▼ Journal of Research (Science), Bahauddin Zakariya University, Multan, Pakistan.
Vol.16, No.1, June 2005, pp. 11-18 ISSN 1021-1012

MICROBIOLOGICAL AND CHEMICAL ASPECTS OF DRINKING WATER AND TREATMENT ENHANCED ITS QUALITY

Muhammad Anjum Zia[1], Khalil-ur-Rehman[1], Fozia Anjum[2] and Rizwana Latif[1]
[1]Department of Chemistry (Biochemistry), [2]Departmrnt of Botany, University of Agriculture, Faisalabad, Pakistan.
email: rmazia@hotmail.com

Abstract: The present study was undertaken to determine the suitability of ground water of Faisalabad city for drinking purpose and the treatment was applied on the samples to remove the impurities. Total forty-five samples, 15 from each of the three colonies of Faisalabad (Gulistan colony No. 2, Taj colony and Maye-de-Jhugi) were collected. pH of the samples was found to range from 6.6-7.2 while electrical conductivity from 1.0-3.2 dS m^{-1}. The dissolved oxygen for the water samples ranged from 3.7-5.7 mg L^{-1}. The chemical oxygen demand gives the high COD values of the samples that are not safe. The total dissolved solids showed very high values that ranged from 1000-6666 mg L^{-1}. Hardness and bacterial examination also showed very high values in samples. The treatment of activated carbon, hydrogen-zeolite and chlorination was applied to remove bacteria, colored compounds and hardness from the water samples, to provide better purity of water. Therefore, the results showed that there was a great contamination in ground water of the under studied colonies.

Keywords: Drinking water, Faisalabad, quality, treatment.

INTRODUCTION

In order to use a healthy fluid for human consumption, water should be aesthetically acceptable, should be free from apparent turbidity, color, odor, objectionable taste and microbial contamination. The demand for such potable water in Faisalabad has been an important issue, due to poor quality of ground water and rapid increase in population every year. At present, Faisalabad needs 64.7 million gallons of sweet water daily to cope with the demand of 1.6 million people. Only 3 million gallons of this water can be met from the subsoil water by domestic pumps, and tube wells [Bashir *et al.* 1999].

Water pollution is the specific impairment of water quality by agricultural, domestic or industrial wastes to a degree that has an adverse effect upon any beneficial use of water yet that does not necessarily create an actual hazard to public health. Due to urbanization and industrialization, wastewater that is being discharged into natural water bodies results in serious ground water contamination [Awan *et al.* 2002]. The situation is further complicated by the total absence of effluent treatment facilities at the industrial site [Bach *et al.* 1998].

The most serious pollutants in terms of human health worldwide are pathogenic organisms. Altogether, at least 25 million deaths each year are blamed on these water-related diseases, including nearly two-third of the moralities of children under five years old. The main source of these pathogens is from untreated or improperly treated human waste [Howell 2001]. The poor health status of Pakistan's population is reflected in high infant mortality rate of 12.6% and as low as 7% fertility rates. The scanty hospital's data shows that many of the diseases treated are caused by water borne microbes indicating that a substantial proportion of morbidity in Pakistan is due to use of polluted water. Gastrointestinal infections resulting in diarrhea, show high frequency among children as well as adults, accounting for 25% of patients treated at hospitals and clinics [Karim *et al.* 1985, Aslam and Ahmed 1993].

The present study was carried out to investigate the spatial extent of water quality in Faisalabad and to reduce the harmful effects of water through indigenously prepared column.

MATERIALS AND METHODS

The present project was carried out to analyze the ground water for drinking purposes of Gulistan colony No. 2, Taj colony and Maye-de-Jhugi of Faisalabad City. Total forty five random water samples were collected from these colonies and were analyzed for the various parameters like pH, EC, DO, COD, TDS, hardness and bacterial count. Then water samples were treated and again analyzed for the comparison. pH of each sample was determined by using HN-30V pH meter while electric conductivity was measured by using water quality checker model WQC-20A meter.

DISSOLVED OXYGEN (DO)

Dissolved oxygen was determined by water quality checker model WQC-20. Water samples were taken in the beaker, dipped the electrode in it and finally noted the reading [Greenberg *et al.* 1992].

CHEMICAL OXYGEN DEMAND (COD)

Chemical oxygen demand was measured by digital COD meter-model HC-507. In a beaker, 1 mL of $KMnO_4$ solution was added which was filled with distilled water. The beaker was placed on heater and result was recorded [Farah *et al.* 2002].

TOTAL DISSOLVED SOLIDS (TDS)

A 30 mL of water sample filtered, was taken in a pre-weighed china dish and evaporated on a water bath at 100ºC, till constant weight [Greenberg *et al.* 1992]. TDS were calculated by the following formula:

$$\text{TDS (mg)} = \frac{(\text{A} - \text{B}) \times 1000}{\text{Sample volume (mL)}}$$

Where A = weight of dried residue + dish (mg)
B = weight of china dish (mg).

HARDNESS

In a titration flask, 25 mL of sample was diluted to 50 mL with distilled water, and ammonium hydroxide-ammonium chloride (Sigma) buffer was added to attain pH 10. Finally, 2 drops of indicator (Eerichrome Black-T; Merck) were added to solution that was titrated against standard EDTA (Sigma) titrant with continuous stirring until reddish ting disappeared from the solution and end point was blue [Farah *et al.* 2002].

$$\text{Hardness (EDTA) as mg } CaCO_3\ L^{-1} = \frac{(A \times B) \times 100}{\text{mL Sample}}$$

Where A = mL titration for sample

B = mg $CaCO_3$ equivalent to 1mL EDTA titrant.

BACTERIAL COUNT (Plate Count Test)

Ten-fold dilutions of water samples were prepared and 1 mL from each was inoculated on petri dishes (duplicate) containing growth media. These plates were incubated at 37ºC for 24 hours. The *E. Coli* colony count result was estimated by multiplication of the number of colonies by the reciprocal of the dilutions and the arithmetic mean was determined.

SELF-DESIGNED COLUMN

A glass column of 24x1-inch specification was used. In the lower most portion, activated carbon (5-6 inches) then ion-exchange resin i.e. hydrogen zeolite in the second and a small bottle filled with liquid chlorine (50 mL) was taken in the upper most part of column. Polluted water samples (50 mL each) were introduced one by one, outlet of column opened and eluant was collected. To seek the effect of treatment, eluted samples were reanalyzed for pH, EC, DO, TDS, COD, hardness and bacterial count.

STATISTICAL ANALYSIS

Data obtained from above mentioned parameters was subjected to statistical analysis through paired t-test [Steel and Torrie 1984].

RESULTS AND DISCUSSION

pH

pH value of Gulistan colony No. 2 ranged from 6.8 to 7.2, Taj colony, 6.6 to 7.0 and that of Maye-de-Jhugi from 6.8 to 7.2 (Table 1). The pH value of water samples of three colonies was comparable to the standard pH values (6–8.5) recommended by WHO [Rizvi 1994]. Eight samples selected from each colony were treated with indigenously prepared column. There was no significant difference in results that might be due to the treatment applied which could have the same impact on acidic and basic salts.

Table 1: Values of pH and EC of water samples.

Samples	pH		EC (dS m^{-1})	
	Before treatment	After treatment	Before treatment	After treatment
Gulistan colony No. 2				
1	7.0	7.1	1.8	0
2	6.9	7.0	2.1	0
3	6.9	7.1	1.8	0
4	7.2	7.4	2.0	0
5	6.8	7.3	2.1	0
6	7.0	7.6	2.6	0
7	7.1	7.2	2.1	0
8	7.2	7.6	2.1	0
Taj colony				
1	6.8	7.1	2.1	0
2	6.9	7.2	2.8	0
3	6.6	7.0	2.8	0
4	6.6	7.0	2.6	0
5	6.9	7.0	2.9	0
6	6.9	7.5	3.1	0
7	7.0	7.3	3.0	0
8	6.8	7.2	2.9	0
Maye-de-Jhugi				
1	7.0	7.1	1.2	0
2	6.9	7.0	1.0	0
3	6.9	7.1	2.9	0
4	7.2	7.4	2.0	0
5	6.8	7.3	3.1	0
6	7.0	7.6	2.9	0
7	7.1	7.2	3.1	0
8	7.2	7.6	3.2	0

ELECTRICAL CONDUCTIVITY

Highest EC value was found in the samples in the order as Maye-de-Jhugi, Taj colony and Gulistan colony No. 2 (Table 1). Findings of the three colonies are more than recommended value of WHO for EC i.e. 0.5-1.5 dS m^{-1}. The most polluted water samples were treated and reanalyzed for electrical conductivity after which the values of all the samples become zero. The t-test showed statistically significant difference in EC values of water samples before and after treatment of these colonies and this may be due to the reason of the composition of water of different areas. The composition of ground water generally depends on the structure of subsoil. The diversity of soil composition of different areas is due to the presence of different mineral rocks. When water percolates through different subsoil, it dissolves different stagnant in it and reached to the water that is the source of contamination, which could change the electrical conductivity.

DISSOLVED OXYGEN

DO value is an index of pollution mainly due to organic matter. Usually ground water lacks dissolved oxygen so very low concentrations of DO support the growth of anaerobic microorganism and limits the purification capacity of water. The recommended value for DO is 4-6 mg L^{-1} [Rizvi

1994] and among the samples collected from Taj colony 14% of the samples are not in the safe limit. Residents of Gulistan colony No. 2 and Maye-de-Jhugi are consuming harmful water with reference to DO. Polluted water samples were selected, treated for purity and the values decreased after treatment (Fig. 1) that is due to the reason of storage of water samples for some time. Application of paired t-test showed statistically significant difference of DO values before and after treatment.

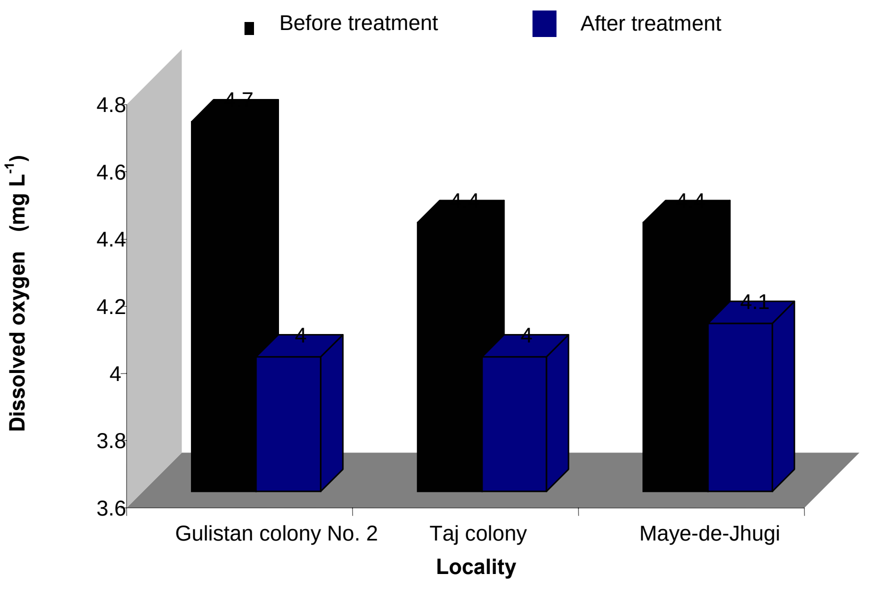

Fig.1: Analysis of mean dissolved oxygen for drinking water of Faisalabad.

CHEMICAL OXYGEN DEMAND

COD values of the polluted samples of Gulistan colony No. 2 were 308.7, 350.5 and 461.1 mg L^{-1}. The COD values for Taj colony are 464.9, 440.9 and 572.3 mg L^{-1} and for Maye-de-Jhugi 492.3, 329.3 and 410.9 mg L^{-1}. The observed values are much higher than the standard values recommended by WHO is 4.0 mg L^{-1}. Such high values of COD represent the presence of organic contamination in water that is harmful for human consumption [Makia *et al.* 1999]. These samples were passed through the column and a marked decreased was observed in results after treatment (Fig. 2). Statistically the results of COD of Gulistan colony No. 2 and Maye-de-Jhugi are non-significant but the result of Taj colony is significant.

TOTAL DISSOLVED SOLIDS

TDS values of three colonies obtained in the range of 1000 to 6666 mgL^{-1} which is very high than the standard value for TDS recommended by WHO i.e. 500–1500 mg L^{-1}. Rahman *et al.* [1991] reported that only

18.5% of the total samples contained TDS within permissible limits and more than 75% sampling locations require chemical / biological treatment.

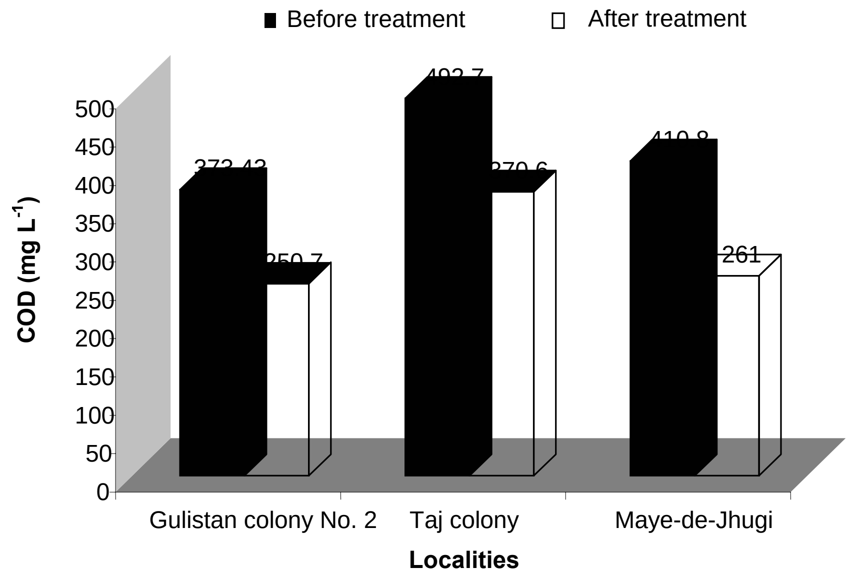

Fig. 2: Analysis of mean COD of the drinking water of Faisalabad.

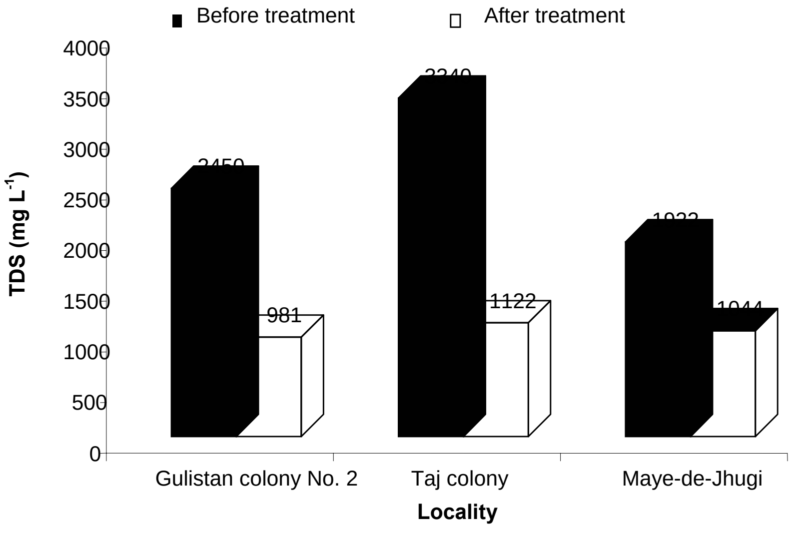

Fig. 3: Analysis of mean TDS of the drinking water of Faisalabad.

So such higher values may be due to the presence of large number of dissolved organic salts such as calcium, carbonates, bicarbonate, sodium, potassium etc. and some non-volatile organic substances which are solid at room temperature. After treatment of selected samples, TDS values of three colonies were decreased (Fig. 3). Hence a significant difference was observed with the application of paired t-test on TDS value before and after treatment. Sawyer [1994] recommended 500mg L^{-1} as safe limit for TDS so our findings proved to be better in this regard.

HARDNESS

Hardness is associated with the capacity of water to precipitate soap. It is due to the presence of divalent metallic cations like calcium, magnesium, strontium, ferrous iron and manganese ions [Abbasi 1998]. Hardness of water samples for three colonies obtained in range of 4000 to 6400 mg L^{-1} (Table 2). All the samples showed greater hardness values as compared to recommended value (250 mg L^{-1}). It shows that the residents of Gulistan colony No. 2, Taj colony and Maye-de-Jhugi are consuming so much polluted water. These samples were treated and reanalyzed as the values of hardness decrease to the permissible limit. It was confirmed by applying paired t-test which showed statistically significant difference between treated and untreated samples. According to Rahman *et al.* [1991] 14.8% of the total samples were in 80-200 ppm range while 57.7% samples ranged between 200-250 ppm and the rest were above 500 ppm which also showed heavy contamination of minerals.

Table 2: Values of hardness and bacterial load of water samples.

Samples	Hardness (mg L^{-1})		Bacterial load (per 100 mL)	
	Before treatment	After treatment	Before treatment	After treatment
Gulistan colony No. 2				
1	4000	100	105x10^3	21x10^3
2	4200	100	79 x10^3	13x10^3
3	4000	100	87 x10^3	8x10^3
4	6000	200	120 x10^3	17x10^3
5	6000	200	127 x10^3	11x10^3
6	4200	100	113 x10^3	23x10^3
7	6400	220	128 x10^3	19x10^3
8	4000	100	70 x10^3	9x10^3
Taj colony				
1	5800	200	63x10^3	12x10^3
2	4200	100	89X10^3	7x10^3
3	4400	100	81X10^3	22x10^3
4	4400	100	97x10^3	15x10^3
5	5000	150	123x10^3	10x10^3
6	4080	100	77x10^3	19x10^3
7	4420	100	102x10^3	27x10^3
8	4560	100	90x10^3	16x10^3
Maye-de-Jhugi				
1	5800	200	105x10^3	21x10^3
2	5000	150	79x10^3	13x10^3
3	5200	150	87x10^3	8x10^3
4	5200	100	120x10^3	17x10^3
5	6000	200	127x10^3	11x10^3
6	5200	100	113x10^3	23x10^3
7	4800	100	128x10^3	19x10^3
8	4920	100	70x10^3	9x10^3

BACTERIAL COUNTS

Bacterial load was in the range of $63x10^3$ to $128x10^3$ per 100 mL water while the most probable number of bacteria in water is < 1 per 100 mL as reported by Rizvi [1994]. Bacterial analysis in the water samples before and after column treatment is given in Table 2. The comparison of values before and after treatment by t-test showed statistically significant results.

References

Abbasi, S.A. (**1998**) "Water quality: sampling and analysis", Discovery Pub., India, pp, 75.

Aslam, M. and Ahmed, M. (**1993**) "An inquiry into the incidence and prevalence of water borne diseases: A case history of Faisalabad", *J. Anim. Plant Sci.,* 3(3-4), 101.

Awan, M.A., Siddiqui, M.T., Khan, R.A. and Shah, A.H. (**2002**) "Combined effect of salinity and industrial effluents on the growth of *Eucalyptus camaldulensis dehnh*". *Pak. J. Agri. Sci.,* 39(2), 80-82.

Bach, H., Tarre, S. and Green, M. (**1998**) "Post treatment of ground water denitrification fluidized bed reactor effluents to achieve drinking water quality", *J. Ind. Microbiol. Biotechnol.,* 20(6), 354-359.

Bashir, R., Nawaz, H. and Khurshid, M. (**1999**) "Chemical analysis of underground water of Faisalabad city", *Pak. J. Biol. Sci.,* 2(3), 715-719.

Farah, N., Zia, M.A., Rehman, K. and Sheikh, M.A. (**2002**) "Quality characteristics and treatment of drinking water of Faisalabad city", *Int. J. Agri. Biol.,* 4(3), 347-349.

Greenberg, E.A, Lenore and Andrew, E.D. (**1992**) "Standard method for the examination of water and wastewater", 18^{th} ed. American Public Health Association, USA, pp, 153-160.

Howell, T.A. (**2001**) "Enhancing water use efficiency in irrigated agriculture", *Agron. J.,* 93(2), 281-289.

Karim, K.M.A., Khattak, M.A. and Shah, R.A. (**1985**) "Pollution studies of Kabul river and Kheshki Lake", *J. Engg. App. Sci.,* 2(2), 20-24.

Makia, D., Fadaly, H.E., Defrawy, M.E. and Zawawy, F.E. (**1999**) "Microbiological and chemical aspects on some fresh water and industrial wastewater samples", *Pak. J. Biol. Sci.,* 2, 1017-1023.

Rahman, K., Ahmad, S., Haq, M.M. and Aziz, T. (**1991**) "Quality characteristics of subsoil water of Faisalabad", *J. Anim. Plant Sci.,* 1(1), 48-51.

Rizvi, S.M.H. (**1994**) "Fundamentals of Environmental Pollution", CBS Pub. and Dist., India, pp, 74-79.

Sawyer, C.N. (**1994**) "Chemistry", McGraw Hill Book Pub., USA, pp, 103-104.

Steel, R.G.D. and Torrie, J.H. (**1984**) "Principles and Procedures of Statistics", McGraw Hill Book Co., USA.