



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 5, May 2023

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

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Development of Low-Cost Water Purification Technique

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ABSTRACT: Water purification is a process of removing undesirable physical and chemical contaminants from water. Water purification system proposed in this project focus on providing a pure drinking water at low cost with high reliability to the rural families. There are various methods available for purification of water but they are not economically feasible for Rural people. Proposed system consists of combination of natural substances like (sand, coarse aggregate, cotton, rice husk, powdered charcoal). It is an effective method to remove harmful bacteria from water. This method can be made portable, cost effective, user complaint and energy efficient which will be self-sufficient to meet the drinking water needs. Water samples selected for Experimentation were Lake Water, tap water and ground water; water samples were tested in laboratory and analysed. The water samples undergo the Physio-Chemical parameters tests. The results of after passing the water through the filter were found to be within the permissible limit for drinking and for domestic use. In this work an attempt was made to develop a “Low Cost Water Purifier” using the basic ideas of bottle filter, some locally available filter material like, Rice Husk, Sugarcane bagasse, fine graded sand. The Designed Low-cost water purifier can be proved economical and efficient as it can be used in Rural households.

KEYWORDS: Fibre model development, Porous based sand, activated carbon, Wood charcoal, anthracite

I. INTRODUCTION

Purified water is essential for living a healthy life as such everyone should have access to it. Drinking water conditions have great impacts on people's everyday life, especially in the rural and remote areas where access to safe drinking water is very crucial. Surface water often is the only source; thus, water contaminations are difficult to avoid due to rigorous and reckless use of surface water. Unsafe drinking water may result in fatal diseases. Statistics shows that these diseases resulted in ninety percent of all deaths of children under five years old in developing countries, due to low immunization of children to infections. Despite of fulfillment of requirement of drinking water standards, the municipal water in used in developing countries is being improved and cost-efficient water filtration techniques are being developed commonly used to improve taste or to eliminate any undesired matters. Various types of filters have been designed to be more suitable for the rural areas of the countries, but the cost as well as the filter effectiveness is still not satisfactory and further improvement is still required. Drinking water is being the biggest issue nowadays in India. Most of the people in the rural areas are not able enough to use water filters or buy mineral water bottles. To overcome this problem many efforts have been done due to which cleaning water may become an affordable commodity. Every household should be able to develop its own drinking water purification system; this should be the aim of development of any low cost water purification technique. In this context a number of contributions that has been made where the filter media varies from a layer of simple cotton cloth to composite nano materials. Some of the typically used water filtration methods in India have been discussed here. In some of the rural areas of Karnataka, women use cotton cloth layers for water filtration. This method is very cheap, cost effective in removal of sediments or any suspended solids, but may be not completely suitable for drinking purpose. Some places people are using simple plastic bottles with open end, inside which a layer of bone char followed by a layer of sand and a layer of pebble on both sides of the bone char layer is being used through which water will be passed for filtration. This kind of filtration process is capable of removing sediment and microbes effectively from water. 2 Solar distillation and solar sterilization are the recent but convenient technologies developed as a low-cost water filtration process. In this process water filled clean plastic bottles are left in sun for several hours so that the UV radiation and the heat generated will be able to kill the microbes present in water causing many water borne diseases. Now these methods are improvised by using thermal indicators inside the bottle letting the users know when it will be safe to drink the water. But despite of being cheap and

effective, this method is a function of availability of solar light. So maybe not abundantly used in water purification process. In comparison with solar sterilization, the solar distillation technique is even capable of purifying muddy water or salty water through the process of evaporation and condensation. Among widely used naturally occurring adsorption media, bamboo charcoal provided with base gravel layer also is very effective in purifying water with the advantages of being low cost, environment friendly and requires minimum maintenance. Activated carbon, silver beds, charcoal, sand is being widely used in portable filters for disinfection and filtration of water. Bone char is proved to be very efficient in removing heavy metal ions from water, the excess amount of which can cause many fatal renal and cardiac diseases and high blood pressure. Ceramic filters provided with saw dust or rice husk in the shape of pots are very much efficient in microfiltration which removes suspended solids and microbes to great extents. The main disadvantage is for small house hold purpose where pressure filtration is not an option; it has to be used for gravity filtration and thus the rate of filtration will be very much less and the filter requires continuous maintenance. Recently IIT M has developed an effective low cost water filtration model specifically meant for rural areas which uses a cheap plastic mesh which is capable of removing 98 percent of impurities from water including pathogens. The cost of the filter is somewhat Rs 700 to 800 and very easy for reuse. Another recent development of IIT M is development of composite nano material used as a filter media which capable of removing toxic metal ions as well as killing the pathogens. The filter is worth rupees Rs 500 excluding the cartridge. Another attractive feature of this filter media is that the cartridge can be reused by simply boiling in water or rubbing with lemon juice which is easily available in common households. India's largest company Tata Group has developed a very cheap water filter known as "Swachh", cost of which is less than Rs1000. It uses nano-technology for filtration and silver particles for eradicating bacterial contamination. 3 Ultimately the aim of development of any low cost water filtration model should be to operate with minimum energy, minimum maintenance, cost effective, environment friendly, implementable with ease and can be developed from local artisans. This will subsequently inspire the people to put hygiene in to habit and of course will help in the social and economic growth of the country.

II. Related Work

- ❖ Hasan in 1990 studied the contact aeration for iron removal method. The iron removal process utilized the catalytic effect of ferric iron. Again in this experiment it was theoretically demonstrated that by keeping high concentration of ferric iron, the volume of the aeration tank can be significantly reduced and it was according to the oxygenation rate equation. Ferric iron is very much effective in decreasing the reactor volumes at lower pH values. It is proposed to recycle the ferric sludge to maintain the high ferric iron concentrations in the reactor.
- ❖ William, et al. in 1992 studied the impact of dissolved organic carbon on the removal of iron during water treatment. He used the iron removal process by oxidation and coagulation method. Humic and fulvic acids, tannic acid and oxalic acid were estimated in the organic content. Potassium permanganate, chlorine dioxide and free chlorine were used as oxidizing agent.
- ❖ Catherine in 1988 studied the control of biological iron removal from drinking water using oxidation-reduction potential. In this study a pilot plant was used for treating raw water with pH 5.7 for biological removal of iron to produce drinking water. Here oxidation- reduction potential was used as a tool for evaluation and determination of relationship with dissolved oxygen and residual iron concentration in the infiltrate by using a biological filter.
- ❖ Tomotada studied the Current bioremediation practice and perspective in 2001. In the method he used in-situ fluorescence hybridization (FISH), in situ PCR, and quantitative PCR for removal of contamination by bioremediation .In this method the detection and reorganization of bacteria and pathogens is very vivid and these are being directly related to the rate of degradation of contaminants.
- ❖ Wang, et al. in 2003 studied the removal of heavy metal ions from aqueous solutions using various adsorbents with minimal cost. He used various low cost adsorbents like Fe₂O₃, Fe₃O₄, FeS, steel wool, Magnesium pallets, Copper pallets, Zinc pallets, Aluminum pallets, Iron pallets, coal, GAC for removal of heavy metal ions like cobalt and zinc from ground water.

III. FILTRATION MODEL DEVELOPMENT AND MATERIALS USED

Filtration Model Development Here we have manufactured a simple cylindrical filtration tube as shown in figure (a) with the following dimension Length = 30cm Internal diameter = 8cm Outer diameter = 10 cm

- Base is covered with a porous plate of 5mm diameter pores as per fig (c).
- From the base, a conical portion is extended to collect water with a tap as shown in fig (d) to regulate filtered water.
- Top of the cylinder was covered with a perpeX sheet of 1 inch thickness as shown in figure (b)
- A hole of 2 cm diameter was made to connect with the inlet pipe.

In the proposed design of the model, the prefabricated water of known iron concentration was passed through the inlet pipe above. Inside the cylinder, different adsorption media of specified thickness were placed with proper gravel support. Then after filtration, the filtered water was collected through the conical part in a beaker and the final iron concentration was measured in the Atomic Absorption Spectrometer (AAS). The rate of filtration was noted and for each adsorption media, three samples were tested and average iron concentration was considered for analyzing filter effectiveness.

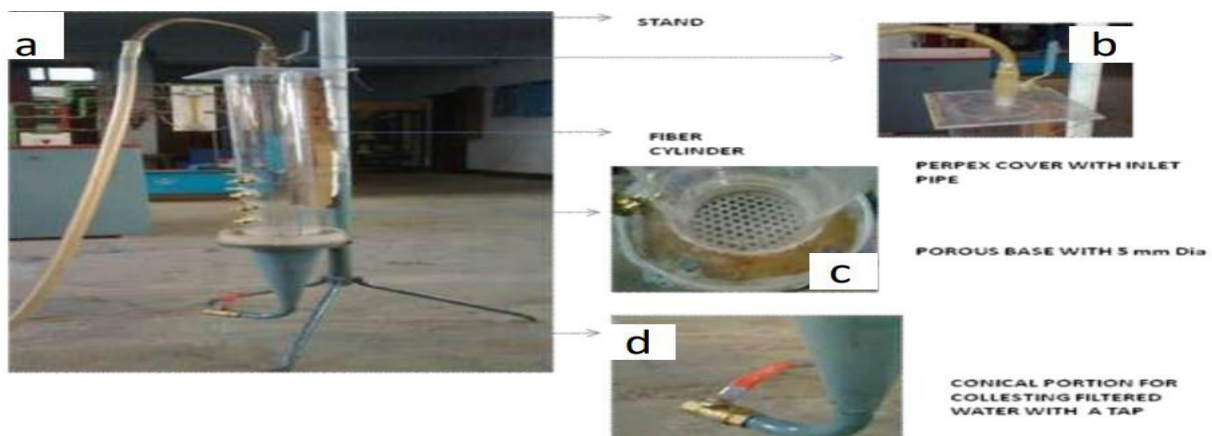


Fig.3.1(a) Filtration Model, (b) Inlet pipe fitted with the perpeX cover, (c) Porous base, (d) Conical portion for water collection

IV. METHODOLOGY

For removal of iron broadly two phenomena had been used in the experiments i.e. adsorption, oxidation followed by precipitation and for removal of turbidity microfiltration by ceramic filter has been adopted.

Adsorption- Basically the adsorptive filtration is operated under anoxic conditions for removal of iron where oxidation of ferrous iron is suppressed i.e. in case of filtration of ground water [1]. Here we have taken aerobic conditions for filtration in the adsorption media. Among some well known adsorption media like anthracite, olivine, magnetite, zeolite, sand, pumice, bituminous coal [2], carbonaceous shale [3] etc. The following adsorption media had been experimented here for removal of iron from drinking water.

Sand Fine sand and gravel are naturally occurring glacial deposits high in silica content and low in soluble calcium, magnesium and iron compounds are very useful in sedimentation removal. But here the media is used for iron (Fe) removal from drinking water [4]. As per mentioned in specified sand was taken and cleaned with distilled water and dried in oven for 6 hours at 373 K. After being cooled to room temperature, the sand was used in the filtration model previously developed with a gravel base of specified size to support the sand bed. Known concentration of 1000ml of iron solution was passed through the sand and the filtrate was collected in a beaker. The rate of filtration was calculated and final iron concentration was measured with AAS (Atomic Absorption Spectrometer)

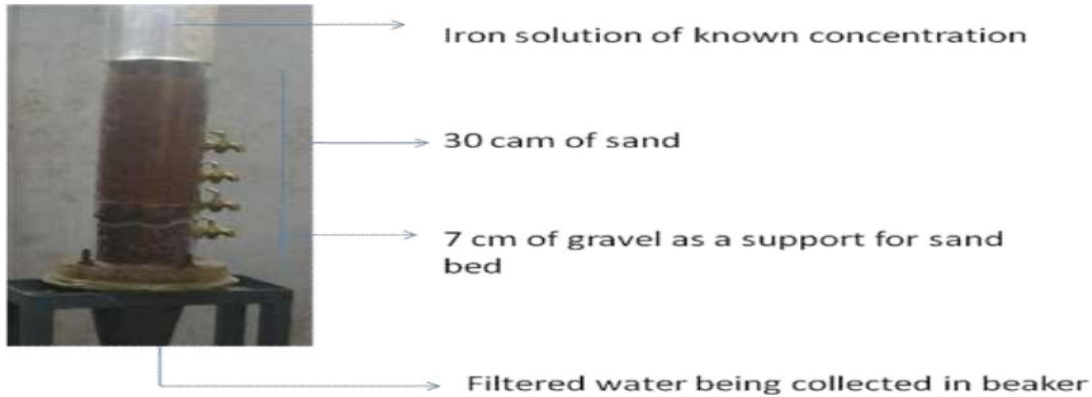


Fig 4.1 Filtration using plane sand as filter media

Activated carbon- The micro contaminants present in water cannot be effectively removed by traditional method where as the activated carbon proved to be very useful for removal of organic as well as inorganic contaminants. As specified in crushed activated carbon was obtained and used above sand bed of specified thickness in the filtration model for removal of water. For experimentation 1000 ml of iron solution of known concentration was taken and the filtered water was collected after filtration and the rate of filtration was noted

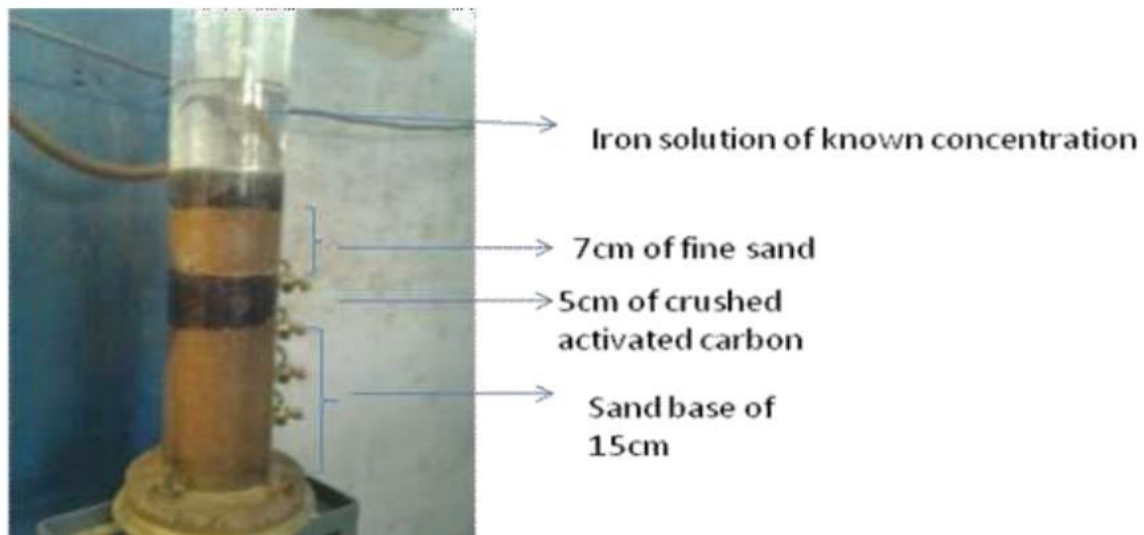


Fig 4.2 Filtration using Activated carbon as adsorption media

V. RESULT & DISCUSSION

5.1 Results obtained for Adsorption Process- The following results are obtained in removal of iron by using different adsorption media as mentioned in 5.1. The rate of filtration and the effectiveness in removing iron are tabled here.

5.2 Sand media- The initial iron concentration was 5.208 PPM in case of 425 micron sand and after filtration the final concentration was found to be 0.17 PPM by averaging the three sample results. Similarly in case of sand of size 600



micron the iron concentration reduced from 5.211 PPM to 0.386. The rate of filtration in case of sand of smaller size was lesser due to smaller pore size and larger specific area which increased the surface for adsorption.

Table 5.1 Results of filtration in sand media

Size of sand (micron)	Sample no.	Initial Iron content (PPM)	Final Iron Content (PPM)	Rate of filtration (ml/min)
425	1	5.208	0.142	333
	2		0.144	333
	3		0.222	333
600	1	5.211	0.36	500
	2		0.41	500
	3		0.39	500

5.3 Activated Carbon- due to crushing of the activated carbon, the specific surface for adsorption may be increased, but the pore size increases. So there was not so significant removal of iron. Activated carbon for removal of iron should be separately fabricated instead of using the used carbon filter for better iron removal as well as removal of other impurities. The result obtained for activated carbon is given below.

Table 5.2 Results of filtration in activated carbon media

Size of Activated carbon (mm)	Sample no.	Initial Iron content (PPM)	Final Iron Content (PPM)	Rate of filtration (ml/min)
2	1	10.008	5.42	6700
	2		5.144	6700
	3		6.222	6700

5.4 Cost of the filter- used Here we have provided a crude chart for the cost of all the adsorbent media we have used for experimentation excluding the labor cost, maintenance cost and energy cost

Table5.3 cost of ceramic filter used per cm³

Sl. No.	Ingredient	Percentage by weight	weight in kg	Unit price / kg in Rs.	Cost (rupees)
1	Clay	46.67	0.4	0	0
2	Sod. carbonate	3	0.0175	250	4.375
3	Sod. metasilicate	1.5	0.00855	310	11.2
4	Boric acid	1.5	0.00855	460	3.91
5	Rice husk	23.34	0.2	20	4
					Total= 23.6 /filter volume= 23.6/11.78 cm ³ = 2rupess/ cm ³

Here the material cost of each adsorption media per kg used for experimentation is given in the table and the total cost as per the amount of material used is also mentioned. From the table, it is clear that ash from banana residue is with minimal cost and maximum efficiency in removing iron.

Table5.4 Material cost of different adsorbent media used in experimentation

Material	Amount used for experiment (kg)	Rate per kg In rupees	Total cost In rupees
sand	0.6	15	9
Reused Activated carbon	0.4	20	8
Charcoal	0.2	10	2
Rice husk	0.3	20	6
Anthracite	0.6	330	198
KMnO ₄	0.037	150	5.5
Banana ash	0.1	10	1
Aluminum sulphate	0.054	20	2

VI. CONCLUSION

- ❖ Adsorption being the simplest and cheapest technique for iron removal, it has several advantages, like longer filtration runs, shorter ripening time, better filtrate quality. But the only limitation is back wash water requirement is essential for the filter media to run effectively.
- ❖ Sand being the cheapest adsorbing surface is very effective in removal of dissolved iron from drinking water and the rate of filtration is also very high. The only demerit is subsequent development of bacterial layer due to rigorous use. Again back washing is needed time to time.
- ❖ In case of activated carbon and wood charcoal, the removal is not so significant. This may be due to larger particle size of material being used. Smaller the size of particle larger will be the specific surface and better will be the removal.
- ❖ The SEM images showed that the uncoated sand has fairly uniform surface with small fractures giving a slight rough surface. In contrast, due to new born coating the coated sand appears to be somewhat rougher at the same magnification. These new developed surfaces proved to be a good adsorbent surface for iron removal. There is negative concentration of iron after filtration signifies no traces of iron in water.
- ❖ Aluminum hydroxide coated RHA also proved to be a good adsorbent in removal of iron. Previously it has been experimented that it forms complexes with fluoride ion for its removal. Here in case of iron, there is no proof of formation of any complex. So the removal may be credited to roughening of RHA surface due to modification by aluminumhydroxide.
- ❖ Banana ash has been proved to be effective enough for removal of iron ion and being the cheapest material used in the experiment. The production of banana ash is also very cost effective where it is only burned by controlled combustion at 500 degree Celsius for 4 hours. But only some manual mixing is required for

filtration when large amount of water is supposed to be filtered. By a simple cotton cloth the filtered water can be separated.

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