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Canal water treatment with rapid sand filtration

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Abstract

This study was carried out to characterize and treat the canal water for making it suitable for human consumption. Samples of water were collected from a canal running near Peshawar known as Warsak lift canal. The samples were evaluated both chemically and microbiologically and found unfit for drinking purpose. Therefore, physical treatment using sand as a filtering media was applied for making the water suitable for drinking purpose. Sand filtration technique significantly reduced the selected quality parameters and made canal water suitable for human consumption according to World Health Organization.

Keywords: *Canal water, treatment, biological parameter, chemical parameter, rapid sand filter*

Introduction

Water treatment describes a process used to make water more acceptable for desired end-uses, including drinking, industrial processes, medical and many others. The goal of water treatment process is to remove existing contaminants from the water and improving it for subsequent use (Anil, 1989). Treated water can be discharged into the natural environment without causing adverse ecological impacts. The Water treatment processes may be physical (settling), chemical (disinfection or coagulation) or biological (slow sand filtration or activated sludge techniques) (Chatwal *et al*., 1989).

Water purification is the removal of contaminants from untreated contaminated water to produce water for drinking purpose that should be pure enough for its intended use, most commonly human consumption. Substances that are removed during the process of drinking water treatment include bacteria, algae, viruses, and fungi, minerals such as iron, lead and sulphur, and man-made chemical pollutants (Chapman, 1992) from chemical industries.

The common method for filtration of a public water supply is to pass it through a layer of sand. It has been found that by passing water through sand, suspended and colloidal matters are partially removed, the chemical characteristics of water are changed, and the number of bacteria is substantially reduced. Thus, filtration through sand does aid in the removal of color, taste, odors, iron and manganese. To suggest appropriate water treatment technique, the water treatment through sand filter was used.

Filtration is the passage of water through a porous medium for the removal of particles in suspension. The effectiveness of filters was initially evaluated for the removal of suspended solids (or turbidity), color (apparent), organic matter (volatile solids), and plate count bacteria (Fuller, 1898). Comprehensive assessments of the actual removal of total bacterial cells, particle-associated bacteria, algal micro colonies, and nematodes were conducted at a water treatment plant treating Missouri River water (Brazos and Connor, 1990).

The present study was aimed to examine the chemical and the microbiological aspects of the Warsak lift canal water and the performance of the rapid sand filtration to make the canal water fit for human consumption through the process of physical treatment.

Materials and Methods

Sample collection sites

The samples were collected from the areas where the canal water is being used for drinking purposes. The areas were identified through field inventory visits as: S_1 = Bara river water coming to treatment plant; S_1 T = Bara river water (Treated); S_2= Warsak lift canal at Shahab Khel; S_2T= Warsak lift canal at Shahab Khwel (Treated); S_3= Warsak lift canal at Sarband; S_3T= Warsak lift canal at Sarband (Treated); S_4= Warsak lift canal at Mashokhel; S_4T= Warsak lift canal at Mashokhel (Treated).

Sampling

Samples were collected in 1.5 L capacity polythene bottles. The bottles were cleaned with cleaning mixture and then thoroughly washed with distilled water. At the sampling sites, the bottles were again washed thrice with the sample water and then filled with sample water. Samples were stored below 40°C and preserved according to the preservation method given in the standard method for

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examination of water and wastewater as given by American Public Health Association (APHA, 1998).

In water samples, pH was determined using Mettler Delta 320 pH meter (United Kingdom). Total solids (TS), total dissolved solids (TDS), total suspended solids (TSS) were determined as per APHA standard methods (APHA, 1998). Electrical conductivity (EC) was measured by using CM-4060 conductivity meter, made in Jenway electrochemical measuring instrument. UK. Alkalinity was determined as per standard methods (APHA, 1998). Similarly anions such as sulphate (SO^{-}_{4}) nitrite (NO_3) and chloride (Cl^{-}) were determined according to the standard methods (APHA, 1998).

Sodium, calcium, magnesium and potassium were determined using flame photometer (UK) model PFP7, 13VA.

Microbiological parameters

Aerobic plate count

The aerobic plate count was designed to provide an overall estimate of the total number of aerobic organisms in a given sample. A series of dilutions of the water was mixed with an agar medium and incubated at 35 °C for 48 h. It is assumed that each visible colony is the result of multiplication of single cell on the surface of the agar. The total plate count is useful for indicating the overall microbiological quality of product and, thus, is useful for indicating potential spoilage in perishable products. Media was prepared by dissolving 23.5 g of agar in 1 liter deionized water, placed over water bath for 30 minutes for mixing. Then it was sterilized at 121 °C for 30 minutes. Prior to its use, media was kept over water bath at 50 °C.

Total coliform bacteria

Total coliform was determined by WHO method as described (APHA, 1992). Two types of media lactose broth and brilliant green broth were prepared. For lactose broth 13 g of lactose broth was dissolved in 1 litre deionized water. Ten milliliters of the media was added to test tubes having Durham tubes in inverted position and sterilized at 121 °C for 30 minutes. Brilliant green broth (BGB) (40 g) was added to 1 litre deionized water, Ten milliliters of the media to test tubes having Durham tubes in inverted position and sterilized at 121 °C for 30 minutes.

Confirmatory test for total coliform

Each gassing LT tube was agitated and loopful of suspension was transferred to the tube of BGB broth. BGB tubes were inoculated for 48 hours at 35 °C. Tubes were examined and recorded. MPN of total coliform was calculated based on combination of confirmed gassing LT tubes for 4 consecutive dilutions. The major advantage of rapid sand filter (Gravity filter) is its great flexibility in being able to produce satisfactory water. The high rate of filtration reduced filter area to sizes economical for production of large quantities of water for large cities. Removal of bacteria is 90-95%. Highly skilled supervision is the limitation of rapid sand filter. The filtration was undertaken by rapid sand filter as shown in Figure 1. Total number of beds in rapid sand filter is five each with different size and having depth of about 30.98cm. The cross section of filter bed from top to bottom consisted of 8.9 cm of fine sand, 5.08 cm coarse sand, 6.35 cm of coarse grit, 4.318 cm round bajri (gravel) and 6.35 cm bed of boulders. The total depth of the beds was 30.98 cm.

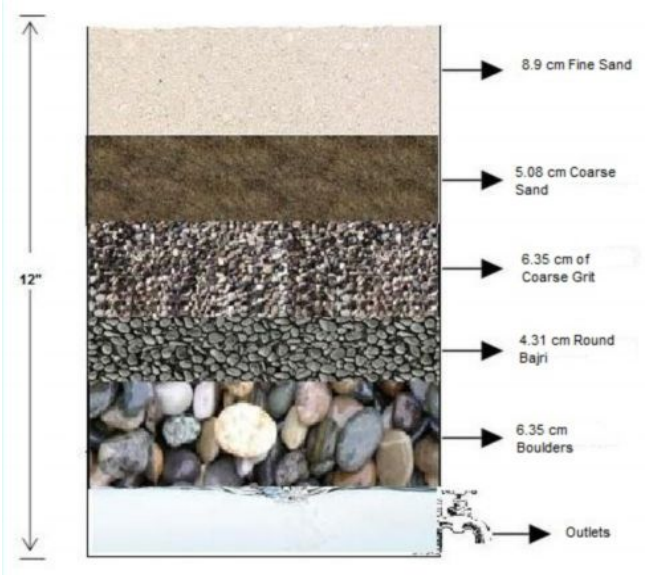

Figure 1: Diagrammatic representation of rapid sand filter used in this study

Results and Discussions

Rapid sand filter

Physical treatment of water through rapid sand filter was done and the samples were analyzed again in order to check the water quality after treatment (Table 1). The values of pH and EC were observed within permissible limits (Table 2). Total suspended solid in water of canal in raw form was ranged from 98-1508 mg L^{-1} but after passing through the sand bed its value reduced from 2-4 mg L^{-1}. The maximum permissible level for suspended solids suggested by WHO is 5 mg L^{-1}. After filtration with reference to suspended solids, the water became fit for human consumption.

The total dissolved solids (TDS) level in raw water of canal was ranged from 184-350 mg L^{-1} but when it was

passed through sand filtration bed its value reduced from 132-248 mg L^{-1}, while the WHO limits for TDS is 1000 mg L^{-1}. The values of sulphate (SO_4) before treatment in canal water were ranged from 441.6- 61.44mg L^{-1} but after treatment its value was ranged from 26 - 233.92 mg L^{-1} while the WHO limits for SO_4 is 250 mg L^{-1}.

Table 1: Characterization of canal water before and after treatment

Parameter	S_1	S_1T	S_2	S_2T	S_3	S_3T	S_4	S_4T
T.H (mg L^{-1})	240	235	240	180	240	180	160	140
Ca^{+2} (mg L^{-1})	144	124	140	124	140	124	88	80
Mg^{+2} (mg L^{-1})	116	91	100	56	100	56	72	60
NO^{-2} (mg L^{-1})	NIL	NIL	NIL	In traces	Nil	Nil	In traces	Nil
EC (Us cm^{-1})	430	422	385	370	235	234	376	213
pH	7.5	7	7.80	7.10	7.80	7.3	7.54	7.53
T. Alkalinity* (mg L^{-1})	188	184	172	168	172	168	104	96
P. Alkalinity* (mg L^{-1})	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Cl^- (mg L^{-1})	18	18	33	20	30	20	30.4	18
Na^+ (mg L^{-1})	14.5	12	20	12.6	20	11.6	18	5
K^+ (mg L^{-1})	2.4	1.8	16.2	5.1	16.2	5.1	3.6	3.4
SO^{-2}_4 (mg L^{-1})	441.6	233.92	153.6	26.8	150.6	26	61.44	57.6
T.S.S (mg L^{-1})	404	2	98	4	1146	4	1508	4
T.D.S (mg L^{-1})	184	140	292	248	196	134	350	132
T.S (mg L^{-1})	544	186	346	296	1280	200	1640	354
BOD (mg L^{-1})	-	-	0	0	0	0	50	43
COD (mg L^{-1})	-	-	0	0	0	0	80	60
Total Plate Count (Cfu 100mL^{-1})	185	0	-	-	-	-	9000	-
Coliform (MPN index mL^{-1})	9.2	<1.1	-	-	-	-	23	-

In canal water total alkalinity before filtration was from 188-104 mg L^{-1}, while after filtration its value reached from 96-168 mg L^{-1} recommended level for alkalinity by the WHO is 500 mg L^{-1}. The value of total hardness (T.H) in canal water was from 160-240 mg L^{-1} but after passing it through the sand filtration bed the value was reduced from 140-180 mg L^{-1}, while the WHO limits is 500 mg L^{-1}.

The calcium level in canal water was ranged from 88-144 mg L^{-1} before treatment while after treatment it reduced from 80-124 mg L^{-1}, similarly, magnesium was from 72-116 mg L^{-1} and after filtration process it reached from 56-60 mg L^{-1}. In canal water chloride value was ranged from 18-33 mg L^{-1}, while after filtration it reduced from 18-20 mg L^{-1}, while the recommended maximum level is 250 mg L^{-1}. Sodium in canal water was 14.5-20 mg L^{-1} in raw water, after treatment it was reduced to 5-11.6 mg L^{-1}. The recommended maximum level was for sodium in drinking water is 250 mg L^{-1} as set by WHO.

Chemical oxygen demand (COD)

The chemical oxygen demand (COD) in canal water was 80 mg L^{-1}, after treatment it was reduced to 60 mg L^{-1} while the WHO limits for COD is 150 mg L^{-1}. The chemical oxygen demand (COD) is the quantity of oxygen in water consumed during chemical reaction of some chemicals added to the water body as pollutant. This value indicates the quantity of oxygen needed for potable water resources.

Table 2: WHO standards for waste water

Parameter	WHO Limit
pH	6.5-9.20
BOD	80 mg L^{-1}
Total suspended solids TSS	5 mg L^{-1}
Total Dissolve solids TDS	1000 mg L^{-1}
Chloride	250.00 mg L^{-1}
Sulphate	400 mg L^{-1}
Coliform cell/ 100 mL	Zero
Selenium 4	40 µg L^{-1}
Zinc	3 mg L^{-1}
Barium	700 µg L^{-1}
Arsenic	10 µg L^{-1}
Boron	2.4 mg L^{-1}
Chlorine	250 mg L^{-1}
COD	150 mg L^{-1}

Biological oxygen demand (BOD)

The biological oxygen demand (BOD) values in canal water was 50 mg L^{-1}, after treatment it was reduced to 43 mg L^{-1} while the WHO standard in case of BOD is 80 mg L^{-1}. The biological oxygen demand is the quantity of

oxygen in water consumed during a biological activity in the water body. This value indicates the quantity of oxygen needed for deficiency of oxygen in water body as a result of biological activity.

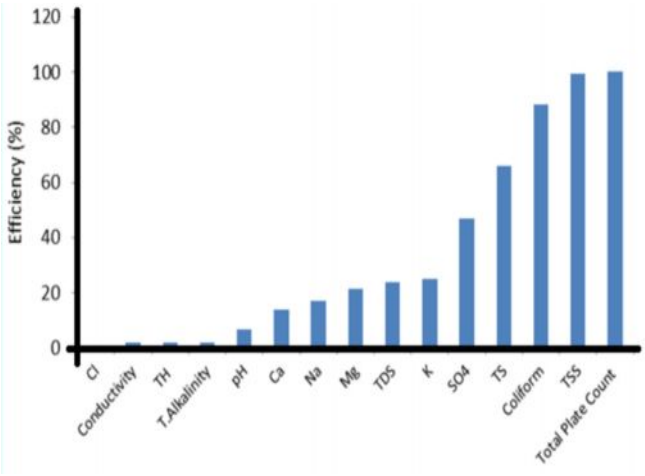

Figure 2: Treatment efficiency of sand filtration plant at Bara River

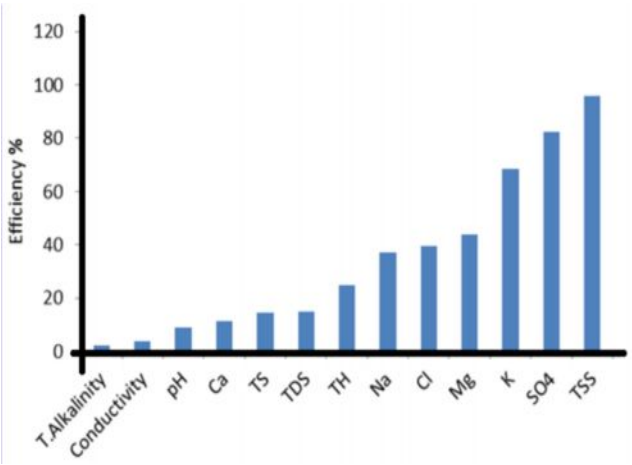

Figure 3: Treatment efficiency of sand filtration plant at Warsak lift canal at Shahab Khel

Total plate count (TPC)

Test was carried out for canal water where it was determined to be 9000 colony forming unit mL^{-1} the WHO standard for TPC is less than 100 cfu mL^{-1}. The water is not fit for human consumption because it also needs some chemical treatment like chlorination, ultraviolet radiation and ozonation. In canal water coliform was determined to be 23 MPN index mL^{-1} which also exceeded the WHO limits, the WHO limits for coliform in drinking water is zero coliform.

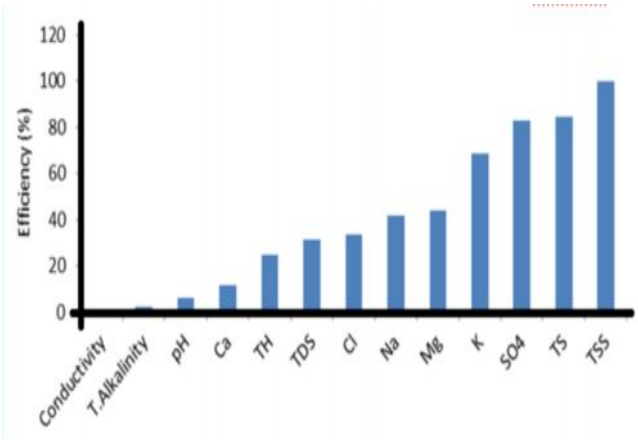

Figure 4: Treatment efficiency of sand filtration plant at Sarband

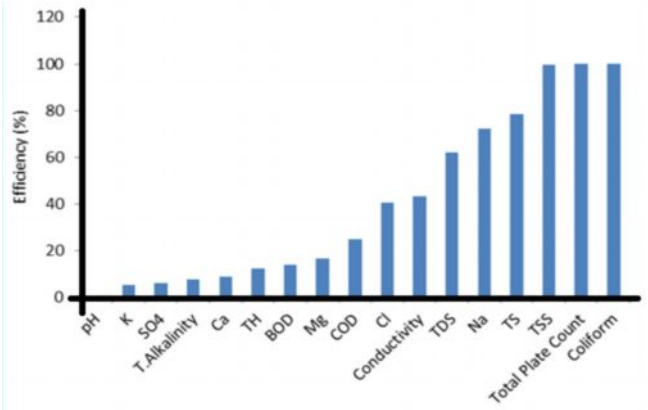

Figure 5: Treatment efficiency of sand filtration plant at Mashokhel

Conclusion

On the basis of findings, it can be concluded that the water of Warsak lift canal is unfit for drinking purpose. Except pH and EC, other chemical parameters like TDS, TSS, Total hardness, chlorides and sulphates were higher than the WHO permissible limits whereas the biological parameters such as coliform, total counts and bacterial counts were also higher than the WHO limits. Sand filtration techniques were applied for treatment of the water to make it potable for human consumption. The results were very encouraging as almost all the stated parameters were found to be in the permissible level after applying these treatment techniques. Proper disinfection process i.e. chlorination should be carried out after the physical treatment to avoid the microbiological hazards. Industries as well as community should avoid dumping waste in the canal. This kind of filter should be used in the areas where there is a lack of improved groundwater sources both on

small and large scale to get drinking water from raw water sources i.e canal etc. This kind of technique can also be used in the desert areas where turbid water is collected from ponds.

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