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Comparison On The Effectiveness Of Slow Sand Filters With Difference In Granular Sizes In Treating Water

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***Abstract*—This study basically compares the effectiveness of Slow Sand Filter (SSF) using different granular sizes as a simple water treatment technology. In course of the study, two SSF model samples were constructed using same plastic material of same size labeled: SSF 1 and SSF 2. Water samples were collected from two shallow boreholes, labeled sample A and sample B: put under analysis of physical parameter, total coliform count, E-coli and salmonella. Both samples were treated using SSF 1 and SSF 2 with sample B under the treatment of SSF 2 yielded a better result. From the results, it was observed that the smaller the effective grain size, the better the result obtained. SSF 2, indeed, is a better option to have in households so as to reduce the consumption rate of contaminated water which leads to various waterborne diseases.**

Keywords— Contaminated Water, Granular sizes, Slow Sand Filter, Treated water, Water.

I. INTRODUCTION

Clean water is essential for healthy living for humans. The access to clean water and sanitation facilities have increased around the world in the recent decades, but still, a child under the age of five dies every 20 seconds today, due to water-related diseases (Corcoran et al, 2010). For areas with widespread poverty and poor living conditions, it has shown that the access of clean water is fundamental factor in order for people to rise from misery and get the area developing (Corcoran et al, 2010). UNESCO (2009) claims that is possible to extinguish about 10% of all disease worldwide by implementing water treatment methods and sanitation facilities in vulnerable areas to improve the water quality (united nations educational, scientific and culture organization. With these progress, there is seldom a problem to find water in developing countries, rather the problem is to get access to clean water (UNDP, 2006). In industrial countries, on the other hand, issue of accessible to clean water seems to be forgotten because most of their populace can access clean and portable water. Better illustration of this claim is the way people in Nairobi (Kenya) and Manila (Philippines) are paying more water bill per unit (5-10 times) than people in London (Great Britain) and New York (USA) according to the IMF (2015); despites the former is considered as under-developed or developing countries and the latter are considered as industrial countries (IMF, 2015; UNDP, 2006).

There has been an improvement in the recent years in the developing countries based on the efforts of implementing water treatment techniques in large cities with high population and larger demands of water (Corcoran et al., 2010). However, with these efforts, the water distribution, sometimes, only reach the urban areas, and aren't expanded to the rural areas due to some factors such as lack of electricity, economic situations, crime, practical issues among others (Corcoran et al., 2010). To implement and spread knowledge and techniques about water treatment in rural areas is vital for national development and social integration. To further implement and expand the access of clean water in the rural areas can also make the largest marginal effect to the country (UNESCO, 2009).

Both WHO and UNESCO claims that there is a clear connection between clean water and economic growth. UNESCO describes the links in their report: *Water in a changing world* from 2009; and in WHO's report from 2005, where it presents that developing countries with more developed water treatment systems and sanitary possibilities have an average economic growth of 3.7 % per annual. This growth is far higher compared to similar developing countries without the same improved water quality with the annual economic growth 0.1 % (Sanctuary & Trop, 2005).

The connection between access to clean water and economic growth, the WHO explains like this: access to clean water and developed water treatment facilities leads to less water-related diseases and illness which in the long term strengthens the country's work force and increases productivity. Less diseases also means less costs for health care and gains a positive effect to education while more children can be in school instead of being sick. This boosts the country's average education level which also gains the economic growth and development in the country, due to the link between educational level and welfare (Sanctuary & Trop, 2005).

There are different methods for treating water and one of which is the Slow Sand Filtration. This is one of the oldest methods of water treatment is Slow Sand Filtration (SSF) also known as Biological Sand Filtration (BSF). The method is adapted from nature's own way of treating water by filtration and has been used artificially by humans since the beginning of the nineteenth century when John Gibbs designed and build a slow and filter for his bleacher in Paisley, Scotland and sold the cleaned water to the public. Some two centuries later, to some critics, the SSF method is old-fashioned; but it is a myth that it is an ineffective water treatment method. Under suitable circumstances, the method is very cheap and also a very (if not the most) effective water treatment method. It has advantages to other methods because it is easy to maintain and are driven without electricity, it also often makes a better use of the local skills and materials available in the developing countries (Mathias 2015). This could assist in reaching the local populace, especially, in the developing and under-developed countries with clean water.

Considering this simple and cheaper method may help in achieving the number seven of the UN millennium goals aimed to ensure environmental sustainability and that includes the access of fresh clean water all over the world (UN report, 2014). Therefore, this research is aimed to examine the effectiveness of this method in ensuring portable and clean water to the less privilege societies.

II. MATERIALS AND METHODS

A. Sample analysis

The sample analyses here are the parameters. The parameters tested include: PH, turbidity, nitrate, electric conductivity, fluoride, cadmium, total coliform count, e-coli, and salmonella.

B. Water sample

Samples were collected from two boreholes located from two different locations: densely populated old settlement in the main city and densely populated new settlement in the suburb of the city, both in Maiduguri. Sample A was collected from the new settlement while sample B was collected from old settlement.

C. Material sample

a. Coarse aggregate: crushed granite aggregate of maximum size was crushed and sieved in the laboratory.
b. Fine aggregate used was clean-river sand free from deleterious substances.
c. Bama gravel was collected.

D. Procedure for Determining Aggregate Size

Collected sample of coarse aggregate was crushed and sieved to 19.5mm and 14mm sizes to be used for the two samples. The Bama gravel and fine aggregates were sieved into 2mm and 1.18mm sizes, respectively, to be used for the two samples, as well.

E. Procedure for the construction of Slow Sand Filters

Three plastic containers joined together was placed on a formwork as support, the third plastic container act as a drain to which a fluid regulator is attached to control the flow of the filtered water. The grain sizes were placed in the two remaining plastic containers, with the largest grain sizes placed at the second plastic container in the following order up to the first plastic container: 19.5mm, 14mm, and 2 mm in SSF 1 and 19.5mm, 14mm, and 1.18mm in SSF 2, respectively.

Then, the water samples were collected in four air tight containers. Two samples from each site. The containers were careful labeled as sample A and B for both SSF1 and SSF2, and immediately transferred to the geology laboratory where the physical characteristics of the samples were analyzed. While the second sample containers were taken to water treatment plant laboratory where the biological analysis was carried out. The analyzed samples were allowed to pass through the arranged SSFs at a steady flow rate. Filtered water was then collected at the drain and transferred to another air tight containers and repeat analysis at the laboratories, separately.

III. RESULTS AND DISCUSSION

Table 1: Raw water data (Physical Parameters)

N	Turbidity (NTU)	EC(μ/cm)	PH	NO_3	Cd	F
Sample A	7	230	6.5	1.02	0.011	0.44
Sample B	4	200	6.8	0.84	0.003	0.10

The physical characteristics of the two samples show that sample A has high NTU, EC(μ/cm), NO_3 Cd, and F. Sample B tends to have high level of PH as shown in table 1.

Table 2: Raw water data (coliform bacteria)
Sample A:

PARAMETER	OBTAINED RESULT (cfu)	WHO STANDARD (cfu)
Total coliform count	9×10^3	0×10^3
Differential E. Coli	$6^3 \times 10^3$	0×10^3
Salmonella	$4^3 \times 10^3$	0×10^3

Table 3: Raw water data (coliform bacteria)
Sample B:

PARAMETER	OBTAINED RESULT(cfu)	WHO STANDARD (cfu)
Total coliform count	7.4×10^3	0×10^3
Differential E. Coli	5.5×10^3	0×10^3
Salmonella	3.8×10^3	0×10^3

Tables 2 and 3 present the level of coliform bacteria in both samples. Though, both samples are above the WHO permissible standard, but sample A contains high count of coliform, differential E. Coli, and Salmonella in the raw water sample.

Table 4: Filtered water data (physical parameter)

s/n	Turbidity (NTU)	EC (μ/cm)	PH	NO_3	CD	F
Sample A	5.4	150	6.5	0.72	0.009	0.231
Sample B	2.1	120	6.6	0.51	0.001	0.O79

After the laboratory analysis, there seems a slight reduction in the physical parameter but still sample A accounting for higher presence of the contaminant than sample B as indicated in table 4 above.

Table 5: Filtered water data (coliform bacteria SSF1)

Sample A

PARAMETER	OBTAINED RESULT(cfu)	WHO STANDARD(cfu)
Total coliform count	7.6×10^3	0×10^3
Differential E. Coli	5.8×10^3	0×10^3
Salmonella	3.7×10^3	0×10^3

Table 6: filtered water data (coliform bacteria SSF2)

Sample A

PARAMETER	OBTAINED RESULT(cfu)	WHO STANDARD(cfu)
Total coliform count	5.4×10^3	0×10^3
Differential E. Coli	4.6×10^3	0×10^3
Salmonella	3.1×10^3	0×10^3

Comparative analysis of SSF 1 and SSF 2 of sample A indicate that the two methods provided slightly different results as shown in table 5 and 6. With SSF 1 accounting for higher counts of the following coliform, differential E- Coli, and Salmonella as against SSF 2 using the same sample, despites both being above the WHO permissible standard.

Table 7: filtered water data (coliform bacteria SSF1)

Sample B

PARAMETER	OBTAINED RESULT(cfu)	WHO STANDARD(cfu)
Total coliform count	3.7×10^3	0×10^3
Differential E. Coli	2.5×10^3	0×10^3
Salmonella	1.8×10^3	0×10^3

Table 8: filtered water data (coliform bacteria SSF2)

Sample B

PARAMETER	OBTAINED RESULT (cfu)	WHO STANDARD (cfu)
Total coliform count	3.2×10^3	0×10^3
Differential E. Coli	1.6×10^3	0×10^3
Salmonella	0.76×10^3	0×10^3

Comparative analysis of SSF 1 and SSF 2 of sample B indicate that the two methods provided slightly different results as shown in table 7 and 8. With SSF 1 accounting for higher counts of the following coliform, differential E- Coli, and Salmonella as against SSF 2 using the same sample, despites both being above the WHO permissible standard.

CONCLUSION

The water samples were contaminated which rendered it unfit for human consumption. The SSF model used have improved on the water quality. This SSF is a simple and effective technology for treating water in households of low living standard who are denied or get very little access to potable water. The aggregates with smaller grain sizes arranged in SSF 2 yielded a better result as compared to SSF 1. Hence, the smaller granular size the better the results obtained. However, the treated water was above the approved WHO standard of 0×10^{3} cfu. Therefore, there is need for further research on the use of different grain sizes to confirm this conclusion.

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