Approximation of ground water quality for microbial and chemical contamination

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\textbf{Abstract}

Present study was designed to obtain estimation about ground water quality of Bhimber, Azad Jammu and Kashmir (AJK), Pakistan. A total of 12 water samples were collected from different localities of study area to analyze for various physicochemical and biological parameters i.e. namely temperature, pH, turbidity, color, odor, taste, electric conductivity (EC), total dissolved solids (TDS), total hardness (Calcium + Magnesium), chloride, arsenic, phosphate, lead, ammonium ion, nitrite, \textit{Fecal coliform} and \textit{Escherichia coli}. Results exposed that all ground water samples of study area were grossly contaminated with pathogenic microorganisms like \textit{E. coli} and \textit{Fecal coliform} except one water sample that was obtained from community filter plant Samahni Chowk site. Besides it, values of some physicochemical water quality determining parameters also deviated from recommended limits of World Health Organization (WHO). Chloride ion concentration was little below the prescribed limits in almost all water samples. It has been proven that consumption of unsafe drinking water is one of the major cause of prevalence of water borne diseases like diarrhea, gastroenteritis, typhoid fever and malaria etc. in study area. Community water supply and sanitation projects should be encouraged; government should provide filter plants in all regions of the country so that people could have easy approach to safe drinking water.

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1. Introduction

Groundwater is one of the more reliable and extensively used natural resources, it constitute about twenty percent of the world’s fresh water supply, which is about 0.61% of the entire world’s water. This makes it an important resource which can act as a natural storage that can be utilized during water scarcity periods (CWC, 2009). (See Fig. 1)

Ground water satisfies about 91 percent of overall drinking water demand and is considered the more reliable source of water as compared to surface water (Shankar et al., 2010). Due to lack of any centralized policy regarding use of ground water resources, the exploitation of resources reached at the peak in the beginning of 20th century, due to which a stress produced on ground water system, when rate of withdrawal crossed the rate of mean ground water restoration (Llamas and M. Cortina, 2009). 3.

Groundwater withdrawal rate is different in all countries India is at the top where this rate is 251 km\textsuperscript{3} per year, China 112 km\textsuperscript{3} per year, USA 112 km\textsuperscript{3} per year, Pakistan 64 km\textsuperscript{3} per year, Iran 60 km\textsuperscript{3} per year, Bangladesh 35 km\textsuperscript{3} per year, Mexico 29 km\textsuperscript{3} per year, Saudi Arabia 23 km\textsuperscript{3} per year, Indonesia 14 km\textsuperscript{3} per year and Italy 14 km\textsuperscript{3} per year. (Marget, 2008).

Ground water exploitation continued not only quantitatively but also qualitatively. Ground water quality is deteriorated commonly by two factors; external factor, that comprises meteorological events like floods, earthquake etc, they cause pollution and chemical imbalance in the water body. Secondly, internal factors those comprises the events which take place between and within plankton population present in the water body, they disturb the biochemical processes which take place in water and affect the optimal range of physicochemical parameters (Zamxaka et al, 2004).

The disposal of waste product into aquatic system is the man made factor of pollution (Khalid et al., 2011). That waste product contains organic runoff or heavy metals. Those heavy metals...
migrate to food chain where they can prove very injurious to human health (Tuzen, 2003)\(^7\).

Imbalance of all physicochemical parameters in water that occurs by various factors has harmful effects on consumers. If total dissolved solids and Magnesium are above optimal value, they create gastrointestinal irritation in human beings. Deviation from normal pH value causes corrosion and disagreeable taste. Excessive amount of calcium increase water hardness and results more scale formation. Copper if present in excess creates unpleasant taste and corrosion of pipes, fittings and utensils that carry water to the public sector. Similarly presence of extreme amount of Iron results discoloration of clothes, pipes and utensils. A great extent of nitrate in drinking water cause disease named, methemoglobinemia commonly called “blue baby”.

In Manga Mandi near Lahore (Pakistan) 100 cases of limb deformities has been reported that is attributed to high fluoride in ground water (NWQS, 2002)\(^9\). In Kasur intrusion of tannery effluents in ground water has caused prevalence of many diseases like abdominal disorders, nausea and skin irritation (UNIDO, 1999)\(^10\). Physicochemical imbalance and microbial contamination result the well known term called, water pollution. Increased water pollution has posed a serious threat to human health. Diarrhea, Typhoid, Tetanus, cholera etc are some more common diseases associated with poor water quality (Shengii et al., 2004)\(^11\).

In developing countries 2.2 million people die every year because of water born diseases (GWSSAR, 2000)\(^12\). In Pakistan only 25% of total population has access to safe drinking water. (Bhatti et al., 2002)\(^13\). Where more than 3 million people approximately suffer from water born diseases every year and out of them approximately 0.1 million dies annually (Bhatti et al, 2006)\(^14\).

The ground water pollution has reached at alarming point in Pakistan. The situation demands activation of water purifying measures at emergency basis. But the major hurdle in instantaneous starting of such water treatment strategies is scarcity of data about water quality estimation of targeted area. Therefore, it is the responsibility of researchers to work on water quality issues and provide valuable data about water quality measurement of whole country. The need of time is, the assessment of water quality so that environment and human lives can be protected (Sartaj et al, 2012)\(^15\).

The present study is designed to examine the ground water quality of Tehsil Bimber (AJK) by considering physical, chemical and biological parameters (selected) to highlight all those factors which are damaging drinking water quality. This study will provide a valuable data concerning the assessment of ground water quality of Tehsil Bimber, as there is no prior study or comprehensive published data on this issue. The result will be supportive in unveiling the ground water contamination in the study area and will be considered as the initiative for possible management of ground water.

2. Methodology

The study area selected for investigation of ground water quality is Tehsil Bimber. It is located by latitude: 32–48 to 33–34 and longitude 73–75 to 74–45. District Bimber is situated at the southern region, amongst ten districts of Azad Jammu and Kashmir (AJK) commonly known as Azad Kashmir, Pakistan. Bimber is bordered by Mirpur city to the northwest it has a distance of 50 km from Mirpur. It is only 166 km from capital Islamabad and is divided into 3 teshils (1) Bimber (2) Samahni (3) Barnala.

It has climate similar to adjacent areas of Punjab. Summer is hot from April to October and winter proceeds from December to January, people are fortunate to enjoy all seasons. Water resources are well water, bore hole water, spring water and surface water. These resources are declining day by day because of inadequate management. Most of the population rely on ground water resources i.e. bore hole water, well water etc, for drinking and irrigation purposes.

Sampling and chemical analysis 12 ground water samples were collected from different localities of Tehsil Bimber. Ground water samples including well water, borehole water and tap water of water supply lines were collected according to the standard methods of American Public Health Association (APHA 1998). Samples collection and transportation was according to standard methods of APHA (APHA 1998). Samples were collected in plastic polyethylene bottles. Samples were carried in the lab in refrigerator and they were transferred to the laboratory as soon as possible. Ground water samples were analyzed for (selected) physical, chemical and biological parameters, namely temperature, pH, turbidity, color, odor, taste, Electric Conductivity (EC), TDS, Total hardness (Calcium + Magnesium) Chloride, Nitrite, Phosphate, Lead, Ammonium ion, Arsenic, Fecal coli form and Escherichia coli (present or absent basis).

These water quality determining parameters were analyzed in well-established laboratory of Environmental Protection Agency.
(EPA), Mirpur, and Azad Kashmir. The results had been compared with WHO guidelines for drinking water quality.

3. Results

Results of the ground water analysis of Tehsil Bhimber for physicochemical and biological parameters are illustrated from Tables 1 and 2 and Figs. 2–9.

3.1. Results of chemical analysis of ground water of Tehsil Bhimber

See Table 1

3.2. Results of physical and biological analysis of ground water of Tehsil Bhimber

See Table 2

3.3. Results of physical parameters of ground water of District Bhimber

3.3.1. pH

In Tehsil Bhimber pH ranges from 7.5 to 8.8. Results revealed that pH values were within prescribed limits of WHO in all water samples of Tehsil Bhimber.

3.3.2. Temperature, taste, color and odor

Temperature of all sampling sites of Tehsil Bhimber ranges from 33.3 to 33.8°C. Taste, color and odor of all water samples of district Bhimber were unobjectionable.

3.3.3. Turbidity

In Tehsil Bhimber maximum turbidity was noted in water sample of Bhotosyal i.e. 0.22 NTU. Turbidity range in rest of samples were within range of 0.01 – 0.17 NTU.

3.3.4. Total dissolved solids and electric conductivity

Values of Total Dissolved Solids ranges from 105 to 440 PPM in all water samples of Tehsil Bhimber. Maximum value of EC measured in ground water of Tehsil Bhimber was 980 μS/cm in Panjeri.

3.4. Results of biological parameters of ground water of district Bhimber

Out of 12 water samples, only one water sample was found free from E. coli and Fecal coliform, that was collected from Samahni chowk filter plant of city Bhimber. Other water samples were contaminated with pathogenic microbes.

3.5. Results of chemical parameters of ground water of district Bhimber

3.5.1. Total hardness

In Tehsil Bhimber the minimum value of total hardness recorded in water sample of Machhia and Panjeri was 52.3 and maximum value was 120 in Bharing.

3.5.2. Ammonium ion

Mean value of Ammonium observed in all water samples of Tehsil Bhimber was 0.03 mg/L. Results exposed that values of Ammonium were within prescribed limits of WHO in all water samples of District Bhimber.

3.5.3. Phosphate

In Tehsil Bhimber phosphate values range from 1.4 to 3.8 mg/L in water sample of Maghlura and Bhotosyal respectively.

3.5.4. Chloride ion

Maximum and minimum value of chloride measured in ground water of Tehsil Bhimber were 38.5 and 22.11 mg/L in Samahni Chowk and Bhotosyal Rajani respectively.

3.5.5. Nitrite

Average value of Nitrite measured in all water samples of Tehsil Bhimber was approximately 0.02 mg/L.

3.5.6. Lead

In Tehsil Bhimber the highest value of Lead measured in water sample of Qasimabad was 0.25 mg/L and the lowest value was 0.01 mg/L in water sample of Samahni Chowk filter plant.

Table 1

| S# | Site Names | Arsenic (mg/L) | Total Hardness (Ca + Mg) | Ammonium Ion (mg/L) | Phosphate (mg/L) | Chloride Ion (mg/L) | Nitrite (mg/L) | Lead (mg/L) |
|----|------------|----------------|--------------------------|---------------------|-----------------|---------------------|---------------|-------------|
| 1  | TWBH       | 0              | 120                      | 0.05                | 2.5             | 27                  | 0.02          | 0.08        |
| 2  | LBMG       | 0              | 80                       | 0.05                | 1.4             | 30.4                | 0.04          | 0.08        |
| 3  | WLBS       | 0              | 100                      | 0.04                | 2.6             | 28.4                | 0.11          | 0.21        |
| 4  | LBQA       | 0              | 97                       | 0.03                | 2.08            | 25.6                | 0.02          | 0.25        |
| 5  | SWLA       | 0              | 82                       | 0.02                | 2.07            | 27.2                | 0.02          | 0.11        |
| 6  | LBBR       | 0              | 95                       | 0.03                | 2.11            | 22.2                | 0.03          | 0.034       |
| 7  | LBSB       | 0              | 85                       | 0.04                | 2.34            | 27                  | 0.02          | 0.08        |
| 8  | LBMA       | 0              | 52.3                     | 0.03                | 2.92            | 30.2                | 0.02          | 0.07        |
| 9  | FPSC       | 0              | 97                       | 0.02                | 1.5             | 38.5                | 0.03          | 0.01        |
| 10 | LBGC       | 0              | 92.5                     | 0.04                | 2.08            | 26.4                | 0.04          | 0.02        |
| 11 | HPBT       | 0              | 77.5                     | 0.05                | 3.8             | 31.9                | 0.03          | 0.03        |
| 12 | LBPN       | 0              | 52.3                     | 0.06                | 2.08            | 23                  | 0.03          | 0.05        |
4. Discussions

After a detailed analysis of ground water of Tehsil Bhimber, it is discovered that some physical water quality determining parameters like pH, turbidity and temperature values were within prescribed limits of WHO in all water samples of Tehsil Bhimber. However values of some parameters were not found according to prescribed limits. A higher amount of turbidity was calibrated in Table 2 showing results of physical and biological analysis of ground water of Tehsil Bhimber.

![Turbidity (NTU)](image)

![TDS (PPM)](image)

![Electric Conductivity](image)

![Ammonium (mg/L)](image)

**Fig. 2.** Showing concentration of Turbidity in ground water samples of Tehsil Bhimber.

**Fig. 3.** Showing values of EC in ground water samples of Tehsil Bhimber.

**Fig. 4.** Showing values of TDS in ground water samples of Tehsil Bhimber.

**Fig. 5.** Showing concentration of Ammonium in ground water samples of Tehsil Bhimber.

Table 2

| S# | Site Name | Turbidity NTU | TDS ppm | EC (µS/cm) | Temp. (°C) | pH | Color | E.coli & F.coli | Odor & Taste |
|----|-----------|---------------|---------|------------|------------|----|-------|----------------|--------------|
| 1  | TWBH      | 0.03          | 140     | 281        | 33.3       | 7.6| colorless | Present        | Un objectionable |
| 2  | LBMG      | 0.05          | 105     | 210        | 33.3       | 8  | colorless | Present        | Un objectionable |
| 3  | WLBR      | 0.09          | 271     | 542        | 33.4       | 7.8| colorless | Present        | Un objectionable |
| 4  | LBQA      | 0.03          | 150     | 300        | 33.2       | 7.5| colorless | Present        | Un objectionable |
| 5  | SWLA      | 0.01          | 230     | 460        | 33.5       | 8.8| colorless | Present        | Un objectionable |
| 6  | LBBR      | 0.17          | 383     | 767        | 33.6       | 8.1| Slightly Turbid | Present | Un objectionable |
| 7  | LBSB      | 0.05          | 255     | 510        | 33.7       | 7.6| colorless | Present        | Un objectionable |
| 8  | LBMA      | 0.01          | 135     | 270        | 33.6       | 8.1| colorless | Present        | Un objectionable |
| 9  | FPSC      | 0.01          | 249     | 498        | 33.4       | 8.2| colorless | Absent         | Un objectionable |
| 10 | LBGC      | 0.03          | 225     | 450        | 33.7       | 7.5| colorless | Present        | Un objectionable |
| 11 | HPBT      | 0.22          | 383     | 766        | 33.6       | 8.3| turbid | Present | Un objectionable |
| 12 | LBPN      | 0.03          | 440     | 980        | 33.4       | 7.5| colorless | Present        | Un objectionable |
Color, taste and odor of all samples had slight fluctuation from prescribed limit, they were also found satisfactory. EC and TDS measurements also showed that concentration of dissolved solids in ground water of District Bhimber did not exceed the recommended limit.

Chloride ion concentration was found a little below the recommended limits, normal value of Chloride was present in water sample of city Bhimber filter plant, where chlorination is being done to balance its ratio. Total Hardness (Ca$^+$ + Mg$^+$) values in a few water sites were lower than prescribed limit. Lead is present in very small amount in ground water of Tehsil Bhimber and its ratio is not problematic in any area of District Bhimber.

Arsenic was absent completely in all water samples of Tehsil Bhimber and Ammonium concentration in ground water was found satisfactory, its ratio is not hazardous in any area of Tehsil Bhimber. Phosphate values were also found within the prescribed limits. No deviation from suitable value was observed in any water sample of Tehsil Bhimber. Chemical imbalance in ground water of Tehsil Bhimber was found in rare cases.

Biological contamination was present in almost all water samples of Bhimber except one water sample, which indicated that there is sure possibility of intrusion of fecal matter with ground water. Due to which prevalence of water born diseases is common in the area. Diseases like diarrhea, gastroenteritis, shigellosis and flu is common especially in small children who are more susceptible to attack of disease causing microbes.

5. Conclusions and recommendations

In the light of above discussions it is concluded that ground water of District Bhimber is not suitable for drinking without treatment as it is grossly contaminated with pathogenic micro organisms like E.coli and Fecal coliform. Besides it, values of some physicochemical water quality determining parameters are also beyond the recommended limits of WHO. Results has proven that consumption of unsafe drinking water is one of the major cause of prevalence of water born diseases like diarrhea, typhoid fever and malaria etc in the study area. Following measures can be adopted to decontaminate the water so that water born infections can be controlled:

1. Since this was the first study Regarding the assessment of ground water quality Tehsil Bhimber, the results and the Discussions can be used as a model for teaching students involved in fields of Environmental Biology and Bioremediation.
2. There is an urgent need of mass public awareness campaign to educate people for implementation of water treatment strategies before consumption, for this purpose print and electronic media can play an efficient role.
3. Water should be disinfected by water supply agencies before its distribution to rural and urban communities.
4. At house hold level water contamination can be avoided by proper storage of water in clean utensils and boiling of water before consumption particularly for drinking purpose.

Declaration of Competing Interest

The authors declared that there is no conflict of interest.
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