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Assessment of groundwater contamination and its impact on public health in Bhalwal City, Pakistan

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Abstract

Water is essential for human beings but poor quality of water has become a serious problem now a days. In the study area (Bhalwal city) ground water is one of the main sources of drinking water. The quality of ground water is getting worse due to untreated industrial discharge, agricultural subsistence and urban affluent. This study investigates ground water impurity in study area and its effects on public health. The quality of drinking water was compared with the criteria of WHO (World Health Organization). The recent study discloses that only Cu values were in limit as compared to WHO guidelines. EC (83.3%) TDS (69.05%), K (61.9%), and P_H (4.0%) results were out of limits as compare to WHO standard for drinking water. A survey was also conducted for public views about water quality in study area and results show that 49% respondent were very dissatisfied, 26% somewhat dissatisfied, 11% somewhat satisfied and 14% very satisfied. Some of the diseases have been pointed out by Tehsile head quarter (THQ) hospital report, 522 patients of cardiovascular, 181 patients of asthma and rapid heartbeat, 16 patients of kidney stone and 211 patients of Diarrhea are registered monthly in 2017. Most of these patients are victim of poor-quality water. In Bhalwal city five Babu Pani (بابو پانی) Water filtration plants are functional which cannot fulfill the requirement of safe & pure drinking water. In this regard, improved, planned and properly treated water supply is essentially required to meet the drinking requirements of the city.

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Introduction

Ground water pollution has become a global environmental threat (Abbas *et al.*, 2018; Riaz *et al.*, 2017; Kareem, *et al.*, 2016; Riaz *et al.*, 2016; Zara *et al.*, 2015). About 70% of the earth surface is covered with water out of which 97.3% is sea water that is not suitable for drinking purposes. Remaining 2.7% is the contribution from fresh water which is either frozen in the forms of glaciers or flowing in streams and ground water (Lalzad, 2007).

It has many beneficial uses such as drinking, household, industries, fisheries, recreations, irrigation, propagation of wild life, aesthetics etc. (Abhineet, 2014). As the civilizations progressed the population of the world also increased. With Rapid growth of population, continuous industrial and agricultural development has placed huge stress on water resources (Gilani *et al.*, 2013). Quality of life can be assessed and evaluated by accessibility to safe drinking 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 during previous two decades that the ground water quality has been changing and getting extremely polluted due to physical, chemical and biological conditions. Water quality is directly or indirectly dependent upon human activities (Dix, 1981). Ground and surface water can be contaminated by several ways, like domestic wastes, municipal wastes, industrial wastes, mining, human and animal feces, ultimate disposal of toxic materials and random usage of fertilizers, pesticides and fungicides for agricultural purposes (Hamed *et al.*, 2013). It is a universal reality that water in liquid form is used in a great amount by all living things in the world. Being the universal solvent water picks up impurities easily. Therefore, it is often potential source of causing infections (Khan, 2013). A survey conducted by World Health Organization (WHO) states that almost 80% of all human diseases are made up of water in developing countries (Abera *et al.*, 2011). Serageldin (2000) 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 that was conducted between2004 to 2005 in Pakistan, about 38 million people have no access to safe drinking water sources that would be increased to 52.8 million people in 2015 (Faheem *et al.*, 2007). As far as drinking water in Pakistan is concerned, ground water plays a vital role. Ground water contributes almost 1/3rd of Pakistan's water reserves.

As compared to surface water ground water is much more clean and safe. More than three million people are suffering from water related diseases every year, of which 0.1 million die (Water and Sanitation Program, 2005). About 70% people in Pakistan depend upon ground water for drinking and household purposes (Tahir, *et al.*, 1998). Big cities like Karachi, Lahore, Multan, Rawalpindi, Sialkot, Faisalabad, Peshawar and Gujarat are using impure water due to different human activities (Bhutta *et al*, 2002). Ground water contamination is becoming the major cause in deteriorating the health-related problem in the country. (Global Water Partnership 2000) reports also indicate 30% of all diseases are related to water and 40% of all deaths are related to poor water quality in Pakistan.

It gives birth to many diseases such as vomiting, hepatitis, typhoid, diarrhea, kidney damage and liver problems. Study area (Bhalwal city) is also suffering the same condition of impure and contaminated water supplied by the municipal water supplies. Generally, it has been examined that groundwater is saline, brackish and unsuitable to drink. While the ground water near the canals and river Jhelum is suitable to drink. Number of complaints against the declining quality of water supply registered by natives of the study area to Tehsile Municipal Administration (TMA) Bhalwal has been raised.

The major objective of the current study is to assess the quality of ground water and compare it with the standards of World Health Organization (WHO).

Present study also focuses on the water borne diseases and its impact on public health in the city of Bhalwal, Sargodha.

Material and methods

Study Area

Bhalwal is the tehsil headquarter of district Sargodha. Bhalwal lies between 32°8' north to 73°7' east (Fig. 1). City is located on Bhalwal Sargodha road which is 30 km north of Sargodha. Bhalwal is an agricultural city and is well known for the production of (kinnu) citrus, so it is called the California of Pakistan. The other major crops of Bhalwal are rice, wheat and sugar cane. Some other important industries are noon sugar Mill, Noor Pur noon dairy farm and Neeli Bar Group of textile industries. This tehsil is bounded on the north by Bhera, east by Kotmomin, south by Sargodha and west by Tehsil Shahpur.

The whole is known as Chaj Doab (The land lying between the two rivers of Chanab and Jhelum). Lower Jhelum canal is 3km away from the city. The total area of Tehsile Bhalwal is about 2115km and has an average elevation of 609 feet from sea level. The population of Tehsile Bhalwal is about 819887 and urban population is 20.3%, while its population in 1981 was 633,517 which Increased at the rate of 1.53% (GDS, 2007).

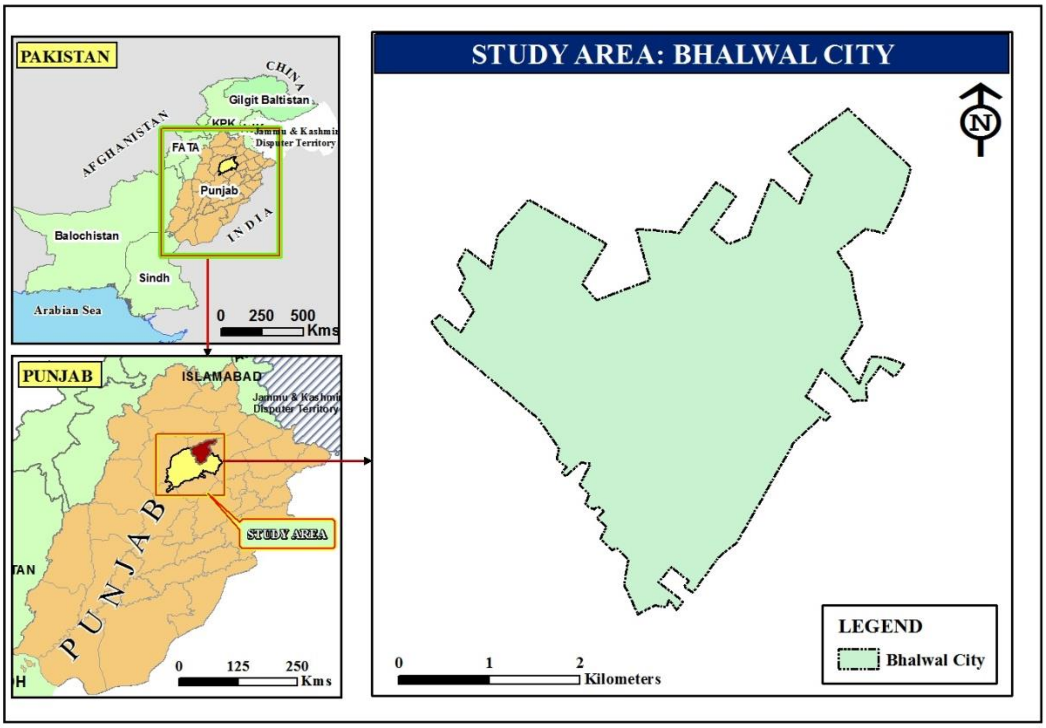

Fig. 1. Location Map of the Study Area Bhalwal City.

Sampling Methods

In this research, random sampling method is used in selecting 42 sample sites to collect ground water samples. Polythene bottles of one liter are used to collect ground water quality. Before their usage, the bottles are washed carefully and after the collection of the samples, the bottles are properly sealed according to the standards of sampling. These samples are transferred to laboratory and prior to that they are kept in a cool place for their safe keeping. The samples are collected from hand pumps and that also after 4-5 minutes of hand pumping in order to achieve better results. A table is prepared that took stock of samples, location, depth, and the condition of the hand pumps.

Data Analysis

The collected samples are tested in the laboratory of Pakistan Council of Research in Water Resources (PCRWR) in Sargodha. To get the responses of the population a questionnaire is also prepared to assess the public perception regarding quality of water and ground water change in the study area. For purpose of marking the different locations of collected water samples from the area of study, Geographic Positioning System (GPS) was used. GIS technique was used to prepare the maps according to their ground water quality and spatial distribution maps were produced.

Results and discussion

The total of 42 samples has been taken from the study area to assess groundwater quality (Table 1). All the samples were taken from borehole water (hand pump) which is mostly in used. Six water quality parameters were chosen to examine in research i.e. hydrogen ions, electric conductivity, total dissolved solid, copper, potassium and calcium which are shown in table below.

Table 1. Locations and Results of selected parameters.

Sample ID	Latitude	Longitude	Depth (m)	pH	EC (µs)	TDS (mg)	K (mg)	Ca (mg)	Cu (mg)
GW1	32°16′58″	72°53′95″	110	7.8	520	375	2.5	28	0.34
GW2	32°16′51″	72°53′66″	140	7.3	1240	893	04	50	0.44
GW3	32°16′01″	72°54′22″	156	7.2	10840	7805	8.7	28	0.63
GW4	32°16′28″	72°53′96″	138	7.4	550	396	2.7	24	0.49
GW5	32°16′68″	72°54′53″	190	9.1	5800	4176	5.7	8	0.47
GW6	32°16′45″	72°53′49″	144	6.7	4020	2894	22.4	16	0.58
GW7	32°15′98″	72°54′12″	186	7.2	7080	5098	7.9	20	0.48
GW8	32°16′06″	72°53′96″	143	7.3	800	576	2.6	18	0.39
GW9	32°16′15″	72°54′26″	134	7.3	3100	2233	19.7	36	0.50
GW10	32°16′50″	72°54′43″	138	7.6	3630	2614	3.7	16	0.61
GW11	32°16′79″	72°55′02″	125	7.3	1660	1995	14.7	48	0.55
GW12	32°16′24″	72°54′64″	174	7.4	5860	4219	6.1	20	0.67
GW13	32°16′04″	72°54′45″	167	7.3	10890	7841	8.7	70	0.47
GW14	32°16′05″	72°53′73″	114	7.5	8550	6156	10.2	38	0.59
GW15	32°15′99″	72°53′80″	170	7.0	10300	7414	9.9	40	0.47
GW16	32°16′24″	72°53′08″	124	6.8	5960	4291	9.0	102	0.51
GW17	32°16′37″	72°53′55″	143	6.9	2720	1958	7.2	90	0.53
GW18	32°16′03″	72°53′38″	178	6.8	5560	4003	8.4	30	0.68
GW19	32°16′45″	72°53′32″	181	7.0	860	619	6.5	52	0.60
GW20	32°16′07″	72°38′28″	186	8.0	2050	1394	19	17	0.68
GW21	32°16′18″	72°53′17″	156	7.1	2360	1603	11	23	0.54
GW22	32°16′19″	72°53′21″	168	7.1	6110	4095	14.5	61	0.58
GW23	32°16′20″	72°53′25″	140	6.9	7120	4386	19	38	0.48
GW24	32°16′16″	72°53′32″	130	8.0	2010	1971	21	26	0.43
GW25	32°16′12″	72°53′36″	155	7.1	6060	3801	28	32	0.68
GW26	32°16′13″	72°53′17″	170	8.8	579	394	11	16	0.47
GW27	32°16′21″	72°54′24″	134	7.2	705	567	10	36	0.48
GW28	32°16′31″	72°54′28″	148	7.2	4070	4312	28	34	0.67
GW29	32°15′54″	72°54′30″	143	7.7	2440	979	29	35	0.81
GW30	32°15′49″	72° 53′49″	157	7.9	4380	2162	39	18	0.86
GW31	32°15′44″	72°53′54″	170	7.9	3810	2591	18	23	0.68
GW32	32°15′44″	72°54′06″	150	8.2	2040	767	9	22	0.44
GW33	32°15′49″	72°54′10″	168	8.3	2139	674	19	30	0.61
GW34	32°15′57″	72°54′16″	170	7.4	558	499	13	17	0.47
GW35	32°16′04″	72°54′17″	154	8.0	5500	4020	20	27	0.78
GW36	32°16′09″	72°54′19″	140	7.0	3530	2664	28	35	0.71
GW37	32°16′08″	72°54′22″	165	7.9	7650	4122	15	37	0.76
GW38	32°16′03″	72°54′25″	175	8.4	1068	784	26	21	0.78
GW39	32°16′00″	72°54′27″	169	8.0	1044	678	12	19	0.77
GW40	32°15′53″	72°54′31″	180	7.6	2680	1042	20	21	0.49
GW41	32°15′46″	72°54′30″	170	7.0	2680	2302	14	15	0.69
GW42	32°16′09″	72°53′27″	165	7.1	4990	3713	19	25	0.68

Presence of Hydrogen Ions (pH)

Most important and basic natural acidic parameter find out in drinking water is pH. pH determines the acid balance of a solution and is defined as a negative of the logarithm to the base 10 of the hydrogen ions concentrations. The ph scale varies between 0 to 14 (very acidic to very alkaline), whereas ph 7 is neutral condition. The lower value of ph indicate acidic condition while the above 7 basic condition. The pH of human blood is 18.2; acidity of blood caused abnormal heart beating and increases the pulse rate. According to (WHO, 2004) permissible limit pH of water should be 6.5 to 8.5 (Gupta *et al.*, 2009). The overall concentrations of pH in collected samples is shown in Table 1 and Fig. 2. The concentration of pH values in samples varies from 6.8 to 9.1. Almost all the pH values of ground water samples are within the safe limit of WHO except 2 locations.

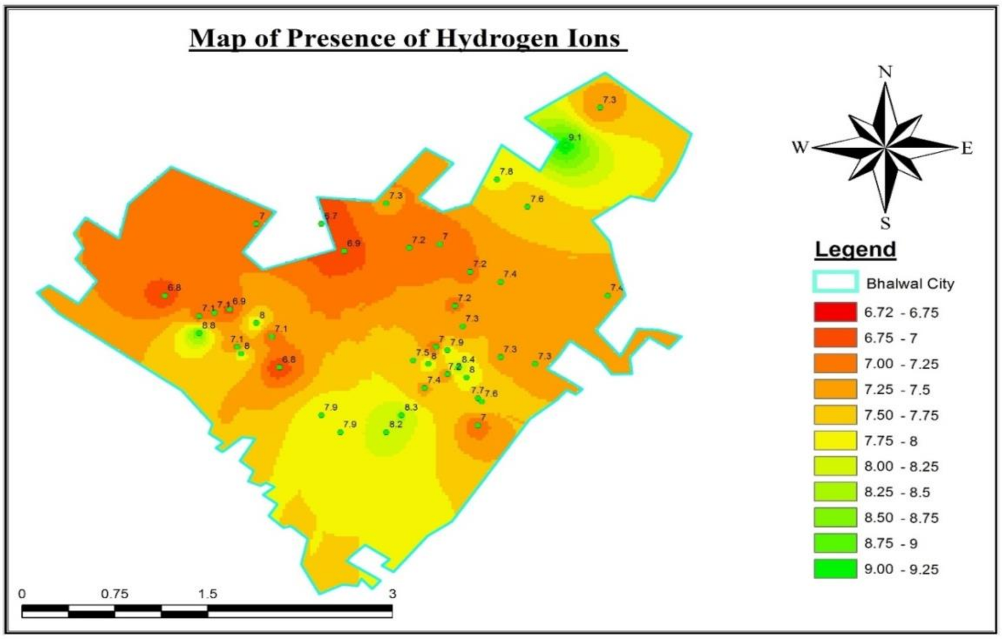

Fig. 2. Spatial Distribution of pH in Bhalwal City.

Electrical Conductivity (EC)

The total dissolved solid (TDS) performs the function of electrical conductivity and also known as ions concentration that delimit water quality. The salt contents in the water facilitates the current to pass through it when a potential is applied through it. As distilled water or de-ionized water has very few dissolved ions so no current flows across the gap. EC is an amount of how much total dissolved salt or total dissolved ions present in the water.

Measurement of electrical conductivity used to locate water quality problems. Ten parameters such as pH value, temperature, calcium, alkalinity, chloride, chemical, Oxygen demand total solids, total hardness, total mixed, solids and iron concentration of water has very important relation with electric conductivity. If the value of EC increases automatically the saline level will increase in water (Kumar *et al.*, 2010). The concentration of EC in study area, 42 ground water samples are shown in Table 1 and Fig. 3.

The WHO recommended a value of EC is 1000 µs/cm. EC values Varied from 521µs to 10881µs in all ground water samples. Only 7 samples (16.7%) of ground water were in limits and 35 samples (83.3%) were above the limit of WHO. In study area (Bhalwal city) very high concentration of EC has been found in south east and central part of study area. Low concentration of EC is found in the north east, northwest, southeast and western part of city as shown in Fig. 3. The result of ground water samples clearly shows, water of the study area was greatly ionized and has the higher level of ionic concentration activity due to extreme dissolve solids. So the area of Bhalwal city is a fine conductor of electric current.

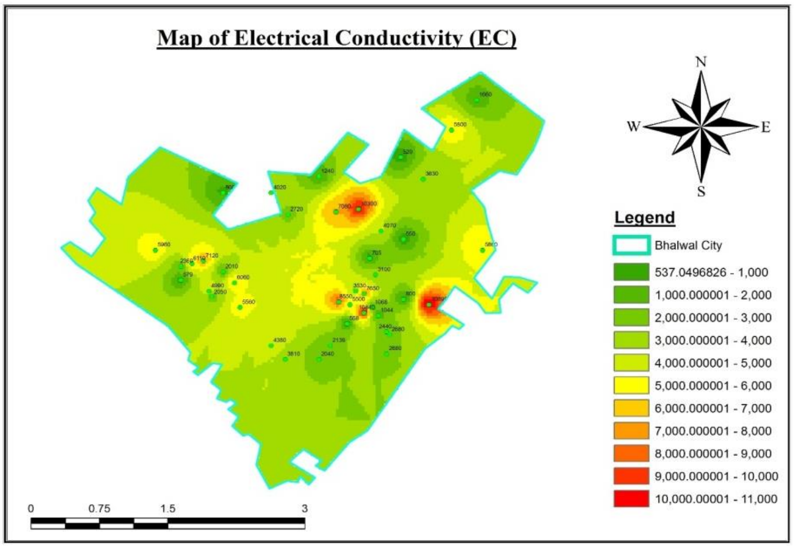

Fig. 3. Spatial Distribution of EC in Bhalwal City.

Total Dissolved Solid (TDS)

Water has capability to liquefy organ and some inorganic minerals or salts such as magnesium, sodium, calcium, potassium, bicarbonates, chlorides, sulfates etc. These minerals bring a thin color and abdicable last in water. The Concentration of TDS in ground water may be due to natural resources, urban runoff, sewage waste and industrial waste. All the mean value of TDS in 42 ground water samples is shown in table 1 and Fig. 4. WHO counseled that the permissible limit of TDS in drinking water is 1000 ppm. TDS values varied between 375ppm to 7841ppm in all ground water samples locations. Only 13 samples (30.95%) result of ground water were in limits and remaining 29 samples (69.04%) were out of limit. High concentration of the TDS in ground water is due to poor management of water waste, urban runoff and industrial waste in the city and also nearness of salt range. Bruvold (1968) rated drinking water according to total liquefy solid. The 300ppm concentration of TDS is excellent for health and taste of water between 300-600ppm considered good 600 to 900 is fair concentration between 900-1200ppm is poor and greater than 1200ppm considered unacceptable for drinking. In study area, the concentration of TDS is very high and contaminates the water. TDS plays a role along with other contaminates that cause cardiovascular in human in study area.

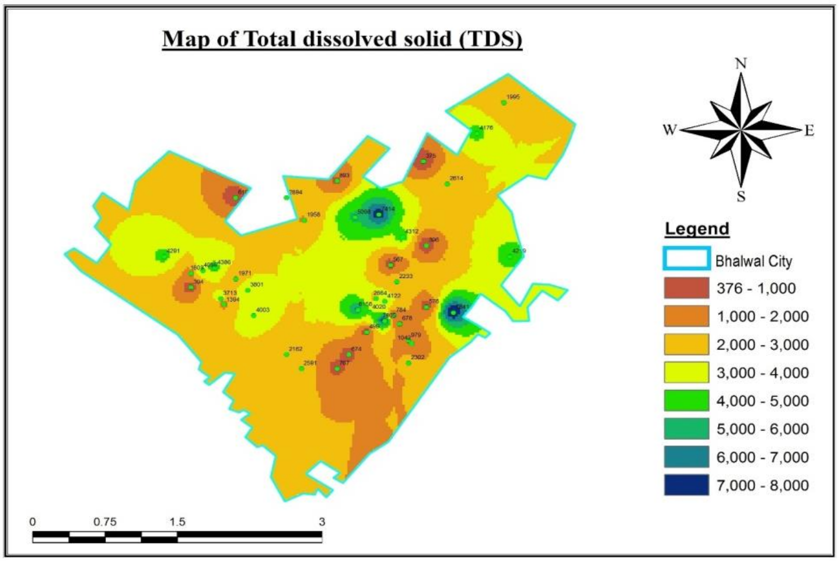

Fig. 4. Spatial Distribution of TDS in Bhalwal City.

Copper (Cu)

An important micronutrient of human body as well as soil and irrigation water is copper. For good health minute quantity of copper is required for human body, however its higher concentration can cause many abnormalities such as irritation of nose, mouth and eyes, diarrhea, vomiting, stomach issues and even death (Alloway, 1990). The WHO recommended values of Cu are 0.5ppm to 1.5ppm. All the values of ground water copper (Cu) concentration show in table 1 and Fig. 5. Copper values varied between 0.3ppm to 0.9ppm and 35.5% ground water samples were below the minimum limit of WHO. No one single sample out of 42 ground water samples was exceeded the limit set by WHO. Low concentration of copper is present in north east, west and southern portion of study area which is shown with white color while high concentration were noted in the southern part which is shown by blue color in Fig. 4.

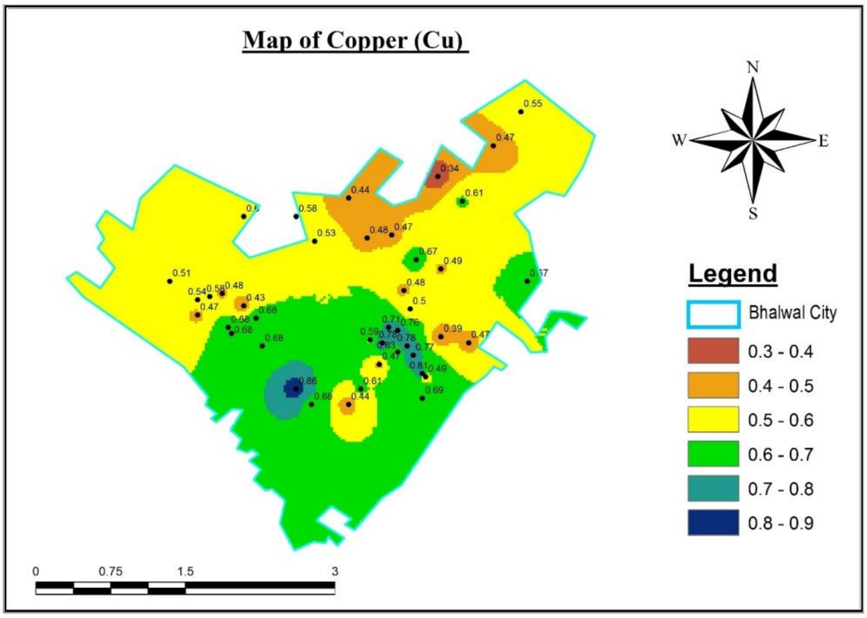

Fig. 5. Spatial Distribution of Cu in Bhalwal City.

Calcium (Ca)

On the earth crust calcium is the 5th most common element which is very necessary for human bones and cell physiology. Calcium responds with water displacing hydrogen and forming hydroxide. Calcium is very important for muscle concentration, strong building of bones, teeth blood clotting, nerve impulse, transmission, regulating heartbeat and fluid balance with in cells. Lack of calcium in body causes osteoporosis and weakness of bones (Kahlown *et al.*, 2006). Ninety five percent (95%) of calcium is stored in teeth and bones of human body. The increasing level of calcium caused of cardio vascular disease. The lack of calcium in human body may produce bones factures, poor blood, clotting, tickets etc (Lal *et al.*, 1996). All the mean values of Ca in 42 ground water samples are shown in table 1 and Fig. 6. According to WHO and Pakistan standards its permissible rang in drinking water are 75ppm to 200ppm. Calcium values varied between 8ppm to 102ppm. All 42 samples of Ca were under the permission able value of WHO. Riaz *et al.*, (2016) has been reported also very low concentration of calcium in Bhalwal city.

Potassium (K)

An important micronutrient for human body both for cellular and electrical function is potassium. The amount of potassium in human body and blood serum varies from 4-5 mg/100 ml. Potassium deficiencies causes' high rate of heartbeat, muscle weakness, weakened immune system, bladder weakness and kidney disease (Kahlown *et al.*, 2006). A higher level of potassium in blood is called hyperkalemia which leads to disturbance in renal function, abnormal breakdown of protein and severs infection. All the values of K in 42 ground water samples are shown in table 1 and fig 7. The WHO recommended values of K are 10 mg/l. Potassium (K) values varied between 2.5ppm to 39ppm in ground water samples. Only 16 samples (38.1%) results of ground water were in limit and remaining 26 samples (61.9%) out of permission able limits.

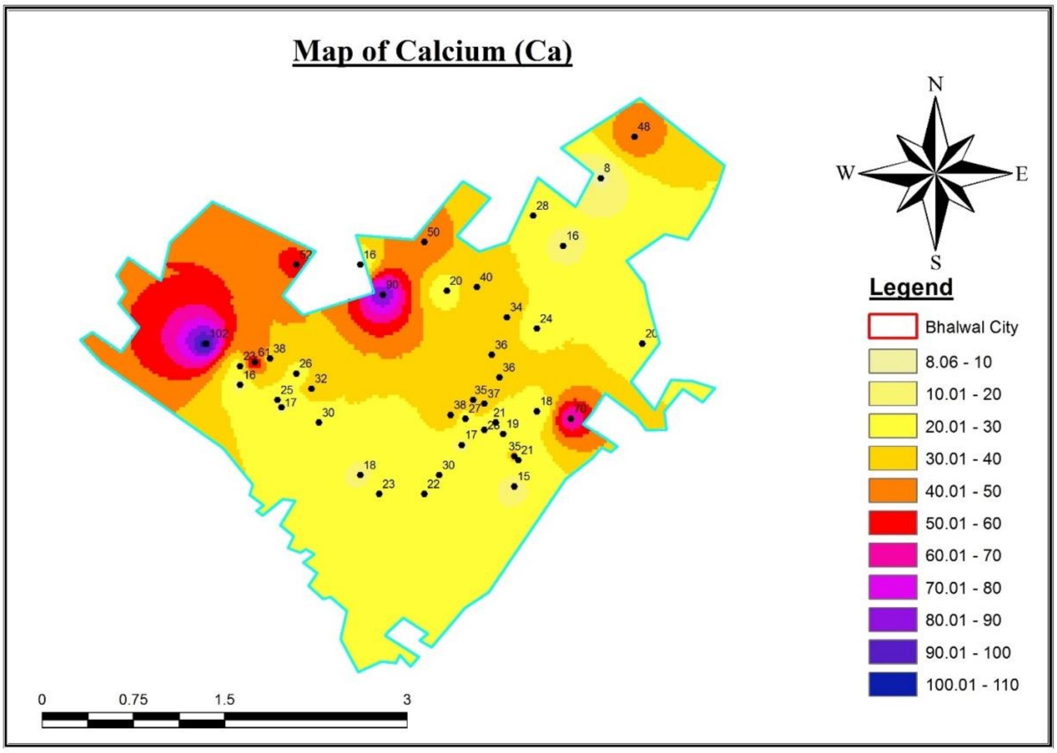

Fig. 6. Spatial Distribution of Ca in Bhalwal City.

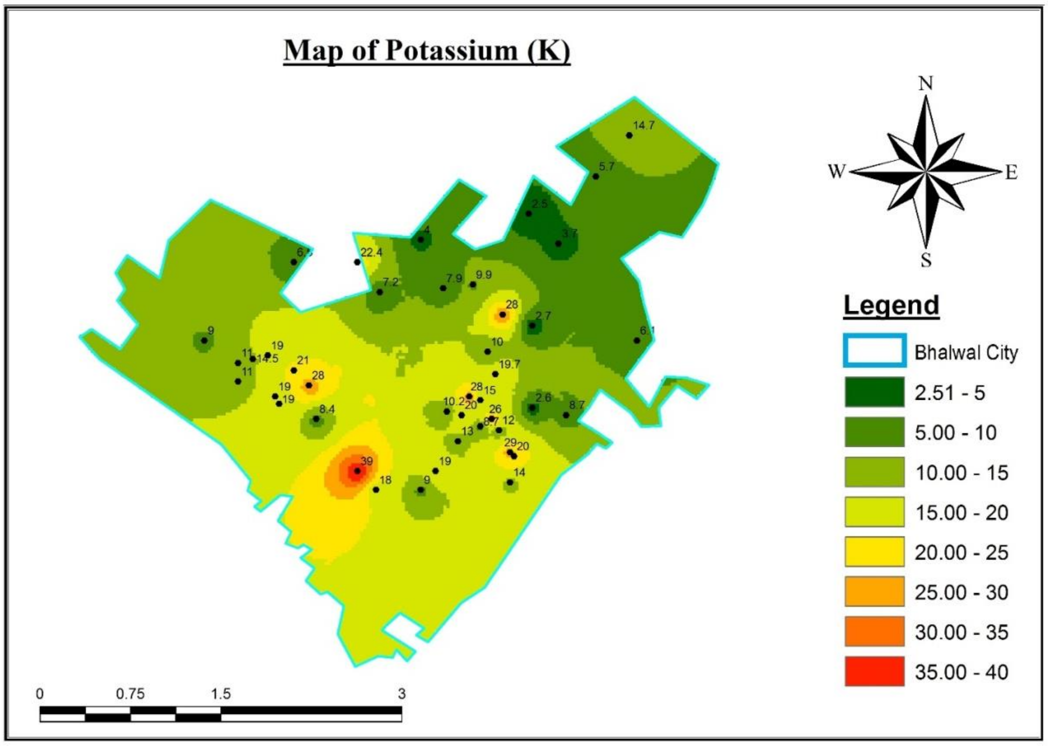

Fig. 7. Spatial Distribution of K in Bhalwal City.

Water related Diseases and Public Opinion in Study area

Pure water for drinking is necessary for human and other biodiversity on planet earth. Anthropogenic activities are main cause of water pollutants in developing countries. Contaminated water is the cause of various diseases. Pollutants e.g industrial waste, sewerage water etc are the main of drinking water. A survey about the water quality was conducted in study area which shows that 49% respondents are very dissatisfied, 26% somewhat dissatisfied, water are cholera, diarrhea and gastro disturbances, dental caries, whipworm, filarial, typhoid, flukes, hookworm and leeches. The diseases pointed out in the Tehsil headquarter hospital (THQ) reports are 522 patients of cardiovascular, 181 patients of asthma and rapid heartbeat, 16 patients of renal dysfunction and 211 patients of diarrhea are average registered patents in year,2017. Most of them are victim of poor-quality water. Water related diseases in Bhalwal city such as warm infection, hepatitis, gastro, diarrhea, dysentery, vomiting, scabies, asthma kidney stone and cardiovascular are given below in Table 2.

Table 2. Water Pollutants and its Related Disease in the study area.

Sr. No.	Pollutants	WHO limit	Diseases caused by High concentration	Diseases caused by low concentration	Monthly Patient
1	Ph	8.5	Abnormal heartbeat, Pulse rate	---------	58
2	Total Dissolved Solid	1000mg/l	Cardiovascular,	----------	522
3	Electric Conductivity	1000us/cm	-----------	----------	……
4	Potassium	10mg/l	Abnormal breakdown of protein, Sever Infection	Rapid heartbeat, Kidney disease, Muscle weakness, Asthma	181
5	Calcium	75mg/l	Kidney stone, Stroke	Weakening of the bones, Osteoporosis	16
6	Copper	1.5 mg/l	--------	Stomitch cramps, Diarrhoea, Vomiting,	211

Conclusion

The study investigated physic-chemical properties of the groundwater which is a main drinking water source in study area. The spatial distribution analysis of groundwater quality in the study area and comparing different parameter with WHO guideline, it was concluded that the water quality of study area is not suitable for drinking purpose. The results obtained show the need of awareness campaign among public about the poor-quality of water in their area. The local administration must take some necessary steps to produce awareness about this issue in general public. The government needs to make a scientific and effective planning for ground water quality management system. The public awareness on present quality crisis, their involvement and cooperation in the actions of local administration is need of the hour. It is suggested that this study is helpful for further planning in future.

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