Treatment of Contaminated Water Using a Modified Compacted Sand Filter

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Abstract - As we all know water is a fundamental human need. Human life depends significantly on safe and clean water, be it for drinking, cooking or cleaning purposes. According to a survey, each person requires at least 20-50 litres of safe and clean water on a daily basis. Contaminated water has always been the greatest foe of human wellbeing. It gives rise to many ailments such as cholera, typhoid, dysentery, hepatitis A, diarrhea and polio which are caused by excessive amount of pathogens or chemicals present in water. According to World Health Organization (WHO) some 829,000 people are estimated to die each year from diarrhea and since diarrhea is a rather preventable disease these deaths could've been averted if certain measures were taken to ensure clean and safe water. Some dangerous chemicals such as MTBE and chlorinated solvents present in water result in liver damage or even cancer in worst cases. Also these diseases, caused by the contaminated water, cost a huge capital. This paper addresses the aforementioned problems caused by contaminated water and ensures certain measures to minimize these problems by fabricating a Modified Drawer Compacted Sand Filter (MDCSF).

Key Words: Contaminated Water, Modified Drawer Compacted Sand Filter, Water Filtration, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), Coliform.

1.INTRODUCTION

The effects of contaminated water on health, economic and social aspects are severe and need to be addressed and for that certain control measures are to be ensured. This study aims for the filtration of contaminated water by fabricating a Modified Drawer Compacted Sand Filter (MDCSF). As evident from the name, it's a modification of conventional drawer compacted sand filter. The modification being an additional aeration system and silver coated sand as one of the filter media. MDCSF consists of six different drawers and each drawer contains a different filter media. The filtration, using this model, relies mainly on adsorption method. Different tests are conducted on various samples before and after filtration and these test results are compared with permissible limits of drinking water as per B.I.S 10500 which has specifications in uniform drinking water quality monitoring protocol. According to which, if any parameter exceeds the limit, the water is considered unfit for human consumption.

1.1 Objectives of study:

1. To check different characteristics of pre and post filtered water samples such as:
    a. Biological Oxygen Demand (BOD)
    b. Chemical Oxygen Demand (COD)
    c. Total Coliform
    d. Total Dissolved Solids (TDS)
2. To check the difference in biological and chemical characteristics subjected to different retaining time.
3. To compare test results of pre and post filtered samples with permissible limits of drinking water as per B.I.S 10500.
4. To get safe drinkable water after filtration.

2. Model Fabrication

Modified Drawer Compacted Sand Filter (MDCSF) consists of six different drawers which are placed in a stand. The dimensions of the model are 42 cm X 28 cm X 150 cm. Each drawer contains different filter media of 10cm depth. Air space of about 10 cm, between the lower surface of one drawer and the upper of surface of the drawer immediately under, is provided for additional aeration. The position of each drawer and the respective material is such as:

1. The topmost drawer consists of the aeration system. Aeration mixes air with water thus removing dissolved gases in the process. It also oxidizes dissolved metals such as iron. Aeration, in this drawer, is provided using the help of a motorized fan. A tap and a pipe have been provided through which we discharge the aerated water sample into the next drawer.

2. The second drawer contains gravel and the depth of this filter media is kept as 10 cm. Gravel sample passing through a 4.75 mm sieve and retaining on a 2.36 mm sieve was used. Gravel filters are most effective for minimizing turbidity of water. Perforations of 4 mm size and 2 cm spacing are provided in this drawer so that the water sample flows from this drawer to the next.

3. Sand of effective size 1.18 mm was used as the filter media in the third drawer. Sand is used as a major filtering media. The purity of water increases with the fineness of sand as the water flows from the upper drawers to the lower ones. The depth of filter media in this drawer is also kept as 10 cm. However, the perforation size for this drawer is 2 mm while the spacing is same (2 cm).

4. This drawer contains activated charcoal of effective size 1.18 mm-600 m. The main reason of using activated charcoal is because of its property to remove many toxic substances such as volatile organic compounds and chlorine through the process of adsorption. Also, it helps to control taste and odour of water. The orifice size and spacing is same as in the third drawer.

5. The fifth drawer contains silver-coated sand of effective size 600 μm. Here, silver has been used due to its anti-bacterial properties against both Gram-negative and Gram-positive bacteria. The orifice size and spacing is same in this drawer also. The silver-coated sand was prepared as follows:

    a. About 500 g of graded, washed, and dried sand was mixed with 1 g silver nitrate dissolved in 1 L of distilled water, mixed thoroughly and allowed to stand for a period of 1 h.

    b. This mixture was then treated with 2 g of NaOH and dissolved in 50 ml distilled water and mixed thoroughly.

    c. The sand was treated with 10 ml of 1% of NH_4OH solution and 15 ml reducing agent (9% of sugar solution) mixed thoroughly as before and left for 1 h.

    d. The treated sand after solar drying was washed with distilled water and finally oven dried at 100–110 °C.

6. The final drawer contains fine graded sand, passing through a 600 μm sieve and retaining on a 75 μm sieve, along with a collection system. This fine graded sand helps in purifying the water from the remaining few impurities.

Filter Media	Specifications
Drawer 1	Aeration System
Drawer 2	Gravel; effective size 4.75 mm
Drawer 3	Sand; effective size 1.18 mm
Drawer 4	Activated Charcoal; effective size 1.18 mm to 600µm
Drawer 5	Silver-coated sand; effective size 600µm
Drawer 6	Sand; effective size 75µm along with collection system
Depth of Media	10 cm for each drawer
Perforation for each layer except for the first and the last one	Orifice size – 4 mm second drawer 2mm – third, fourth & fifth drawer Orifice spacing 2 cm

Table -1: Configuration of MDCSF

3. Results and Discussions

For the purification of contaminated water, about 1L of water was poured into the aeration drawer. After aerating for around 5 minutes the water sample was fed into the second drawer, with uniform distribution, through a pipe. The water sample was filtered through gravel and subsequently discharged into the next drawer through perforations. The same process is repeated till the water sample reaches the final drawer where the filtered water sample is collected using the collection system provided. The water samples were filtered once subjected to 3-minute retention and also under no retention. Different chemical and biological parameters like TDS, BOD, COD, Total coliform, Phosphates, Nitrates, Fluoride, Sulphate, pH, Turbidity, Total Hardness and Conductivity were tested by standard laboratory instruments before and after filtration. Also, both the samples, one subjected to retention and the other without retention, were tested. Table 2 shows the comparison of water quality parameters for treated and contaminated water

Parameters	Raw Water	Treated Water		Desirable/Permissible limits B.I.S 10500
		No retention	3-Minute retention	
COD (mg/l)	25	10	8	<10
BOD_5 (mg/l)	2.6	Nil	Nil	<5
TDS (mg/l)	166.6	458.5	315	500-2000
Total Coliform	Present	Absent	Absent	Absent
Nitrate (mg/l)	20	15	10	0-45
Fluoride (mg/l)	0.5	0.3	0.3	1.0-1.5
pH @°C	6.5	7.0	7.5	6.5-8.5
Turbidity (NTU)	15.10	5.4	5.1	1.0-5.0
Total Hardness(mg/l)	375	240	210	200-600
Conductivity (µs/cm)	238.1	655	450	-
Phosphate (mg/l)	0.2	0.2	0.1	-

Table -2: Comparison of water quality parameters for treated and contaminated water

Note: Activated charcoal increases conductivity of water and since TDS was calculated using conductivity method, TDS also increases.

3. Economic Aspects

The cost of every material required in the fabrication of Modified Drawer Compacted Sand Filter (MDCSF) was noted. Table 3 shows the cost parameters of MDCSF and it clearly indicated that the filtration through this model was much cheaper and efficient, compared to other existing filters. The major underlying cost involved setting up of the six drawers and the stand fabrication. Maintenance of MDCSF is easier and inexpensive, as compared to other filters, as the drawers are movable.

Item	Primary cost (INR)
Stand fabrication	2000
Drawers	1200
Silver-coated sand (1kg)	500
Pipe fittings	150
Miscellaneous	200
Total cost	4050

Table -3: Cost of setting up of MDCSF.

4. Conclusion

Contaminated water has a grave effect on human well-being as well as social and economic aspects of a country. It not only effects the human life but also has an equally adverse effect on flora and fauna. Therefore, it is really important that the contaminated water be treated properly before any use, be it drinking, cleaning or other purposes. Drawer compacted sand filter and other systems are the conventional techniques of this modified system. However, these conventional systems don't provide desirable results. MDCSF rectifies these problems while also providing a much cheaper and convenient system for filtration. The modifications in this model incorporate natural/forced aeration, an activated charcoal layer and the use of a layer of silver-coated sand. The final results clearly indicate that the filtration process using MDCSF is fruitful as the results meet the permissible limits of drinking water standards as per B.I.S 10500. After keenly observing and analyzing the overall results, it was concluded that there was not a distinguished difference between the results of retained and non-retained filtration. Thus, there is no particular need for retaining water sample in the filter media, however, for slight improvement in the overall results, the retention proves to be beneficial.

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