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Physical and Bacteriological Characteristics of Drinking Water of Peshawar

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Abstract: Ninety drinking water samples of fifteen each from three urban and three rural areas of Peshawar were collected and analyzed for their pH, Electrical Conductivity (EC), turbidity, coliform and *E. coli* were determined for bacteriological assessment and its quality. In the urban area were Hayatabad, City and Sadder while from rural area Shikhmohamadi, Palosi and Jagra. Coliform and *E. coli* were by Most Probable Number (MPN) and Ejakman method respectively. pH, EC and turbidity mean value were 7.44±0.16, 0.64±0.08 μscm^{-1}, 0.88±0.77 FTU respectively. Total Coliform ranged from 0.00-150.00 with mean value of 37.79, while *E. coli* was present (+ve) in 26% sample and absent (-ve) in 74% drinking water sample. All the physical parameters were in the safe limit recommended by WHO. Hence considered unfit for drinking purpose and it was concluded that the water from Peshawar region should be checked and monitored regularly in order to omit all possible sources of contamination or to reduce it.

Key words: Drinking water, pH, electrical conductivity, turbidity, coliform

INTRODUCTION

Water is clear, colorless, odorless and tasteless liquid, essential for most plant and animal life and the most widely used of all solvents. Freezing point 0°C (32°F); boiling point 100°C (212°F); specific gravity (4°C) 1.0000; weight per gallon (15°C) 8.338 pounds (3.782 kilograms).

Water is second to oxygen as being essential for life. People can survive days, weeks, or even longer without food, but only about four days without water. The average adult consumes and excretes about 2.5-3 quarts of water a day. Some of this water is supplied through foods but most is consumed through beverages. It is generally recommended that adults consume 6-8 cups (48-64 ounces) of liquids daily.

Water makes up about 60% of the human body Most of the living tissue of a human being is made up of water; it constitutes about 92% of blood plasma, about 80% of muscle tissue, about 60% of red blood cells and over half of most other tissues. It is also an important component of the tissues of most other living things (Turgut *et al*., 2005).

It covers some 70% of the earth's surface, with only 3% being from fresh water sources. With the world population growing and the increasing pollution of our natural resources, we are facing a water crisis. The World Health Organization has estimated that over 1 billion people lack access to safe drinking water and about 4000 children die every day from water borne disease (Virkutyte and Sillanpa, 2006).

As world population grows, drinking water is becoming increasingly scarce. Even in countries with sufficient supplies, this resource is often contaminated, especially in the world's threshold and developing nations. There are 1.2 billion people who do not have enough drinking water and 2.4 billion who are not connected to a sewage system.

Polluted water has direct effect on human health while sewerage and industrial effluents, have indirect effect through consumption of foodstuffs being irrigated with such type of discharge. According to World Health Organization more than 80% human diseases are water born. In developing countries 80% of the population has not easy excess to pure drinking water and more than 5 million human being die with and early death annually as a result of illness linked to unsafe drinking water unclean domestic environments and improper excreta disposed. Water pollutants mainly consist of heavy metals, microorganism, fertilizer and thousand of toxic organic compounds (WHO, 1999). Heavy metals consist of Cd, Cr, Cu, Pb, Ni, Fe, Mn, Hg, Zn, Al, Se as well as metals of group III and IV, which have toxic effect on human physiology. Along with the heavy metals the next most important pollutants are microorganisms. Surface and ground water contains bacteria, protozoa and other synthetic microorganisms. These affect water quality by assimilating NO_3, CO_2 and also solubilize some heavy metals in water. These also produce toxicants in ground water. They cause many epidemic diseases in human (Khan *et al*., 2000).

More than 2.6 billion people-forty percent of the world's population-lack basic sanitation facilities and over one billion people still use unsafe drinking water sources. As a result, thousands of children die every day from diarrhoea and other water-, sanitation- and hygiene-related diseases and many more suffer and are weakened by illness.

The World Health Organization estimates that 500 million diarrhea cases reportedly take place each year in children less than five years in Asia, Africa and Latin

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America. The extent of enteric diseases in different areas depends upon the extent to which water is exposed to contamination. The incidence of typhoid fever, bacillary dysentery, infectious hepatitis and other enteric infections are common and are transmitted through contaminated water. Cholera is still a wide spread water borne disease in some developing countries. There are numerous other diseases that are transmitted through polluted water. It has been shown that cancer may be caused by the accumulation of certain materials carried out by water to human organs (Afia *et al*., 2006).

The excess of cadmium accumulated in the kidney causes hypertension as is evident from study conducted on animals. The deficiency of chromium in drinking water favour atherosclerotic diseases in human. The compounds of chlorobenzenes and chlorophyll's may affect taste and odor of water.

Pakistan's current population of 141 million is expected to grow to about 221 million by the year 2025. This increase in population will have direct impact on the water sector for meeting the domestic, industrial and agricultural needs. Pakistan has now essentially exhausted its available water resources and is on the verge of becoming a water deficit country. The per capita water availability has dropped from 5,600-1,000 m^3. The quality of groundwater and surface-water is low and is further deteriorating because of unchecked disposal of untreated municipal and industrial waste water and excessive use of fertilizers and insecticides. Water quality monitoring and information management is lacking, even though it's crucial to any water quality improvement program (Shakirullah *et al*., 2005).

It is estimated that by 2025 world water consumption will rise by 40%. This is why investments are urgently needed in the entire water infrastructure around the world, especially in mega cities. An additional main user of water is industry, whose plants can only be kept running with the aid of a wide range of process waters (Sidhu and Warner, 2003).

The purpose of present study to observed the physical and bacteriological characteristics of Peshawar.

The objective of the study was:

- Examine the physiochemical characteristics such as pH, conductivity and turbidity of drinking water
- Assess bacteriological quality of drinking water by Coliform and *E. coli* count

MATERIALS AND METHODS

The water samples were tested for physical and bacteriological analysis. Drinking water samples from different areas of Peshawar were tested for pH, EC, turbidity and pathogens in order to evaluate its quality. Urban and Rural areas of Peshawar were selected randomly. Urban area constitutes Hayyatabad, Sadder and City and while rural constitutes Sheikh Mohammadi, Jagra and Palosi.

From each location 15 water samples were collected in one liter capacity plastic bottles for physical analysis and in 100 ml sterilized glass bottles for bacteriological analysis. Before sampling the bottles were washed with detergents, followed by tape water and finally several time with distilled water. The water at the samples site was allowed to flow for some time then the bottles were rinsed two to three times by this water and one liter was taken as sample from drinking water. The samples were properly tagged indicating code. These samples were air tightened and stored in refrigerator.

Physical characteristics

pH: I standardized instrument with standard with pH near that of specimen and then with two other to check the accuracy of electrodes then analyze water sample as soon as possible and let the bottles to be closed till analysis, then 10 ml water sample was taken in clean beaker and pH was measured by pH meter using fisher automatic tetrameter model 36-pH meter (AOAC, 2003 method no 973.41).

Turbidity: Turbidity was measured by using turbidity meter Wag-WT-300 by taking 1 ml water sample in cuvate. The result was displayed by turbidity meter and noted.

EC: 10 ml water sample was taken from water sample collected in a tube and EC of all drinking water sample were determined by using EC meter LF-91.

Microorganisms: Total coliform was counted (most probable number method) while just the existence of *E. coli* was tested (Tandon *et al*., 2005).

Statistical analysis: Physical, chemical and becterlogoical data were checked by using Epi-info statistical software. Descriptive statistical analysis was carried out in order to check the mean, standard deviation and range in collected data. Difference between urban and rural was checked by F-test (ANOVA).

Bacterial test: For total coliform count MacConkey broth was used as culture media. A duplicate water samples along with samples for chemical analysis collected in clean sterilized glass bottles for the becterlogoical analysis and tested at Food Analysis Lab City Hospital Kohat Road Peshawar, where the test for total coliform and *E. coli* were also conducted.

Water analysis (Coliform/100 ml): Media used for microbial colony development was MacConkey Broth and actual method was MPN (most probable number), for this purpose water samples were collected from water sources in sterilized glass bottles in 100 ml capacity.

Media preparation: Prepared two types of Media i.e. single strength and double strength media. Double Strength Broth was prepared by weighting 8 gm media and dissolved it in 100 ml distilled water. 10 ml Broth was distributed in 5 test tubes sealed with cotton plugs. Before adding the Durham tube was placed in every test tube in inverted position. Single Strength Broth was prepared by weighting 4 gm of broth in 100 ml distilled water. Add 5 ml broth to each 10 test tubes and Durham tubes then sealed. All test tubes along with other required material are sterilized in autoclave at 121°C for 15 min. After cooling, 10 ml water sample was added to each 5 test tubes having double strand Broth (10 ml). Then 1 ml testing water sample was added to each 5-test tubes having 5 ml single strand Broth (5 ml). Put 0.1 ml testing water sample into remaining test tubes of single strand. Then all these sample were put for Incubation in incubator at 30-37°C for 18-24 h and observed growth, of acid and gas. After completion of incubation period Count the number of positive tubes in each set of 5 test tubes (Appendix 1) and consulted the appropriate number in the table (Tandon *et al*., 2005).

Confirmatory test (Ejakman test): Prepared sterilized *E. coli* media for *E. coli* in same way as for coliform and inoculate the positive tube in the same manner as for coliform i.e. from 10 ml coliform positive to 5 test tubes, from 5 ml coliform positive to 5 test tubes and from 0.1 ml coliform positive to 5 test tubes having EC media. Incubate it at 44°C for 24 h. If acid and gas were found, means that contamination is feacal one and *E. coli* is also present.

RESULTS AND DISCUSSION

Water sample collected from Peshawar valley were analyzed for their physical and bacteriological characteristics. Among the physical characteristics pH, EC and turbidity were measured. For bacteriological characteristics total coliform count and only existence of *E. coli* was performed. The results obtained were summarized in the Tables 1 and 2.

Table 1 indicates the physical properties of water sample collected from six different locations of Peshawar. In all locations the main source of drinking water is tube wells. Among the physical parameters pH, EC and turbidity were analyzed and compared with WHO standards.

pH: pH is the measure of the activity of the hydrogen ion (H+) and is reported as the reciprocal of the logarithm of the hydrogen ion activity. Therefore, a water with a pH of 7 has 10^{-7} moles per liter of hydrogen ions; whereas, a pH of 6 is 10^{-6} moles per liter. The pH scale ranges from 0-14. In general, a water with a pH < 7 is considered acidic and with a pH > 7 is considered basic. The normal range for pH in surface water systems is 6.5-8.5 and for groundwater systems 6-8.5. Alkalinity is a measure of the capacity of the water to resists a change in pH that would tend to make the water more acidic. The measurement of alkalinity and pH is needed to determine the corrosivity of the water.

pH was found in water sample of Peshawar valley in the range of 7.04-7.85 with Total mean pH value 7.41. Which is in the safe limit as recommended by the WHO, which is from 6.5-8.5. Mean value of pH for Hayatabad, Sadder, City, SheikhMohammadi, Jagra and Palosi were 7.55, 7.43, 7.41, 7.46, 7.40 and 7.37 respectively.

In general, water with a low pH (< 6.5) could be acidic, soft and corrosive. Therefore, the water could leach metal ions such as iron, manganese, copper, lead and zinc from the aquifer, plumbing fixtures and piping. Therefore, a water with a low pH could contain elevated levels of toxic metals, cause premature damage to metal piping and have associated aesthetic problems such as a metallic or sour taste, staining of laundry and the characteristic “blue-green” staining of sinks and drains. The primary way to treat the problem of low pH water is with the use of a neutralizer. The neutralizer feeds a solution into the water to prevent the water from reacting with the house plumbing or contributing to electrolytic corrosion; a typical neutralizing chemical is soda ash. Neutralizing with soda ash increases the sodium content of the water (Shakirullah *et al*., 2003).

Water with a pH > 8.5 could indicate that the water is hard. Hard water does not pose a health risk, but can cause aesthetic problems. These problems include: Formation of a "scale" or precipitate on piping and fixtures causing water pressures and interior diameter of piping to decrease Causes an alkali taste to the water and can make coffee taste bitter.

Table 1: Physical properties of water sample

Area	pH Mean±SD	EC µscm^{-1} Mean±SD	Turbidity (FTU) Mean±SD
Total urban (n = 45)	7.46±0.18	0.65±0.10	0.53±0.54
Hayatabad (n = 15)	7.55±0.23	0.56±0.06	0.29±0.38
Sadder (n = 15)	7.43±0.16	0.70±0.07	1.01±0.56
City (n = 15)	7.41±0.12	0.70±0.09	0.29±0.31
Total rural (n = 45)	7.41±0.13	0.64±0.06	1.23±0.80
SheikhMohammadi (n = 15)	7.46±0.08	0.69±0.07	0.50±0.57
Jagra (n = 15)	7.40±0.12	0.62±0.03	1.37±0.58
Palosi (n = 15)	7.37±0.17	0.60±0.03	1.82±0.61
Grand total (n = 90)	7.44±0.16	0.64±0.08	0.88±0.77

Formation of a scale or deposit on dishes, utensils and laundry basins; difficulty in getting soaps and detergents to foam and formation of insoluble precipitates on clothing, etc. and decreases efficiency of electric water heaters.

Exposure to extreme pH values results in irritation to the eyes, skin and mucous membranes. Eye irritation and exacerbation of skin disorders have been associated with pH values greater than 11. In addition, solutions of pH 10-12.5 have been reported to cause hair fibres to swell. In sensitive individuals, gastrointestinal irritation may also occur. Exposure to low pH values can also result in similar effects. Below pH 4, redness and irritation of the eyes have been reported, the severity of which increases with decreasing pH. Below pH 2.5 damage to the epithelium is irreversible and extensive. In addition, because pH can affect the degree of corrosion of metals as well as disinfection efficiency, it may have an indirect effect on health (WHO, 1999).

Electrical conductivity: Conductivity of a substance is defined as the ability or power to conduct or transmit heat, electricity, or sound. 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 0.10 μscm^{-1}. 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.

EC was found in water sample of Peshawar valley in the range of 0.47-0.82 μscm^{-1} with Total mean EC value 0.64 μscm^{-1}. The recommended limit of WHO for EC ranges from 0.5-1.5 μscm^{-1}. Mean value of EC for Hayatabad, Sadder, City, SheikhMohammadi, Jagra and Palosi were 0.56, 0.70, 0.70, 0.69, 0.62 and 0.60 μscm^{-1} respectively. All the water sample were in the safe limit as recommended by WHO.

Turbidity: Turbidity is a measure of the degree to which the water looses it's 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. There are various parameters influencing the cloudiness of water. Some of these are Phytoplankton, Sediments from erosion, resuspended sediments from the bottom (frequently stir up by bottom feeders like carp), Waste discharge, Algal growth and Urban runoff (EPA, 2002).

Turbidity was found in water sample of Peshawar valley in the range of 0.00-2.90 FTU with Total mean turbidity value 0.88 FTU. Mean value of turbidity for Hayatabad, Sadder, City, SheikhMohammadi, Jagra and Palosi were 0.29, 1.01, 0.29, 0.50, 0.37 and 1.31 FTU respectively. The suspended particles absorb heat from the sunlight, making turbid waters become warmer and so reducing the concentration of oxygen in the water (oxygen dissolves better in colder water). Some organisms also can't survive in warmer water (Rosborg *et al*., 2003).

As a consequence of the particles settling to the bottom, shallow lakes fill in faster and insect larvae are covered and suffocated, gill structures get clogged or damaged. The main impact is merely aesthetic: nobody likes the look of dirty water. But also, it is essential to eliminate the turbidity of water in order to effectively disinfect it for drinking purposes. This adds some extra cost to the treatment of surface water supplies. The suspended particles also help the attachment of heavy metals and many other toxic organic compounds and pesticides (EPA, 2002).

Pathogenic microorganism: Table 2 show pathogenic bacteria which directly effect the human and causes acute and chronic diseases.

In drinking water sample of Peshawar valley total coliform count ranged from 0-150 coliform per 100 ml, with grand mean of 38 coliform per 100 ml. while *E. coli* were present in 26% of the samples. Mean value of Coliform count for Hayatabad, Sadder, City, Sheikh Mohammdi, Jagra and Palosi were 7, 45, 64, 13, 64 and 35 coliform per 100 ml.

The WHO recommended level for Coliform count should be less than 10 per 100 ml while presence of *E. coli* must be negative in the all cases (WHO, 1999).

The presence of bacteria and pathogenic (disease causing) organism are a concern when considering the safety of drinking water. Pathogenic organisms can cause intestinal infections, dysentery, hepatitis, typhoid fever, cholera and other illnesses.

Human and animal wastes are a primary source of bacteria in water. These sources of bacterial contamination include runoff from feedlots, pastures, dog runs and other land areas where animal wastes are deposited. Additional sources include seepage or discharge from septic tanks and sewage treatment facilities. Bacteria from these sources can enter in wells that are either open at the land surface, or don't have water tight casings or caps, or don't have seal in the annular space (the space between the wall of the drilled well and the outside of he well casing). Insects, rodents and animals entering the well are other sources of contamination. Old wells were dug by hand and lined (cased) with rocks or bricks. These wells usually have large openings and casings that often are not well sealed. This makes it easy for insects, rodents, or animals to enter the well. Another way through which bacteria can enter the water supply is through inundation or infiltration by flood waters or by surface runoff. Flood water commonly contains high level of bacteria. Small depressions filled with flood water provide and excellent breeding ground for bacteria (Ley and Samant, 2003).

Table 2: Bacteriological characteristics of drinking water

Area	Location	Coloform/100 ml Mean±SD	*E. coli* +Ve	*E. coli* -Ve
Urban (n = 45)				
	Hayatabad (n = 15)	7±5.66	0	15
	Sadder (n = 15)	45±40.51	4	11
	City (n = 15)	64±39.50	8	7
Total urban (n = 45)		38.38±40.13	12	33
Rural (n = 45)				
	SheikhMohammadi (n = 15)	13±7.09	0	15
	Jagra (n = 15)	64±30.30	9	6
	Palosi (n = 15)	35±19.13	3	12
Total rural (n = 45)		37.20±29.60	12	33
Grand total (n = 90)		37.79±35.07	24	66

Fecal Coliform is a portion of the Coliform bacteria group originating in the intestinal tract of warm-blooded animals that pass into the environment as feces. Fecal Coliform often is used as an indicator of the bacteriological safety of a domestic water supply.

Coliform bacteria may not cause disease, but can be indicator of pathogenic organisms that causes diseases. The latter could cause intestinal infection, dysentery, hepatitis, typhoid fever, cholera and other illnesses. However these illnesses are not limited to disease causing organism in drinking water. Other factors not associated with drinking water may be the cause. Intestinal infections and dysentery are generally considered minor health problems. They can, however prove fatal to infants, the elderly, and those who are ill. Today typhoid, hepatitis and cholera are rarely encountered in the developed countries.

Conclusion: The main source of contamination is the untreated sewerage water. In Peshawar City these sewage effluents are discharged directly into non-bricked and uncommented drains, sewage carrier streams and Naray Khwar running across the palosi. From there due to the seepage of polluted water, it percolates into the underground fresh water body and contaminates it. Moreover, in irrigated farming lands the chemicals, fertilizers and pesticides are used in the fields and most of these chemicals residues reached the ground water table. Smoke and wastes of vehicles are deposited on the soil surface and in rainy season it results in considerable rise in the contamination of shallow well's water. The other possible sources of heavy metals pollution, for all categories include leaching from time old water supply pipes which are rusted, Pb/Cd based solder pipes, joints and use of sub-standard chemicals for water treatments.

In Hayyatabad and Palosi the main source of heavy metal contamination may be the near by flowing Palosi drain, as it is uncemented and carries the industrial effluent discharged in to it directly from Hayyatabad industrial estate. In Peshawar the sewerage and industrial effluents are also disposed into canals or rivers, which are used for irrigation in the vicinity of Peshawar and results in the contamination of irrigation as well as drinking water. In City and Saddar the main source of water pollution is the vehicle discharged and the polluted environment and their accumulation in old piping system and solder pipes and joints. For SheikhMohammadi and Jagra the main source of water contamination is the leaching of chemical and synthetic fertilizer in water table as there are more agriculture land for cultivation and the improper irrigation system.

The drinking water form all the study areas is contaminated with heavy metals, so it is essential that the supply of water for human consumption should be free from unpleasant or harmful impurity and for this reason it should be subjected to various treatments to render it safe for the use of man. The study indicates from the background values that it should be monitored regularly in order to evaluate the toxic, logical significance of commonly used water for drinking.

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