EFFICIENCY OF SAWDUST ADSORBENT IN WATER TREATMENT

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ABSTRACT

The goal of any water treatment method is to remove pollutants from such water. This study is an investigation into the efficiency of sawdust adsorbent in removing raw water pollutants. The sawdust adsorbent was set up in a plastic bucket as follows viz: 4cm of gravel layer at the bottom, followed by 4cm of river sand layer, 8cm of sawdust layer and 4cm of gravel layer at the topmost layer. The apparatus has a flow rate of 1.10litre/min, and samples of rain and river water were passed through the apparatus. The study revealed that river water is more turbid than rain water but the adsorbent performed efficiently in attenuating the degree of turbidity and other contaminants in the water samples. Though, the sawdust adsorbent brings about the slight increase in the level of some elements in the water samples but the contaminant level of those elements is still within the water quality guidelines. Hence, sawdust is established as a good filter material.

KEYWORDS: Adsorbent, Efficiency, Raw Water, Sawdust, Treatment

1. INTRODUCTION

Filtration plays an important role in the natural treatment of groundwater as it percolates through the soil. It is also a major part of most water treatment. Filtration can be compared to a sieve or micro-strainer that traps suspended material between the grains of filter media. However, since most suspended particles can easily pass through the spaces between grains of the filter media, straining is the least important process in filtration. Filtration primarily depends on a combination of complex physical and chemical mechanisms, the most important being adsorption (Filtration, n.d.). The goal of all water treatment process is to remove existing contaminants in the water, or reduce the concentration of such contaminants so the water becomes fit for its desired end-use. One such use is returning water that has been used back into the natural environment without adverse ecological impact (Introduction to Filtration, n.d.). Contaminated water causes water-borne diseases such as diarrhoea, which often lead to deaths, children being the most vulnerable (Varkey and Dlamini, 2018). Other common infections that may be acquired from contaminated water are shigellosis, salmonellosis, campylobacteriosis, amoebic dysentery, giardiasis, cryptosporidiosis, typhoid fever, cholera, infections caused by Escherichia coli, hepatitis A, rotavirus, Norwalk-like viruses, a variety of protozoan and helminthic (PHTHC, n.d.). Therefore, the need to intensify research on point-of-use (POU) water purification techniques cannot be overemphasized (Varkey and Dlamini, 2018). A variety of methods or researches have been developed for water treatment or filtration and Österdahl (2015) posits that filters help in decreasing the levels of turbidity, colour, phosphate, total coliform and E.coli in water. The application of water treatment units with slow sand filtration according to Mallongi, Daud, Ishak, Ane, Birawida, Ibrahim, Selomo and Rahman (2017) clearly represent an effective method to supply clean water in an emergency situation where the water source for the communities does not meet the requirements for health. Filtrated water is much cleaner in terms of odour, density, taste and pH. Familusi, Afolayan, Adewumi, Ogundare and Oladipo (2017) had once worked on the suitability of charcoal filter in purifying raw water and their work indicated that high adsorptive capacity of activated carbon enables the filter to adequately remove taste and odour from the filtered water. They concluded that the filter is efficient in the removal of sediments, potential harmful contaminants, volatile organic compounds (VOC) present in the raw water as compared with WHO's standard. It was also concluded in the work of Ajayi and Lamidi (2015), that introduction of Glass-Snail shell ratio into a ceramic water filter composition can be effective for the removal of heavy metals and correction of physicochemical parameters in home use water. Similarly, the use of the Disc Ceramic Water Filters can contribute significantly to the removal of microbial pathogens from drinking water in the developing world, where about 5,000 people die every day from the effects of consuming contaminated water. The porosity, permeability and overall flow rates increase with increasing volume fraction of sawdust (Ndungu, 2015). Countries like Nepal face tough challenges in terms of providing safe, clean drinking water for their citizens. Centralized water supply systems seem to be a solution in the long-term, but the immediate need for clean drinking water necessitates new approaches that can provide solutions and solve the crisis as at the time. Household water treatment technologies, such as ceramic water filters, were able to offer a potentially viable solution to providing clean drinking water by treating water at the point-of-use. These advancements in low-cost ceramic water filter technology coupled with the pressing need for clean drinking water offers an attractive business opportunity for local Nepali entrepreneurs – especially local ceramists who have the resources and capability to manufacture ceramic water filters (Dies, 2003). It is pertinent to submit according to Wan Azlina, Gabriel and Azil (2014) that the main characteristics of raw sawdust based on ASTM method D 5373 include Carbon (53.4%), Hydrogen (6.7%), Oxygen (36.8%) and Nitrogen (3.1%). It was further established in the work of Wan Azlina et al. (2014) that elemental compositions of raw sawdust include elements like Al (13.89%), Ca (12.72%), Fe (8.35%), Mg (0.35%), Si (8.78%) and Zn (19.32%). The thrust of this research work is to assess the efficiency of filter made of local materials like sawdust in the treatment of raw samples of rain and river water.

2. MATERIALS AND METHODS

3.1 Materials and Equipment Required for the Study

The materials and equipment used in carrying out this research work include:

- Two Nos. of 15-litre plastic buckets
- Gravel (retained on 9.50mm, 4.75mm and 2.36mm sieve sizes) thoroughly washed as shown in Plates 1a and 1b.
- River sand (passing through 1.0mm sieve size) thoroughly washed.
- Sawdust (passing through 2.36mm sieve size) thoroughly washed.
- Taps and accessories
- Four Nos. of 5-litre gallons
- Standard physical, chemical and bacteriological laboratories.

Plate 1a: The Larger-Sized Gravel

Plate 1b: The Smaller-Sized Gravel

3.2 Experimental Procedure

Sample Preparation

The sawdust used was collected from a saw mill, along Agbale road, Ede, Osun State. It was washed thoroughly with clean water to remove the organic and inorganic matters. The sawdust was sun dried as shown in Plate 2 and sieved with BS sieve size 2.36mm at the soil laboratory, Federal Polytechnic Ede, Osun State. The gravel used was also thoroughly washed and sieved with a set of BS sieves (1.18mm, 2.36mm, 4.75mm, 9.50mm and 19.0mm sizes) thoroughly washed, while the river sand after thorough washing and sun-drying (as shown in Plate 3), was sieved with BS sieve size 1.0mm.

Plate 2: River Sand Being Sun-Dried

Plate 3: Sawdust Being Sun-Dried

The setup of the sawdust filter

The sawdust filter was set up in a plastic bucket as follows viz: 4cm of gravel layer at the bottom, followed by 4cm of river sand layer, 8cm of sawdust layer and 4cm of gravel layer at the topmost layer.

Determination of flow rate

After the arrangement of various materials in the filter medium, a known volume of water (10 litres) was fed into the bucket and left for the pressure time of 5minutes before the discharge per unit time was determined from the setup.

Filtration process

Distilled water was used to flush the sawdust filter several times until the water discharged from the filter became clear; then the bucket was fed with a known volume of raw water as shown in Plate 4. When the five-minute pressure time was exceeded, the tap was opened fully and white 5-litre gallon was used to collect the filtrate.

Plate 4: The Apparatus Filled with Raw Water

Physico-chemical and bacteriological analyses

Samples of the raw water and the filtrate collected were taken to the laboratory for analyses. The physico-chemical and bacteriological tests were carried out at Osun State Water Corporation Central Laboratory, Ede Nigeria.

3. RESULTS AND DISCUSSION

Determination of Flow Rate

The result of the flow rate carried out on the filter setup is as shown in Table 1. It reveals that the apparatus has an average flow rate of 1.10l/min.

Table 1: Determination of Flow Rate

Trials	Flow Rate (l/min)
First	1.075
Second	1.065
Third	1.057
Total	3.197
Average	**1.10**

Physico-Chemical and Bacteriological Analyses

From Tables 2, 3 and 4, the river water after treatment (with sawdust filter setup) was safe for parameters like Taste, Conductivity, pH, Total Dissolved Solids, Total Alkalinity, Residual Chlorine, Total Hardness, Iron, Copper, Magnesium, Zinc, Nitrate, Sulphate, Chloride, Ammonia, Fluoride, Hydrogen Sulphide, Nitrite, Lead, Cyanide, Cadmium, Arsenic, Bicarbonate, Carbonate, Barium and Mercury but the treated water was unsafe for parameters like Physical Appearance, Colour, Turbidity, Temperature, Dissolved Oxygen, Free Carbon dioxide, Manganese, Phosphate and all of bacteriological parameters, in line with Nigerian Standards for Drinking Water Quality.

Table 2: Result of Physical Test on River Water Sample

S/N	Parameters	Raw Water	Filtered Water	NIS Limit (SON, 2007)	Efficiency (%)	Remarks
1	Physical Appearance	Not clear	Not clear	15.0	-	Unsafe
2	Colour, TCU/HTU	50	30	Unobjectionable	40	Unsafe
3	Taste/odour	Unobjectionab	Unobjecti onable	Unobjectionable	-	Safe
4	Turbidity, NTU	44.20	20.12	5.0	54.5	Unsafe
5	Temperature, ^0C	25.80	26.1	Ambient	-1.2	Unsafe
6	Conductivity, us/c m	254.50	163.00	1000	36	Safe

Table 3: Result of Chemical Test on River Water Sample

S/N	Parameters	Raw Water	Filtered water	NIS Limit (SON, 2007)	Efficiency	Remark
1	pH	7.62	7.18	6.5-8.5	5.8	Safe
2	Total dissolved solids mg/L	25.0	61.0	500	-144	Safe
3	Total alkalinity, mg/L	75.0	100.0	200	-33.3	Safe
4	Dissolved oxygen, mg/L	8.7	8.7	4.0	-	Unsafe
5	Free Carbon Dioxide, mg/L	325	45	10	86.2	Unsafe
6	Residual chlorine mg/L	Nil	Nil	0.2-0.25	-	Safe
7	Total hardness, mg/L	35	40	150	-14.3	Safe
8	Iron, mg/L	0.03	0.20	0.3	-566.7	Safe
9	Copper, mg/L	Nil	Nil	1.0	-	Safe
10	Magnesium, mg/L	1.2	1.5	20	-25	Safe
11	Manganese, mg/L	0.002	0.003	0.001	-50	Unsafe
12	Zinc, mg/L	0.07	0.42	3.0	-500	Safe
13	Nitrate, mg/L	19.0	5.0	50	73.7	Safe
14	Sulphate, mg/L	6.0	Nil	100	100	Safe
15	Chloride, mg/L	12.0	Nil	250	100	Safe
16	Phosphate, mg/L	26.2	26.4	3.5	-0.8	Unsafe
17	Ammonia, mg/L	1.9	1.8	2.0	5.3	Safe
18	Fluoride, mg/L	Nil	Nil	1.5	-	Safe
19	Hydrogen sulphide, mg/L	Nil	Nil	0.06	-	Safe
20	Nitrite, mg/L	Nil	Nil	0.2	-	Safe
21	Lead, mg/L	0.01	0.01	0.01	-	Safe
22	Cyanide, mg/L	Nil	Nil	0.01	-	Safe
23	Cadmium, mg/L	Nil	Nil	0.003	-	Safe
24	Arsenic, mg/L	Nil	Nil	0.01	-	Safe
25	Bicarbonate, mg/L	24.40	61.00	200	-150	Safe
26	Carbonate, mg/L	35	40	100	-14.3	Safe
27	Barium, mg/L	Nil	Nil	0.7	-	Safe
28	Mercury, mg/L	Nil	Nil	0.001	-	Safe

Similarly from Tables 5, 6 and 7, the rain water after treatment (with sawdust filter setup) was safe for parameters like Physical Appearance, Taste, Turbidity, Conductivity, pH, Total Dissolved Solids, Total Alkalinity, Dissolved Oxygen, Free Carbon dioxide, Residual Chlorine, Total Hardness, Iron, Copper, Magnessium, Zinc, Sulphate, Chloride, Phosphate, Ammonia, Fluoride, Hydrogen Sulphide, Nitrite, Lead, Cyanide, Cadmium, Arsenic, Bicarbonate, Carbonate, Barium and Mercury but the treated water was unsafe for parameters like Colour, Temperature, Manganese, Nitrate and all of bacteriological parameters, in line with Nigerian Standards for Drinking Water Quality.

Table 4: Result of Bacteriological Test on River Water Sample

S/N.	Parameters	Raw Water	Filtered water	NIS Limit ((SON, 2007)	Efficiency	Remark
1	Total plate count (TPC), cfu/ml	32	20	10	37.5	Unsafe
2	Total coliform, MPN/ml	1,4,3 20	1,2,1 17	Nil	17.7	Unsafe
3	E. coli, cfu/ml	Growth	Growth	Nil		Unsafe
4	Growth on EMB at 35^0C for 24 hours of Incubation	-	+	Nil		Unsafe
5	Growth on SS Agar at 35^0C for 24 hours of Incubation	+	+	Nil		Unsafe
6	Growth on MAC. Agar at 35^0C for 24 hours of Incubation	-	-	Nil		Unsafe

Table 5: Result of Physical Test on Rain Water Sample

S/N	Parameters	Raw Water	Filtered water	NIS Limit (SON, 2007)	Efficiency (%)	Remarks
1	Physical appearance	Clear	Clear	15.0	-	Safe
2	Colour, TCU/HTU	10	5	Unobjectionable	50	Unsafe
3	Taste/odour	Unobjection nable	Unobjectio nable	Unobjectionable	-	Safe
4	Turbidity, NTU	10.12	2.37	5.0	76.6	Safe
5	Temperature, 0C	26.1	25.9	Ambient	20	Unsafe
6	Conductivity, us/c m	29.30	14.30	1000	51.2	Safe

Table 6: Result of Chemical Test on Rain Water Sample

S/N	Parameters	Raw Water	Filtered water	NIS Limit (SON, 2007)	Efficiency (%)	Remarks
1	pH	8.07	7.14	6.5-8.5	11.5	Safe
2	Total dissolved solids mg/L	14.70	7.11	500	51.6	Safe
3	Total alkalinity, mg/L	130	120	200	7.7	Safe
4	Dissolved oxygen, mg/L	2.4	3.5	4.0	-45.8	Safe
5	Free Carbon Dioxide, mg/L	8	8	10	-	Safe
6	Residual chlorine mg/L	Nil	Nil	0.2-0.25	-	Safe
7	Total hardness, mg/L	8.00	10	150	-25	Safe
8	Iron, mg/L	0.47	0.01	0.3	97.9	Safe
9	Copper, mg/L	Nil	0.08	1.0	-	Safe
10	Magnesium, mg/L	0.4	0.6	20	-50	Safe
11	Manganese, mg/L	0.004	0.004	0.001	-	Unsafe
12	Zinc, mg/L	0.52	0.47	3.0	9.6	Safe
13	Nitrate, mg/L	41.0	77.0	50	-87.8	Unsafe
14	Sulphate, mg/L	4.0	Nil	100	100	Safe
15	Chloride, mg/L	6.0	Nil	250	100	Safe
16	Phosphate, mg/L	0.8	0.6	3.5	25	Safe
17	Ammonia, mg/L	Nil	Nil	2.0	-	Safe
18	Fluoride, mg/L	Nil	Nil	1.5	-	Safe
19	Hydrogen sulphide, mg/L	Nil	Nil	0.06	-	Safe
20	Nitrite, mg/L	0.007	0.003	0.2	57.1	Safe
21	Lead, mg/L	0.01	0.01	0.01	-	Safe
22	Cyanide, mg/L	Nil	Nil	0.01	-	Safe
23	Cadmium, mg/L	Nil	Nil	0.003	-	Safe
24	Arsenic, mg/L	Nil	Nil	0.01	-	Safe
25	Bicarbonate, mg/L	73.20	61	200	16.7	Safe
26	Carbonate, mg/L	8.00	10	100	-25	Safe
27	Barium, mg/L	Nil	Nil	0.7	-	Safe
28	Mercury, mg/L	Nil	Nil	0.001	-	Safe

Table 7: Result of Bacteriological Test on Rain Water Sample

S/N	Parameters	Raw Water	Filtered Water	NIS Limit **(SON, 2007)**	Efficiency (%)	Remarks
1	Total plate count (TPC), cfu/ml	53	24	10	54.7	Unsafe
2	Total coliform, MPN/ml	1,1,3 09	0,1,0 01	Nil	88.9	Unsafe
3	E. coli, cfu/ml	Growth	Growth	Nil	-	Unsafe
4	Growth on EMB at 35^0C for 24 hours of Incubation	-	-	Nil	-	Unsafe
5	Growth on SSAgar at 35^0C for 24 hours of Incubation	+	+	Nil	-	Unsafe
6	Growth on MAC. Agar at 35^0C for 24 hours of Incubation	-	-	Nil	-	Unsafe

It is also noteworthy that treating the water samples through the sawdust filter setup causes increase in the level of some parameters like Carbonate, Nitrate, Magnesium and Total Hardness for both water samples while it only causes increase in the level of Copper and Dissolved Oxygen for the rain water sample. However, the river water sample witnessed increase in the level of Zinc, Phosphate, Iron, Temperature, Total Alkalinity and Total Dissolved Solids. This increase in the level of water contaminants after treatment with sawdust filter setup could be traceable to the presence of some elements like Carbon, Oxygen, Nitrogen, Aluminium, Calcium, Iron, Magnesium, Silicon and Zinc in the raw sawdust.

Efficiency of the treatment unit

The efficiency (Ƞ) of the treatment unit as posited by Adeosun, Adewumi, Dairo, Dada and Ajibade (2016) was determined from equation 1:

$$Ƞ = \frac{(C1-C2)\ X\ 100}{C1} \qquad (1)$$

where Ƞ is the efficiency of the treatment unit,

C_1 is the parameter's value before treatment, and

C_2 is the parameter's value after treatment.

The efficiency of the treatment unit with respect to each of the parameter is represented in Tables 2 through 7.

4. CONCLUSION

From the results, it can be concluded that the sawdust adsorbent performed effectively in making the water samples safe against almost all the physico-chemical parameters, but unsafe against the bacteriological parameters. Likewise, it is also revealed from the result that river water is more turbid than rain water but the adsorbent performed efficiently in attenuating the degree of turbidity in water. It is obvious that making the water samples potable through sawdust adsorbent will require coagulation and/or chlorination. Though, the sawdust adsorbent brings about the slight increase in the level of some elements in the water samples but the contaminant level of those elements is still within the water quality guidelines. Hence, sawdust is established as a good filter material.

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