RESEARCH ARTICLE

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Bacteriological and Chemical Analysis of Drinking Water in Sargodha City, Pakistan

Mariyum Naz Gondal[1] and Sajida Munir[2]
[1.] University of Lahore, Sargodha, Pakistan.
[2.] NUR International University, Raiwind Road, Lahore.

Correspondence
E-mail: sajida.munir@niu.edu.pk

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ABSTRACT

In Pakistan, the chemical and bacteriological quality of drinking water is not closely monitored and prevalence of waterborne diseases due to the bacterial contamination is among the most common problems faced in urban and rural areas. Due to major health concerns, it was decided to examine the water quality of Sargodha city. In this work, a total of 31 water samples were collected from eight different areas of Sargodha city. These samples included tap water, bore water, water filter plants, bottled water from different companies, hand pumps and canal water. Chemical analysis results indicated that calcium, magnesium, total dissolved solids (TDS) and alkalinity level of tap water and bore water was higher than normal range of world health organization (WHO). Nitrate level was also high in few water samples. Chlorine was found below detectable range in almost 90% water samples. 70% of water samples were contaminated with coliforms. The presence of E. coli was detected in 45% water samples. Most of the water samples contained a high number of Pseudomonas aeruginosa. All these unhygienic conditions of water are responsible for spreading harmful diseases such as bloody diarrhea, abdominal pain, eyes and skin infection, fluorosis, dental plaque etc.

Keywords: EDTA, Titration, Drinking water, Coliforms, Diarrhea, *Pseudomonas aeruginosa.*

INTRODUCTION

Water is an essential component for all living organisms as it not only maintains food supply but also a productive environment. Along with water, its resources are also very important (Kılıç, 2020). It is the second most essential component of life after oxygen but despite this drinking water has never been pure. For humans, water quality is very important as the water quantity (UNESCO, 2012). All activities in life are impossible without water whether it is for drinking purposes, domestic usage or recreational purposes. The country's economy will flourish and help reduce poverty if it has good water and sanitation systems and better management of its water resources. But if we look at history, since 1990s, pollution has increased in rivers of many world regions including Africa, Asia, and Latin America (Nti et al., 2023).

According to a report published by Word Health Organization (WHO), about 2 billion individuals across the globe used coliform contaminated water for drinking purposes that significantly affected their

health (WHO, 2008). Water should be clear and colorless, free from any toxins and pathogens then considered to be acceptable and suitable for drinking purposes (N, 2008). Although in recent years, many developing countries have succeeded in reducing diseases that are caused due to poor water quality and sanitation by advancements in their safe water resources as the major public health concerns, but it cannot be completely perfect due to increased demand of water due to population explosion (Li and Qian, 2018). Physical and chemical pollutants are also contaminating the water, but mostly disease-causing agents are of biological origin. The most important organism that contaminates the drinking water is coliform bacteria. A coliform bacterium is used as an indicator for determining water quality. High concentration of fecal coliforms in water indicates that water is highly contaminated with feces of humans and other animals (Hurst, 2018).

Many factors are involved in determining the quality of water before its consumption, which is important to be considered for water quality management. The source of water, its treatment process in treatment plants, distribution system and its storage in tanks all contribute towards water quality. Understanding the factors influencing drinking water quality is also a necessary step to get wise decisions on drinking water quality protection and management. If we consider the drinking water of rural and small populated areas, there is no proper treatment process, but water is directly pumped from wells or obtained from rivers which causes lot of water related problems on human health (Li and Wu, 2019).

Higher concentration of calcium and magnesium in drinking water also deteriorate the quality of drinking water. High concentrations of sulphate in water cause skin irritation; if nitrate concentration is high in it causes blue baby disease, headache, dizziness and blood pressure problems. There may be 95 % chances of cancer if there is a high concentration of chlorine in water (Din et al., 2023).

Pakistan has been blessed by many surface and ground water resources but due to increasing growth rate, water resources have been depleting day by day (Husnain Riaz and Sajid, 2017). The main reason of water contamination in Pakistan is the poor sewerage system. Industrial waste like toxic materials which have been thrown in rivers and lakes pollute the ground as well as surface water. Mostly the general population is affected by these contaminations (Azizullah et al., 2011). Poor water quality is the main health concern in Pakistan. Microorganisms and toxic compounds contaminate both the ground water as well as the surface water (Hisam et al., 2014). Water purification plants exist in a few cities but unfortunately these plants are not working properly and unable to detect microbial contaminants (Farooq et al., 2008). So, therefore most people in Pakistan unable to drink safe and pure water. National statistics reveal that 56 % of the total population in Pakistan has access to safe drinking water, but in rural areas the condition is worse, safe water is hardly available to 45 % of the population (Adil et al., 2021).

This study was planned to find the effect of contaminated water on human health in Sargodha city with the help of a questionnaire and survey of different local hospitals for analysis of water-borne diseases. Also, we investigated those chemical parameters of drinking water which are linked with microbiological load and compare their range with the normal range of WHO. We analyzed the prevalence of total coliform, fecal coliform (E. coli) and Pseudomonas (fluorescein) in drinking water and their effects on residents.

MATERIALS AND METHODS

Study area and sampling:

Water samples were collected from eight different regions of Sargodha city such as Satellite town (B block), Farooq colony, Bismillah Homes, Rehmat Park, Peer Muhammad colony, Kot Fareed, Iqbal colony, and Defence Garden. Bottles were labelled and samples were delivered to laboratory.

Analysis of chemical parameters:

All samples were transferred to Pakistan Council of Scientific and Industrial Research (PCSIR) laboratory, Islamabad, for chemical analysis. Different methods were used such as EDTA titrimetric method (Standard method 2340-C) for

estimation of calcium. The SPADNS (Hach) method (Method 8029), using spectrophotometry, was used for identifying fluoride concentration. Total dissolved solids (TDS) of the water samples were measured through TDS meter. The method used for analysis of sulfate was the turbidimetric method. Emission photometric method (Model: PFP-7, JENWAY, UK) was used for the analysis of sodium while UV-VIS Spectrophotometer (Analytik Jena) was used for analysis of nitrate. Titration with silver nitrate method was used for estimation of chlorine.

Bacteriological examination:

For the isolation of coliforms, MacConkey agar was used while for *Pseudomonas* isolation, *Pseudomonas* agar media was used. Spread plate technique (Yam, 2017) was used for the isolation of *coliforms*, fecal *coliforms* (*E coli*) and *Pseudomonas aeruginosa.* Plates were incubated at different temperatures as for *coliform's* isolation at 37 ℃ for 24 hours but for *E. coli* the plates were incubated at 45℃. For *Pseudomonas,* the petri dishes were placed in incubator at 42 ℃ for 18-20 hours (Karim et al., 2012). Gram staining, lactose fermentation test, and pigment formation test were performed for further confirmation of *coliforms*, *E. coli* and *Pseudomonas aeruginosa*.

RESULTS

It was found that 34% of people have utilized water supplies for drinking purposes (Figure 1). 25% of people have utilized ground water for drinking. 23% preferred canal water for drinking purposes and 19% people preferred bottle water for drinking purposes.

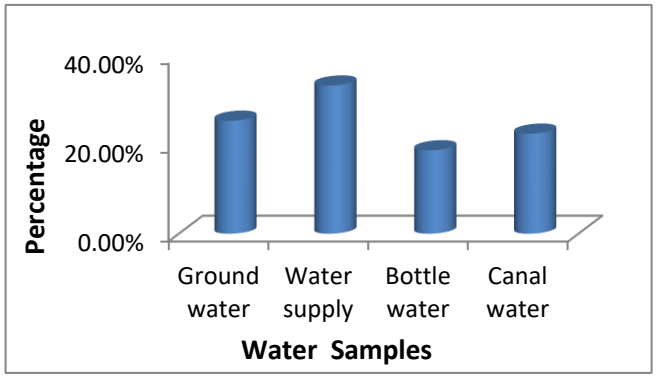

Figure 1: Sources of water samples collected from different areas.

50% of the people have reported that their drinking water quality is good while 26% reported that their quality of drinking water is fair. 20% of people reported that they have excellent drinking water quality. Only 4% people reported that they have availability of poor quality of drinking water. Most people said that their water looks clear. 39% people said that their water looks cloudy. Only 3% people said that their water looks dirty. 66% of families reported that their water is odorless while 34% of families reported that their water gives foul smell. Only 50% of people have availability of good taste of water for drinking. 67% of the people have never complaints to the higher authorities about the problems related to the bad quality of drinking water availability. Only 33 % of the people said that they have complained to the government.

Equipment for water purification is not common in households to make water quality better. Majority have closed sewer kind of toilet facility in their home and some poor people also reported that they preferred open fields for toilet because of unavailability of conservancy. Figure 2 indicates that a large ratio of people have diarrheal problems after drinking contaminated water. Some people face skin problems, and some have eyes infection occurred due to impure water. Few of them also reported the prolonged fever due to drinking contaminated water.

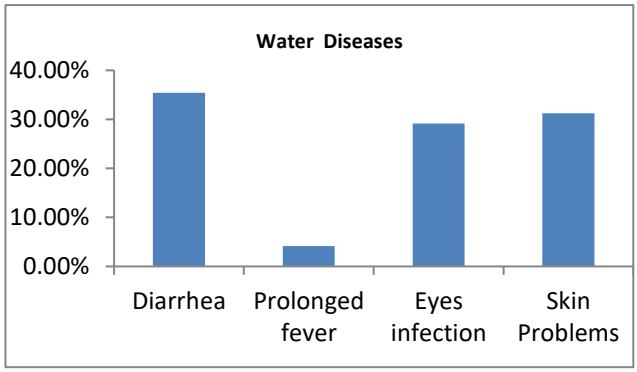

Figure 2: Water Borne diseases due to drinking unsuitable water.

Almost 50% of the people have never seen any serious medical problem in their area after drinking contaminated water. 40% of people said that they do not have any information related to this question. Very few people said that quite often they have heard this kind of news from their area. 40% of people have utilized bottled water for cooking in their home and

Table 1: Chemical analysis of drinking water

Area	Water Resource	Alkalinity (NGVS)	Calcium (75)	Chlorine (NGVS)	Flouride (1.5)	Magnesium (150)	Nitrate (10)	Sulfate (250)	TDS 1000	Sodium (200)	Odour
Bismillah.H	Tap water	612	**295**	BDL	1.40	**425**	**16.5**	**1765**	**9783**	170	No
Bismillah.H	Hand pump	570	70	BDL	1.07	103	**12.4**	**820**	**4120**	110	No
Bismillah.H	Bore water	620	**280**	BDL	1.40	**413**	**15.6**	**1760**	**9780**	150	No
Farooq colony	Tap water	545	**178**	BDL	1.2	**220**	**12.5**	**1751**	**9751**	180	No
Farooq colony	Bore water	510	61	BDL	1.1	125	**13.2**	**1710**	**1050**	103	No
Farooq colony	Bottle water (kinley)	65	BDL	10	0.08	27	BDL	80	166	20	No
Satellite town	Tap water	89	**81**	BDL	0.2	115	11	225	**4225**	**220**	No
Satellite town	Bottle water (meezab)	70	28	BDL	BDL	15	0.3	58	227	32	No
Satellite town	Bore water	410	**95**	BDL	1.2	**151**	2.5	180	**4410**	110	No
Peer.M colony	Tap water	490	44	BDL	0.6	90	1.4	125	734	106	No
Peer M colony	Water supply	425	47	BDL	0.8	87	3.5	135	660	120	No
Rehmat Park	Bore water	520	**105**	BDL	1.2	125	08	225	765	**215**	No
Rehmat Park	Hand pump	88	51	BDL	1.1	122	2.1	160	670	145	No
Rehmat Park	Water supply	520	66	BDL	0.8	129	1.7	**321**	760	155	No
Rehmat Park	Tap water	630	**110**	BDL	0.6	125	08	210	820	**212**	No
Defence Park	Tap water	340	36	BDL	0.6	68	1.1	170	679	120	No
Iqbal colony	Tap water	510	68	BDL	**1.8**	90	0.7	135	853	129	No
Iqbal colony	Bore water	570	68	BDL	**1.9**	50	3.2	210	**1047**	**290**	No

The normal range according to WHO (2004) are given with the parameters. **NGVS**: No Guideline Value Set., **BDL**: Below Detection Limit. **Unit** : mg/l

60% do not have bottled water utilized for cooking. Figure 3 indicates that canal water contains highest number of Gram-negative bacteria. Tap water contains Gram-negative bacteria in high amount but its quantity is less than canal water. Bottle water of all areas contains least number of Gram-negative bacteria.

The chemical analysis of all areas water gave results that were not according to WHO standards as mentioned in table 1. The values marked in red are above standard values that makes the water unfit for drinking purposes.

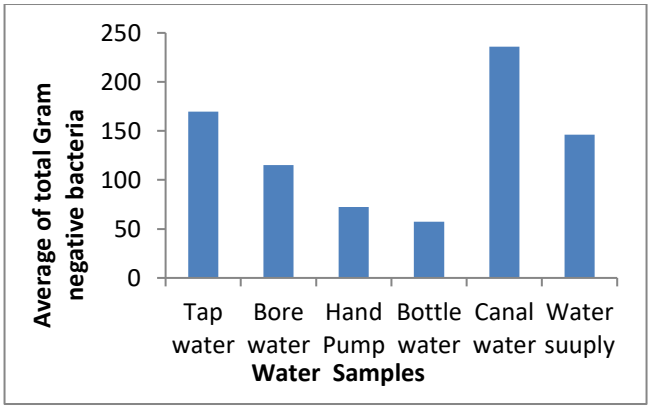

Figure 3: Gram-negative bacteria prevalence in different water samples.

Figure 4 indicates that Peer Muhammad colony contains highest number of Gram-negative bacteria. Satellite town contains second highest number of Gram-negative bacteria. Kot Fared contains least number of Gram-negative bacteria among all other areas.

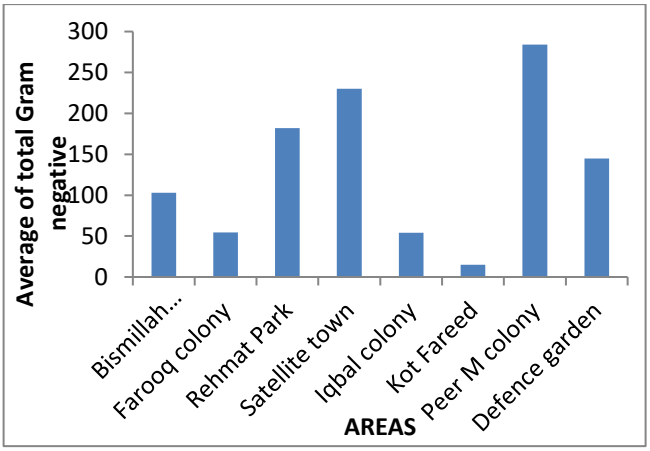

Figure 4: Presence of Gram-negative bacteria in water samples of different areas.

Figure 5 indicates that the water supply contains the highest number of coliforms. Canal water contains the second highest number of coliforms. Bottled water containsthe leastt number of coliforms among all samples.

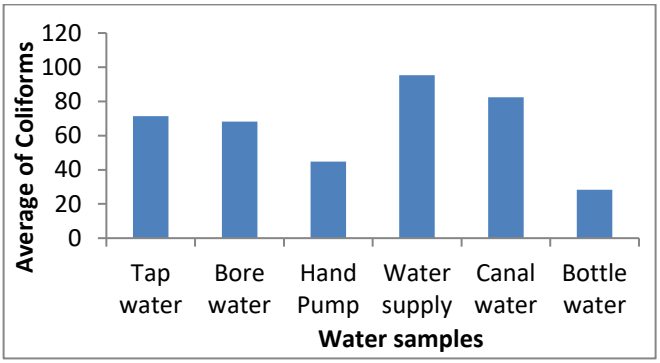

Figure 5: Water supply at homes contains the highest number of coliforms.

Canal water contains the highest *Pseudomonas*. All other water samples contain almost equal amount of *Pseudomonas*. Bottled water contains a smaller number of *Pseudomonas*.

The *p*-value of Gram-negative bacteria was 0.0028, that is less than 0.05. It indicates that all the areas drinking water samples contain different numbers of Gram-negative bacteria. The p-value of coliforms is 0.00765 which is less than 0.05. It also indicates that all the drinking water samples of different areas show dissimilarity in the presence of coliforms. On the other hand, p value of *Pseudomonas aeruginosa* is 0.567 which is more than 0.05. This p value indicates that all the areas drinking water sample contain almost an equal amount of *Pseudomonas* bacteria.

DISCUSSION

The result of chemical analysis indicates that chlorine level is below detectable range (5mg/l) in most of the water samples except bottled water of some companies like Kinley, Nestle, Aqua Fina and Gourmet. Tap water and Bore water of Bismillah Homes, Farooq Colony, Satellite Town, Rehmat Park, Iqbal Colony contains TDS level higher than WHO normal range. TDS and alkalinity are also linked with microbiological load. According to some researches bacterial abundance in drinking water increases with the increase of TDS and alkalinity (PCRWR, 2005)

When nitrate concentration of drinking water was checked it indicates tap water, bore water and hand pump of Bismillah homes contains the nitrate level beyond the normal range of WHO which is 10mg/l. Farooq colony tap water and bore water also contain nitrate level beyond normal range. High amount of nitrate in drinking water is one of the indications of water contamination with fertilizers and animal waste (Akber et al., 2020). High sodium in water stimulates the growth of Gram-negative bacteria *Vibrio cholera* which causes cholera in humans. Sodium was found high in tap water of Satellite town and Rehmat Park. Bore water of Rehmat Park and Iqbal colony also contain sodium level higher in concentration. Some other parameters such as calcium, magnesium and sulphate were also checked through laboratory. The results indicate that calcium was found higher in concentration in tap water of Bismillah homes, Farooq colony, Satellite town and Rehmat Park. Bore water of Bismillah homes, Satellite town, and Rehmat Park also contain calcium beyond the normal range of WHO. Magnesium was also found higher in range in tap water of bismillah homes and Farooq colony. Bore water of Satellite Town and Bismillah Homes also contain calcium in high amount. Tap and Bore water of Bismillah homes and Farooq colony shows sulphate concentration higher in amount and beyond the normal range of WHO. Hand pump of Bismillah Homes and water supply of Rehmat Park contains

high sulphate concentration. High Ca and Mg concentration along with high sulphate are responsible for various diseases like scaling and diarrhea (Kozisek, 2020). Similarly, research was conducted by National Water Quality Programme (NWQMP) in Sargodha city. Their results were also like these results. Their results indicate the high amount Ca, Mg, sulphate, nitrate and fluoride in drinking water of Sargodha city. All these parameters were initial indicators of water quality and bacterial prevalence (Hussain et al., 2022).

Almost 45% of water samples were considered fecal contaminated and remaining 55% were considered non fecal contaminated. The result of this study is similar to the results of PCRWR. According to the PCRWR research different water samples were collected from different areas of Sargodha city, and majority of the water samples were contaminated with coliforms and fecal coliforms (PCRWR, 2005).

Pseudomonas was highest in canal water. Other water samples such as tap water, bore water, and hand pump contained almost an equal amount of this bacteria. Bottled water of all companies contained very little amount of *P. aeruginosa*. Among all areas Bismillah homes drinking water samples were highly contaminated with *Pseudomonas*. But the conditions of other areas were also not satisfactory. Water samples collected from Defence Garden area contained very few bacteria, so they were considered suitable for drinking. Similar research was done for drinking water in Karachi. The results of the study indicated that most of the tap water, bore water and even filtered water contain *Pseudomonas aeruginosa* (Amin, 2014).

After the survey of different local hospitals of Sargodha city such as Bucha Hospital, Fatima hospital, Mubarak Hospital, DHQ Hospital and Sadiq Hospital, it was estimated that there are many miserable diseases which are spread out after drinking contaminated water. Top of the disease was diarrhea and was most common among all age groups. Other diseases were stomach cramps, vomiting, bone and joint infection, urinary tract infection, abdominal pain, dental plaque, methemoglobinemia, fluorosis, sudden severe water diarrhea that changes to blood stools, gas and skin infection which is in accordance with previous study in Sargodha (Omar Riaz et al., 2017).

The reason behind bacterial contamination in tap water and bore water may be intermittent water supply, poor maintenance, improper layout of water and sewer lines and poor sewage and drainage system in the area. Canal water was contaminated due to various human activities. Most of the poor women of this city washed their clothes in canals. Some children used canal for swimming purposes. Animals lay feces in canals and when mixed with soil of canal water, they also contaminate the ground water. Water filters were contaminated due to improper working of these filters. Filters remove salt from water and make it useful for drinking, but the microbial contaminants remain undetected. All the bottled water was considered safe during research except Meezab.

Conclusion

The bacteriological and chemical analysis of drinking water in Sargodha City reveals significant concerns regarding water quality and public health. Many water samples tested showed contamination by coliform bacteria, indicating possible fecal pollution and the potential presence of waterborne pathogens. Chemically, several parameters such as turbidity, TDS, nitrates, and heavy metals were above the permissible limits set by WHO and Pakistan's national standards, posing serious health risks of population. These findings highlight the urgent need for improved water treatment infrastructure, regular monitoring, and public awareness campaigns to promote safe water practices. Municipal authorities and relevant stakeholders must prioritize investments in water purification systems, enforce environmental regulations to prevent industrial discharge and sewage infiltration, and ensure consistent testing of water sources. Ensuring access to safe and clean drinking water is not only a matter of public health but also a fundamental human right, critical to the sustainable development of Sargodha City.

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Conflict of Interest

Authors declare no conflict of interests.

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