INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 11, No. 5, p. 376-384, 2017
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Physio-chemical analysis of ground water and its impact on public health in Sargodha City, Pakistan

Omar Riaz[*1], Taswar Abbas[1], Saifur Rehman[1], Muhammad Fahad Ullah[1], Maryam Khalid[2]

[1]*Department of Earth Sciences, University of Sargodha, Pakistan*

[2]*Department of Geography, Govt. College University, Faisalabad, Pakistan*

Article published on November 30, 2017

Key words: Physio-chemical, Water quality, Water borne diseases, GIS, Sargodha

Abstract

Water pollution has always been a serious global threat and water born diseases are the major issue in third world countries now a day. Pakistan is no exception and also facing worst conditions. For current research Sargodha city was taken as a Study Area. Water samples were collected throughout the study area through random sampling technique. These samples were tested in Hi-Tech Instruments Lab, University of Sargodha and the data was analyzed to compare with WHO permissible standard for drinking purposes. A survey was also conducted in the study area to know the public opinion about water related diseases. Around 200 educated inhabitants of the study area participated in filling the survey performa out of which 76 percent were found dissatisfied from water quality and reported number of water borne diseases. Public perception was compared with the prevailing diseases and it was concluded that water contaminants are the major source of diseases like, diarrhea, typhoid, hepatitis, eye problem, stomach problem, blood pressure, heart diseases, and gastro in the study area. Current study also suggested different strategies to mitigate these problems.

***Corresponding Author:** Omar Riaz ✉ omarriazpk@gmail.com

Introduction

The ground water quality is the matter of serious concern today (Misra *et al*., 1991; Momodu *et al*., 2010; Mc. Arthur *et al*., 2012). Clean, safe and adequate water is essential for the endurance of all animate organisms on planet of earth (Vanloon *et al*., 2005). It has many beneficial uses such as drinking, household, industries (Tihansky, 1974; Ross *et al*., 1981), fisheries, recreations, irrigation, propagation of wild life, aesthetics etc. (Abhineetand, 2014). As the civilizations progressed the population of the world also increased. With Rapid population growth, industrial and agricultural development has placed huge stress on water resources (Ogundiran *et al*., 2008; Basavaraja *et al*., 2011; Gilani *et al*., 2013). Quality of life can be assessed and evaluated by accessibility to clean water. A very close relation exists between water quality, water usage and economic development of the world (Chennakrishnan *et al*., 2008). It has been observed in last few decades that the ground water quality has changed and is getting extremely polluted due to physical, chemical and biological conditions. Water quality is directly or indirectly dependent upon the human activities (Witter *et al*., 1996; Riaz *et al*., 2016).

Ground and surface water can be contaminated by several ways, like domestic wastes, municipal wastes, industrial wastes, mining, human and animal faces, ultimate disposal of toxic metals and random usage of fertilizers, pesticides (Adefemi *et al*., 2010; Rizwan *et al*., 2011) and fungicides for agricultural purposes (Hamid *et al*., 2013). It is well known fact that water is most drinking fluid by living organisms and universal solvent (Trivedi *et al*., 2010). Water picks up impurities easily. Therefore it is often potential source of causing infections (Khan, 2006). It gives birth to many diseases such as vomiting, hepatitis, typhoid, diarrhea, kidney damage and liver problem, approximately 75% of the world wide transmissible diseases are water borne (Faheem *et al*., 2007; Riaz *et al*., 2016). A survey conducted by World Health Organization (WHO) states that in developing countries, 80% of all human diseases are water borne (Abera *et al*., 2011).

Serageldin, (1999) reported that a child is dying after every 8 seconds on account of water borne diseases which makes approximately 4 million a year.

Like many other developing nations around the globe, Pakistan is facing severe threat related to availability of hygienic and uncontaminated drinking water. A large population of Pakistan is using polluted water (Khan, 2006). According to survey during 2004 to 2005, about 38.5 million people in Pakistan do not have access to safe drinking water sources which may increase to 52.8, million peoples by 2015 (Faheem *et al*., 2007). Ground water contributes almost 1/3 of Pakistan's water reserves. As compared to surface water, ground water is much more clean and safe. More than three million peoples suffer from water related diseases every year, out of which 0.1 million die (Water and Sanitation Program, 2005). Rizwan *et al*., (2011) has declared that 60% of infant mortality is caused by water borne diarrhea in Pakistan which is the highest in Asia.

In Pakistan about 70 percent population rely on ground water for drinking and their household purposes (Tahir, *et al*., 1998). Major cities like Karachi, Lahore, Multan, Rawalpindi, Sialkot, Faisalabad, Peshawar and Gujarat are using contaminated water due to different anthropogenic activities (Bhutta *et al*, 2002). The major aim of the current study is not only to assess the ground water quality of Sargodha city (Pakistan) but also its impact on human health. Water impurities have been assessed by different parameters of international standards while the impact on public health has been detected through hospital records as well as by public perception.

Material and method

Study Area

Sargodha is the 11th largest city of Pakistan. Ground water quality of city is poor and ground water is mostly saline. National Water Quality Monitoring Program (Kahlown *et al*, 2006) carried out a survey of water supply in Sargodha and reported that 24 samples were collected from various locations.

Out of these 24 samples only one location had a facility to supply safe drinking water and remaining samples have a high concentration of sodium chloride, calcium and magnesium, sulphate, total dissolve solid (TDS) and turbidity as per NWQMP (2007) report.

Sargodha, generally known as city of Eagles is the eleventh largest city of Pakistan. The latitude of Study area (Sargodha city) is 32°5′1″ in North andLongitude 72°40′ 16″ in East (fig.1). According to provisional report of 2017 census, the urban population of Sargodha is around one million (GOP, 2017). It is bounded by Jhelum in north, Mandi Bahu-ud Din and Hafizabad in east and Jhang from south while Khushab district is in the west. It is the part of lower Indus basin with the altitude of 607 feet from the sea level (GOP, 1999).

Methodology

Water quality parameter provides important information about the water and its consumer's health. A number of physiochemical parameters were chosen to check the ground water quality depending upon available resources. These parameters include potential Hydrogen (pH), Electric Conductivity (EC), Total Dissolved Solid (TDS), Chloride (Cl), Potassium (K), Calcium (Ca), Magnesium (Mg), and Copper (Cu).Sargodha was divided into 4 zones and 12 samples of ground water were collected from each zone in the study area as per International standard. All the samples were tested in Hi-Tech Instrument Lab, University of Sargodha. The concentration of pH (Presence of Hydrogen ions) and EC (Electric Conductivity) in all collected samples was determined by using a pH meter (Jenway model, 3510) and Conductivity meter (Jenway model, 3510), TDS (Total Dissolved Solid) through Electric Conductivity while the concentrations of remaining parameters were determined by using Atomic Absorption Spectrometry (AAS, AA 6300, Shimadzo). Ground water quality of study Area was also compared with World Health Organization (WHO) standard for drinking purpose. In addition, a field survey was conducted to judge the satisfaction level of water consumers according to the 5 points Likert scale.

Data were also collected from Divisional Head Quarter (DHQ) Hospital records regarding water borne diseases in the sample area to verify the public opinion and lab results. GPS (Global Position System) was used to identify the samples location and spatial maps and graph were produced by using GIS technique to understand groundwater quality.

Results and discussion

Water Quality Analysis

PH of drinking water has no direct effects on human health but it has some indirect health effects by bringing change in other water quality parameters. According to WHO permissible limit of pH values should not exceeded 8.5. All the mean values of pH in study area samples were varied from 7.9 in zone I, 7.8 in zone II, 7.9 in zone III and 8 in zone IV. A function of total dissolved solid is Electric conductivity and also known as ions concentration that defines the water quality. According to WHO standard of EC in drinking water should not exceeded 1000 µs/cm. In study area mean values of EC were 3035µs/cm in zone I, 2652 µs/cm in zone II, 2415 µs/cm in zone III and 2214 µs/cm in zone IV which shown in table 1.

The concentration of Total Dissolved Solid (TDS) in drinking water considered more valuable to determine the water quality. According to WHO 500-1000ppm concentration of TDS is good for health and taste of water. In study area these mean values were 2067 ppm in zone I, 1803ppm in zone II, 1612 ppm in zone III and 1505 ppm in zone IV. Magnesium is natural constituent of water and found in minerals. According to WHO permissible limits of magnesium in drinking water is 150mg/l. All means value of study area in samples were 123mg/l in zone I, 123mg/l in zone II, 106mg/l in zone III while 110mg/l in zone IV. Calcium is an essential mineral to human health and about 95% of total Calcium of human body stored in teeth. According to WHO standard the permissible limit of Calcium should be 75 mg /l. In study area mean values of calcium varied from 24.8mg/l in zone I and 28.4mg/l in zone II. The zone III shows the concentration of 23 mg/l while 21.8 mg/l in IV zone which shown in Table 1.

Table 1. Detailed results and means values of water analysis in study area.

ZONE 1										
S. ID	Locations Name	pH 8.5	Ec 1000 µs/cm	TDS 1000 mg/l	K 20 mg/l	Ca 75 mg/l	Cu 1.5 mg/l	Bico. 500 mg/l	Cl 250 mg/l	Mg 150 mg/l
1	Bissmillah park	7.9	1639	1114	18	23	0.64	639	296	143
2	Istaqlalabad Colony	8.0	2050	1394	19	17	0.68	523	255	132
3	Mujahid Colony	8.2	3180	2162	17	13	0.76	487	273	105
4	PAF	7.6	3990	2713	16	35	0.58	397	199	128
5	14 Block	7.5	4117	2836	14	41	0.53	564	251	137
6	Jail Road	7.9	2031	1381	19	28	0.58	248	283	152
7	M.C. society	7.9	3140	2135	13	28	0.55	411	231	123
8	5 block	8.3	1333	906	19	12	0.51	462	246	97
9	15 block	7.9	3690	2509	18	29	0.65	560	187	102
10	10 block	7.6	4120	2801	17	20	0.56	449	238	79
11	Chungi No. 12	8.1	3870	2632	15	21	0.53	516	215	147
12	Madni Colony	8.0	3267	2221	12	31	0.44	343	195	133
	Mean Values	7.9	3035	2067	16.4	24.8	0.58	466	239	123
ZONE 2										
1	W Block	8.0	3330	2264	24	30	0.61	381	241	152
2	Z Block	8.0	2951	2007	16	31	0.56	428	178	134
3	X Block	8.4	1168	794	16	25	0.68	463	191	128
4	Basheer Colony	8.0	1144	778	9	17	0.72	546	254	84
5	Javed Town	7.6	1680	1142	22	22	0.56	424	246	89
6	Marryam Town	7.8	3680	2502	13	11	0.49	471	231	136
7	Model Town	7.4	3146	2139	17	29	0.71	537	240	149
8	Kalyar Town	7.7	4400	2992	18	30	0.62	593	173	161
9	Rehmatouratown	7.9	1909	1298	19	37	0.50	448	184	55
10	Canal Colony	8.0	2310	1571	20	25	0.58	429	249	124
11	Queen Chowk	7.6	2441	1659	18	38	0.63	523	169	122
12	Nazer colony	7.4	3671	2496	21	46	0.48	438	232	148
	Mean Values	7.8	2652	1803	17.75	28.41	0.595	473	216	126
ZONE 3										
1	New Muhammdi colony	7.9	1992	1354	18	24	0.58	482	258	125
2	Bakshi colony	8.2	2303	1566	12	25	0.34	510	263	73
3	Shouqat colony	8.0	2160	1469	15	19	0.47	562	249	142
4	29 block	7.9	2167	1473	18	19	0.44	497	211	69
5	26 block	7.9	2719	1849	24	28	0.47	546	284	86
6	Ittefaq colony	8.3	2396	1629	8	23	0.63	452	258	68
7	24 Block	7.9	2460	1673	16	20	0.64	571	269	132
8	18 block	7.8	3186	2166	23	42	0.47	532	240	147
9	Meer Colony	7.7	2872	1593	11	12	0.51	543	282	94
10	Iqbal colony	7.8	2720	1849	19	22	0.49	541	211	102
11	20 Block	8	1631	1109	17	21	0.78	491	235	96
12	Maqam e hayat	8	2381	1619	20	24	0.71	498	246	138
	Means values	7.9	2415	1612	16.7	23	0.54	518.7	250	106
ZONE 4										
1	Mehboob Colony	8.1	1139	774	16	20	0.64	548	287	78
2	ZubaidaRaza Town	8.2	1040	707	7	21	0.49	487	233	92
3	S.T D Block	8.4	1588	1079	5	14	0.49	532	214	109
4	S.T A Block	8.5	2979	2027	19	31	0.71	493	192	130
5	C Block	8.1	1379	937	19	19	0.57	396	156	81
6	S.T B Block	7.9	1805	1227	11	26	0.58	464	238	106
7	Zafar Colony	7.9	4870	3312	20	24	0.84	519	261	139
8	Islam Pura	7.7	1440	979	21	25	0.68	503	209	86
9	Mubarak colony	8	3330	2264	24	30	0.61	445	239	132
10	Munawer colony	8.1	2213	1504	19	16	0.47	495	257	124
11	Sadique colony	7.9	3810	2591	18	23	0.68	511	281	149
12	university Mosque	8.1	982	668	19	13	0.79	341	201	93
----	Mean Values	8	2214	1505	16.5	21.83	0.629	477.83	231	110

Source: Laboratory analysis.

Potassium is very reactive with water and necessary for human beings for heart protection, muscles construction and blood pressure. The mean values of potassium in samples were 16.4mg/l in zone I, 17.4mg/l in zone II; 16.7mg/l in Zone III while 16.1mg/l in zone IV. Chloride is very important and key factor for metabolism activity in human body. WHO recommended value of chloride in drinking water is 250mg/l. In study area all means values varied from 239ppm in zone I, 216ppm in Zone II 250ppm in zone III and 231ppm in zone IV. The concentrations of bicarbonates usually found less than 500mg/l in ground water. The mean values of bicarbonates were 466mg/l in zone I, while 473mg/l

in zone II and mean values varied from 518mg/l in zone III to 477mg/l in zone IV. Copper (Cu) is very important nutrients for good health, low and high intake of Copper causes different diseases in human. WHO desirable quantity of Cu in drinking water varies from 0.5- 1.5mg/l.

In study area mean values of Cu in water samples were 0.58ppm in zone I, 0.59ppm in Zone II, 0.54 in zone III and 0.64 in zone IV which shown in Table 1.

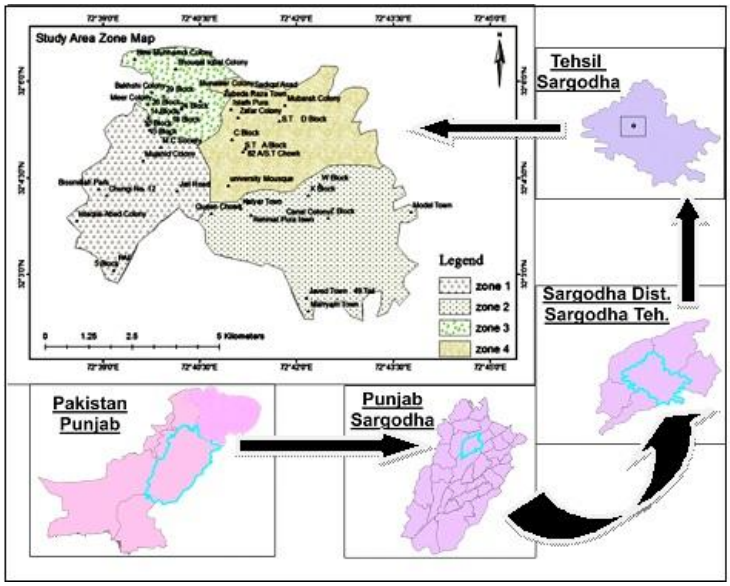

Fig. 1. Study area map.

Impact of water pollutants on Human health in Study Area

Pakistan needs to concentrate on a vast problem of water availability, quality and deaths caused by water-borne diseases. It is contaminated from different heavy metals range, and their extreme intake effects on human health. Sargodha City ground water is saline like many other cities of Pakistan and unfit for human health. Government has constructed treatment plant at different locations in the city.

Around 30% towns are served by municipal water supply system and remaining uses their own sources of drinking water. Almost 30 complaints are made daily about water quality in Sargodha city (The urban Unit P & D, GoP, 2000). District Head Quarter (DHQ) hospital Sargodha has reported a number of water born diseases in Sargodha district such as, Warm Infection, hepatitis, Bloody diarrhea, Gastro, Diarrhea dysentery, Vomiting, Scabies, Asthma, Kidney stone, Cancer and cardiovascular. Numbers of patients according to their diseases in zones are given in table 2 and Fig. 2.

Table 2. Patient data about Water born diseases of Sargodha City.

Sr. No.	Zones	Patient	Percentage
1	I	5547	33.84%
2	II	4785	29.20%
3	III	2692	16.44%
4	IV	3367	20.52%
Total	.....	16391	100%

Source: District Health Information System (DHIS) Report District Sargodha 2013.

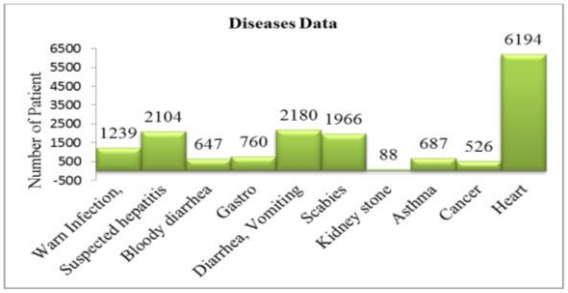

Fig. 2. Number of patient in study area in 2013 (Source: DHIS, 2013).

Public views about water quality in the study area

A field survey was also carried out in the study area to determine public opinion about water quality and related health risks. A total of 200 households were visited and fifty respondents were interviewed from each zone who utilized the groundwater in their houses, shops and mosques.

Likert scale was used to compute the respondents' approach for particular statement "Ground water of Sargodha city is suitable for drinking purpose".

Survey results showed that water quality of the Study area is not fit for drinking purpose. Fig. 3 shows that 54% of respondents were strongly disagree, 22% were disagree, 10% were agree, 8% respondents were strongly agreed with the statement and only 6% remained neutral (Fig. 3).

They complained that poor water quality is generating number of diseases including typhoid, diarrhea, eyes problem, hepatitis, skin diseases, blood pressure, stomach problem, gastro and heart diseases in the study area.

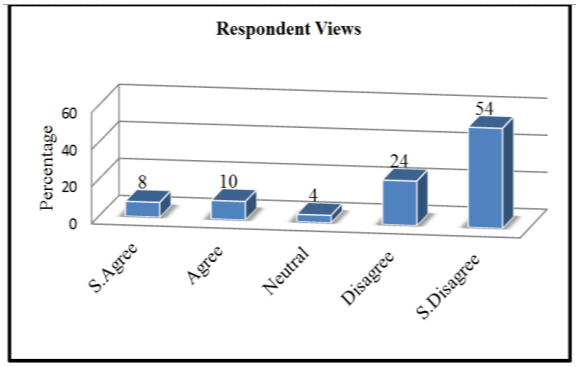

Fig. 3. Public opinion about water quality according to Likert Scale.

Table 3. Waterborne diseases in study area.

Diseases	Zone I	PHD*	Zone II	PHD*	Zone III	PHD*	Zone IV	PHD*
Kidney	3.9%	5.9%	2.8%	3.61%	2.1%	3.31%	1.9%	3.48%
stone	11.1%	14.8%	6.5%	7.23%	8.5%	6.27%	9.1%	11.62%
Diarrhea	1.2%	7.31%	1.1%	6.58%	0.89%	6.30%	0.92%	4.12%
Heart	4.2%	5.48%	7.9%	8.30%	4.8%	6.33%	5.8%	7.59%
disease	4.8%	7.36%	7.1%	6.40%	5.2%	7.84%	4.4%	5.19%
Typhoid	5.3%	6.10%	4.2%	5.11%	4.7%	6.40%	3.6%	3.70%
Gastro	13%	15.3%	8.4%	9.84%	14.2%	12.7%	11%	10.75%
Hepatitis	56.50%	38.75%	70.32%	.....	73.67%	.....	74.17%	53.63%
Cholera		.....	.....	52.93%	.....	50.85%	.....	.....
No disease	100%	100%	100%	100%	100%	100%	100%	100%
Other disease								
Total								

Source: Field survey (2016). *PHD (Patient Hospital Data).

Diseases caused by Poor Water Quality in Study Area

Waterborne diseases in developing countries are high due to contaminated water and unhygienic conditions. High level of contamination in drinking water is the causes of diarrhea, typhoid, cholera and hepatitis in Pakistan. Diarrhea, water born disease is the leading cause of death in children (kahlown *et al.*, 2006). In study area number of diseases associated with contaminated water was reported by inhabitants. Table 3 and Fig. 4 present that in zone-1, 3.9% people were suffering from kidney stone, 11.1% from diarrhea, and 1.2% from heart disease, 4.2% from typhoid, 4.8% from gastro, 5.3% from hepatitis and 13% from cholera diseases. This high number of diseases in zone is result of high contaminated water and unawareness of people regarding to water quality. In zone II, 2.8% people were suffering from kidney stone, 6.5% from diarrhea, and 1.1% from heart disease, 7.9% from typhoid, 47.1% from gastro, 4.2% from hepatitis and 8.4% from cholera diseases. In zone III, 2.1% people were suffering from kidney stone, 8.5% from diarrhea, 0.89% from heart disease, 4.8% from typhoid, 5.2% from gastro, 4.7% from

hepatitis and 14.2% from cholera diseases while similar condition were in zone IV, 1.9% people were suffering from kidney stone, 9.1% from diarrhea, 0.92% from heart disease, 5.8% from typhoid, 4.4% from gastro, 3.6% from hepatitis and 11% from cholera diseases. It was concluded that zone I was the most affected area from water related diseases. Survey analysis presented that 43.49% people were suffering from waterborne diseases while the situation in other zones was comparatively better as 29.68%, 26.33% and 25.83% people were affected in zone II, III, IV respectively.

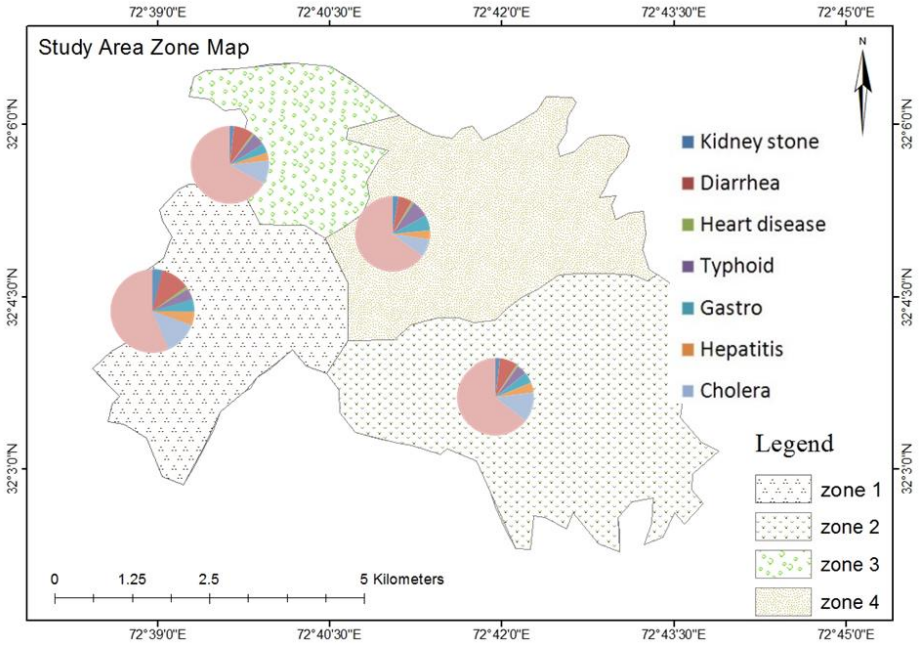

Fig. 4. Waterborne diseases in the study area.

Conclusion

Ground water is the main source of drinking water in study area while in most part of the study area; ground water is not fit for drinking purpose. Inhabitants are using poor quality water due to unawareness and financial limitations. The concentration of TDS, EC and Bicarbonates are very high as compared with WHO recommended limit for drinking purpose. The statistical analysis of water quality and DHQ hospital report proved that the ground water quality of study area is not fit for drinking purpose and 31.33% of people are suffering from waterborne diseases. Most of the inhabitants in study area are poor and unable to afford bottled water from market. It is essential to note that water consumers are commonly unaware of the potential health risks allied with exposure to water born contaminations. Some people even consider that ground water is free from contamination; hence, they did not think about any treatment before intake.

The present study proves the existence of contaminated ground water and its relationship with related diseases. It is an eye opener for people of the study area as well as local authorities to address this grave problem and to minimize health risk.

References

Abera S, Ali S, Deribew A, Kebede B, Zeyinudin A, Zemene E. 2011. Bacteriological analysis of drinking water source. Afr. Microbio. Res. **5(18),** 2638-2641.

Abhineetand N, Dohare ERD. 2014. Physico-Chemical Parameters for Testing of Present Water Quality of Khan River at Indore. India **4,** 74-81.

Adefemi SO, Awokunmi EE. 2010. Determination of physico-chemical parameters and heavy metals in water samples from Itaogbolu area of Ondo-State, Nigeria, African Journal of Environmental Science and Technology **4(3),** 145-148.

Basavaraja SSM, Hiremath KNS, Murthy KN, Chandrashekarappa AN, Patel ET, Puttiah. 2011. Analysis of Water Quality Using Physico-Chemical Parameters Hosahalli Tank in Shimoga District, Karnataka, India, Global Journal of Science Frontier, Research **1(3),** 31-34.

Bhutta MN, Hafeez CA, Ramzan M. 2002. Ground Water Quality and Availability in Pakistan, Proceedings of Seminar on Strategies to Address the Present and Future Water Quality Issues. Islamabad, Pakistan: Pakistan Council of Res. in Water Resources.

Chennakrishnan C, Manju T, Stephren A, Raveen R. 2008. Water Quality status of three vulnerable freshwater Lakes of Suburban Chennai. India: Delhi. Indian Journal of Public Health **40(2).**

Faheem JK, Yasser J. 2007. Delivering access to safe drinking water and adequate sanitation in Pakistan. Pakistan institute of development Economics, Pide working papers, Quaid-e-Azam University Islamabad.

Gilani SR, Mahmood Z, Hussain M, Baig Y, Abbas Z, Batool S. 2013, A Study of Drinking Water of Industrial Area of Sheikhupura with Special Concern to Arsenic, Manganese and Chromium, Pakistan Journal of Engineering & Applied Sciences **13,** 118-126.

Government of Pakistan. 2017. Provisional Census Report. Pakistan Bureau of Statistics Islamabad.

Government of Pakistan.1999. District Report Census of Sargodha. Population Census Organization Statistics Division Islamabad.

Hamed AR, Sannen AM. 1993. The development of rural water supply in the province of Fayoum. Water Science and Technology **1(1).**

Haydar S, Arshad M, Aziz JA. 2009. Evaluation of Drinking Water Quality in Urban Areas ofPakistan: A Case Study of Southern Lahore. Pakistan Journal of Engineering & Applied Sciences **5,** 16-23.

Kahlown M, Tahir MA, Rasheed H, Bhatti KP. 2006. Water quality status in Pakistan. Fourth Technical Report, (PCRWR). Government of Pakistan Islamabad.

Khan FK. 2006. Pakistan Geography Economic and People (New Ed.). New York, USA: Oxford University Press.

Khan N, Hussain ST, Hussain J, Jamila N, Ahmed S, Riaz U, Zain U, Saboor A. 2012. Physiochemical Evaluation of the Drinking Water Sources from District Kohat, Khyber Pakhtunkhwa, Pakistan. International Journal of Water Resources and Environmental Engineering **4(10),** 302-313.

Kosek M, Bern C, Guerrant RL. 2003. The Global Burden of Diarrheal Disease, as Estimated From Studies Published Between 1992 and 2000. Bulletin of the World Health Organization **81,** 197-204.

McArthur JM, Sikdar PK, Hoque MA, Ghosal U. 2012. Waste Water Impact on Groundwater: Cl/Br Ratios And Implications For Arsenic Pollution of Groundwater in the Bengal Basin and Red River Basin, Vietnam, Journal of Science of the Environment **437,** 390-402.

Misra SG, Dinesh D. 1991. Soil Pollution. New Delhi, India, Ashing Publishing House.

Momodu MA, Anyakora CA. 2010. Heavy Metal Contamination of Ground water: The Surulere Case Study: Research Journal Environmental Sciences **2(1),** 39-43.

NWQMP. 2007. National Water Quality Monitoring Program fifth monitoring report (2005-06). Pakistan Council of Research in Water Resources (PCRWR), Islamabad, Pakistan.

Ogundiran OO, Afolabi TA. 2008. Assessment of the physicochemical parameters and heavy metals toxicity of leachates from municipal solid waste open dumpsite. Int. J. Environ. Sci. Tech **5(2),** 243-250.

Riaz O, Abbas T, Minallah MN, Rehman, S, Ullah F. 2016.Assesment of Ground Water Quality: A case study in Sargodha City, Pakistan. Science International **28(5),** 4715- 4721.

Rizwan R, Gurdeep S, Kumar JM. 2011. Application of Heavy Metal Pollution Index for Ground Water Quality Assessment in Angul District Orissa, India Int. J. of Research in Chemistry and Environment **1(2),** 118-122.

Rizwan U, Riffat N, Qadir M. 2009. Assessment of Groundwater Contamination in Industrial City, Sialkot, Pakistan. Journal of Environmental Science and Technology **3(12),** 429-449.

Ross JS, Wilson KJW. 1981. Foundations of Anatomy and Physiology in Health and llness. (5th Ed.). UK: Churchill Livingstone.

Serageldin I. 1999. World Water Vision Commission Report. A Water Secure World. www.watervision.org.

Tahir MA, Chandio BA, Abdullah M, Rashid A. 1998. Drinking water quality monitoring in the rural areas of Rawalpindi. In proceedings of the national workshop on quality of drinking water Islamabad. Pakistan Council of Research in Water Resources 35-39.

Tihansky DP. 1974. Economic damage from residential use of mineralized water supply. Water Resources Research **10(2),** 145-154.

Trivedi P, Bajpai A, Thareja S. 2010. Comparative Study of Seasonal Variation in Physico-Chemical Characteristics in Drinking Water Quality of Kanpur, India With Reference To 200 MLD Filtration Plant and Ground Water. Nature and Science **8(4),** 11-17.

Vanloon GW, Duffy SJ. 2005. The hydrosphere. In: Environment Chemistry: A Global Perspective. 2nd Ed. New York: Oxford University Press 197-211.

Witter E. 1996. Towards Zero Accumulation of Heavy Metals in Soils. An Imperative or a fad? Journal of Fertilizer Research **43(1/3),** 225-233.