Comparison of Water Quality Indices of Surface Water and Ground Water Sources Using Geotextile-Marble Column Filter

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Abstract— The project is to study about the effectiveness of geotextile and marble chips, in filtration of surface water and ground water. Two kinds of water samples are to be required for the study. Surface water sample is taken from Kuttiadi river. Ground water sample is taken from a tubewell located in Nadapuram, 13 km away from Kuttiadi. Various water quality parameters of both surface water and ground water like turbidity, pH, EC, Chloride, TDS, TSS, total hardness, alkalinity, DO and BOD are to be determined. Then water quality index of both water samples are to be determined to understand the pollution standard. Both water samples are to be filtered through a geotextile – marble column filter. The filter medias used for the experiment are sand, geotextile and marble chips. Filtration process can be repeated by altering the arrangement of filter medias. The water quality parameters and water quality index are to be determined again after filtration. The analysis helps to determine, the most suitable arrangement of filter medias and effectiveness of geotextile-marble column filter in water purification.

Keywords— Filtration, Geotextile, Groundwater, Marble chips, Purification, Surface water, Water quality parameter

1 INTRODUCTION

The Earth's surface is around 71% water that is mostly saline. Water is also present in the ground, air and within living organisms. Nowadays, there is an increasing environmental concern about the quality of surface water in the world since the quality of our life is dependent on water as a life source. Water quality can be affected by point and non-point sources. Surface water quality is mostly influenced by groundwater and less by surface run off. During periods of heavy precipitation though, the reverse phenomenon is observed. Groundwater is the world's largest accessible freshwater and an important resource for human daily uses. Groundwater can be used as drinking water supply, irrigation, industrial uses and many other uses [3]. Approximately one- third of the world's population depend on groundwater for drinking purpose. Groundwater is one of the potential natural resources for human consumption in many countries around the world.

There are several materials and methods exists for the treatment of water. Geotextiles can serve as an efficient part of stormwater filtration within the urban water environment. The treatment process of using limestone alone is less effective than using a combined limestone with other materials for heavy metal removal [1]. According to current studies lime stones are very effective in purifying ground water.

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2 MATERIALS AND METHODS

2.1 Geotextile

Non woven geotextile fabrics of size 500 GSM are used for the study. A geotextile is a synthetic fabric made of different polymer compounds. The four most important groups of raw materials used in the manufacture of geotextiles are polyamides, polyethylene terephthalate (polyester), polyethylene and polypropylene.

2.2 Marble chips

Marble chips are made up of calcium carbonate. The presence of $CaCO_3$ in limestone increases the removal of pollutants. Calcium carbonate has been proven effective in removing metals, turbidity, suspended solids and total coliform from water. It has alkali properties to act as pH regulator in acidic water just as limestone.

2.3 Sand

Along with geotextile and marble chips, sand is also used as a filter media. Sand used here is normal coarse sand. In the study, sand is not used alone, but used with either geotextile or marble chips or both. In the study, sand is a common filter media for all filter arrangements.

2.4 Surface water and ground water

Surface water sample is collected from Kuttiadi river. The sample collected from Devarkovil, at which kuttiadi river undergo severe pollution due to exploitation by rural settlements. The raw groundwater samples were collected from tube well which is located in the rural area of Nadapuram, 13 km away from Kuttiadi.

2.5 Filter column

The filter column should be made up of glass and also should be transparent. A filter material is a porous material placed in a filter column, that separates the liquid and suspended particles and changes the water quality after flowing through the media [2].

2.6 Sample collection

Surface water sample is collected from Kuttiadi river. While collecting the surface water sample, rinse the sample bottle 3 times with the sample before it is filled.

Samples for groundwater quality monitoring would be collected from tube well fitted with a hand pump in rural area of Nadapuram far away from the river. Sampling of groundwater is important to obtain a representative sample of groundwater with contamination concentration [4].

2.7 Water Quality IndeX

The Bureau of Indian Standard and ICMR Standards have been considered for calculation of WQI. The WQI value lies between 0 to 25 indicates that the water has excellent quality. If WQI value lies between 26 to 50, water is good. If the WQI value lies between 51 to 75, the water quality is poor. WQI value between 76 to 100 indicates that, the water quality is very poor. When WQI value exceeds greater than 100, the water is unfit for drinking purpose.

2.8 Filtration

For the study, there are 6 types of filter arrangements for surface and ground water purification. In arrangement 1, sand is placed in the top layer of the filter coloumn. Below sand layer geotextile fabric is placed. In arrangement 2, sand is placed in the top layer and marble chips placed in the layer below sand. In arrangement 3, top layer is sand, geotextile is placed below sand layer and marble chips placed below geotextile layer. In arrangement 4, top layer filled with sand, below sand layer marble chips are placed and below marble layer geotextile fabrics are placed. In these four arrangements, all layers have equal thickness. In arrangement 5, geotextile layer is placed above and below of sand layer and marble chips layer. The thickness of geotextile layer is half the thickness of sand and marble chips layer. In arrangement 6, marble chips layer is placed above and below of sand layer and geotextile layer. The thickness of marble chips layer is half the thickness of sand layer and geotextile layer. After filtration, the water quality parameters like turbidity, pH, EC, Chlorides, TDS, TSS, Total hardness, Alkalinity, DO and BOD are tested from laboratory. In filtration, two or more components from a liquid stream are separated based on their size differences, so it can be one of the beneficial techniques for removal of suspended solids (SS) and contaminants adsorbed on solids from water and sediments [5].

3 RESULTS AND DISCUSSION

As described earlier, there are 6 types of filter arrangements for surface water and ground water purification. After filtration, the filtered water were tested for above mentioned water quality parameters. Ten water quality parameters were tested in both surface water sample and ground water sample before and after filtration. The tests were conducted in water lab Kozhikode. After determining the water quality parameters, the water quality index of both surface water sample and ground water sample were determined for each filter column arrangements.

After calculating the water quality index, water quality rating of filtered water samples in each filter column arrangement is determined.

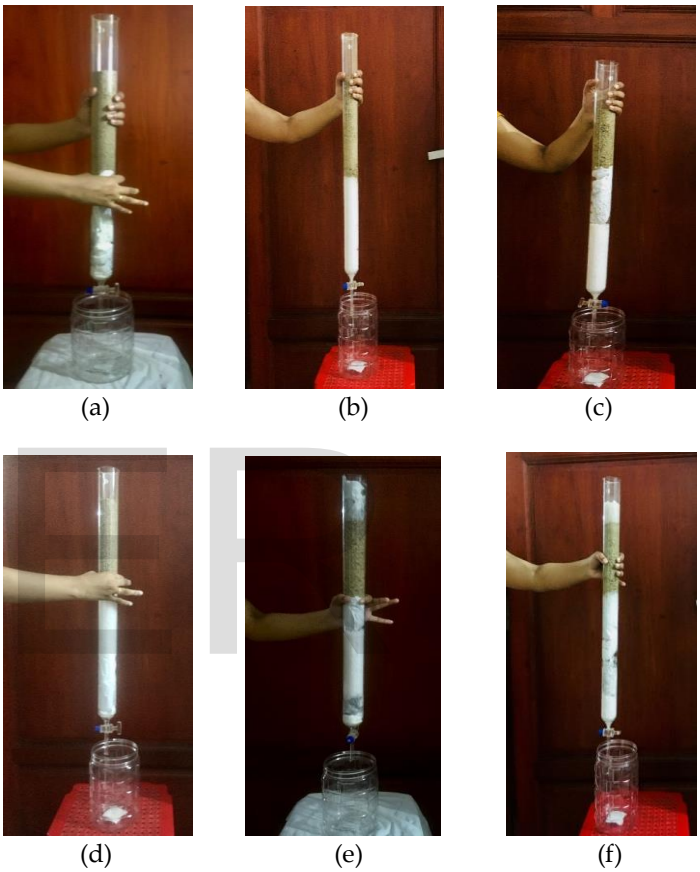

Fig. 1 (a) Arrangement 1, **(b)** Arrangement 2, **(c)** Arrangement 3, **(d)** Arrangement 4, **(e)** Arrangement 5, **(f)** Arrangement 6

Surface water and ground water passes through each of this filter arrangement at a flow rate 0.5 L per minute. From the obtained results and graphs, the best filter column arrangement, which gives high quality of filtered water is determined among the 6 arrangements. After determining the best filter column arrangement, compared the water quality indices of surface water and ground water, before filtration and after filtration through the best filter column arrangement.

Then the removal percentage of each parameter is determined with necessary graphical representations. And finally, the effectiveness of geotextile marble column filter in purifying surface and ground water is determined .

Each observations of both surface water and ground water experiments were correctly noted and tabulated. Analysis and results of the experiments are shown through necessary graphical representations.

The below table shows the values of water quality parameters of surface water and ground water before filtration.

TABLE 1
WATER QUALITY PARAMETERES

No	Parameter	Before Filtration		Drinking water standard
		Surface water	Ground water	
1	Turbidity (NTU)	13	4.7	5
2	pH	8.5	8.4	6.5 – 8.5
3	EC (micro S / cm)	293.4	831.7	1400
4	Chloride (mg/l)	285	318	250
5	TDS (mg/l)	1170	2640	500
6	TSS (mg/l)	2205	200	500
7	Total hardness (mg/l as $CaCO_3$)	126	229	200
8	Alkalinity (mg/l as $CaCO_3$)	205	211	200
9	DO (mg/l)	4.5	5	5 or > 5
10	BOD (mg/l)	18	2	< 5

The observed values of water quality parameters compared with standard values as per IS 10500- 2012 , except EC, DO and BOD. The permissible limit for EC is taken from WHO manual and permissible limit of DO and BOD taken from ICMR manual. The IS 10500-12 standard prescribes the requirements for the essential and desirable characteristics required to be tested for ascertaining the suitability of water for drinking purpose.

From the testing of water samples before filtration, Chloride, TDS, Alkalinity were exceeded the permissible limit in both surface water and ground water samples. In the case of turbidity, TSS, and BOD the amount exceeds the permissible limit in surface water. But in ground water, the amount of turbidity,TSS, and BOD are within the limit.

In the case of total hardness the amount exceeds the permissible limit in ground water. But, in surface water, the amount of total hardness is within the limit. In ground water, there is sufficient amount of dissolved oxygen, but in the case of surface water dissolved oxygen is less than the required amount.

The value of pH and EC are within the permissible limit in both surface water and ground water samples. The values of parameters like turbidity, pH, TSS, Alkalinity, BOD are higher in surface water than ground water. The river water is used for several purposes like bathing, washing, animal feeding and bathing etc. so, the river water is in frequent contact with soap and that's why the pH and alkalinity of river water is more than ground water.

Water quality index of surface water before filtration and after filtration through arrangement 1,2,3,4,5 and 6, are determined. WQI values are 105, 104, 91, 86, 52, 49 respectively. After filtration through arrangement 1 and 2, the filtered water is 'unfit for drinking'. Water quality rating of filtered water after filtration through arrangement 3 and 4 is 'very poor'. After filtration through arrangement 5, water quality rating of filtered water is 'poor'. After filtration through arrangement 6, the water quality rating of filtered surface water is 'good'.

TABLE 2
WATER QUALITY INDEX

Water sample	Filtration Status	WQI value	Water quality rating
Surface water	Before filtration	107	Unfit for drinking
	Arrangement 1	105	Unfit for drinking
	Arrangement 2	104	Unfit for drinking
	Arrangement 3	91	Very poor
	Arrangement 4	86	Very poor
	Arrangement 5	52	Poor
	Arrangement 6	49	Good
Ground water	Before filtration	54	Poor
	Arrangement 1	52	Poor
	Arrangement 2	51	Poor
	Arrangement 3	46	Good
	Arrangement 4	42	Good
	Arrangement 5	37	Good
	Arrangement 6	35	Good

In the case of ground water, the WQI value before filtration is 54. After filtration through arrangement 1,2,3,4,5 and 6, WQI values are 52,51,46,42,37,35 respectively. After filtration through arrangement 1 and 2, the filtered water is 'poor'. The water quality rating of filtered ground after filtration through arrangement 3,4,5 and 6 is 'good'.

3.1 WQI value Vs filter column arrangement

A graphical representation of WQI value and filter column arrangements are shown in figure. Through the graph we can easily understand the variation of WQI value and water quality rating with each filter column arrangements. In the graph, filter column arrangements are taken in X axis and WQI values are taken in the Y axis. Blue line represents surface water and red line indicates ground water.

WQI values of surface water is more than ground water in all arrangements. From the graph, we can understand that, WQI values are decreasing from before filtration to arrange-

ment 6.

Before filtration, surface water is 'unfit for drinking purpose', but after completion of filtration through arrangement 6, the water quality rating of surface water became 'good'.

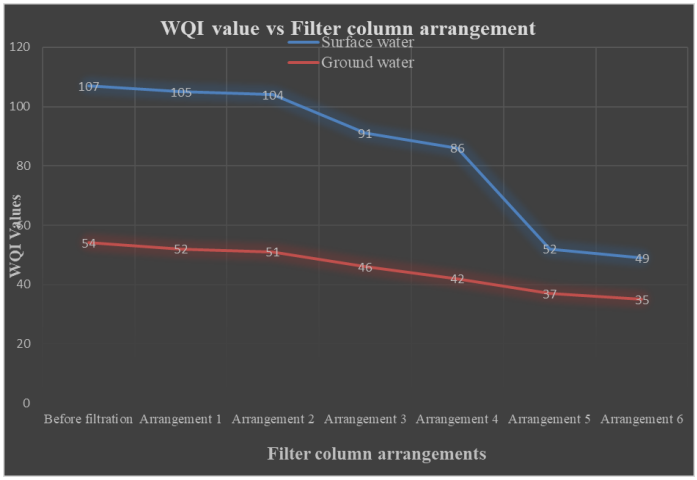

Fig. 2 WQI value Vs filter column arrangement

In the case of ground water, the water quality rating before filtration is 'poor'. But after the completion of filtration through arrangement 6, the water quality rating of ground water became 'good'.

From the graph, we can understand that, in both surface and ground water, the best quality is obtained after filtration through arrangement 6. So, the best arrangement is arrangement 6 i.e, alternate arrangement of marble chips in between sand and geotextile layer.

3.2 WQI values Vs water quality rating in surface water

In the above graph, water quality rating is taken in X axis and WQI value is taken in Y axis. From the graph, we can understand that after filtration through arrangement 3 and 4, the water quality rating of surface is 'very poor'.

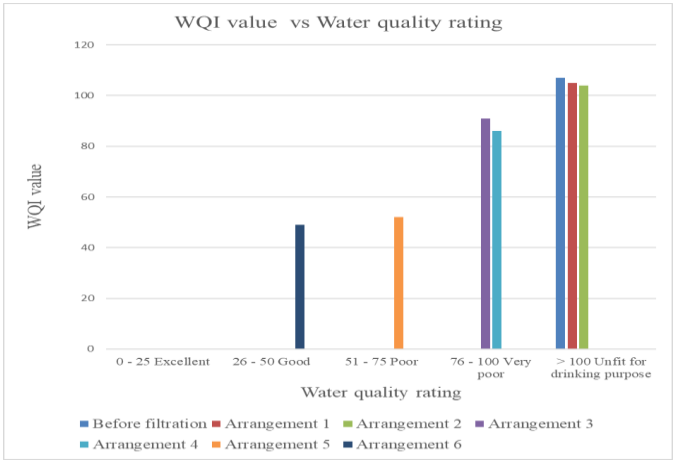

Fig. 3 WQI value Vs water quality rating in surface water

The water quality rating of surface water after filtration through arrangement 5 is 'poor'. After filtration through arrangement 6, the water quality rating of surface water became 'good'. So, in the case of surface water best quality of water obtained after filtration through arrangement 6.

3.3 WQI values Vs water quality rating in ground water

Graph shows the relationship between WQI value and water quality rating of ground water, before and after filtration through different arrangements. In the below graph, water quality rating is taken in X axis and WQI value is taken in Y axis.

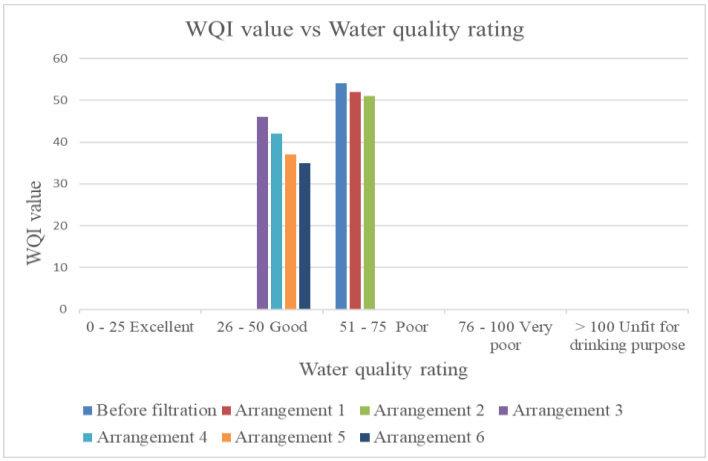

Fig. 4 WQI value Vs water quality rating in ground water

Before filtration and after filtration through arrangement 1 and 2, the water quality rating of ground water is 'poor'. After filtration through arrangement 3, 4, 5 and 6, the water quality rating of ground water became 'good'. So, in the case of ground water, best quality of water obtained after filtration through arrangement 6.

3.4 Removal percentage Vs water quality parameters

From observations and calculations, it is determined that, the best arrangement of filter media is arrangement 6.

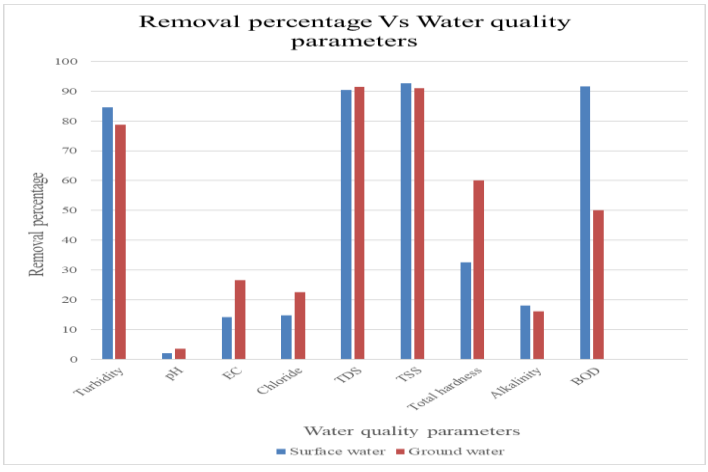

Fig. 5 Removal percentage Vs water quality parameters

So, comparison of the water quality parameters of surface water and ground water, before filtration and after filtration through arrangement 6, is completed and removal percentage is determined. It is shown in the above graph. X axis is taken

as water quality parameters and Y axis is taken as removal percentage. From the above graph, it is understood that, removal efficiency of turbidity, TSS and BOD is higher in surface water than ground water.

4 Conclusion

It can be concluded that, the water quality rating of both surface water and ground water is improved after filtration process and best quality of water is obtained after filtration through arrangement 6.

As per the conclusions after determining WQI, after filtration through arrangement 1 and 2, the surface water was 'unfit for drinking'. Water quality rating of filtered water after filtration through arrangement 3 and 4 is 'very poor'. After filtration through arrangement 5, water quality rating of filtered water is 'poor'. After filtration through arrangement 6, the water quality rating of filtered surface water is 'good'.

In the case of ground water, after filtration through arrangement 1 and 2, the filtered water is 'poor'. The water quality rating of filtered ground after filtration through arrangement 3,4,5 and 6 is 'good'.

After comparing water before filtration, and after filtration through the best arrangement i.e arrangement 6 , the arrived conclusions are, In the case of surface water, TSS has higher removal efficiency. In ground water TDS has higher removal efficiency. In surface water, TSS, TDS and BOD have above 90 percentage removal and turbidity has above 80 percentage removal efficiency. All other parameters have below 50 percentage removal. In ground water, TSS and TDS have above 90 percentage removal efficiency and turbidity has above 75 percentage removal efficiency. All other parameters have below 50 percentage of removal efficiency. In surface water, the water quality parameters which are effectively removed by geotextile – marble column filter are TSS, TDS, BOD and turbidity. In ground water, the water quality parameters which are effectively removed by geotextile- marble column filter are TSS and TDS. It is concluded that, geotextile – marble column filter is very effective for removing TSS, TDS, turbidity and BOD in surface water and TSS and TDS in ground water.

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