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Treatment of Polluted Water using Natural Rock Materials at the Household Level

[1]Gana A.J., [2]Esayeas Alemayeu & [2]Wondwossen Birke
[1]Department of Civil Engineering, Collage of Science and Engineering, Landmark University, Omu-Aran, Kwara
[2]School of Environmental Health, Faculty of Public Health, Jimma University, Jimma, Ethiopia
Emails: phildebo123@gmail.com
Corresponding author: Gana A.J.

ABSTRACT

In rural and semi-urban communities of developing countries, including Ethiopia adequate water treatment procedures are almost non-existing mainly for economic reasons as well as settlement characteristics of the people hence a technology that does not demand much financial resource at household level is required the aim of this study was to test the filtering capacity of natural rock material obtained in the rift valley of Ethiopia. The rock material pumice was collected from metehara and awash=7 kilo areas the rift valley of Ethiopia and then designed in to rock vessel having 2cm ,4cm and 6cm side and bottom thickness, cylindrical and hemispherical shapes at the top and bottom respectively for the study purpose three experimental cycles ere under taken polluted water sample that had initial purpose .three experimental cycles were under taken .polluted water sample that had initial average concentration of 497 mpn per 100ml of faucal colophons , 93 .2 ftu of turbidity 83.3 tcu of color ,1.405 mg/l of fluoride,0.63 mg/l of iron ,0.028 mg/l of manganese of a ph of 6.74 at a temperature of 20.5 c were passed through the rock vessels. The finding shows that very good reductions of contaminants were achieved in which faucal coli forms became 96.4%, 97.6% and 98.3%. turbidity 96.7 and 96.9%, color 88%, 89.% and 92 .8%:temperature 5.9%,6.15% and 6.3% fluoride 22%, 38.6% and 67.5%: iron 79.4%, 89.3% and 88.9% manganese 67.%, 9.% 89.3% and 92 .9%:but the mean average for the hydrogen ion concentration (P^H value) increased gradually to 6.53%. 8.2% and 6.7% in2cm, 4cm and 6cm rock filters respectively. The study has revealed that, as the filter run increased, the efficiency to eliminate the contaminants was positively significant ($p>0.05$). It was also observed that there is a declining trend in filtration rate as the frequency of the filter run increased. National rock filter has the capacity to filter impurities from contaminated water. It is a relatively simple technology for household water treatment. Further studies also need to be done on another removal mechanism (adsorption capacity of the rock), characterization of the rock and the application of this natural rock as a conventional water treatment media, which are not included in this study.

Keywords: *Natural rock water filter vessels, Physiochemical, Microbial Impurities, filtering capacity, household level, polluted water*.

INTRODUCTION

Water to act as a vehicle for the spread of a specific disease must be contaminated with associated disease causing organism or hazardous chemicals. Disease causing organism can survive for period of days to years depending up on their form, environment and treating given to the contaminated water. All sewage contaminated water is presumed to be potentially dangerous. Other impurities such as inorganic and organic chemical and heavy concentration of decaying organic matter may also find their way into water supply, making the water hazardous, destructive or otherwise unsuitable for domestic use (Abayneh, 1998). More than 80 percent of the communicable diseases, some of them in an epiady demie form are caused due to lack of safe and adequate water. Provision of potable water supply for prevention of water born and other related disease is the most important consideration in the field of public health this is also expressed as a component of primary health care. Water which is safe for drinking must be free from pathogenic organisms, toxic substances excess mineral and organic matters tube attractive to consumer it should be free color turbidity odor and it should contain sufficient oxygen and an acceptable test (abayneh,1998:pickford, 1991) based on the above facts, some methods are required to make water suitable for human consumption. Although safe and reliable water supply is badly needed, a number of factors have made it impossible to utilize the conversation engineering solution of extending the municipal water system (irc, 1990). In this case small-scale treatment processes seem to be suitable methods of providing relatively clean water for those who draw their water supplies from unprotected wells, Ponds and Streams. Boiling straining (by cloth), strong to remove silt load the use of natural coagulant such as chatoyant moringa and normalized (scuhlz, 1984: Mayer 1995) up flow-down flow filters (pick ford, 1991), ceramic candles and homemade sand filters (teka, 1997) are some of the options that are applicable at household level in different parts of the word. Although there is no clear information on the extent of natural rock water filter, its use as a means of household level water purification is know in some parts of Ethiopia such as among the people living in the rift valley rural and urban areas of the country. The purpose of this study is evaluating the physical-chemical and bacteriological filter capable of the nature rock material.

METHODOLOGY

An experimental study to evaluate the effectiveness of nature rock water filter was conducted in environmental health school laboratory, Jimma University. The nature rock was collected from metehara and awash-7-kilo areas the rift valley of Ethiopia for the study purpose the amorphous rock (pumice). Locally knows as BEHA was then cut and shaped into three vessels (pot) like structures of 2cm 4cm and 6cm side and bottom thickness using locally available hand tools. The filter medium has designed to have a shape of right circular (hemispherical) at the bottom with an internal diameter of 18cm and a 30cm height for the cylindrical part the radius of the speroid part was the same as the top cylindrical portion and the dept (height) was taken to be as suitable as possible, but the same depth was kept for the three pots see on the appendices page (figure 1). Shaping of the rock in such a way would enable to facilitate its operation under the influence of gravity since it was assumed to ooze out liquid (water) in its entire body surface the cylindrical portion of the rock that remained above the filtered water holding tank (a plastic bucket shaped like a frustum of a cone with a capacity of 10 liters in volume was utilized) was covered and guarded extraneous forces (agents) by plastic sheets see on the appendices page (figure 2). In so doing the plastic sheets was glued only at the top rims of the cylindrical portion of the rock.

The raw water holding capacity (internal volume) of each pot was found to be; volume (by volume postulate) = the volume of right circular cylinder + the volume of the spheroid part. Therefore, each pot had approximately a capacity to hold 7 liters of raw water at a time. Filter media and tanks might come in contact with foreign agent while they were prepared. This contamination thus had a direct influence on the findings of bacteriological tests. Therefore both were disinfectant with a liquid bleach of 5% NaOCI at a 50ppm to minimize the occurrence (outcome) of false results. In disinfecting each medium and tank the inside parts of both as well as the outer parts of the medium were cleaned thoroughly by brushing and flushing the solution was poured in them when they were half-full of water (water from piping system) and left for at least 12 hours and then they were emptied and the water was left to ran to waste. The disinfection operation might be expected to have an effect on the bacteriological findings and hence the continuation of the bactericidal action that might be occurred of the halogen (chlorine)was controlled (avoided)by using a dechlorinating agent called sodium thiosulphate ($Na_2S_2O_3$ 0.88m\l) (MOH 1998) with the addition of water from a tap before the onset of the pretest and cycles of the experiment aseptic condition made in such a manner was counter checked by adding distilled and sterilized water (sterilization was made with the help of an autoclave) in to the medium and bacteriological tests was carried out. Consequently, the filter medium was inserted into the plastic sheets glued at the tank in order to avoid the entrance of foreign agents during filtration operation. Deterioration in the real quality of the raw water (i.e. the raw water quality that was already known before filtration) might have been expected to occur as a result of some dropping from the top to the medium and hence the problem was tackled by preparing a cover (lid) made of timbered wood (lumber; plank). During the filtration operation, the filter media and the filtered water holding talkers were undisturbed throughout the experiment (i.e. no washing and rinsing of them after each cycle of the experiment was occurred) in order not to cause re-suspension of any of the settled matters available there. The users' of the rock also have a trend of not washing it for a period of a month or more. Drying of filter bed was prevented between cycles of the experiment to avoid cracks that act as a conduit allowing short-circuiting of raw water by adding distilled and sterilized water. Water sample for study and analysis were collected from River Awetu, crossing Jimma town, and 2km from the research area. The river has solid and liquid wastes. The indiscriminate disposal of town waste created aesthetically unsightly conditions by being washed down with storm water and sewage. There are more than ten open ditches in which sewage from different source is collected and continuously ends up in the stream course by gravitational pills (Dejene, 1997). The river water had a large bacteriological load (about 1100 faucal coli forms per 100 mL of untreated water), which makes it an ideal source for the experiment. Fecal coli forms were analyzed by using multiple tube fermentation technique for the easy availability of chemicals. Samples were taken aseptically from the Jerycan (raw water) and from the out let tap of the filter units. Standard laboratory procedures were used during the analysis. Turbidity of the samples was measured using absorptometric method. Visual colorimetric method, thermometer (Digital probe), Electrometric method Alizarin photometric method, and plainest photometric methods were used to measure color, temperature, p^H, fluoride, iron and manganese respectively. The experiment was done in three phase. In each phase the water sample was brought with a 20L plastic jerriycan. From this, five liters were allotted for the analyses of the selected water quality parameters and the rest voluminous amount was equally shared and poured in to the filter media. The results obtained in the study are explained in the respective heading.

ANALYSIS AND FINDINGS

Faecal Coliform Test

Faecal coliform count using most probable number (MPN) method was conducted from sample before and after filtration. Results before filtration indicated that 240, 150 and 1100 MPN/100mL for sample I, II and III respectively, mean average of which is about 497 MPN per 100mL. the mean average measurement of the three composite samples per rock thickness (2cm, 4cm and 6cm) became 18 (96.4% reduction), 12 (97.6% reduction) and 8 (98.4% reduction) MPN per 100 mL of faucal coli form count respectively see on the appendices page.

Physical tests and p^H

Parameters used for physical test were; turbidity, color and temperature. All of the samples showed pattern of changes for the physical parameters and p^H while they were passed through the rocks. Sample which had an initial concentrations of 14.5FTU, 120FTU and 145FTU of turbidity; 50 TCU, 75TCU and 125TCU of color, and 19.57^{o}C, 21.14^{o}C and 20.8^{o}C of temperature were reduced in the 2cm think filter vessel to 82.8%, 96. 83% and 97.7% of turbidity; 74%, 90% and 92.5% of color and 0.72%, 12.2% and 4.81% of temperature respectively, But, the p^H measurement with the initial value of 6.5 and 6.93 were increased to 0.74%, 13.85% and 5.1% respectively in the 4cm filter medium with the above initial concentrations, the impurities were reduced in the filters to 83.45%, 97% and 97.7% of turbidity; 80%, 90.7% and 93.2% of color; 0.87%, 12.3% and 4.9% of temperature respectively. With the above initial p^H value in the 4cm, they were increase to 0.4%, 15.4% and 8.95% respectively. With the same initial values for all parameters, the contaminants in the 6cm were reduced to 84.83% 97.7% and 97.9% of turbidity; 90%, 92.7% and 94.9% of color; 1%, 12.5% and 5.05% of temperature respectively. The p^H measurement values increase to 0.15% 17.2% and 3.2% respectively see on the appendices page (Tale 1) the mean average concentration changes observed in the 2cm, 4cm and 6cm rock thickness were; from 1.405 mg/L to 1.10mg/L (22% reduced), 0.863 mg/L (38.6% reduced) and 0.45mg/L (67.5% reduced) respectively see on the appendices page (Table 1)

Chemical Test:

Fluoride tests:

From Table 1, it can be seen that filtering raw water samples through the rocks had a reduction effect on the concentrations of fluoride. The mean average concentration changes observed in the 2cm, 4cm and 6cm rock thicknesses were; from 1.405 mg/L to 1.10mg/L (22% reduction), 0.863 mg/L (36.6% reduction) and 0.456mg/L (67.5% reduction) respectively see on the appendices page (table 1

Iron test

The calculated mean average (table 1 above) of iron concentrations showed that, filtering the raw water samples though 2cm, 4cm and 6cm rock thicknesses decreased the concentration from 0.63mg/L to 0.13mg/L (79.4% reduced). 0.08mg/L (87.3% reduced) and 0.07mg/L (88.9% reduced) respectively see on the appending page (table 1)

Manganese test

Manganese also greatly reduced when filtering the raw water sample through the intervened rocks.

The mean average concentration of manganese showed a decline of manganese showed a decline from 0.028mg/L to 0.009mg/L (67.9% reduction), 0.003mg/L (92.9% reduced) in the 2cm, 4cm and 6cm respectively see on the appendices page (table 1).

From table one, it can be seen that measurement of the mean average value of faucal coliforms, turbidity, color, temperature, fluoride, iron and manganese showed a general trend of decreasing in magnitudes after filtering the three raw water sample samples in the 2cm, 4cm and 6cm rock thicknesses respectively. On the other hand, the mean average value for pH showed a general trend of increasing in magnitudes while filtering the three composite samples in the 2cm, 4cm and 6cm rock thicknesses.

CONCLUSION

The use of "Beha" rock is a relatively simple technology for household water treatment. The filter can be used to treat raw water from surface sources. This is a great improvement for those who have no alternative to consuming the raw water. For sufficient treatment through the "Beha" rock, it is advisable to increase the thickness. Although the filtration frequencies decline the filtration rate (filter run), it can bring a dramatic change on physicochemical and microbial impurities and hence can best suit the recommended water quality requirement of the WHO. The major areas of application can include households, emergency water supplies temporary lodgings, and concentration camps where it is economically not possible to provide clean water for domestic use by conventional water supply or other means. Above all, the rural people who do not have access to protected water source are the beneficiaries of the finding of this study. To appreciate the outcomes of this study, the users must know the danger associated with the use of untreated water from contaminated sources.

Further studies need to be done

- On the selection of different rock thicknesses and their effect of reduction on different contaminants;
- Determination of the efficiency of the natural rock to remove other contaminants, namely chromate, cadmium, phosphate nitrate, etc
- Identify the adsorption capacity of the rock by using different models
- Determine the physical and chemical characteristics of the natural rock
- Application of this natural rock as a conventional water and wastewater treatment plant

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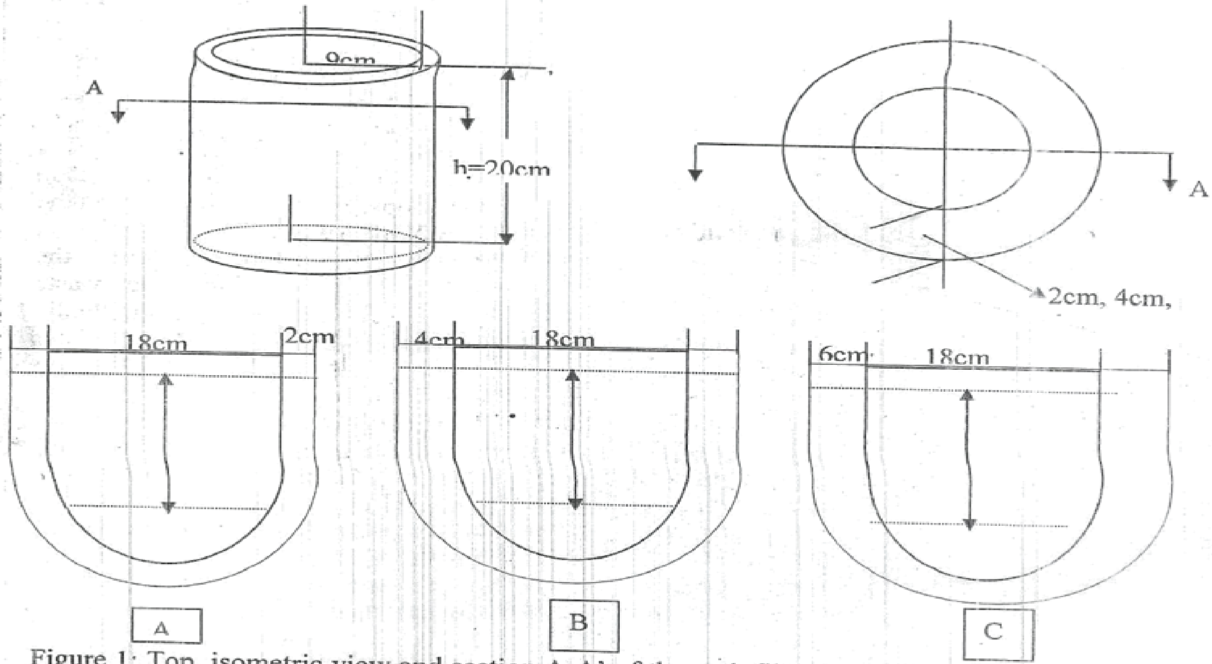

Figure 1: Top, isometric view and section A-A' of the rock filter vessel 2cm, 4cm, and 6cm side and bottom thickness (A, B and C respectively), (not drawn to scale)

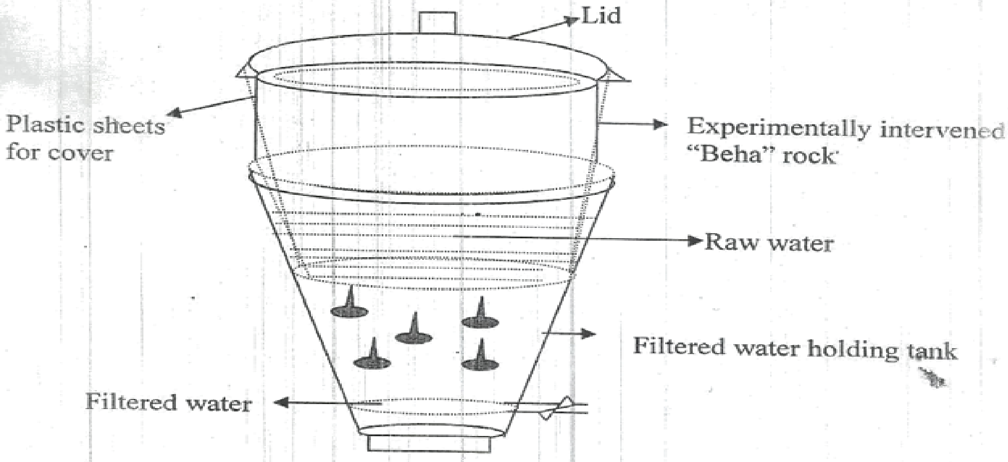

Figure 2: Filter arrangement using the intervened rock.

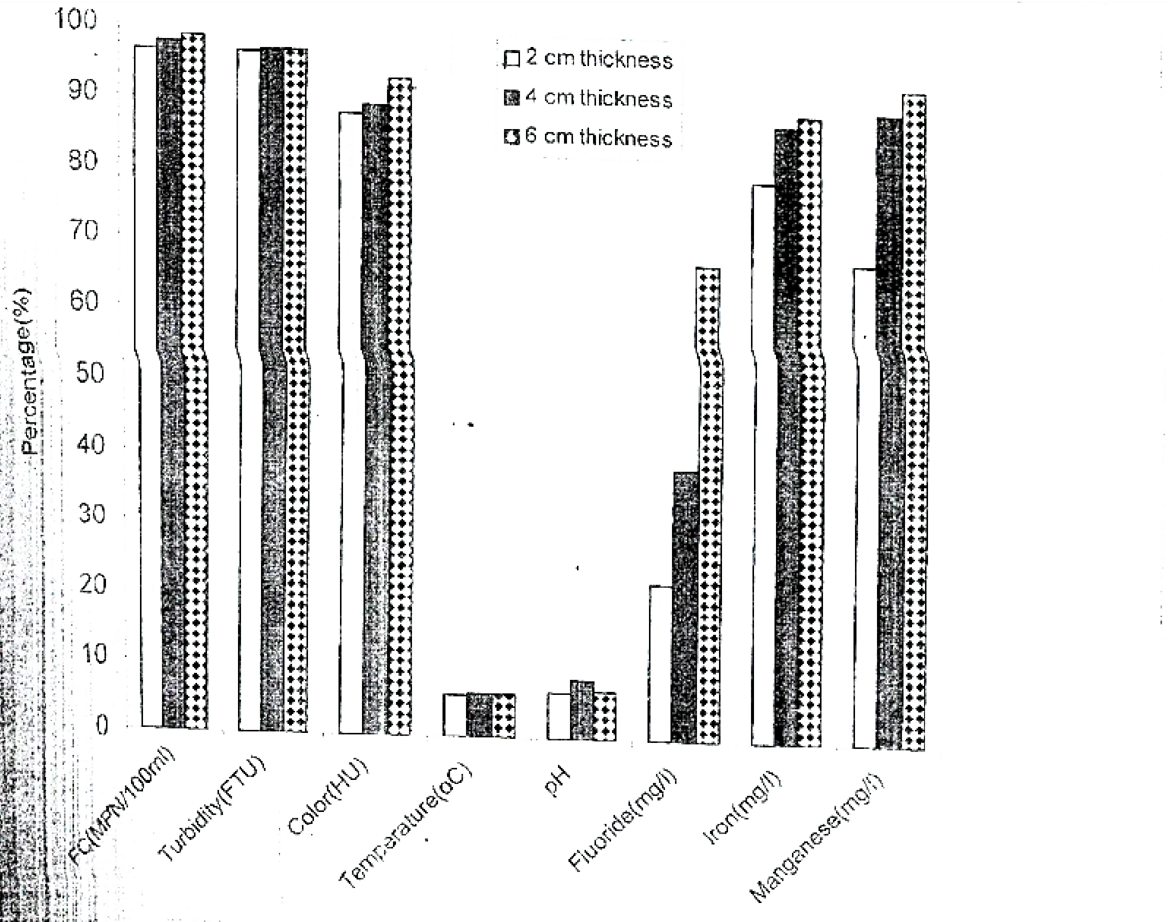

Figure 3: Comparison of percentage reduction of the net mean values of the selected water quality parameters per rock thickness.

Table 2: Determination of "time of operation"/ Filtration rate (for the entire cycles of the experiment) while filtering a total of 15 liters of raw water per rock thickness

Rock Thickness (in cm)	Time of operation in hours			
	1st day Sample	2nd day sample	3rd day Sample	Average
2	3:04	3:06	3:55	3:2[illegible]
4	3:10	3:11	4:10	3:4[illegible]
6	3:15	3:20	4:25	3:5[illegible]

Table 1. Mean values of the selected water quality parameters, for three samples taken for three days per rock thickness

Rock thickens and Mean Value	Day and Sample No.	FC (MPN/100mL)		Turbidity (FTU)		Color (HU)		Temperature (°c)		pH		Fluoride (mg/L)		Iron (mg/L)		Manganese (mg/L)	
		BF	AF	BF	AF	BF	AF	BF	AF	BF	AF	BF	AF	BF	AF	BF	AF
2cm	D_1S_1	240	11	14.5	2.5	50	13	19.57	19.43	6.8	6.85	1.232	0.651	0.33	0.16	0.03	0.012
	D_2S_2	150	14	120	3.8	75	7.5	21.14	18.57	6.5	7.4	1.487	1.322	0.72	0.11	0.028	0.002
	D_3S_3	1100	28	145	3.4	125	9.4	20.8	19.8	6.93	7.28	1.495	1.312	0.83	0.12	0.027	0.012
Mean		496.67	17.67	93.17	3.23	83.33	9.97	20.5	19.27	6.74	7.18	1.405	1.1	0.63	0.13	0.028	0.0
4cm	D_1S_1	240	7	14.5	2.4	50	10	19.57	19.4	6.8	6.83	1.232	0.427	0.33	0.05	0.03	0.004
	D_2S_2	150	9	120	3.6	75	7	21.14	18.55	6.5	7.5	1.487	0.888	0.72	0.09	0.028	0.004
	D_3S_3	1100	21	145	3.3	125	8.5	20.8	19.78	6.93	7.55	1.495	1.274	0.83	0.11	0.027	0.002
Mean		496.67	12.33	93.17	3.10	83.33	8.5	20.5	19.24	6.74	7.29	1.405	0.863	0.63	0.08	0.028	0.003
6cm	D_1S_1	240	4	14.5	2.2	50	5	19.57	19.38	6.8	6.81	1.232	0.232	0.33	0.03	0.03	0.003
	D_2S_2	150	7	120	3.4	75	5.5	21.14	18.5	6.5	7.62	1.487	0.195	0.72	0.08	0.028	0.002
	D_3S_3	1100	14	145	3.10	125	6.4	20.8	19.75	6.93	7.15	1.495	0.942	0.83	0.10	0.027	0.001
Mean		496.67	8.33	93.17	2.9	83.33	5.63	20.5	19.21	6.74	7.19	1.405	0.456	0.63	0.07	0.028	0.002

D1S1: day one sample one; D2S2: day two sample two; D3S3: day three sample three: BF: Before Filtration; AF: After Filtration