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Appraisal of drinking water quality of tehsil Jampur, Pakistan

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ABSTRACT

The quality of drinking water is vital for humans in order to remain alive, healthy and disease free. Consequently, it is indispensible to make sure that the available drinking water is uncontaminated. This study aimed at finding the quality of drinking water in Jampur, which is one of the tehsils of district Rajanpur in South Punjab, Pakistan. Thirty water samples were collected from different locations of the study area. These samples were gathered from different sources such as hand pump, injector pump, tube well and water supply line. The water quality was examined by comparing its standards with World Health Organization provided guidelines. It was found that majority of the Jampur's population were using contaminated water, which is very harmful and alarming. This contaminated water could cause a potential risk to people's health through many waterborne and skin diseases. The contamination of water could be due to dissolved contaminants and excessive ions such as arsenic, sodium, calcium or nitrate, etc. It is recommended that safety measures should be taken before exploiting this water for drinking. For the purification of contaminated water, filtration plants must be installed in the region.

Keywords: Jampur; Drinking water; Water quality; Water contaminants

1. Introduction

Clean drinking water is necessary for human life. Contaminated drinking water has negative effects on human health. In developing countries, a significant part of the population suffers from health issues either due to shortage of drinking water or its contamination [1–5]. Waterborne diseases are the second major cause of death among children out of which a majority of them are from developing countries [6]. The problem has worsened due to burgeoning population that hinders effective management of water quality [7].

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It is reported that 2 billion people worldwide exploits ground water for drinking [8]. People in Pakistan obtain drinking water from different resources such as piped network (house water supply) by Water and Sanitation Agency (WASA), hand pumps, tube wells and injector pumps. Water from these resources is contaminated as little attention has been paid to the quality of drinking water in Pakistan [9]. Most of the water supply is intermittent and outbreak of waterborne diseases such as gastroenteritis, giardiasis, hepatitis, diarrhoea and typhoid are common [10]. In metropolitan cities, the situation is not satisfactory as well [11]. It has been reported that 30% of all diseases and 40% of all deaths in Pakistan are caused by contaminated drinking water [12]. As a result, every fifth citizen in Pakistan suffers from waterborne disease causing 0.1 million deaths each year out of which 250,000 are children [13–15].

Lack of well-equipped laboratories, non-implementation of legal framework for addressing drinking water quality problems and poor institutional management have intensified the situation [9]. Moreover, the public is ignorant about water quality issues, as 62% urban population and 84% rural population do not clean their drinking water [15,16]. It is a need of the hour that these problems should be addressed seriously to find out their root causes so that proper precautionary measures and actions should be taken. This research work aimed at finding the drinking water quality of Jampur, which is one of the tehsils of district Rajanpur in South Punjab, Pakistan. Water quality standards were compared with World Health Organization (WHO) and US Environment Protection Agency (EPA) guidelines. In the end of this paper, some recommendations were made. These recommendations can be taken as preventive measures to avoid such problems. This article includes only the analysis of physical and bacteriological quality parameters of drinking water of Jampur, the detailed chemical analyses of the water of the same samples are in progress and will be published later.

2. Sampling region

Jamapur is one of the tehsils of district Rajanpur of southern Punjab in Pakistan. It lies completely west of the Indus River and positioned approximately 15 km from its west bank. Jampur is situated at 29°38′32′′ N, 70°35′45′′ comprising an area of about 10 sq km, a population of approximately 1,30,450 and 19 union councils (territories) [17].

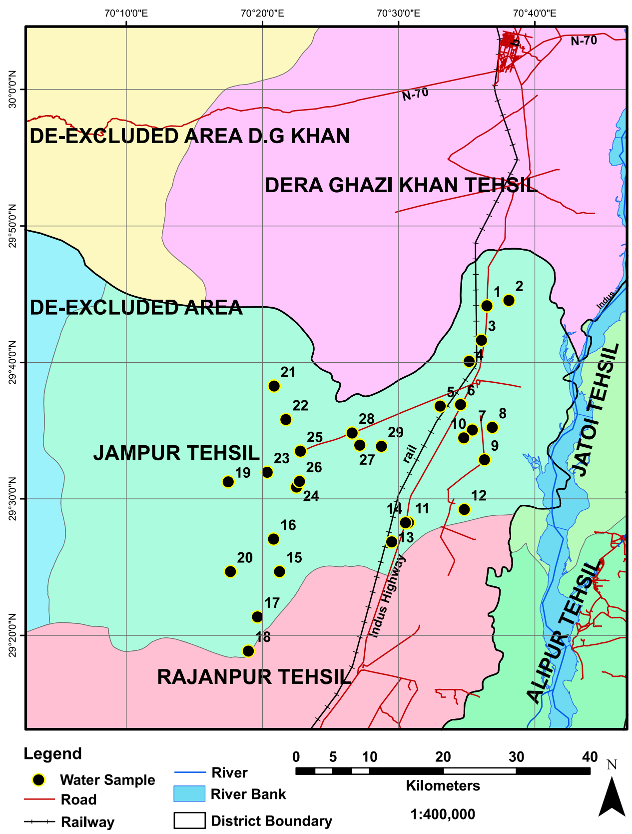

Fig. 1. Map of study area in Jampur showing sampling locations.

3. Sampling methodology and experimentation

From different sampling locations as shown in Fig. 1 and 30 water samples were collected, keeping in view the guidelines of WHO, to measure the standard quality parameters such as colour, odour, temperature, pH, hardness, total dissolved solids, conductivity, turbidity, total coliforms bacteria and faecal coliform. For quality assurance purposes, three samples were taken from each location, tested for each quality parameter and mean values were taken.

The physical quality parameters of all the samples were measured during the field visit. The pH was determined using a portable pH meter (Thermo Orien 240A), turbidity (NTU) by using Turbiditimeter (HI 98703 USA), TDS and conductivity by using conductivity meter (Hi 8033 Hanna Hungry), while hardness by dissolved Calcium ions.

The collection of samples was made in 1 L polyethylene (PET) bottles for physicochemical analyses and 1/2 L sterilized PET bottles were used to collect samples for bacteriological analysis.

Table 1
Details of sampling locations and sources of 30 water samples

Sample no	Village/City/Town/Colony	Lat	Long	Height (m)	Date of survey	Population	Source	Colour	Ordour	Taste
1	Kot Janoon	29.7356	70.6083	111	12/07/2007	4,500	Injector pump	Colourless	Odourless	Brackish
2	Kot Tahir	29.7422	70.6353	107	12/07/2007	3,500	Hand pump	Colourless	Odourless	Brackish
3	Moza Mullan Wala Basti Sulmani	29.6936	70.6017	114	12/07/2007	4,200	Hand pump	Colourless	Odourless	Brackish
4	Moza Pole Wala Cha Doom Wala	29.6678	70.5867	97	12/07/2007	1,000	Hand pump	Colourless	Odourless	Brackish
5	Moza Gahri Sultan Shah Cha Sukhani Wala	29.6131	70.5511	107	12/07/2007	950	Hand pump	Colourless	Odourless	Unobjectionable
6	Tatar Wala	29.6150	70.5761	101	12/07/2007	2,500	Injector pump	Colourless	Odourless	Unobjectionable
7	Kotla Dewan	29.5839	70.5906	110	10/07/2007	7,000	Injector pump	Colourless	Odourless	Unobjectionable
8	Basti Pati Kali	29.5869	70.6150	108	10/07/2007	2,000	Hand pump	Colourless	Odourless	Unobjectionable
9	Kotla Mughlan	29.5475	70.6053	104	10/07/2007	5,500	Injector pump	Colourless	Odourless	Unobjectionable
10	Moza Dohran Hajana	29.5742	70.5800	104	10/07/2007	400	Hand pump	Colourless	Odourless	Brackish
11	Muhammad Pur-1	29.4708	70.5122	99.7	16/07/2007	8,000	Hand pump	Colourless	Odourless	Brackish
12	Chak Piru Wala	29.4867	70.5806	97.9	16/07/2007	2,000	Hand pump	Colourless	Odourless	Unobjectionable
13	Bokhara	29.4472	70.4917	100.6	16/07/2007	5,000	Injector pump	Colourless	Odourless	Brackish
14	Muhammad Pur-2	29.4706	70.5086	111	16/07/2007	8,000	Hand pump	Colourless	Odourless	Brackish
15	Noorpur Mangwala	29.4108	70.3544	113	11/07/2007	10,000	Injector pump	Colourless	Odourless	Brackish
16	Nawan Shaher	29.4506	70.3472	117	11/07/2007	2,500	Injector pump	Colourless	Odourless	Brackish
17	Haji Pur	29.3556	70.3275	107.1	11/07/2007	12,000	Water supply	Colourless	Odourless	Unobjectionable
18	Soon Wah	29.2972	70.3164	96.9	11/07/2007	900	Hand pump	Colourless	Odourless	Brackish

(Continued)

Table 1 (*Continued*)

Sample no	Village/City/Town/Colony	Lat	Long	Height (m)	Date of survey	Population	Source	Colour	Ordour	Taste
19	Wah Lashari (Tibi Solange)	29.5206	70.2917	128	13/07/2007	7,000	Tubewell	Colourless	Odourless	Brackish
20	Miran Pur	29.4108	70.2944	119.2	13/07/2007	5,000	Tubewell	Colourless	Odourless	Brackish
21	Moza Koloi Wala	29.6375	70.3478	121	13/07/2007	1,100	Hand pump	Turbid	Odourless	Very saline
22	Moza Thul Shumali Basti Gudara	29.5967	70.3622	111.3	13/07/2007	1,000	Hand pump	Colourless	Odourless	Unobjectionable
23	Noshahera (W)	29.5322	70.3394	124.1	12/07/2007	6,000	Tubewell	Colourless	Odourless	Unobjectionable
24	Basti Danwar	29.5142	70.3753	116.2	12/07/2007	1,800	Hand pump	Turbid	Odourless	Brackish
25	Dajal	29.5581	70.3800	110	12/07/2007	12,000	Tubewell	Colourless	Odourless	Unobjectionable
26	Basti Mian	29.5211	70.3789	115	12/07/2007	4,500	Water supply	Turbid	Odourless	Unobjectionable
27	Moza Azmat Wala Basti Nawaz Deena	29.5653	70.4528	102.1	12/07/2007	1,000	Injector pump	Colourless	Odourless	Brackish
28	Moza Raqba Diniwala Adda Roshan Walla	29.5803	70.4433	110	12/07/2007	1,100	Injector pump	Turbid	Odourless	Unobjectionable
29	Allah Abad No. 2 Garbi	–	–	–	14/07/2007	6,000	Hand pump	Colourless	Odourless	Unobjectionable
30	Rasool Pur	–	–	–	14/07/2007	4,000	Injector pump	Colourless	Odourless	Brackish

Table 2
Physical and bacteriological quality parameters

Sample no	Temp ℃	pH	Hardness (mg/L)	Conductivity (μS/cm)	Total dissolved solids (mg/l)	Turbidity (NTU)	Total coliform bacteria	Fecal coliform
1	31	7.6	400	2,810	1,798	0.01	−ve	−ve
2	32	7.4	335	1,577	1,009	2.23	+ve	+ve
3	30	7.2	600	1,594	1,020	0.00	−ve	−ve
4	31	7.3	520	1,661	1,063	3.02	−ve	−ve
5	30	7.3	360	1,441	922	3.30	−ve	−ve
6	31	7.6	220	502	321	0.00	+ve	−ve
7	31	8.0	125	435	217	0.00	−ve	−ve
8	32	7.5	460	1,305	783	2.30	−ve	−ve
9	31	7.6	235	961	528	1.01	−ve	−ve
10	30	7.8	800	3,322	2,126	3.40	−ve	−ve
11	31	7.3	550	2,941	1,882	1.09	+ve	+ve
12	32	7.2	350	800	440	1.01	−ve	−ve
13	30	7.4	1,450	5,700	3,648	1.00	+ve	+ve
14	31	7.5	400	3,123	1,998	7.50	−ve	−ve
15	32	7.3	1,525	4,720	3,020	0.01	−ve	−ve
16	31	7.2	1,085	2,660	1,702	0.00	+ve	+ve
17	30	7.4	135	278	178	9.50	+ve	+ve
18	31	7.0	2,500	8,846	5,661	19.25	−ve	−ve
19	31	7.3	610	1,650	1,056	0.00	+ve	+ve
20	30	7.5	635	2,530	1,619	0.01	−ve	−ve
21	31	7.6	2,125	11,049	7,071	95.00	−ve	−ve
22	32	7.3	635	1,440	921	15.70	+ve	+ve
23	31	8.0	530	1,361	871	0.01	+ve	+ve
24	32	7.1	1,850	6,030	3,859	31.14	−ve	−ve
25	30	8.0	145	457	228	0.00	−ve	−ve
26	31	7.9	110	300	150	87.50	+ve	+ve
27	31	7.1	1,550	4,789	3,065	1.05	−ve	−ve
28	31	7.8	160	530	291	49.01	−ve	−ve
29	32	7.4	300	1,079	691	0.00	−ve	−ve
30	31	7.4	615	3,139	2,009	0.00	−ve	−ve

4. Results and discussion

Details of sampling locations, sources and water quality standards of each sample are given in Tables 1 and 2.

4.1. *Colour, odour, taste and temperature*

There is no guideline given by WHO for colour, odour, taste and temperature. However, WHO and EPA suggest watercolour to be below 15 true colour units (TCU). Therefore, samples having above 15 TCU were considered as coloured or turbid. Twenty-four samples were colourless while six samples were turbid. EPA recommended threshold for odour is three. None of the samples were containing any odour. The taste of only thirteen samples was unobjectionable, which is less than half of total samples. Sample No. 21 of Moza Koloi Wala, taken from hand pump, was very saline and turbid, affecting more than thousand people. Temperature of all the samples ranges from 30 to 32℃. Water with higher temperature is less palatable than low temperature. Higher temperatures are the major cause of micro-organisms (bacteria, viruses and protozoa) growth and may lead to changes in colour, odour and taste of water [18].

4.2. *pH and corrosion*

One of the important quality parameters of drinking water is pH. WHO and EPA suggests that 6.5–8.5 is an appropriate pH range for drinking water. The pH

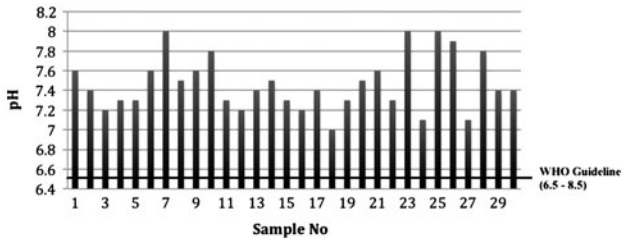

Fig. 2. Comparison of mean values of pH of 30 water samples with WHO standards.

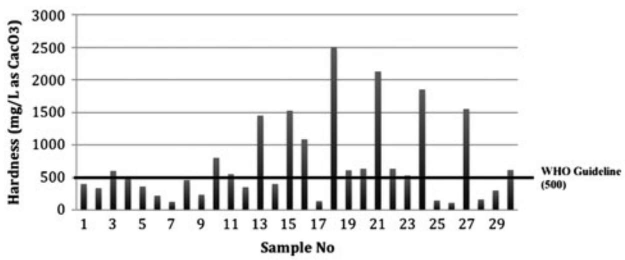

Fig. 3. Comparison of mean values of hardness of 30 water samples with WHO standards.

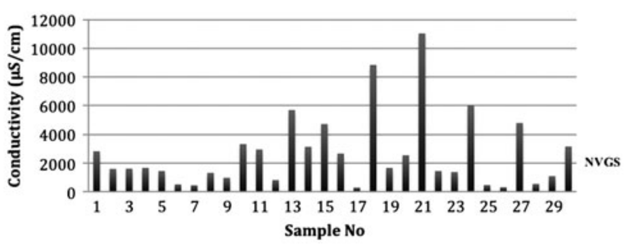

Fig. 4. Comparison of mean values of conductivity of 30 water samples with WHO standards.

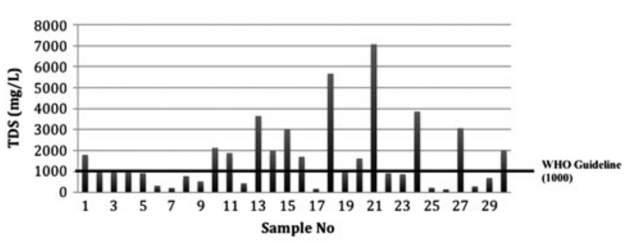

Fig. 5. Comparison of mean values of TDS of 30 water samples with WHO standards.

values less than 6.5 increase corrosion in the water mains and domestic plumbing system while greater than 8.0 are inappropriate for effective disinfection [19,20]. Fig. 2 shows mean pH values of water samples collected from 30 different locations in Jampur. All the values are within suitable range proposed by WHO.

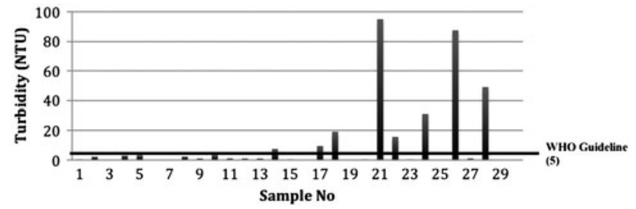

Fig. 6. Comparison of mean values of turbidity of 30 water samples with WHO standards.

4.3. Hardness

The WHO recommended value for hardness, on the basis of health, is 500 mg/L as $CaCO_3$ [18,21,22]. Water hardness above 500 mg/L is intolerable by the consumer. However, water with hardness value of 150 mg/L is ideal from aesthetic point of view [23]. The mean values of hardness for all the samples are shown in Fig. 3. Sixteen samples have hardness more than 500 mg/L.

4.4. Conductivity

Conductivity analysis of water indicates the concentration of total dissolved solids (TDS) in it and primarily gives the mineral content. High conductivity is indicative of high level of contamination of water, whereas low conductivity and TDS suggests that the contamination of water is not serious [24]. The conductivity of all the samples was found in 278–11,049 µS/cm range with maximum value for Moza Koloi Wala (sample No. 21) and minimum for Haji Pur (sample No. 17). A comparison of mean conductivity values for all water samples is shown in Fig. 4. A much larger value of conductivity than hardness is indicative of impurity in water due to various contaminants such as nitrate, sodium, chloride and sulphate ions, etc. [25]. The presence of such pollutants may be natural or human influenced.

For conductivity of water, no WHO or EPA health guidelines are available. However, European Economic Commission has fixed a health standard of 400 µS/cm at 20°C for conductivity of water. All the analysed samples, except two, exceed this value.

4.5. Total dissolved solids

The mean values of TDS for all the samples are shown in Fig. 5. EPA proposed value for TDS is 500 mg/L. WHO does not purpose any health based guideline for TDS but recommends TDS value to be lower than 1,000 mg/L. TDS levels greater than 1,000 mg/L adds undesirable taste to the water and drinking water becomes highly unpalatable [18,26]. Exactly half of the samples exceeded the WHO recommended TDS value, whereas only seven samples very below EPA 500 mg/L value. Sample No. 21 collected from a hand pump, located at Moza Koloi Wala, has the greatest TDS value of 7,071 mg/L of all the samples. Water with high TDS values causes excessive scales in domestic water pipes, industrial water-pipe network, boilers, heaters and industrial appliances [18,27].

4.6. Turbidity

The presence of organic matter, inorganic matter or suspended particles causes turbidity in water [18]. Although WHO or EPA has not suggested any health-based guideline for turbidity, a value of 0.5 NTU is recommended for effective disinfection [18,28]. However, turbidity values up to 5 NTU are acceptable [18,29]. Water having higher turbidity values can provide growth to micro-organisms and may have disease-causing microbes such as viruses, parasites and bacteria [30]. Fig. 6 depicts mean values of turbidity for all the samples. For 8 samples, the value of turbidity was very high which reflects disinfection of water to be carried out effectively. Proper treatment methods could be used to significantly lower down the turbidity of water at large scale [31].

4.7. Total coliform bacteria

Total coliform bacteria are naturally occurring bacteria in the environment. They further indicate the possible presence of potentially harmful bacteria [30]. Water with bacteriological contaminants reported to be more harmful than water comprising chemical contamination [32]. Existence of micro-organisms could lead to diseases such as cholera, dysentery, salmonellosis and typhoid, which are the major cause of millions of deaths in developing countries every year [33]. WHO and EPA have set zero maximum contaminant level (MCL) for total coliform bacteria. Ten samples out of thirty were bacteriologically contaminated with total coliform bacteria, which is exactly one third of the total samples.

4.8. Faecal coliform

Faecal coliform indicates the potential existence of human and animal waste. The micro-organisms in the waste, present health risk to infants, children and people with highly compromised immune system [30]. WHO and EPA have set zero MCL for faecal coliform. Nine out of ten samples having positive values for total coliform bacteria also tested positive for faecal coliform, which is quite alarming. The presence of faecal coliform may lead to diseases such as diarrhea, cramps, nausea and headaches [30].

5. Conclusions and recommendations

The drinking water quality parameters (hardness, conductivity, total dissolved solids, turbidity, total coliform bacteria and faecal coliform) of majority of the water samples within the sampling region were beyond the values set by WHO and EPA. Therefore, it is concluded that the drinking water of majority of the locations in the study area is not appropriate for household and drinking purposes. Following recommendations should be implemented before utilizing this water especially for drinking.

(1) Old, rusty and leaking water pipes of WASA needed to repaired/replaced to avoid contamination of water.
(2) Water filtration plants must be installed for the provision of pure and fresh water.
(3) Most of the population in the region is uneducated, so public health awareness regarding the usage of contamination free water must be promoted among the people.
(4) Last but not least, the poor quality standard of drinking water of Jampur suggests that the legislation and its implementation must be made by the Government of Pakistan for the improvement of drinking water quality in the area.

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References

[1] F.X.R Van Leeuwen, Safe drinking water: The toxicologist's approach, Food. Chem. Toxicol. 38 (2000) 51–58.
[2] E. Caylak, Health risk assessment for arsenic in water sources of Cankiri province of Turkey, CLEAN - Soil, Air, Water 40 (7) (2012) 728–734.

[3] E. Caylak, Health risk assessment for trace metals, polycyclic aromatic hydrocarbons and trihalomethanes in drinking water of Cankiri, Turkey, E-J. Chem. 9(4) (2012) 1976–1991.
[4] E. Caylak, M. Tokar, Metallic and microbial contaminants in drinking water of Cankiri, Turkey, E-J. Chem. 9(2) (2012) 608–614.
[5] E. Caylak, M. Tokar, Investigating chemical and microbiological contaminants in drinking water in regions of Cankiri, Turkey, Environ. Earth Sci. 67 (2012) 2015–2025.
[6] J.A. Johnson, C.H. Stoskopf, Comparative Health Systems: Global Perspectives for the 21st Century, Jones & Bartlett, Boston, MA, 2009.
[7] G.H. Huang, J. Xia, Barriers to sustainable water-quality management, J. Environ. Manage. 61(1) (2001) 1–23.
[8] UNEP, Groundwater and its Susceptibility to Degradation: A Global Assessment of the Problem and Options for Management, United Nations Environment Program (UNEP), BGR Hannover, Nairobi, 2003.
[9] WWF Pakistan, Pakistan's Waters at Risk; Water & Health Related Issues in Pakistan, Freshwater & Toxics Programme, WWF–Pakistan, Lahore, 2007.
[10] G. Bridges, Asian Water Development Outlook 2007, Country Paper Pakistan, Asian Development Bank, ADB Publishing, Karachi, 2007.
[11] S. Haydar, M. Arshad, J.A. Aziz, Evaluation of drinking water quality in urban areas of Pakistan: A case study of southern Lahore, Pak. J. Eng. Appl. Sci. 5 (2009) 16–23.
[12] W. Bank, Global Water Partnership, Draft South Asia - Water Vision 2025, Country Report Pakistan, Islamabad, 2000.
[13] M.A. Kahlown, M.A. Tahir, H. Rasheed, K.P. Bhatti, Water Quality Status, National Water Quality Monitoring Programme, Fourth Technical Report, Pakistan Council of Research in Water Resources, Lahore, 5 (2006).
[14] W. Bank, Water and Sanitation Program, Managing Karachi's Water Supply and Sanitation Services: Lessons from a Workshop, UNDP-Water & Sanitation Program, Washington, DC, The World Bank, 3 (2005).
[15] USAID Report, PuR Water Purification Reaches Pakistan, United States Agency for International Development (USAID). Available from: http://www.usaid.gov/sites/default/files/success/files/fp_pakistan_water.pdf
[16] J.A. Aziz, Management of source and drinking-water quality in Pakistan, Eastern Mediterranean Health J. 11 (2005) 1087–1098.
[17] NRB, National Reconstruction Bureau, Government of Pakistan. Available from: http://www.nrb.gov.pk/lg_election/union.asp?district=27 & dn=Rajanpur (accessed 20 January 2013)
[18] WHO, Guidelines for Drinking-Water Quality, fourth ed., World Health Organization (WHO), Geneva, 2011.
[19] J. DeZuane, Handbook of Drinking Water Quality, John Wiley & Sons, New York, NY, 1996.
[20] Awrf, Crs Proaqua. Online Monitoring for Drinking Water Utilities, Water Works Association American, Denver, CO, 2002.
[21] B.T. Basavanthappa, Community Health Nursing, Jaypee Brothers Publishers, New Delhi, 2008.
[22] R.M. Harrison, Pollution: Causes, Effects and Control, Royal Society Chemistry, Suffolk, 2001.
[23] PEP Component, Investigation of Drinking Water Quality of Water Filtration Plants Installed at Islamabad and Rawalpindi - A Case Study, Pakistan Environment Programme Component, Islamabad, 2005.
[24] P.K. Goel, Water Pollution: Causes, Effects and Control, New Age Internat, New Delhi, 2006.
[25] A.C. Twort, D.D. Ratnayaka, M.J. Brandt, Water Supply, Butterworth-Heinemann, London, 2000.
[26] O.G. Palanna, Engineering Chemistry, Tata McGraw-Hill Education, New Delhi, 2009.
[27] N.F. Gray, Water Quality Drinking: Problems and Solutions, Cambridge University Press, Cambridge, 2008.
[28] Srinivasa Lingireddy, Control of Microorganisms in Drinking Water, Technical Committee Report, Water Supply Engineering Committee, American Society of Civil Engineers, Lexington, KY, 2005.
[29] T.V. Cech, Principles of Water Resources: History, Development, Management, and Policy, third ed., John Wiley & Sons, Lincoln, NE, 2009.
[30] EPA. Drinking Water Contaminants. Environmental Protection Agency, Washington, DC, 2013. Available from: http://water.epa.gov/drink/contaminants/index.cfm (accessed 27 April 2013).
[31] C.N. Lei, I.C. Lou, H.U. Song, P. Sun, Turbidity removal improvement for Yangtze River raw water, Desalin. Water Treat. 45 (2012) 215–221.
[32] S.A. Larmie, D.A. Paintsil, A Survey of the Hygienic Quality of Drinking Water Sold in Accra. CSIR-Water) 1996.
[33] T. Clasen, W.P. Schmidt, T. Rabie, I. Roberts, S. Cairncross, Interventions to improve water quality for preventing diarrhoea: Systematic review and meta-analysis, Br. Med. J. (2007) 782–791.