SAND WATER FILTERS: A LOW-COST TREATMENT SOLUTION FOR WATER POLLUTION PROBLEMS IN RURAL REGIONS

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Abstract- Water is one of the essential needs of our life, without which the survival does not exist. For a healthy life it is important to consume water free of contaminants. Whether people residing in urban or in rural region, faces the problem of unhealthy drinking water. As in cities with day to day increase in population the quality of available water declines, whereas in villages people have to rely on open sources such as surface water, wells, lakes, rivers and ponds which might not be safe to drink all the time. In this paper we have presented the use of a simple filtration technique by using locally available material like sand, aggregate and charcoal as a filter media. Some of the parameters such as TDS, pH, Turbidity, Total Hardness, color and odor have been tested for checking the quality of filtered water to rendered it fit for drinking. This technology is economic, easy to operate and can easily serve the drinking water need of a rural family and a better alternative to RO technology common for an urban household.

Keywords: Sand-Filters, Low-cost water treatment, Water Pollution, Bio-sand filters.

1. INTRODUCTION

Unfortunately, 785 million people in world are deprived of basic drinking water. About 144 million people have to rely on surface water and open sources. About 80% of diseases are caused by contaminated water in the developing countries. Contaminated water causes diseases such as cholera, diarrhea, dysentery and typhoid. Everyday 6000 children die of water related diseases [1]. In case of rural areas people rely on water obtained from open sources such as ponds, lakes, rivers or streams. On the other hand, they use groundwater and water from wells. Safe and clean water is necessary for public health. Provision of safe drinking water in rural areas is one of biggest problem faced by government. For this government are attempting various conventional technologies, techniques and methods such as chlorination, cleaning water through solar radiations and artificial UV radiation to clean contaminated water. Unfortunately, due to lack of skilled manpower, budget and electricity condition in rural areas it is difficult to implement such methods. In cities people however have more facilities compare to people residing in rural areas regarding impure water. But in context to rural areas, it is important to adopt such methods which are environment friendly and can be implemented easily by the use of locally available materials. Some methods adopted in rural areas includes boiling of water, use of clay vessels, use of cloth, clarification of water by using plant material or seeds and by constructing simple filtration tank with use of locally available materials such as rice husk, bamboo, dry banana leaf, wood, saw dust, sand, gravels, charcoal etc [1]. All over the world, rural communities have adopted simple treatment techniques that mainly works for filtering out the visible impurities from the water collected from local sources. Though these traditional methods are convenient and can remove certain types of particles in water, but they do not provide water necessarily pure of what it should be.

2. LITERATURE REVIEW

A lot of research has been done previously on this technology by using different materials as filter media as this offers a viable option for tackling drinking water need of rural society. Mecha and Pillay (2014) has used a modified chemical reduction method by combining woven fabric microfiltration (WFMF) membranes with silver nanoparticles [2]. Mwabi et. al.,(2011) has compared four low cost techniques, Biosand filters (BSF), Bucket Filters (BF), Ceramic Candle Filters (CCF) and Silver-Impregnated Porous pot filters (SIPPF). They reported the highest turbidity removal is by CCF 95% and pathogenic bacteria by BSF 94% [3]. Ratnoji and Singh (2014) has done experimentation using activated carbon derived from coconut shell. They have examined reduction and removal of iron, BOD, COD and turbidity [4]. Vinka et.al. (2008) has used Cylindrical colloidal-silver-impregnated ceramic filters to test flow rate and bacteria transport [5]. Thus, the literature survey shows the effectiveness of technology with varying filter media. In this view, the current study shows the use of locally available material which can be obtained free of cost to make the technology suitable for in-use of rural community.

3. MATERIAL USED

The material used for preparing sand water filter is locally available, cheap and environment friendly. The container used for the filter system can be of concrete, plastic or clay pots. For the experiment purpose, Plastic container is used as it is convenient to obtain but for rural community earthen pots will be the most suitable and economical. Other material which are used as filter media includes gravel, coarse sand and wood charcoal [6].

3.1 Plastic Container as Enclosure tank

A simple plastic container of dimension 90 cm × 30 cm is used fitted with an outlet pipe to collect filtered water. The filter media is arranged in this tank in the layer pattern keeping gravel layer upto 10 cm thick at the bottom, it is topped by sand layer which is kept 40 cm thick and above the sand layer 10 cm thick wood charcoal layer is placed. The contaminated water is poured from the top and after passing through all the layers the filtered water is drawn out from the bottom by an outlet pipe. The schematic diagram of the system is presented in fig 3.1.

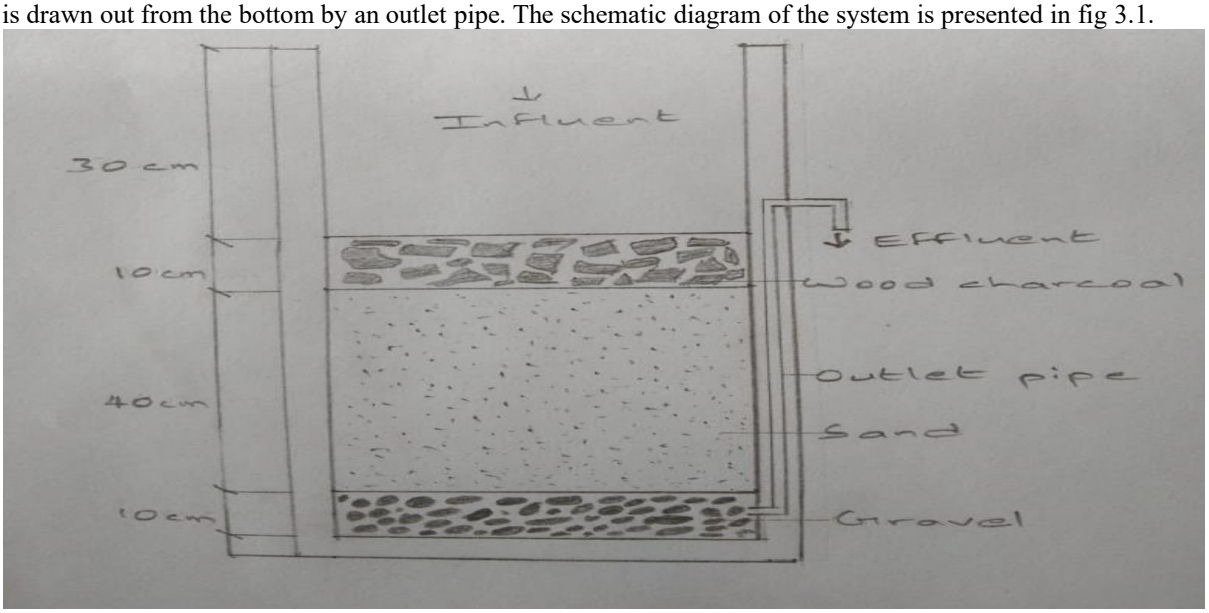

Fig 3.1 Schematic diagram of filter System

3.2 Gravel Layer

The gravel layer is kept at the bottom to support the sand packing. The specific size of gravels is not defined but they are randomly chosen aggregate of small size.

3.3 Sand Layer

The sand layer is 40 cm thick which is well graded and washed thoroughly. The effective size of sand (D_{10}) is 0.4 mm and uniformity coefficient (C_u) is 2. Sand is layered in such a way that finer sand is at the top followed by coarser in the bottom layer.

3.4 Wood Charcoal Layer

The topmost layer of media is of wood charcoal. It is porous in nature and can be used to adsorb liquid and gases on its surface. It is specifically used for removing color and odor and removing harmful gases [7].

4. WORKING MECHANISM

The working principle of this technique involve four mechanism, sedimentation, straining, adsorption and chemical & bacteriological action. The influent is allowed to enter from the top and it falls on first layer of charcoal where adsorption of gases, color and odor causing agents takes place. Rest of the water get strained through the pore spaces and passes through second layer. Sand layers traps the impurities bigger than its void spaces and allows the water to pass through it. In both these layers first few minutes adsorption and straining takes place then sedimentation occurs followed by chemical and bacteriological actions. When the organic impurities get trapped in the sand and charcoal media the bacteria present in water starts acting on this impurity and decompose them. Within some days a dirty layer of dead cells and trapped contaminants started to form on the filter media which further prevent any impurities to pass through these layers. But as this dirty skin get thickened it will decrease the rate of filtration too. Then either the filter media is to be replaced with the new layers or the same will be thoroughly washed and dried to open the clogged spaces and remove the dirty skin and re-used again. The filtered water passing through the gravels then collected in a separate container through the outlet pipe and fit to be used for drinking purpose.

5. RESULT AND DISCUSSION

After receiving water through the filter media, the same is tested for quality analysis after 1 day, 5 days and 10 days of filtration. The effluent is tested for turbidity, TDS, pH, Total Hardness, Taste and Odor. The result obtained are presented in the table 5.1. The rate of filtration of water in the initial days were observed as 70 ml/hr to 100 ml/hr. After that the rate started to decline after 5-6 days and became around 20-25 ml/hr.

Table-5.1 Test results of water Quality Analysis

Parameters	Raw Water	Flittered water collected after 1 day	Flittered water collected after 5 days	Flittered water collected after 10 days	Standard (BIS)
Temperature (°C)	30	29	24	24	26-28

pH	6.8	6.9	6.9	6.8	6.5-8.5
Turbidity (NTU)	12	3	4	9	5
TDS (mg/l)	1856	1467	675	1387	500
Total Hardness (mg/l as $CaCO_3$)	72	56	46	69	150
Color	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
Odor	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable

The results obtained are more favorable after day 1, satisfactory till day 5 and then keeps on declining which indicate the cleaning of filter needs to be done more frequently. But this drawback can be overcome if rate of filtration can be improved. One of the ways of improving the rate will be to increase the size of filter system so that it can cater to the need of a family comprising of on an average of 5 members whose per day drinking water requirement is of at least 20 litres. As the filtration not only occurs through the layers but also through the sides of the tank and more the size of tank more be the filtration rate. The filter is more suitable for removing biological impurities as seen from the literature but unfortunately cannot be tested for this experiment.

CONCLUSION

In village, people unknowingly consume water form open sources and get infected with various water borne diseases. It is important to practice measures and methods to clean or treat water before consuming. In villages people practice traditional methods for treating water. But as an effective measure it may lack quality or purity in water and there can be chances of contamination as well. There may be certain limitations in various methods adopted by villagers to treat water. This include using clay pots for filters in which there are chances of cracks, it breaks easily. This type of filter is not effective against viruses. No chlorine residual protection can lead to recontamination. Filters can break over time. It has low flow rate of 1-3 liters per hour for non-turbid water [6]. Filters must be cleaned regularly, especially after filtering turbid water. Likewise, Water cleaning by using plants may become difficult where seeds of plants are not easily available. Temperature is the major limitation since effective treatment depends upon active growth of plant. Herbicides and other materials are toxic to the plants can affect their health and lead to a reduced level of treatment. Plants die rapidly when water temperature approaches the freezing point. Water hyacinth is sensitive to high salinity, which restricts the removal of potassium and phosphorus to active growth of plants [8]. Water cleaning by three pot method does not remove smaller suspended particles. Large proportion of bacteria is still present. Disinfection is incomplete and it is time consuming [9]. Water cleaning by using cloth only includes cotton sari cloth whereas all types of clothes are not considerable [10]. Water cleaning by using sun rays need to pre-treat water of higher turbidity with flocculation or filtration. Limited volume of water can be treated [11].

In this context, sand water filter if properly designed and maintained can give effective results. In addition to it can be made with less cost, less time and with the use of locally available materials. There is no complexity in design. There is no need of electricity. There is no use of modern technology. It can be easily prepared by all ages.

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