordingly;

Total dissolved solids

The filtered portions of the influent samples weighing 100 mL through a filter were measured and filtrate from a previously prepared evaporating dish was collected. Thereafter, 100 mL of the samples were poured into the dish and the contents were subsequently allowed to evaporate by

carefully placing the dish onto a steam bath. The dish was then transferred into an oven kept between 103 – 105°C and consequently allowed to dry for 1 hour. Furthermore, the dish was left to briefly cool down in atmospheric air before placing it while still warm in a desiccator for it to completely cool down in a dry atmosphere. The dish was then measured immediately after it had completely cooled, while the mass of the dissolved solids was also measured.

Nitrate

100 mL of each of the influent samples and 2 mls of 2.5 brucine solutions were measured into the conical flasks respectively, while 10mls of concentrated H₂SO₄ was also added into the mixture. The mixture was made up with distilled water and was shaken vigorously for 1 minute, and a noticeable colour developed. The nitrate concentration was then analyzed using the AAS at 420nm wavelength, the colour that developed was matched with a white sheet at about 10cm behind the comparator and the result was recorded in mg/l of nitrate-nitrogen.

Phosphate

100 mL each of the influent samples were collected into an extraction cup, while 5 mls of Murphy and Riley solution (colour reagent) was also added and then 10 mls of distilled water was added to the mixture as well make. The solution was allowed to cool for few minutes and a bluish colour developed. The blue colour solution was then analyzed for phosphate using the AAS at 882nm wavelength.

Biochemical oxygen demand

100 mL each of the influent samples were measured into BOD bottles in a duplicator with the aid of large tip volumetric pipette.

The bottles were filled to the brim with dilution water in accordance with the percentage of dilution required. The stoppers were inserted to prevent air bubbles from entering without leaving air bubbles inside. Dilution greater than 1% was achieved by diluting the water in a volumetric flask before transferring it carefully into the BOD for final dilution. The initial dissolved oxygen (DO) was determined on the undiluted sample and since the sets of

dilutions were made in duplicates; the initial dissolved oxygen (DO) was determined on the one set for 5 days in the dark at 20⁰C in a cooled incubator. Thereafter, the dissolved oxygen (DO) in the incubated samples was determined and the BOD values were thereafter determined at 5days interval.

Colour

The photo electric method was adopted for this work. 10 mL of the standard colour solution were accurately measured into 100ml volumetric flasks which gave a range from 10 to 200 Hazen units. Each of the standard measured quantities were diluted to the required standard with distilled water that was already filtered to remove any turbidity. A calibration graph relating optical density to Hazen units, and care was taken such that the same wavelength to be used for the samples. The samples were filtered through a glass fiber filter paper to remove any turbidity, and the optical density was measured with the AAS at a wavelength between 385 and 470nm. From the calibration graph, the colour of the samples were determined and recorded as colour (instrumental) to the nearest 5 Hazen units.

Turbidity

This was done with the aid of a turbidity meter which uses optical scattering detection techniques for quick and reliable measurements. 100 mL of the influent samples were placed in small glass basins connected electronically to the turbidity meter for measurement in the laboratory. The turbidity meter was switched on and allowed to measure the values of turbidity accordingly.

Hardness

25 mL of the influent samples were diluted into 50 mL of distilled water placed in Erlenmeyer flasks and 1 mL of buffer solution was added to the mixture. Thereafter, 2 drops of indicator solution were added until the colour of the solution became wine red. Furthermore, the standard EDTA titrant was slowly added through continuous stirring till the last reddish colour disappeared out of the solution. When this was completed, the colour of the solution observed at the end point of the experiment turned blue and the volume of the EDTA added to the solution was noted.

pH

This was carried out by measuring 100 mL of the influent samples and putting them in extraction cups. Now, with the aid of a pH meter that was appropriately calibrated the pH of each sample was measured accordingly. Furthermore, the pH meter probe was rinsed with distilled water and standardized with buffer solution of known concentration (pH 7) water. Also, enough quantity of the aliquot sample was poured out into a beaker in order to allow the pH probe to be fully immersed, while the pH meter was turned on.

Calcium, Magnesium, Lead, Potassium, Manganese and Iron: 100 mL of each of the influent samples were collected in the extraction cup and analyzed directly for the presence of calcium, magnesium, potassium, manganese and iron using the AAS and the observed values were recorded.

3. RESULTS AND DISCUSSION

3.1 Designed and Constructed Capacity of BSF

According to the design of the BSF as presented in Figure 1, the results obtained for the BSF bed are;

Length of bed = 27cm

Diameter of the bed (d), = 30.60cm

Length of water space above beds = 13cm

The cross-sectional area of the filter bed can be determined from the mathematical relationship;

$$\Delta A = \frac{\pi}{4} \times d^2$$

$$\begin{aligned} \text{Now, area of water flow} = \Delta A &= \frac{\pi}{4} \times 30.60^2 \\ &= 735.42\text{cm}^2 \end{aligned}$$

1 liter = 1000cm³

30 liters = 30,000cm³

Now, since there are 3 liters flow for 2.48 minutes,

Therefore, it will take 1.27minutes for 1litre to flow

$$\text{Volume of filter water} = 735.42 \times 13 = 9560.46\text{cm}^3$$

$$\begin{aligned} \text{Rate of flow} &= 9560.46 / 1.27 \\ &= 7527.92\text{cm}^3/\text{minutes} \end{aligned}$$

3.2 Results of Particle Size Distribution Analyses

The results for particle size distribution analyses for the aggregate samples (gravel and sand) obtained and analyzed are presented in Table 1 to Table 2 and Figure 4 to Figure 5 respectively. The percentage of aggregates samples passing sieve No 200 in this study were 28.36% and 24.76% respectively. According to the FMW and H Specification Requirements (2017) [17], the percentage by weight that must pass the sieve No.200 must be lower than 35 % for any aggregate material that will be used as fill material for any construction or water retaining structure. Therefore, when the results obtained for particle size distribution analysis are compared with the FMW and H (2017) [17] as seen in Table 1, Table 2, Figure 4 and Figure 5, the results revealed that the aggregates sample largely satisfied the requirements. However, the results still revealed that the soils could still be prone to swelling/expansion and mild shrinkage.

Table 1: Particle size distribution results for gravel

Aperture Sizes (mm) and (µm)	Weight Retained (g)	Percentage Retained (%)	Percentage Passing (%)
4.75	27.55	2.75	97.25
3.35	45.96	4.60	92.65
1.18	170.23	17.0	75.65
500	313.78	32.1	43.55
425	62.84	6.2	37.35
300	119.82	11.9	25.45

212	58.33	5.8	19.65
0.075	156.42	14.8	4.85
Receiver	42.1	4.1	0.75
Total	997.03	99.25	-

Mass lost for this sample was 2.97g
Table 2: Particle size distribution results for sand

Aperture Sizes (mm) and (µm)	Weight Retained (g)	Percentage Retained (%)	Percentage Passing (%)
4.75	28.69	2.87	97.13
3.35	43.89	4.38	92.75
1.18	165.82	16.5	76.25
500	324.5	32.4	43.85
425	61.73	6.17	37.68
300	124.22	12.4	25.28
212	53.88	5.3	19.98
0.075	151.39	15.1	4.88
Receiver	38.6	4.8	0.8
Total	992.72	98.29	-

Mass lost for this sample was 7.28g

3.3 Results of Specific Gravity Analyses

Since specific gravity of the aggregates is often evaluated by the amount of sand present, as well as the mineral contents and the mechanism of soil formation. As such, aggregate materials should have a specific gravity of 2.5 to 2.75 according to the FMWH (2017) [17] specifications, especially those that will be used for construction of water retaining structures. Therefore, the specific gravity results of the soil samples of the

aggregates as shown in Tables 3 and 4 recorded specific gravities of 2.62 and 2.58 respectively. To this end, these values obtained are within the acceptable limits and are fit for use and are presented thus;

Gravel;

Weight of Bottle + Full water (g) (W4) = 1511.1

Weight of Bottle + Gravel + Water (g) (W3) = 1517.4

Weight of Bottle + Gravel (g) (W2) = 603.5

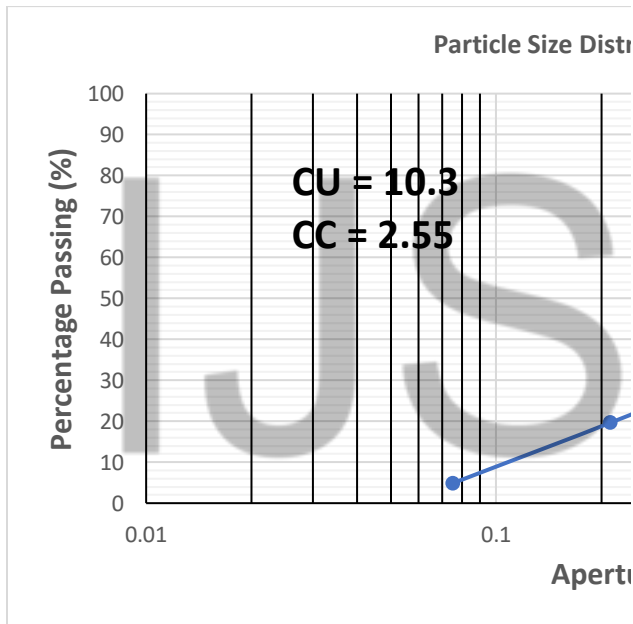


Figure 4: Particle size distribution curve for gravel

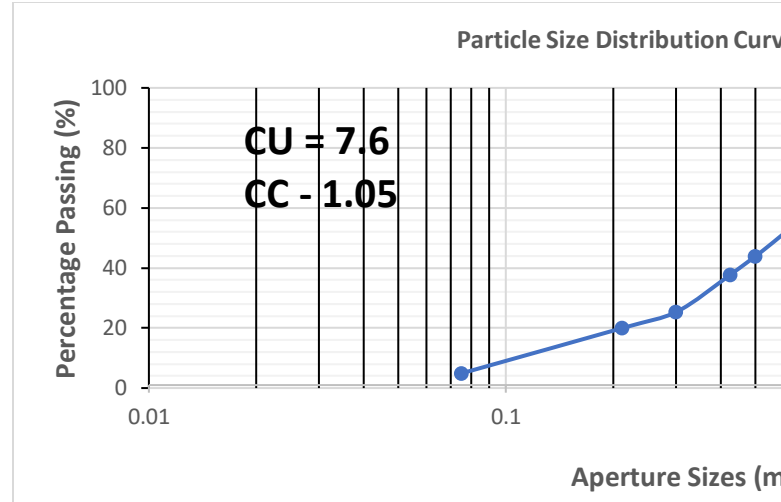


Figure 5: Particle size distribution curve for sand

Weight of Bottle (g) (W1) = 589.1
 Weight of Water to Fill Bottle (g) (W4 – W1) = 922
 Weight of Water Added to Gravel (g) (W3 – W2) = 913.9
 Weight of Gravel (g) (W2 – W1) = 14.4
 Weight of Water Displaced by Gravel (g) = (W4 – W1) – (W3 – W2) = 8.1
 Specific Gravity of Gravel Material (g) (W2 – W1/W) = 2.62

Sand;

Weight of Bottle + Water (g) (W4) = 1505.6
 Weight of Bottle + Sand + Water (g) (W3) = 1512.9

Weight of Bottle + Sand (g) (W2) = 601.4

Weight of Bottle (g) (W1) = 589.1

Weight of Water to Fill Bottle (g) (W4 – W1) = 916.5

Weight of Water Added to Sand (g) (W3 – W2) = 911.5

Weight of Sand (g) (W2 – W1) = 12.3

Weight of Water Displaced by Sand (g) =
 $(W4 - W1) - (W3 - W2) = 5.5$
 Specific Gravity of Sand Material (g) $(W2 - W1/W) = 2.58$

3.4 Results of Physico-Chemical Analyses

The physico-chemical parameters analyzed for in this study were; total dissolved solids, turbidity, alkalinity, hardness, pH, chloride, iron, lead, aluminium, colour, electrical conductivity, phosphate, nitrate, potassium, magnesium, manganese, taste and odour. The analyzed results obtained for both the influent and effluent samples each of the hand-dug well and the stream are presented in Tables 3 and 4 respectively, while the WHO (2018) [5] standards for drinking water quality with which the results were compared is presented in 5 as well.

Table 3: Analyzed results for influent and effluent samples for the hand-dug well

Parameters	Influent for Hand-Dug Well (mg/l)	Effluent for Well (mg/l)
pH	7.9	7.3
Electrical Conductivity ($\mu\text{s}/\text{cm}$)	123	115
Turbidity (NTU)	3.59	3.81
Nitrate	1.53	1.91
Phosphate	0.09	0.08
Calcium	0.08	0.11
Magnesium	0.27	0.29
Potassium	0.19	0.22
Hardness	120	104
Colour	1.29	1.8
Taste	Slightly Objectionable	Objectionable
Sodium	1.3	2.2
Manganese	1.08	1.50
		Lead
		Aluminium
		Biochemical Oxygen Demand
		Iron
		Odour
		Total Dissolved Solids
		Dissolved Solids

Lead	0.66
Aluminium	0.78
Biochemical Oxygen Demand	0.4
Iron	1.1
Odour	Unobjectionable
Total Dissolved Solids	101

Table 4: Analyzed results for influent and effluent samples of the stream

Parameters	Influent for stream (mg/l)	Effluent for stream (mg/l)
Ph	8.5	7.4
Electrical Conductivity ($\mu\text{s}/\text{cm}$)	183	171
Turbidity	4.65	3.98
Nitrate	1.99	1.91
Phosphate	0.12	0.08
Calcium	0.15	0.11
Magnesium	0.31	0.29
Potassium	0.25	0.22
Hardness	106	104
Colour	2.0	1.8
Taste	Objectionable	Slightly Objectionable
		Sodium
		Manganese
		Lead
		Aluminium
		Biochemical Oxygen Demand
		Iron
		Odour
		Total Dissolved Solids
		Dissolved Solids

Table 5: WHO (2018) standards for drinking water quality

Parameters	Values (mg/l)
pH	6.5 – 8.5
Electrical Conductivity	1000
Turbidity	5
Nitrate	50
Phosphate	0.04
Calcium	0.03
Magnesium	0.20
Potassium	0.1
Hardness	150
Colour	15
Taste	Unobjectionable
Sodium	200
Manganese	0.2
Lead	0.01
Aluminium	0.2
Biochemical Oxygen Demand	0.3
Iron	0.3
Odour	Unobjectionable
Total Dissolved Solids	500

The results of the physico-chemical parameters of the effluent sample obtained and analyzed for the hand-dug well as shown in Table 3 mostly fell within the permissible limits prescribed by the WHO (2018) [5], showing a clear departure from the influent sample analyzed. These results confirm the efficacy of the BSF as a water treatment mechanism. However, the results also showed that parameters such as pH, hardness, nitrate, phosphate, sodium and potassium all recorded values that fluctuated noticeably throughout, with most of the values

displaying a tendency to rise. Suffice to mention also that some of the heavy metals analyzed did not also fall within the permissible limits, even though the BSF managed to lower the concentrations of the heavy metals noticeably. This trend may have been so because the water source is groundwater in nature and may also indicate the possibility of leachate and contaminant transport into the water source.

Furthermore, the data is in agreement with the findings of Oladejo and Olanipekun (2018) [6] which also concluded that leachate and contaminant transport contributed noticeably to the prevalence of parameters such as nitrate, phosphate and calcium analyzed in the water sample tested in the study. According to WHO (2006) [2] also, groundwater samples that are intended for domestic uses such as bathing, washing and cooking should be located away from dumpsites, landfills and solid waste collection points where the water could be at risk of being contaminated with the leachate that may be transported into them. However, Olaniyan *et al.*, (2016) [20] also concluded that all it takes for groundwater to be reasonably contaminated is the continued actions of precipitation and infiltration. As these happens, contaminants find their ways into the ground which may eventually be carried down into the groundwater.

This is even more relevant for the hand-dug well sample analyzed in this study because the water source has a pumping machine attached with it and this could have aided the transportation of the contaminants into the influent sample collected. Suffice to mention also that the influent samples for both hand-

dug well and stream were obtained during the rainy season when it is expected that the water table will naturally be high and this may also have contributed to the high values recorded for the parameters mentioned earlier. Furthermore, the effluent sample analyzed for the stream as shown in Table 4 revealed that most of the heavy metals analyzed did not satisfy the minimum requirements as stipulated by WHO (2018) [5].

This is an indication that the anthropogenic activities of the people of Ijako-Ota is contributing significantly to the pollution level of the stream. Although, the BSF reduced some of the physical and chemical parameters analyzed, the reduction however, is not significant enough to make the effluent suitable for domestic use and or consumption. This is because the water source is open to and unprotected from all manner of pollutants generated in its environment.

4. CONCLUSIONS

This study embarked on the treatment of influent samples obtained from a hand-dug well and a stream in Ijako-Ota, Ogun State, Nigeria, through a designed and constructed BSF. From the results obtained, the following conclusions are drawn;

- i) Most of the physico-chemical parameters analyzed for in the effluent of the hand-dug well met the minimum requirements for drinking water quality by WHO showing that the BSF performed optimally well. However, the

results also indicated the possibility of leachate and contaminant presence in the water

- ii) Most of the physico-chemical parameters analyzed for in the effluent of the stream did not meet the minimum requirements for drinking water quality by WHO, indicating the significant pollution that the water is suffering. However, the BSF was still able to bring down the pollution level of some of the parameters tested.

5. RECOMMENDATIONS

This study therefore recommends that Ado Odo-Ota local government should embark on a serious enlightenment campaign that will sensitize the residents of the community, especially the traders in Atajere market about the environmental and public health dangers of the continued pollution of the stream. The local government can also provide a hand-dug well or a borehole water source for in order to take care of the sanitary needs of the traders. Further work should also be carried out to include the bacteriological quality of the water samples tested, while also collecting samples during the dry season as well.

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