Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 8, No. 3, p. 64-76, 2016
http://www.innspub.net

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RESEARCH PAPER
OPEN ACCESS

Evaluation of drinking water quality in urban areas of Pakistan: a case study of Gulshan-e-Iqbal Karachi, Pakistan

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Article published on March 16, 2016

Key words: Water quality, Karachi, WASA, physicochemical characteristics; microbial characteristics.

Abstract

A study was carried out to evaluate the quality of water supplied by Water and Sanitation Agency (WASA), Karachi. Gulshan-e-IQbal was selected for this purpose. Water samples from different source (12 houses) connections (one from each) were collected making a total of twelve sampling points. Physicochemical parameters (pH, Eh, turbidity, conductivity, temperature and total dissolve solid), only one microbial parameter and one chemical test (As) were tested for each sample and values compared with World Health Organization (WHO) guidelines for drinking water. The results of the study demonstrated that physical and chemical quality of water was satisfactory. Some samples (3 samples) were contaminated possible causes of contamination were leaking water mains and cross connections between water mains and sewers due to close proximity. It is recommended to carry out compulsory chlorination at water sources while maintaining reasonable residuals at the consumers end to eliminate the microbial contamination.

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Introduction

Water is necessary for the survival of every form of life. Every day human beings consume about 2 litres of water. Water is used for drinking purposes, agriculture, industrial, and domestic consumption (Dara, 1993). Drinking water must be free from components which may adversely affect the human health. Such components include minerals, organic substances and disease causing microorganisms. A large portion of the population in developing countries suffers from health problems associated with either lack of drinking water or due to the presence of microbial contamination in water (Leeuwen,2000) . Poor water quality is responsible for the death of an estimated 5 million children in the developing countries (Holgate, 2000). According to the World Health Organization (WHO) 1.1 billion people of all over the world do not have supply of potable drinking water. This situation is worse in Pakistan where supply of pure water has been reduced from 60% to 40% because the Urbanization increased from 31% to 34% (Anwar, 2010). WHO states that 80% of all human diseases are due to the biological contamination of water in the developing countries (Wright, 2004). The studies have revealed that in major cities (e.g. in Lahore 81.4%) widespread contamination of water occurs (Anwar, 2010). The problem is further aggravated by rapidly increasing population which results in poor water-quality management (HuangandXia,2001).

In Pakistan, water supply coverage through piped network and hand pumps is around 66% (PMDG, 2006). It is estimated that, in Pakistan, 30% of all diseases and 40% of all deaths are due to poor water quality (GWP, 2000). Diarrhea, a water borne disease is reported as the leading cause of death in infants and children in the country while every fifth citizen suffers from illness and disease caused by the polluted water (Kahlown, 2006) Unfortunately, little attention is being paid to drinking-water quality issues and quantity remains the priority focus of water supply agencies. There is a lack of drinking-water quality monitoring and surveillance programmed in the country. Weak institutional arrangements, lack of well-equipped laboratories and the absence of a legal framework for drinking-water quality issues have aggravated the situation. Above all, the public awareness of the issue of water quality is dismally low (Aziz, 2005).

Irregular water supply is common in urban areas and outbreaks of gastroenteritis and other water born diseases have become a normal feature (Bridges,2007). Estimates indicate that more than three million Pakistanis suffer from water born diseases each year of which 0.1 million die (KWS,2005). Thus there is a need to find out where the actual problem lies; whether the water sources are contaminated or lapses occur in the distribution system. Presently, Pakistan has no national drinking water quality standards and WHO guidelines are followed (WHO, 2004). This research work was undertaken with the objective: (1) to evaluate the drinking water quality in Eastern District of Karachi both at the source and in the distribution system according to WHO guidelines and (2) to suggest preventive measures in case of any lapses found.

Materials and methods

Study Area

Gulshan Town is one of the towns in Karachi, Sindh, Pakistan. The town is also known as Gulshan-E-Iqbalwas named in honor of Pakistan's national poet Allama Muhammad Iqbal. It is bordered by Gadap Town to the north, the Faisal and Malir Cantonments to the east, Jamshed Town to the southwest, and Gulberg and Liaquatabad to the west.

The population of Gulshan Town was estimated to be about 650,000 at the 1998 census, of which 99% are Muslim. The population of Gulshan Town is estimated to be nearly one million today.

The federal government introduced local government reforms in the year 2000, which eliminated the previous third tier of government (administrative divisions) and raised the fourth tier (districts) to become the new third tier. The effect in Karachi was the dissolution of the former Karachi Division and the merger of its five districts to form a new Karachi City-District with eighteen autonomous constituent towns including Gulshan Town.

District East Karachi (Gulshan-e-iqbal) was selected for the purpose of this study as a test case. It mainly consisted of well-plannedgovernment and private housing societies. Localities selected were Block #4, #5, #6, #7, #11 in Fig. 1. Shows WASA supplies water to all these localities (Wikipedia, 2013).

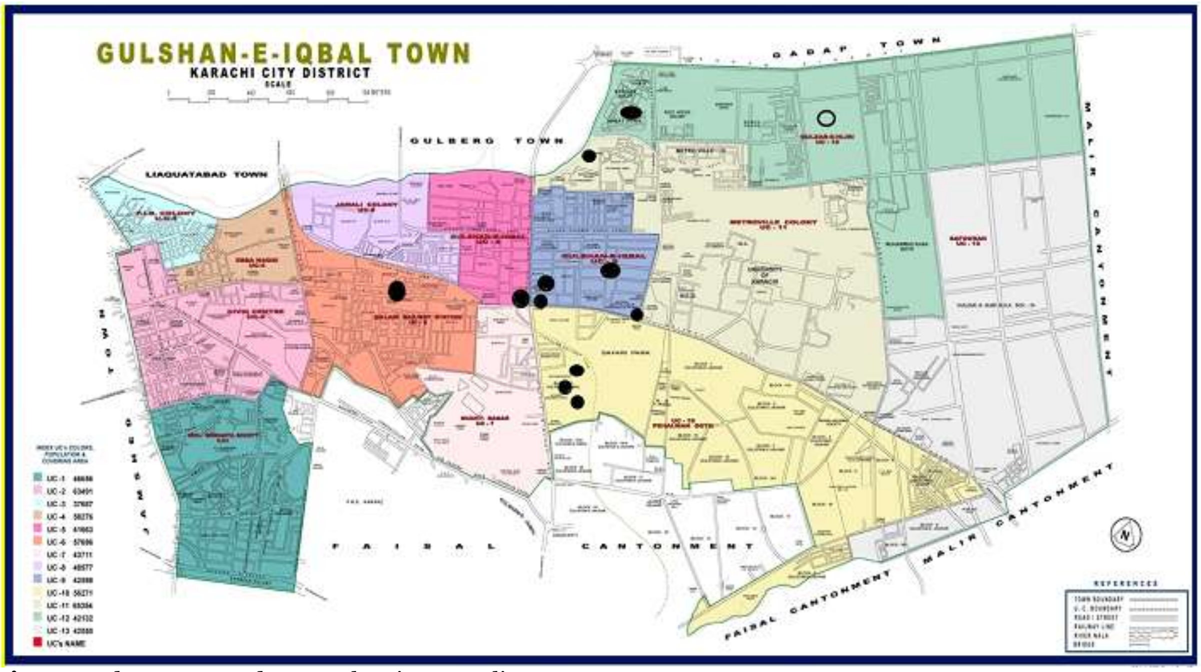

Fig. 1. Study area map: dots are showing sampling areas.

According to WHO guidelines, one sample per 5000 heads of population should be collected from the distribution system (Hayder, 2009). Since all these localities had a population ranging from 5000 to 10000 so for the test only one sample can be used.

Sampling Methodology

For physicochemical analysis, water samples were collected in a 1.5 L polyethylene (PET) bottle while a 0.5 liter sterilized PET bottle was used to collect sample for microbial analysis. In case of water samples from the distribution system, un-rusted taps supplying water from a service pipe, directly connected to the main and not served from the household storage tank were selected. Samples were not taken from those taps which were leaking between the spindle and gland to avoid outside contamination. Taps were opened fully and let run for 2 to 3 minutes before sampling to get a truly representative sample both from the source and the distribution system.

Laboratory Analysis

Eight water quality parameters; six physical, only one chemical and one microbial were tested for the samples collected for this research work. Physical parameters tested werecolour, taste, odor, pH, Eh, turbidity, conductivity and TDS. These parameters play an important role in the disinfection of water. Turbidity should be less than 0.5 Nephelometric Turbidity Units (NTU) and pH should be less than 8 for effective disinfection (WHO, 2004). Chemical parameters chosen were total dissolved solids (TDS) and Arsenic. Water with high hardness results in excessive use of soap for washing purposes in household use while water with high TDS may impart taste. High values of this result in scale deposition in pipes and utensils. Microbial parameters tested were used to check whether the presentation of any microorganisms. These parameters indicate the possibility of the presence of pathogenic bacteria in the supplied water. All the tests were conducted according to the procedures laid down in the Standard Methods (WHO, 1996).

Total 12 samples were taken out of which only 1 sample was Ground Water. 6 samples were collected from block 4 and given code as I1, I2, I3,W3,M1,M2, 1 from block 5named as A2, 2 from block 6 named as A1 and A3, 1 from block 7 named W1, 1 from block 11 named as M3. The ground water sample was named M1 and taken from block 4.

Results and discussion

pH

In chemistry, pH is one of the most important operational water quality parameters (Hydar, 2009 and NSDQW, 2008). The pH of a solution is the negative logarithm of the molar hydrogen ion concentration which indicates its acidic character. pH= - log [H+]. It is a measure of acid-base equilibrium in natural water. An increased concentration of carbon dioxide will lower the pH and vice versa. Careful attention to pH control is necessary at all stages of water treatment and distribution system to ensure satisfactory water clarification and disinfection and also to minimize the corrosion of water mains and pipes in household water systems. If this is not done, contamination of the drinking water may result manifesting itself in the form of taste, odour and appearance changes.pH is a measure of the free hydrogen ion and hydroxyl ions in the water (NSDQW, 2008).pHof 7 is neutral and under 7 indicates acidity, higher than 7 indicates alkalinity. Because pH can be affected by chemicals in the water, pH is an important indicator of water that is changing chemically. (Johnson and Scherer, 2012) pH less than 7 corrosion of water pipes may be accelerated releasing metals into the water; this may be a cause of concern if the concentration of such metals exceeds the permissible limits. (NSDQW,2008).

Table 1. Details of 12 sampling location and nomenclature used.

Serial No.	1	2	3	4	5	6	7	8	9	10	11	12
Sample loc. (Block#)	6	5	6	4	4	4	7	11	4	4 (GW)	4	11
Code No.	A1	A2	A3	I1	I2	I3	W1	W2	W3	M1	M2	M3

The direct effects of exposure of humans and animals to extreme pH values (below 4 or above 10) for extended periods of time may result in irritation to the eye, skin and mucous membranes (WHO, 1986; NSDQW, 2008). In sensitive individuals gastrointestinal irritation may also occur, however, occasional pH changes may not have any direct impact on water consumers (NSDQW, 2008). Eye irritation and exacerbation of skin disorders have been associated with pH greater than 11 additions to that, a solution of pH 10 – 12.5 have been reported to cause hair fibers to swell, pH below 12.5 damage epithelium (WHO, 1986).It is necessary to know the pH of water, because more alkaline water requires a longer contact time or a higher free residual chlorine level at the end of the contact time for adequate disinfection (0.4–0.5 mg/litre at pH 6–8, rising to 0.6 mg/litre at pH 8–9; chlorination may be ineffective above pH 9) Napacho and Manyele (2010). In most natural waters, pH is controlled by the carbon dioxide-carbonate-bicarbonate equilibrium system. An increased carbon dioxide concentration will lower the pH, whereas a decrease will cause it to rise. The pH value of water may also be affected by domestic sewage (generally neutral or slightly alkaline), industrial wastes (may be strongly acidic or alkaline depending on the type of industry), etc. Municipal and industrial wastewater discharges may influence the pH values of rivers and wells (Bhattacharya, 1988).

Tale 2. Summary of the results of the all samples.

Sample loc. (Block#)	Code No.	Biolog. activity	Arsenic Test	pH	Eh	TDS (mg/l)	Conduct. (µS/m)	Turbid. (NTU)	Temp. C°
6	A1	present	Not any (N/A)	7.76	-49	551	1107	1.22	30.2
5	A2	Not any (N/A)	Not any (N/A)	7.11	-40	515	1111	1.21	30.2
6	A3	Present	Not any (N/A)	7.76	-48	550	1109	1.23	30.1
4	I1	Present	Not any (N/A)	7.45	-26	526	1045	0.30	30.2
4	I2	Not any (N/A)	Not any (N/A)	7.07	-26	354	710	0.06	30.3
4	I3	Not any (N/A)	Not any (N/A)	7.70	-41	376	751	0.62	30.2
7	W1	Not any (N/A)	Not any (N/A)	7.44	-30	425	843	1.36	30.4
11	W2	Present	Not any (N/A)	6.73	6	558	1122	0.32	30.2
4	W3	Present	Not any (N/A)	7.21	-14	360	716	1.14	30.1
4 (GW)	M1	Not any (N/A)	Not any (N/A)	7.62	-39	1370	2.74 S/m	0.10	30.6
4	M2	Not any (N/A)	Not any (N/A)	7.64	-35	510	1019	0.69	30.2
11	M3	Not any (N/A)	Not any (N/A)	7.69	-36	344	686	0.18	30.3

From some literature we come to know that WHO proposes a desirable range of 6.5 to 8.0 for pH of drinking water quality. Water is corrosive below 6.5 and soapy above 8.5 (WATER AID, 2010; hydar, 2009). According to some other scientists drinking water with a pH between 6.5 and 8.5 generally is considered satisfactory (Johnson and Scherer, 2012) but some contradict this opinion, the pH values higher than 8 are not suitable for effective disinfection (Hydar, 2009).

The mean value of pH of twelve samples is 7.43. The lower pH value is 6.73 and the highest value is 7.76. All the pH values at all the houses connections are within the WHO desirable limit.

Eh (redox potential)

Eh is a measure of the reduction-oxidation (redox) potential (pe) of a water sample, or stated another way, the ability of an environment to supply electrons to an oxidizing agent, or to take up electrons from a reducing agent. Eh measurements are semi-quantitative measurements and assume that equilibrium in the system has been achieved. Eh is measured in millivolts (mV, or milliV), or volts (V) and like specific conductance is reported as a corrected value at 25C°.

Temperature of the water, amount of dissolved gases, and amount of oxygen present have a strong effect on Eh measurements. Eh is temperature dependent and measurements should be taken *in situ*, or immediately after a water sample is taken.

Eh meters are calibrated to one of two solutions: Zobell's Solution or Light's Solution. Both are potentially hazardous and should be handled with care. Used calibration solutions should be saved in sturdy waste containers, and disposed of in a laboratory setting. Never dump used calibration solutions into the environment. (Field water chemistry).

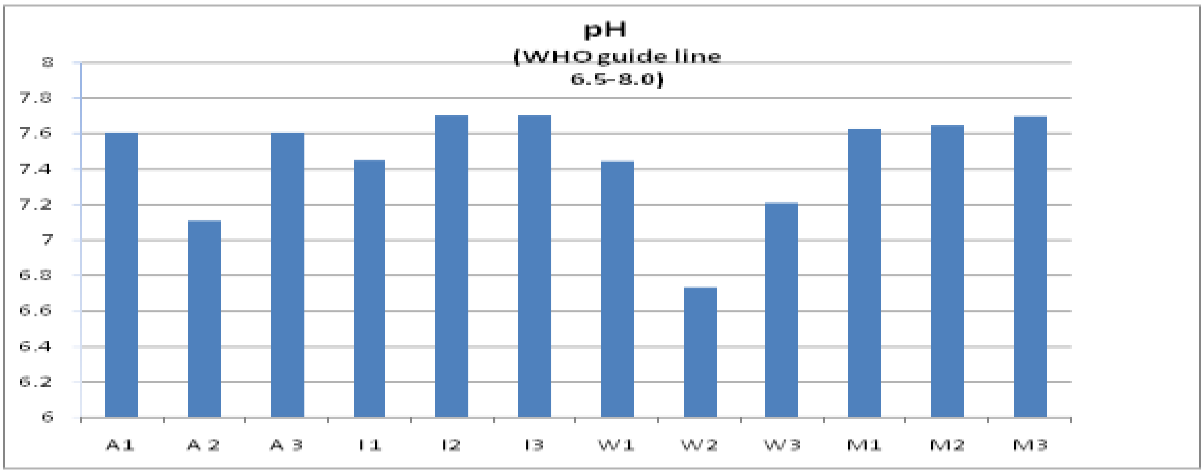

Fig. 2. pH values of various samples and comparison with WHO.

The mean value of Eh is -26.5 the lowest values is -49 and the highest is 6. It is not defined by WHO for drinking water. No guideline is define for Eh by the WHO.

Total Dissolved Solids TDS

TDS stands for total dissolved solids,the inorganic salts (magnesium, calcium, potassium, sodium, bicarbonates, chlorides and sulphates) and small amounts of organic matter comprise TDS. Concentrations of TDS in water vary too much extent due to the variability in the geographical locations. There is no reliable data available on the health effects of the TDS in drinking water (WHO, 2004).

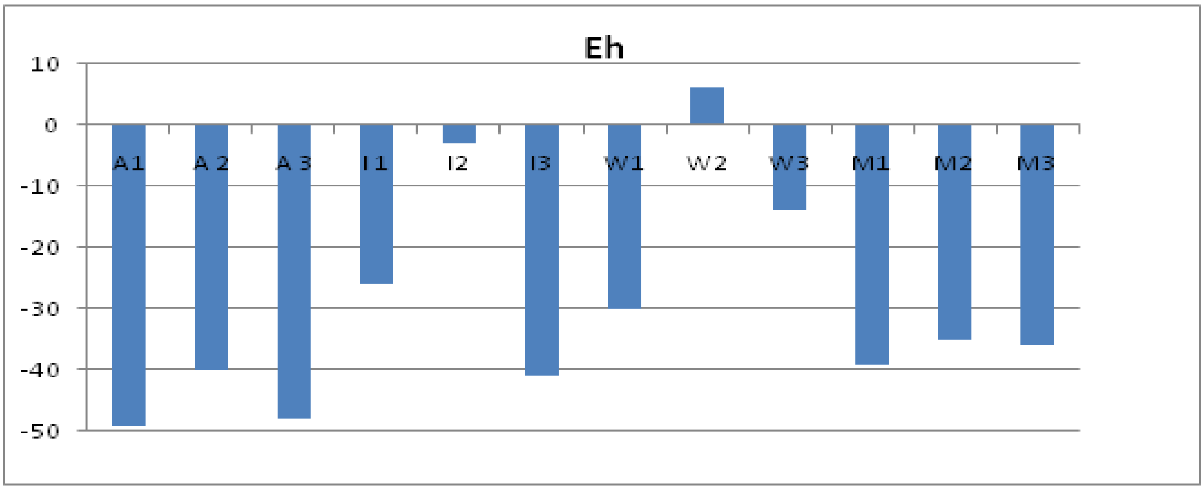

Fig. 3. Values of Eh of all samples.

TDS in drinking-water originate from natural sources, sewage, urban runoff and industrial wastewater. Salts used for road de-icing in some countries may also contribute to the TDS content of drinking-water. Concentrations of TDS in water vary considerably in different geological regions owing to differences in the solubilities of minerals. Reliable data on possible health effects associated with the ingestion of TDS in drinking-water are not available, and no health-based guideline value is proposed. However, the presence of high levels of TDS in drinking-water may be objectionable to consumers(WHO, 2006).

The palatability of water with a TDS level of less than 600 mg/litre is generally considered to be good; drinking-water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/liter. The presence of high levels of TDS may also be objectionable to consumers, owing to excessive scaling in water pipes, heaters, boilers and household appliances. (WHO, 2006).

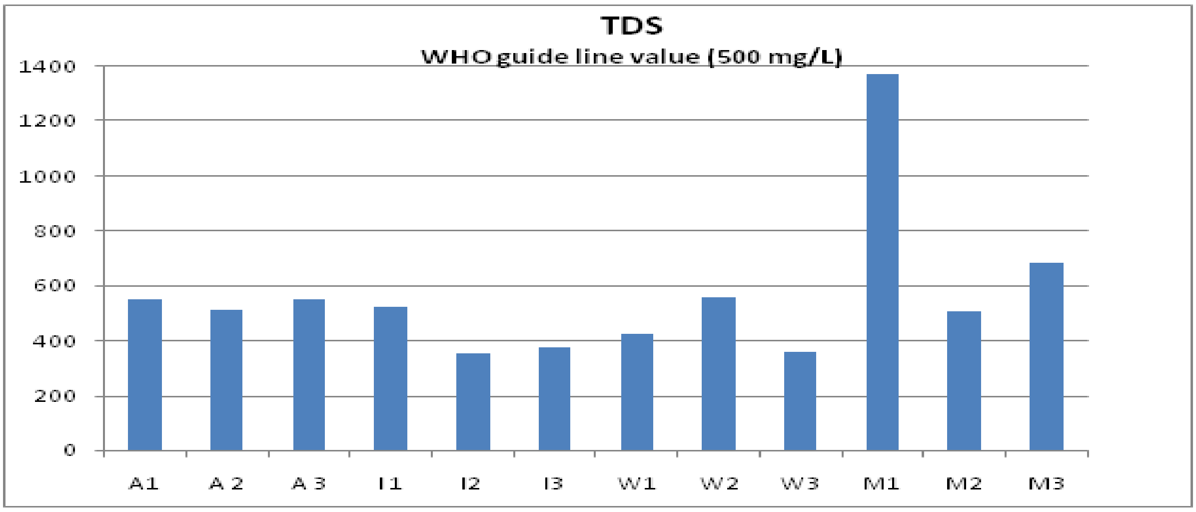

Fig. 4. Shows all the values of TDS.

TDS higher than 1000 mg/l impart taste to the water, therefore, a desirable value of 1000 mg/L is proposed by WHO. Furthermore, a value higher than 1000 mg/L results in excessive scales in water pipes, heaters, boilers and household appliances (WHO, 2004; Hydar, 2009).

The EPA recommends that water containing more than 500 mg/l of dissolved solids not be used if other less mineralized supplies are available.

However, water containing more than 500 mg/l of TDS is not dangerous to drink. Exclusive of most treated public water supplies, the Missouri River, a few freshwater lakes and scattered wells, very few water supplies in North Dakota contain less than the recommended 500mg/l concentration of total dissolved solids.

Many households in the States use drinking water supplies with concentrations of 2,000 mg/l and greater. Treatment for household use is reverse osmosis (Johnson and Scherer, 2012).

The minimum value of TDS of our sample is 344 mg/L and the highest values of 1370 mg/l2. Most of our sample values were between 400 and 500 except in the Ground water sample of A1 whose TDS Value were higher than 1200.Since the desirable values proposed by WHO is 1000 mg/l so the values are below the upper limit of TDS. The TDS values higher than 1000 changes the taste of water.

Conductivity

Conductivity of a substance is defined as 'the ability or power to conduct or transmit heat, electricity, or sound'. Its units are Siemens per meter [S/m] in SI and milliohms per centimeter [mm ohms/cm] in U.S. customary units its symbol is k or s.

Water conductivity

Conductivity is a measure of the conductance of an electric current in water. This is an easy measurement to make and relates closely to the total dissolved solids (mineral) content of water. The maximum contaminant level (MCL) is 0.4 to 0.85 micro Siemens per centimeter. Treatment with reverse osmosis is effective for drinking water purposes (Johnson and Scherer, 2012). It indicates the presence of dissolve solid in water, but does not provide information about a specific chemical. Its might indicate a water quality problem that requires further investigation.

Conductivity is a proxy indicator of total dissolved solids, and therefore an indicator of the taste or salinity of the water. Although this parameter does not provide information about specific chemicals in water, it acts as a good indicator of water-quality problems, particularly when it changes with time. There is little direct health risk associated with this parameter, but high values are associated with poor taste, customer dissatisfaction and complaints (Howard et al., 2003; WHO, 2004).

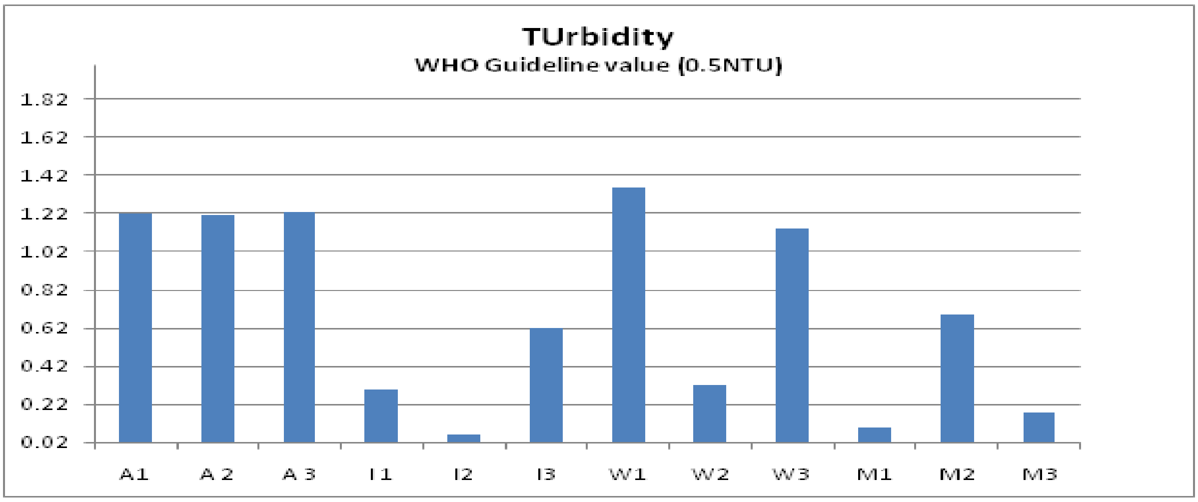

Fig. 5. Shows the values of various samples.

Pure water is not a good conductor of electricity. Ordinary distilled water in equilibrium with carbon dioxide of the air has a conductivity of about 10 x 10^{-6} $W^{-1}*m^{-1}$ (20 dS/m). Because the electrical current is transported by the ions in solution, the conductivity increases as the concentration of ions increases. Thus conductivity increases as water dissolved ionic species. (In many cases, conductivity is linked directly to the total dissolved solids (T.D.S.). High quality deionized water has a conductivity of about 5.5 μS/m, typical drinking water in the range of 5-50 mS/m, while sea water about 5 S/m (i.e., sea water's conductivity is one million times higher than that of deionized water). (http://en.wikipedia.org/wiki/Conductivity_(electrolytic))The minimum value of our sample conductivity was 686 μS/m and the highest values were2.74S/m.The conductivity of water is mainly controlled by the TDS in the water. No guide line is given by WHO about this parameter.

Turbidity

Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates. The more total suspended solids in the water, the murkier it seems and the higher the turbidity. Turbidity is considered as a good measure of the quality of water, measure of suspended minerals, bacteria, plankton, and dissolved organic and inorganic substances. Turbidity often is associated with surface water sources. Treatment includes mixing with a substance such as alum that causes coagulation of the suspended materials, which then can be removed by sand filter filtration (Roxanne Johnson and Tom Scherer, 2012). Turbidity in drinking-water is caused by particulate matter that may be present from source water as a consequence of inadequate filtration or from resuspension of sediment in the distribution system. It may also be due to the presence of inorganic particulate matter in some ground waters or sloughing of biofilm within the distribution system. The appearance of water with a turbidity of less than 5 NTU is usually acceptable to consumers, although this may vary with local circumstances. Particulates can protect microorganisms from the effects of disinfection and can stimulate bacterial growth. In all cases where water is disinfected, the turbidity must be low so that disinfection can be effective.

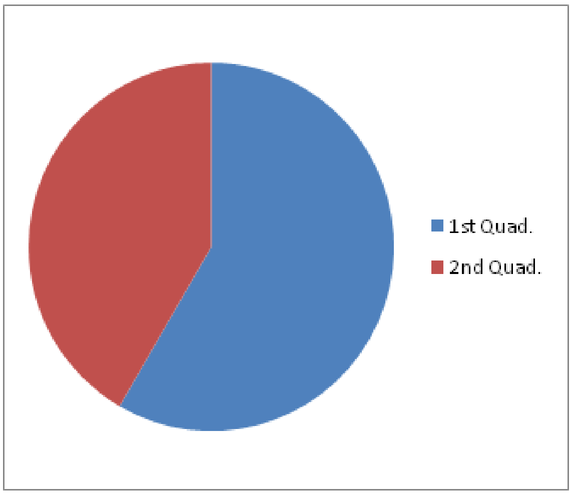

Fig. 6. Red Colour shows contamination while blue is uncontaminated.

Turbidity is also an important operational parameter in process control and can indicate problems with treatment processes, particularly coagulation/sedimentation and filtration. No health-based guideline value for turbidity has been proposed; ideally, however, median turbidity should be below 0.1 NTU for effective disinfection, and changes in turbidity are an important process control parameter (WHO, 2006). Turbidity is also measured to determine what type and level of treatment are needed. (WHO, 2004).

Minimum value of turbidity in our samples was 0.06 NTU and the highest values of 1.36NTU. The WHO standards for the turbidity values are 0.5 NTU nevertheless a value of 0.5 NTU is recommended for effective disinfection. In the bar diagram some values are well below the WHO standard and in some cases higher than WHO value.

Microbial Activity

A large portion of the population in developing countries suffers from health problems associated with either lack of drinking water or due to the presence of microbiological contamination in water (Hydar, 2009). Pakistan Council for Research in Water Resources (PCRWR) conducted a national water quality study in 2001. During first phase of this programme, covering 21 cities, 100% samples from 4 cities and 50% samples from 17 cities indicated bacteriological contamination. A second study conducted by PCRWR in 2004 found no significant improvement and almost 95% of the shallow ground supplies in Sindh had bacteriological contamination. The links between water quality and health risks are well established and proved. An estimated 250,000 child deaths occur each year in Pakistan due to waterborne diseases (WATER AID, 2010).

The great majority of evident water-related health problems are the result of microbial (bacteriological, viral, protozoan or other biological) contamination (WHO, 2006). It has been recognize that microbial parameters can provide useful information throughout the drinking water production processes including catchment survey, source water characterization, treatment efficiency and examination of disturbed system (Payment; White and Dufour).

The ground water is relatively free from microbes than surface water in most cases contamination results either from improper well construction or poor waste disposal facilities (American Water Works Association, 1971). The greatest microbial risks are associated with ingestion of water that is contaminated with human or animal (including bird) faeces. Faeces can be a source of pathogenic bacteria, viruses, protozoa and helminths. Faecally derived pathogens are the principal concerns in setting health-based targets for microbial safety. Microbial water quality often varies rapidly and over a wide range. Short-term peaks in pathogen concentration may increase disease risks considerably and may trigger outbreaks of waterborne disease (WHO, 2006).

Out of 12 samples the microbiological contamination found in 5 samples (A1, A3, I1, W2 &W3). This means that 41.66% contain microorganisms. Water of these areas samples is dangerous for health.

Pie diagram shows 1st Quadrant 58.33% uncontaminated while 2nd Quad. Shows 41.66% is contaminated.

Fig. 7. Shows drinking water pipes association with sewage line (Block 6).

It is estimated that, in Pakistan, 30% of all diseases and 40% of all deaths are due to poor water quality (GWP, 2000). Diarrhea, water borne disease is reported as the leading cause of death in infants and children in the country while every fifth citizen suffers from illness and disease caused by the polluted water. Possible causes of contamination were leaking water mains and cross connections between water mains and sewers due to close proximity.

Arsenic

Arsenic is a semi metalic element that is odorless and tasteless. It enters drinking water supplies from natural deposits in the earth, or from agricultural and industrial practices. According to the EPA, long-term exposure to arsenic in drinking water is linked to cancer of the bladder, lungs, skin, kidneys, nasal passages, liver and prostate. Noncancerous effects of ingesting arsenic include cardiovascular, pulmonary, immunological, neurological and endocrinal (for example, diabetes) problems. Treatment depends on the level of contamination. Typical recommendations include the addition of an anion filter or tank media (Roxanne Johnson & Tom Scherer, 2012).

Arsenic is widely distributed throughout the Earth's crust, most often as arsenic sulfide or as metal arsenates and arsenides. Arsenicals are used commercially and industrially, primarily as alloying agents in the manufacture of transistors, lasers and semiconductors. Arsenic is introduced into drinking-water sources primarily through the dissolution of naturally occurring minerals and ores. Except for individuals who are occupationally exposed to arsenic, the most important route of exposure is through the oral intake of food and beverages.

There are a number of regions where arsenic may be present in drinking-water sources, particularly groundwater, at elevated concentrations. Arsenic in drinking-water is a significant cause of health effects in some areas, and Arsenic is considered to be a high-priority substance for screening in drinking-water sources. Concentrations are often highly dependent on the depth to which the well is sunk (WHO, 2006).

Most Arsenic in water is naturally occurring and derives from the dissolution of Arsenic-bearing minerals associated with volcanic activity, but it may also originate from anthropogenic sources, such as mining and other industrial activities. Arsenic accumulates in humans (and is amplified in the food chain) and is associated with skin disease and cancers. Drinking from a water source contaminated by low arsenic concentrations (<50 µg/l) over many years can result in toxic concentrations in humans, and carcinogenic effects may develop in some individuals. Arsenic became one of the principal water-quality issues in the late 1990s because of the rising levels of Arsenic in ground waters in Bangladesh and neighbouring countries (RADWQ, 2004-2005).

Fig. 8. Open Sewage tanks may be one of the major causes of contamination.

In Pakistan contamination of ground water by Arsenic is also becoming a serious problem. In Sindh (Dadu, Khairpur) & Punjab (Multan, Shiekhupura, Lahore, Kasur, Gujranwala & Bahawalpur), approximately 36% of the population is exposed to a level of contamination higher than 10ppb and 16% is exposed to contamination of 50 ppb. In Sindh & Punjab 36% of the population is exposed to Arsenic contamination higher than 10ppb & up to 50 ppb (Water AID, 2010). The 1958 WHO International Standards for Drinking-water recommended a maximum allowable concentration of 0.2 mg/litre for arsenic, based on health concerns. In the 1963 International Standards, this value was lowered to 0.05 mg/litre, which was retained as a tentative upper concentration limit in the 1971 International Standards. The guideline value of 0.05 mg/litre was also retained in the first edition of the *Guidelines for Drinking-water Quality*, published in 1984. A provisional guideline value for arsenic was set at the practical quantification limit of 0.01 mg/litre in the 1993 Guidelines, based on concern regarding its carcinogenicity in humans (WHO, 2006).

Possible Reasons for the contamination in drinking water

The possible water contaminations may be from

1. Sewage water
2. Industrial wastes
3. Rocking containg injurious elements

In our observation area we found many sewage line associated with the drinking water pipes which may be the major cause of contamination.

In concern area no industries were observed so there is less possibility of industrial contamination automobile workshops may contribute to contamination to some extent. Rock containing injurious elements may be present in the source area from where water is supplied.

Common diseases in the area

Although no diseases are reported but few common and dangerous waterborne diseases in concern area may be:

(ARI) Acute Respiratory Infection,
Cholera,
Malaria,
Typhoid fever,
Gastroenteritis,
Bacterial diarrhea,
Dysentery.

According to a study conducted by the United Nations, 62% of Pakistan's urban and 84% of Pakistan's rural population does not treat their water properly and hence it results in more than 100 million cases of diarrhea being registered within the hospitals of Pakistan.

This further leads to around 40% deaths within the country as a result of contaminated water consumption. Unsafe drinking water can lead to several diseases such as diarrhea, typhoid, intestinal worms and hepatitis and an estimated number of 250,000 deaths occur within the country as a result of water-borne diseases.

Recommendations

Little attention is being paid to drinking-water quality issues and quantity remains the priority focus of water supply agencies. There is a lack of drinking-water quality monitoring and surveillance programs in the country. Weak institutional arrangements, lack of well-equipped laboratories and the absence of a legal framework for drinking-water quality issues have aggravated the situation. Above all, the public awareness of the issue of water quality is dismally low.

Irregular water supply is common in urban areas and outbreaks of gastroenteritis and other water born diseases have become a normal feature.

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