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ASSESSMENT OF DRINKINGWATER QUALITY IN RELATION TO SANITAION IN HARIPUR CITY PAKISTAN

IDREES KHAN[1], ABDULLAH KHAN[1], WISAL SHAH[1], MUHAMMAD ZIAD[1] AND MUHAMMAD RIZWAN[1]

[1]*Department of Environmental Sciences, University of Haripur, Pakistan*

Abstract: The present research work was conducted for the purpose to assess drinking water quality in relation to sanitation system in Haripur city. Drinking water samples were collected at consumer end from 31 various locations for physico-chemical and biological analysis. Major Chemical parameters like were pH, Electric Conductivity (EC), Total Dissolved Solids (TDS),Total Suspended solids (TSS), Total Solids (TS), alkalinity, phosphate (PO_4^{-3}), nitrate (NO_3^-), sulphate (SO_4^{-2}), chloride (Cl^-), total hardness, calcium hardness (Ca^{+2}), magnesium hardness (Mg^{+2}), sodium (Na^+)and potassium (K^+) were analyzed. Results of the study showed that all the parameters were inpermissible limits except pH (8.7) and total suspended solid (TSS) (29.7). Both pH and total suspended solid (TSS) were found exceeding the recommended level addressed by WHO and Pakistan water quality standards. On other hand, biological contamination was found to be in the form of total coli form and *E.coli*that makes the water of the study area unsuitable for drinking and is causing major health implications such as diarrhea, dysentery, cholera, hepatitis etc.

Keywords: water sanitation system, drinking water, total coliform, water quality standards.

Introduction

Clean water is an integral part of all living systems. Industrialization, urbanization and improper environmental planning are responsible not only for shortage of fresh water but also for its contamination with unwanted chemicals. Due to human activity 80 % waste water directly discharge in to rivers without removal of various contaminants. On earth surface adequate fresh water are present but due to dreadful and improper infrastructure millions of people; especially children die from water borne diseases due to unsafe water and poor sanitation. Diarrhea, one of the water born disease is causing the death of 1000 children every year globally.

Safe drinking water is a fundamental requirement for good health. Fresh water is now a constraining asset in numerous parts of the world that is expected to grow further due to expanded population, urbanization and environmental changes (Jakson et al 2001). By 2050 at least 25% of world population will face habitual shortage of fresh water and 1.8 billion will be drinking microbial contaminated water.

Pakistan is ranked among water scarce country with about 1,200 m^3 per capita of water demand. About 30% diseases and 40% deaths are caused due to degrading water quality in Pakistan. A study was conducted by Pakistan Council of Research in Water Resources (PCRWR) regarding drinking water of various cities of Pakistan (Soomro et al 2011). Most of the water samples were found unsuitable for drinking. High arsenic concentration was found in the water of some industrial cities in Punjab.

Materials and Methods

Study area description

Haripur is situated in Hazara region of Khyber Pakhtunkhwa. Population of the city is 56981, latitude 34N, Longitude 73E and altitude 516 m (DCR 1998).

Sample collection

Drinking water samples were randomly collected from different points in the study area for physical, chemical and biological analysis. Polyethylene bottles were washed with detergent and then with distilled water. Water taps were left open for some time to allow water flow. Bottles were rinsed with waterand then were filled with water and sealed. Every essential precaution was observed during sample collection, transport and storage.

Physicochemical Analysis
pH

The pH of the water samples was measured with a pH meter (model PHS-3C). The pH meter was washedand calibrated according to the protocol of American Public health Association. The pH meter was washed with distilled water after measuring the pH of each sample.

Electrical Conductivity (EC)

The electrical conductivity of samples was measured withconductivity meter DDS-11AW microprocessor.

Total Dissolved Solids (TDS)

About 100 ml fine assorted water sample was filtered through filter paper in a beaker, the remaining water was evaporated for determination of total dissolved solid and weighted china dish before and after filtration.

Total Suspended Solids (TSS)

About 100 ml sample was filtered through filter paper. The filter paper was weighted before and after filtrate on electronic digital balance to find the weight of filter paper.

Total Hardness

About 100 ml of water was taken in conical flasks. The buffer solution was added and few drops of Erio chrome black T were added. After that samples were titrated against standard (0.01M) EDTA. The colorof the solution was changed from blue to wine red to blue. EDTA volume used in the procedure was noted.

Calcium hardness (Ca^{+2})

About 100 ml water sample was taken in pointed flasks. In order to increase the pH to 12-13, 1ml of NaOH was added to the sample. After that sample was titrated with EDTA and colour was changed from purple to pink.

Magnesium Hardness (Mg^{+2})

About 100 ml water sample was taken in separately pointed flasks. 1ml of NaOH was added in order to increase the pH to 12- 13. After that sample was titrated with EDTA and colour was changed fromwine-red to a clear blue. Use these results to determine the molar concentration of the EDTA solution for use in the titration of Mg^{+2}.

Alkalinity

About 100 ml water sample was taken in the conical flask then phenolphthalein drops were added as an indicator to check the alkalinity. P-alkalinity was absent in all samples. Methyl Orange indicator was used for bicarbonate alkalinity. $H_2SO_4$was used for titration until the yellow color changed to orange.

Chloride (Cl^-)

About 100 ml fine assorted sample was taken in a beaker, potassium dichromate indicator was added. Then titrated against $AgNO_3$. Black red color appeared. The concentration of $AgNO_3$was noted from the burette.

Sodium (Na^+)

Flame photometer (FP 64-china) was used for the measurement of sodium. Flame photometer was standardized with a known concentration of sodium. The instrument was calibrated before the sample analysis. After calibration samples were analyzed.

Sulfates (SO_4^{-2})

In order to find out the level of sulfates, 20 ml water sample was taken and standards from 100, 50, 10, and 5 ppm as well as with the blank solutions were prepared. Then 5 ml $BaCl_2$was added in each sample and standards were run one by one to produce the turbidity. The spectrophotometer (Model E 721) was used to observe the absorbance values at 420nm. The concentration of sulfate was determined from the graph of different standard values (APHA. 1995)

Nitrates (NO_3^-)

Nitrate was analyzed with the help of spectrophotometer. Different standards of nitrate solutions were prepared and then a graph was plotted. The sample to be analyzed for NO_3 was placed in a cuvette and a control sample of distilled water was placed in another cuvette. Both the cuvettes were placed in spectrophotometer then absorbance was noted at 220nm (AWWA. 1992).

Microbial Analysis
Total bacterial count

Total bacterial count was determined by using MPN numerous tube techniques through which all the live organisms were grown and different colonies appeared. 1 ml of microbial suspension was added in 9 ml sterilized distilled water to get 10 fold serial diluted suspension of which 0.1 ml suspension was poured on the surface of nutrient agar Petri plates using micro pipette. Petri plates were incubated at 37^{o}C for 24 to 48 hrs. After incubation, the colonies were observed and counted using magnifying glass.

Gram Staining

The most common and important staining method used for bacterial identification is gram staining. Gram stain divided bacteria into two groups i.e. gram positive and gram negative, which is based on bacterial cell wall chemical composition.
One drop of distilled water was dropped on a slide and a colony from the culture was added to that drop, colony was mixed with the drop of distilled water with the help of inoculating loop. After mixing the culture it was dried and heat fixed. Then crystal violet was poured for 1min on the smear and it was washed with tap water. It was then treated with Gram's iodine was used as a mordant and slid was left for 1-5 mints after that alcohol was poured on the

slide which act as a decolorized. The drop In the end, safranin was added for 45 seconds and finally washed. The slide was dried and examined under oil immersion on a microscope.

Biochemical Tests
Catalase Test

This test is used for the identification of microorganisms that produce the enzyme, catalase. This enzyme converts hydrogen peroxide into water and oxygen gas. The bubbles resulting from production of oxygen gas indicate a catalase positive result. The *Staphylococcus* spp. and the *Micrococcus* spp. are catalase positive while *Streptococcus* and *Enterococcus* spp. are catalase negative.

Citrate Test

Simmons citrate agar is used for citrate test. This test is used to differentiate a bacterium for its ability to utilize citrate as a carbon and energy source. In case of a positive citrate test there is generation of alkaline by-products of citrate metabolism. The subsequent increase in the pH of the medium is demonstrated by the color change of the medium. If the color of the medium turns blue, it means the organism is citrate positive. If there is no change in color, then the organism is citrate negative.

Indole Test

Indole test is used to determine the ability of an organism to degrade amino acid tryptophan to compound indole. Try pto phanase enzyme hydrolyses tryptophan to produce three possible end products; indole is one of these three products. For the detection of indole production Kovac's or Ehrlich's reagent is used which contains 4 (p)-diethyl amino benzalde hyde, this reacts with indole to produce a red colored compound.
Tryptophan broth was taken in tubes and inoculated with the bacterial colony. Then incubated it at 37°C for 48 hours. After 48 hrs about 1mlof Kovács reagent was added in every tube. In case of positive test pink colored rink after addition of appropriate reagent appeared while during negative indole test there is no color change even after the addition of appropriate reagent e.g. in case of *Klebsiellapneumoniae*.

Results and Discussions

Both quantitative and qualitative approaches were used for data analysis. Microsoft excels and SPSS 20 was used for statistical analysis.

Physicochemical Analysis
Water pH

Table 1 summarizes the values of pH for various water samples of study area. The values ranged from 7.1- 8.7 with an average value of 7.9. The highest pH value was observed for Mochibazaar (8.7), while lowest for Kala Khan Hotel (7). It was observed that sanitation pipes of some the study areas were leaked like Mochi Bazaar, Shairanwala Gate, Mohallah Feroz Pora and Circular Road. The pH values of Mochi bazaar, Kala Khan Hotel were exceeded their respective acceptable limits set by WHO and Pakistan Water Quality Standard for drinking water. Irritations of skin, eyes, mucus membrane gastrointestinal and swelling of hair fiber are some of the diseases caused by higher values of pH of drinking water.

Electric conductivity (EC)

The highest value of EC (902 µS/cm) was recorded for water sample of Zafar Park while lowest was (492 µS/cm) for Sainsahali Road (Table1). The EC values showed variation for different sampling sites of study area. High EC value might be due to the geological composition of soil and its hardness. Ullah et al., (2009) and Venkates warlu et al. (2011) reported high values of EC for ground water samples of Sialkot city due to mixing of industrial effluents with drinking water sources which are in line with findings of present study.

Total Hardness

The mean value of hardness in drinking water of Haripur was 299 mg/L (Table 1). The highest value of total hardness (361mg/L) was observed for the drinking water sample taken from Asif Abad and lowest (210 mg/L) was for Mohallah Koh. The values of total hardness of different location of study areas showed variation. Furthermore the values of total hardness were within acceptable limits set by WHO/Pakistan. The results of study are inconsistence with the findings of Khan et al (2012).

Calcium hardness (Ca^{+2})

Calcium is the fifth earth crust abundant element. It not only made the skeleton, tooth, and elastic tissues of animals and human but also plays vital role in human metabolism (Soomro et al 2011. Absorption of Ca^{+2} in water samples of Haripur city ranged from 103 – 222 mg/ L with an average absorption of161 mg/L. The maximum value of Ca^{+2} (222 mg/l) was reported drinking water of Zafar park and lowest (103 mg/l) found in Govt High School NO2. Ca^{+2}concentration was exceeding permissible limit set by WHO/Pakistan stander of water quality (200mg/l) in Zafar park. (Ullah et al., 2009. And et al. 2011.) Reported the high concentration of Ca^{+2} in ground water samples of various locations of Peshawar.

Magnesium (Mg^{+2})

The values of magnesium concentration ranged from 90- 189 mg/L in various sampling points in Haripur city with an average concentration of 137mg/L. The maximum concentration was 189 mg/l found in Darvish and the minimum was 91mg/l found in Chapar Road. The values of magnesium concentration exceeded their respective permissible limits of WHO/ Pakistan water quality standards. Study conducted by Bacha et al. (2010) in Peshawar shows similar results·Khan et al. (2012) found low magnesium concentration in Kohat.

Sulfates (SO_4^{-2})

Absorption of SO_4^{-2} in drinking water samples of Haripur city was ranged from 41.73 – 67 mg/L. The concentration of SO_4^{-2} showed variation sample-to-sample. The highest value was founded in Mohallah Tanki while lowest in Sikandarpur. All values of sulfate found permissible limit recommended by WHO in study area. Present study is in accordance with, in which maximum concentrations of SO_4^{-2} and some other minerals were observed in Faisalabad, Sialkot and Nawab Shah Sind Pakistan (Farid et al., 2012, Venkateswarlu et al., 2011 and Ullah et al., 2009.

Phosphate (PO_4^{-3})

The concentration of phosphate was ranged from 28.8 to 69.3 mg/l. The highest concentration of $PO_4^{-3}$was (69.3mg/l) found in drinking Makan Colony and minimum

concentration of $PO_4^{-3}$was (28.8mg/l) found in MohallahTank.

Nitrates (NO_3^-)

The Nitrates concentration in the study area was ranged from 2.8 – 6 mg/l. Average concentration was 4.3 mg/l. The highest value of nitrates was 6mg/l found in water sample taken from Sabzi Mondi and lowest concentration of nitrates was 2.8 mg/l in sample from Mohallah Resaldaran. High concentration of NO_3 in drinking water may be due to the development of nitrosamines which are carcinogenic as well.

Total Alkalinity

The numerical values of total alkalinity in water samples of Haripur city were ranged between 81.5-132.3mg/L with an average value of 105.6 mg/L. Furthermore, the highest value was 132mg/l noted in sample taken from Makan Colony and the lowest value was 81.5mg/l found in Mohallah Tanki. The values of total alkalinity in all studied samples lies within the permissible limite of total alkalinity set by WHO. Studies conducted by (Mohsi et al. (2013), Simpi et al (2011) are supporting the findings of the present study.

Total dissolved solid (TDS)

Total dissolved solid in water samples of the study area ranged from 285.5 to 451.5 mg/L. The average value was 378 mg/l. Maximum concentration of TDS was 41.5mg/l found in the sample taken from Afzal Abad and the minimum value was 285mg/l found in sample FEF College. All the values of TDS were within the permissible limit as recommended by WHO and Pakistan standards.

The results of the present study were supported by Khan et al. (2013), and Jamal and Jamroz, (2006) in Swat, Majidano et al. (2009) reported the higher concentration of TDS in drinking water of Nawab shah Sind.

Total Suspended Solid (TSS)

The concentration of total suspended solid in drinking water of Haripur City ranged between 9.7 and 29.6 mg/L. The lowest value of TSS was 9.7mg/l found in Fort road while highest was 29.7mg/l found in Asif Abad. The average range of TSS was 21.2 mg/l. TSS value of drinking water of the study area exceeded the permissible limit from WHO and Pakistan water quality standards. The presences of total suspended solid in drinking water is due to the presence of Ca, Mg, Na, carbonates, bicarbonates, chlorides, phosphates and nitrates.

Total solid (TS)

Total solid is the combination of all suspended and dissolved solid in drinking water. The value of total solid was ranging from 304.8 -481.2 mg/l. The average value was 399.2 mg/l. The highest value was 481mg/l observed in the sample Asif Abad and the lowest value was observed 304mg/l in the sample FEF Collage.

Chloride (Cl^-)

Concentartion of chloride was in th range of 9.7 to 18.3 mg/l. The average value was 13.9 mg/l. The maximum concentration of cholride was 18.3 mg/l found in Sabzi Mondi and the minimum concentration was 9.7mg/l found in Asif Abad. Concentration of chloride was within the permissible limit (250mg/L) set by WHO for chloride.

Potassium (K^+)

The cocentration of potassium were found in the range of 1.9 to 5.6 mg/l. The maximum concentration of potassium was 5.6mg/l found in sample Asif Abad and lowest was 1.9mg/l found in sample Sainsahali Road. Average concentration of potassium was 3.6mg/l. The results were supported by Khan et al (2012). The concentration of potassium was with in the permisible limit i.e.12mg/l, according to WHO and Pakistan NEQs.

Sodium (Na^+)

The concentration of sodium in the study area ranged from 12.7-37.8 mg/L. These values were in the permissible limit as recommended by WHO. The average value was 21.9 mg/L (Table 1). The highest and lowest concentration was (37.8m/l, 12.7mg/l) detected in drinking water samples taken from Rangeela Roa, and Dheenda. Azizullah et al (2011) reported that ground water and lakes had a higher concentration of sodum as compared to the running water. Petients of cardic, hypertension and kidney have very low tolearnace to sodium (Bacha et al 2010).

Table 1 Physio-chemical Characteristics of Drinking water Smples of Haripur

Samples	Total Aerobic count Average (standard deviation)	Serial dilution 0.1 ml	Serial dilution 0.01 ml	Serial dilution 0.001 ml	MPN/ml of Sample
Makan Colony	42.5 ± 5.7	3	3	1	500
Chapar Road	60 ± 8.1	3	3	2	1100
Sheranwala Gate	59 ± 7.3	3	3	1	500
Mochi Bazar	55.5 ± 7.7	3	2	3	290
Dheenda	90 ±18	3	3	2	1100
Sainsahali road	90 ± 2.4	3	2	3	290
Bashar colony	60 ± 13.3	3	3	2	1100
MohallahTanki	70 ±4	3	2	2	210
Fruit Mondi	92.5 ± 7.7	3	3	1	500
Rangeela road	8.5 ± 3.6	3	3	1	500
Malkyar	70.5 ±16.7	3	2	3	290
Sikandarpur	77.5 ± 8.5	3	3	1	500
MohallahKoh	83.5 ±8.5	3	1	3	160
Asif Abad	88.5 ± 4.5	3	3	2	1100
Afzal Abad	55 ± 6.5	3	1	3	160
Darvish	49 ±15.5	3	2	3	290
Sabzi Mondi	102 ±11	3	3	2	1100
Shah Baba Masjid	55 ±12.2	3	2	1	150
Zafar park	45 ± 6.5	3	2	2	210
Police choki	70 ± 8.1	3	1	3	160
Sir sayed school	61 ± 7.3	3	1	1	70

Fort road	57.5 ± 4.5	3	3	2	1100
Tehsil Road	67.5 ± 2.0	3	2	2	210
Kala Khan Hotel	48 ± 6.5	3	2	3	290
MohallahMotian	52.5 ± 26.6	3	2	2	210
FEF Collage	80 ± 5.7	3	3	1	500
MohallahResaldarian	77.5 ± 2.0	3	3	2	1100
Loharan Bazar	59 ± 0.8	3	2	3	290
DarbandAddah	71.5 ± 13.5	3	2	2	210
Govt High School 2	79 ± 7.3	3	3	2	1100
BaboMuhallah	59 ± 4.9	3	2	2	210

Total coliform

Total coliform was detected in all tap water samples. Average value of total coliform was 500 CFU. The highest values of Total coliform were (1100 CFU) detected in tap water samples from Chaper Road, Deenda, Bashar Colony, Asif Abad, Sabzi Mandi, Fort Road, Mohallah Resaldaran, and government high school No 2 while the lowest total coliform was (70 CFU) detected in sample taken from Sir Sayed Public School.

Based on findings of study some of the major reasons responsible for bacterial contamination of drinking water were: (i) Damage of drinking water supply lines and sanitation channels which results in mixing of drinking water and sanitation water. (ii) Septic tanks, toilets were generally used for black water storage. (iii) Mixing of rain water with drinking water stored in underground tanks. 12 found during their research conducted in Rawalpindi that leaked pipe, poor hygiene are main responsible factors of waterborne diseases. Similarly, 21 Klebsiella in all drinking water samples taken from Karachi while, Pseudomonas, E. coli, and Staphylococcus aurous in few of the samples.

Conclusion

It can be concluded after examination of the drinking water quality that all the chemical parameters were within permissible limits except pH (8.7) and total suspended solid (TSS) (29.7). Both pH and total suspended solid (TSS) were exceeding the WHO and Pakistan water quality standards. All the water samples were contaminated with total coliform and *E.coli.* The present study shows the unsuitability of collected water for drinking purpose.

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