International Journal of Engineering and Management Research e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-13, Issue-1 (February 2023)
https://ijemr.vandanapublications.com https://doi.org/10.31033/ijemr.13.1.20

Analysis of Groundwater Quality and Design of Low-Cost Water Purifier

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ABSTRACT

The small portion of available fresh water for human consumption is being contaminated by various anthropogenic sources at a very alarming rate. Water pollution is the contamination of water bodies, usually as a result of human activities. Water pollution is one of many types of pollution which results from contaminants being introduced into the natural environment. Pollution causes adverse change. Pollution of groundwater can occur from on-site sanitation systems, landfills, effluents from wastewater treatment plants, petrol filling stations, leaching sewers, or over-application of fertilizers in agriculture. With this view, an attempt was made to assess the quality of groundwater in the rural area near Vijayawada by examining various physicochemical parameters such as colour, turbidity, odour, pH, total dissolved solids, alkalinity, hardness, chloride, fluoride, iron, and magnesium to check the suitability of water for human consumption. In this work, samples of water were collected and various parameters regarding the water quality were analysed &compared with Indian Standards: 10500 (Drinking water specifications) to check the acceptability of water for drinking purposes. Further, an attempt is also made to design a low-cost groundwater purifier that works on the process of adsorption using naturally available materials.

Keywords-- Water Purifier, Chloride, Adsorption

I. INTRODUCTION

Water quality refers to the chemical, physical and biological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to the health of ecosystems, the safety of human contact, and, drinking water.

Groundwater is one of the most important sources of water for drinking and irrigation. Unfortunately, groundwater is susceptible to pollution from on-site sanitation systems, landfills, effluents from wastewater treatment plants, petrol filling stations, leaching sewers, or the over-application of fertilizers in agriculture. Analysis of groundwater pollution may focus on soil characteristics and site zoology, hydrology and hydrogeology, and the nature of the contaminants. There are various purification methods to make water potable, as required by the public water-supply scheme. The water required for domestic consumption should possess a high degree of purity and should be free from suspended impurities, bacteria, etc. Thus, drinking water must meet the highest standard of purity, which is possible by maintaining the various constituent concentrations in water within the permissible limit. There are various methods adopted to produce potable water, of which, the adsorption process is a widely used phenomenon. Adsorption is operative in most natural, physical, biological and chemical systems.

II. STUDY AREA

The study area is located on the North – East side of Vijayawada city, which is an industrial area (Autonagar) and includes four continuous villages namely Ramavarappadu, prasadampadu, Enikepadu and Nidamanuru. A drain called Guntathippa, discharges the industrial and domestic effluents of Autonagar and other surrounding residential areas into the Eluru canal. The Guntathippa drain flows on South – East side of Prasadampadu village. Prasadampadu, Enikepadu and Nidamanuru are recently well-developed on flat agricultural fields, whereas Nidamanuru is situated in low-lying area. So, we have chosen the Nidamanuru village.

The study area is developed on flat top clayey soils and gravel mixed with clay near hill areas. Due to heavy rainfall, the entire study area gets flooded, because of flat topography and the absence of an effective drainage system. The main groundwater recharging areas in the study area are the Krishna River and Eluru canal. The Krishna River is passing on the south side and Eluru canal passes on North – East of the study area. The groundwater levels in open-dug and bore wells are varying from 2 to 3 m below the ground level.

III. SCOPE AND OBJECTIVES OF THE PROJECT

Due to the discharge of Sewage Treatment water from RGUKT IIIT Nuzvid into agricultural fields of the village Goduguvarigudem, the groundwater in that area was polluted. The villagers residing there said that using that groundwater causes health effects to them and it also destroys the water supply system. Because of this reason, the villagers stopped using groundwater. This paper focuses on the experimental study and analysis of groundwater quality and the design of a low-cost water filtration technique. This water filtration system will focus on cutting down the cost while maintaining filter effectiveness. Designing affordable water filters for rural and remote areas, will greatly improve people's quality of living, and reduce the risk of any waterborne diseases, therefore, saving lives.

The basic objectives of the project are as follows:

- To analyze the groundwater quality of Nidamanuru village near Vijayawada in Krishna district, Andhra Pradesh.
- Removal of chloride from water by using adsorption media which are locally available at a low cost.
- Designing a simple household setup for water Purifier focusing on removal of chloride.

IV. MATERIALS AND METHODOLOGY

Water quality analysis was done and each physical and chemical parameter is compared with the drinking water standard prescribed by IS 10500 to check whether the water is safe to drink or not. In this study, an attempt is also made to remove excess chloride by designing a low-cost water purifier.

A. Physical and Chemical Examination of Water

Water samples were collected from two locations of Nidamanuru village near Vijayawada (in Krishna district, Andhra Pradesh and physicochemical parameters such as chloride, alkalinity, total hardness, dissolved solids, suspended solids, pH, magnesium, nitrate, fluoride, and calcium were tested as per standard procedure i.e., IS 3025.

B. Materials used for the Design of the Purifier

Sand: sand and gravel are naturally occurring glacial deposits high in silica content and low in soluble calcium, magnesium, iron, and chloride compounds are very useful in sedimentation removal. But here the media is used for chloride removal from drinking water. Here for the experimentation plane sand passing through 2.36 mm and 1.18mm IS sieves were used.

Wood charcoal: Bituminous coal has been used before as an adsorbent and proved to be very effective in the removal of chloride. Due to the non-availability of bituminous coal, wood coal can be used as an adsorbent media for this experiment. Locally collected wood charcoal crushed to a size less than 10mm and down was used for the removal of chloride from water.

Coarse and Fine aggregates: Course and fine aggregates are used for the removal of chloride from water. Coarse aggregates are in the size 20mm to 25mm and fine aggregates were in the size 10mm to 12mm.

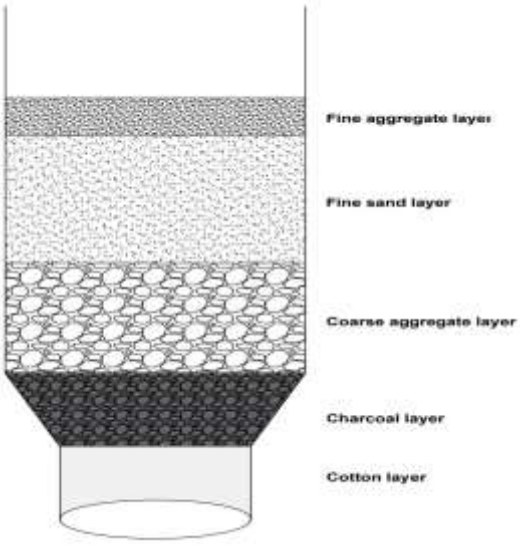

Figure 1: Longitudinal section of water filter

C. Preparation of Filter Media

A two-litre bottle was taken and the base of the bottle was cut off, then cotton was placed at the top side for preventing the charcoal from falling through the opening. Then, the filtering media can be made for the three repeated trails with different depths of the layers of adsorbent as well as aggregates. Charcoal granules of size 20-25mm were added above the cotton. Then, coarse gravels of size 20-25 mm were laid on the charcoal layer on which the layer of fine gravels of size 10-12 mm will be placed. Finally, the top layer of the filter will be filled with sand of particle size 1-1.5mm above the gravel layer as shown in Fig.1. The thickness of the individual layers can be varied for each repeated trail as shown in the following table.

Table I: Thickness of the different layers of filter media

Layer	Thickness of layers (in cm)		
	Trail-1	Trail-2	Trail-3
Charcoal	2	3	4
Coarse Aggregate	3	4	6
Fine Sand	4	5	7
Fine Aggregate	1	2	2
Total Thickness	**10**	**14**	**19**

D. Method of Purification

In this study, adsorption is used as a method of purification. Here, the adsorbate is attached to the surface of the adsorbent resulting in the passage of pure water out. Through this process, a contaminant from wastewater is transferred to the surface of the adsorbent material. Adsorption occurs primarily due to physic-sorption. It is used in the treatment of wastewater containing coloured chemicals, herbicides, pesticides, certain petrochemicals, and heavy metals. Adsorption is operative in most natural, physical, biological and chemical systems, and is widely used in industrial applications with both natural and artificial adsorbents such as activated charcoal, synthetic resins for water purification. For this study, charcoal is used as the main adsorbent for the removal of chloride.

V. RESULT AND DISCUSSION

Physio-chemical parameters such as chloride, alkalinity, total hardness, dissolved solids, suspended solids, pH, magnesium, nitrate, fluoride, and calcium were investigated from the two samples (one from High School and another from near Poranki road in the village) collected from the Nidamanuru village near Vijayawada city of Andhra Pradesh before filtering. These tests were performed as per the standard procedure prescribed in the code IS 3025 and results were compared with standards of drinking water as suggested by IS 10500.

By comparing the physio-chemical parameters with the standard desirable limits, it is observed that the Chloride content in both samples is exceeding its desirable limit. Also, Alkalinity, Calcium, and Magnesium contents are present in an excess amount which is not suitable for drinking before filtering.

Table II: The results and comparison with standard desirable limits of physiochemical tests of two water samples collected from High School and near Poranki road of Nidamanuru Village before filtering.

S.No.	Parameter	Content(mg/l)		Desirable Limit(mg/l)
		Sample-1(from High School)	Sample-2(near Poranki Road)	
1	Chloride	320	592	250
2	Alkalinity	290	220	200
3	Total Hardness	60	60	300
4	Dissolved Solids	390	100	500
5	pH	8.4(no units)	8.2 (no units)	6.5 to 8.5 (no units)
6	Magnesium	52	102	30
7	Fluoride	0.5	0.5	1
8	Calcium	59	105	75

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Table III: Test results of the sample after filtering with respect to depth and time.

Trial	Chloride content(mg/l)	IS Standard as per 10500(mg/l)	Total thickness of layers(cm)	Time period(min)
1	437	250	10	15.6
2	279	250	14	24
3	145	250	19	38

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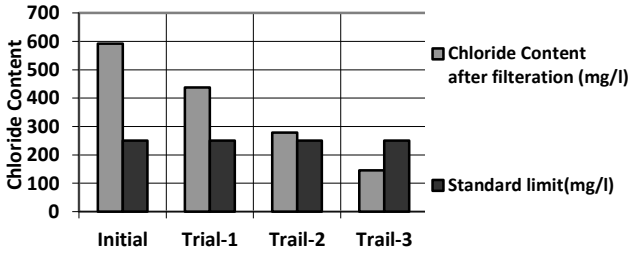

Figure2: Graphical representation of Chloride content before and after filtration

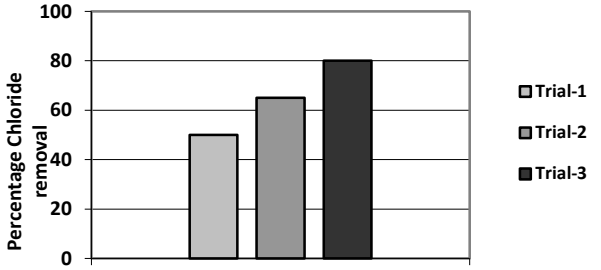

Figure 3: Percentage of chlorine removed in each trial

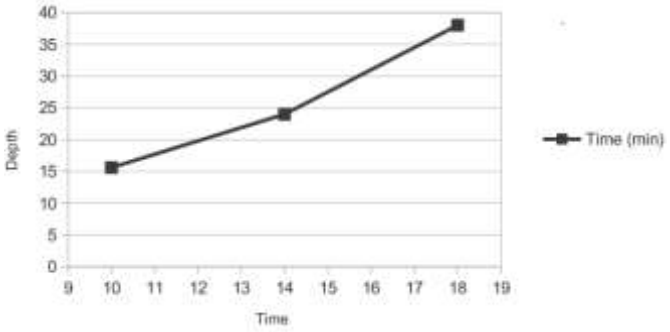

Figure 4: Plot of Depth (in cm) Vs. Time (in minutes)

Removal of chloride can be observed in Table III and Fig-2 as the trials were repeated with the same sample. Chloride deposition takes place in the filtering layers and the adsorbent medium (wood charcoal).

As the number of trials was repeated, the percentage of chloride deposition in the filtering medium increased (from Fig.3).

The time taken for passing all the layers increases as the total depth of the filtering media i.e., sand, course-aggregate, and adsorbent increases which were indicated in Table III as the exposure to each layer will be more.

VI. CONCLUSION

Water samples collected from a rural area near Vijayawada of Andhra Pradesh were analyzed for physiochemical characteristics and a pilot scale working model of a low-cost water purifier was designed using charcoal, gravel, and sand for removal of chloride. It was observed that charcoal could bring down the concentration of chloride from 592 mg/l to 145 mg/l. Sand and gravel can also remove organic and inorganic compounds from water. Most of the Goduguvaarigudem villager's financial status is low. They can't afford that much money for expensive water purifiers since most of them are daily wagers. So, this water filter with the availability of natural materials can be used by people from rural areas. Even unskilled persons also can make this purifier.

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