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***Research Paper***

# AN ASSESSMENT OF THE PHYSICO-CHEMICAL CHARACTERISTICS OF GROUND WATER OF MAHAL VILLAGE OF AMRITSAR, INDIA

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**Abstract**

Physico-chemical study of ground water was performed for determining its suitability for drinking and agricultural purposes. In this study, ground water quality of village Mahal of district Amritsar, Punjab, India was evaluated for various physico-chemical parameters such as pH, electrical conductivity, total dissolved solids, calcium, magnesium, alkalinity, total hardness, sodium, potassium etc. All the results were compared with the standard limits for drinking water prescribed by Bureau of Indian Standards. The present study revealed that the quality of drinking water in Mahal village has been deteriorated which could be accounted to rapid industrialization activities, excess use of chemical fertilizers and pesticides and disposal of wastewater and sewage of the city into the Tung Dhab drain etc.

Key words: Physico-chemical analysis; Ground water; Bureau of Indian Standards.

## INTRODUCTION

Ground water is the most vital resource for all the living beings. But due to rapid industrialization and urbanization, contamination of groundwater has become a serious problem in many states of India like Punjab (1-2). Once contaminated, the quality of groundwater cannot be restored. Main pollutants of water pollution are from anthropogenic activities like industrial effluent, use of chemical fertilizers and pesticides (3). The specific contaminants in water include a wide spectrum of chemical and microbial agents. Consumption of contaminated water induces serious problems in human like reduced fertility, aging process and may develop cancer and DNA damage (4). Recently, Govt. of India has made several laws for providing pollution free water to the population. However, the accessibility of non-polluted drinking water is still a major issue. Regular monitoring of water is required to check the quality of water. The water quality monitoring includes physico-chemical parameters to find its suitability for domestic and agricultural uses. The physico-chemical parameters like pH, hardness, calcium, magnesium, sodium, potassium, chloride, fluoride etc. are very important as they give first-hand information about the quality of water (5). Therefore, the water samples were collected and tested for their physico-chemical parameters to analyse the quality of drinking water.

## MATERIALS AND METHODS

For physico-chemical analysis of water, drinking water samples were collected from Mahal village, Amritsar. It is a small village located towards the west of Amritsar, at a distance of 1 km from Guru Nanak Dev University and 0.5 km from Tung Dhab drain. People residing in the village come from poor and middle class family. Total twenty samples were collected from submersible pumps which were 130-150 feet deep and hand pump bores which were 60-70 feet deep. The drinking water samples were collected in acid washed polythene bottles. The water was pumped for a long time so that the sample represents the ground water that feeds the bore. Parameters like pH, total dissolve solids and electrical conductivity were measured on the spot. For further analysis, the water samples were brought immediately to the laboratory and were preserved at 4°C. The samples were analysed for their various physico-chemical properties in triplicates in accordance to "Standard Methods for the Examination of Water and Waste Water American Public Health Association (6). Methods used for the determination of different parameters are given in the Table 1.

## RESULTS

The results of the physico-chemical analysis of the twenty water samples are given in the Table 4 and 5. The parameters were compared with the drinking water standards provided by Bureau of Indian Standards (7) given in the Table 2.

### 3.1 Acidity

Acidity is a measure of the capacity of water to neutralise bases. Acidity is the sum of all titrable acids present in the water sample. Strong mineral acids, weak acids such as carbonic acid, acetic acid present in the water sample contributes to acidity of the water. Measurement of acidity is important, as acidic water is corrosive. As per BIS guidelines, there is no specific limit for the acidity. Acidity of the samples was found to be in the range of 122.6-367.0 mg/L.

### 3.2 Calcium

Calcium occurs in water mainly due to the presence of minerals such as limestone, gypsum and dolomite. Calcium is an essential mineral element both for animal and plant growth. However, high calcium content is responsible for hardness of water. As per BIS desirable limit for calcium is 75 mg/L. Calcium concentration of all the water sample exceeded the permissible limit except sample no. 4, 6 and 10.

### 3.3 Chloride

It occurs in all type of water. Its concentration serves as an indicator of faecal contamination. It is harmless up to the concentration of 150 mg/L but produces a salty taste at 250-500 mg/L concentration. Chloride concentration of all the samples was found to be within the permissible limits.

### 3.4 Conductivity
Conductivity of water varies directly with the temperature and is proportional to its dissolved mineral content. Conductivity of all the samples was found to be within the permissible limits.

### 3.5 Fluoride
It is toxic to humans in large quantities, while small concentration of approximately 1.00 mg/L in drinking water helps to prevent dental cavities in the children. Discoloration of teeth known as mottling, results when the concentration of fluoride in drinking water may reach up to 2 mg/L. Fluoride concentration of sample no. 1, 2, 4, 7, 8, 9, 10, 11, 16, 17, 18, 19 and 20 exceeded the permissible limit.

### 3.6 Magnesium
Magnesium salts always occurs in natural water. It is major scale forming constituent in water. As per BIS desirable limit for magnesium is 50 mg/L. Mg concentration of all the samples exceeded the permissible limit.

### 3.7 Phosphate

Phosphates are chemical compounds containing phosphorous. Natural water has phosphorous concentration of approximately 0.02 ppm. As per the BIS guidelines there is no specific limit for phosphate. Phosphate concentration of the samples was found to be in the range of 0.022-1.48 mg/L.

### 3.8 Potassium
As per the BIS guidelines there is no specific limit for potassium. Potassium concentration of the samples was found to be in the range of 14.04-28.34 mg/L.

### 3.9 pH
In general, water with a $pH<7$ is considered acidic and a $pH >7$ is considered as basic. The normal range for pH in the surface water is 6.5-8.5 and for groundwater is 6-8.5. The measurement of pH is needed to determine the corrosivity of the water. The pH of all the water samples was found to be within the permissible limits.

### 3.10 Sulphate
It is widely distributed in nature and may be present in natural water in concentration ranging from a few to several thousand milligrams per litre. Desired limit of sulphate in drinking water is 150 mg/L. sulphate concentration of the samples was found to be in the range of 0.002-0.75 mg/L.

### 3.11 Total hardness
Soap consumption by hard water represents an economic loss to water use. Hardness also causes fouling of utensils by scale formation. All the water samples were found to be hard (150-200 mg/L) but the sample number 6, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 were found to be very hard (>300mg/L).

### 3.12 Total dissolve solids
Dissolve minerals, gases and organic constituents may produce aesthetically displeasing colour, taste and odour. Some chemicals may be toxic and some of the dissolved organic

constituents have been shown to be carcinogenic. Not all dissolved substances are undesirable in water. Desired limit of TDS in drinking water is 500 mg/L. TDS of all the samples, except sample no. 12, exceeded the permissible limit.

### 3.13 Turbidity

Turbid water gives an aesthetically displeasing opaqueness or milky coloration. The colloidal material associated with turbidity provides sites for chemicals that may be harmful or cause undesirable taste and odours. Standard for turbidity is 1-5 NTU. All the samples were found to be exceeded the desirable limit except sample no. 1 and 6.

### 3.14 Correlation analysis

The correlation matrices were prepared using SPSS software. Table 5 represents the correlation matrices of physico-chemical analysis. Correlation analysis showed a strong correlation between TDS-EC (r = 0.554); Ca-TH (r = 0.852); Mg-TH (r = 0.837); and EC-$Cl^-$ (r=0.539) at 0.01 level of significance.

Electrical Conductivity (EC) is a substitute measure of Total Dissolved Solids (8). The relationship between TDS and EC is a function of the type and nature of the dissolved cations and anions in the water (9). The relationship between EC and TDS is not linear, since the conductive mobility of ionic species is variable (10). The terms hardness represents the amount of calcium and magnesium salts dissolved in the water. There is a linear relationship between hardness and calcium and magnesium. More the amount of calcium and magnesium more will be the hardness. Chloride, in the form of the $Cl^-$ ion, is one of the major inorganic anions, or negative ions, in water. More the amount of chloride ions more will be the electric conductivity.

Similarly, strong negative correlation was found between Mg-pH (r = -0.917); pH-TH (r = -0.724); Na-EC (r = -0.536 shown in table number IV. Although pH and hardness are different properties of water, they are closely linked. pH is a measure of the acidity and alkalinity of water, hardness is a measure of the dissolved minerals in the water. The two are closely linked because dissolved minerals tend to counter the effects of acids in the water (a process known as buffering), preventing the pH from dropping. In most cases, hard water usually has a high (alkaline) pH, while soft water has a low pH.

## DISCUSSION

Groundwater is an important natural resource which can be used for many purposes like industrial, irrigation and domestic uses (11). But in recent years, the quality of ground water has been deteriorated due to its overexploitation which poses serious health threats to human. According to World Health Organisation (WHO) report 80% of human diseases are caused by the poor water quality (12). Thus regular water quality monitoring is necessary (13). Water quality evaluation by physico-chemical analysis of water samples is a valuable tool to determine the quality of water for drinking and agricultural purposes (14-16). Various countries have drinking water quality standards according the economic, geographical and climatic conditions of the country. In India, BIS has prescribed the water quality standards. The samples exceeded these limits require urgent attention and treatment facility (17-18).

In the present study, majority of the water samples were found to be beyond the permissible limits. This revealed that the ground water quality in study area has been deteriorated. The overall physico-chemical studies conducted in area shows that the water samples are unfit for drinking purposes. Among the different parameters hardness, magnesium, fluoride and calcium exceeded the permissible limits in most of the samples. High level of fluoride in water is a major concern.

## CONCLUSION

The rapid increase in urbanisation and industrialization has contaminated the fresh water resources. The harmful chemicals present in drinking water enter into human and causes serious threat to health. The analysis reveals that the groundwater of the study area needs treatment before consumption and it also needs to be protected from the sources of water contamination.

**Table 1. Methods used for the testing of physico-chemical parameters**

| S.No | Parameters | Method |
|---|---|---|
| 1. | Turbidity | Nephelometric method |
| 2. | Acidity | Titration method |
| 3. | Alkalinity | Titration method |
| 4. | Hardness | EDTA titrimetric method |
| 5. | Conductivity | Conductivity method |
| 6. | Total Dissolve Solids (TDS) | Gravimetric method |
| 7. | Calcium (Ca) | EDTA titrimetric method |
| 8. | Magnesium (Mg) | Calculation method |
| 9. | Potassium (K) | Flame Photometric method |
| 10. | Sodium (Na) | Flame Photometric method |
| 11. | Chloride ($Cl^-$) | Argentometric method |
| 12. | Fluoride ( $F^-$) | SPADNS method |
| 13. | pH value | Electrometric method |
| 14. | Phosphate ( $PO_4^{3-}$) | Stannous Chloride method |
| 15. | Sulphate ( $SO_4^{2-}$) | Turbidimetric method |

**Table 2. Drinking water standards provided by Bureau of Indian Standards (BIS, 2012)**

| S.No | Parameter | Requirement | Permissible limit in the absence of alternate source |
|---|---|---|---|
| 1. | Acidity | - | - |
| 2. | Ca(mg/L) | 75 | 200 |
| 3. | $Cl^-$ (mg/L) | 250 | 1000 |
| 4. | Conductivity (μS) | - | - |
| 5. | $F^-$ (mg/L) | 1 | 1.5 |
| 6. | K | - | - |
| 7. | Mg (mg/L) | 30 | 100 |
| 8. | Na (mg/L) | - | - |
| 9. | pH | 6.5-8.5 | No relaxation |
| 10. | $PO_4^{3-}$(mg/L) | - | - |
| 11. | $SO_4^{2-}$ (mg/L) | 200 | 400 |
| 12. | Alkalinity {Calcium carbonate} [Alk (mg/L)] | 200 | 600 |
| 13. | Total Hardness ($CaCO_3$) (mg/L) | 200 | 600 |
| 14. | TDS (ppm) | 500 | 2000 |
| 15. | Turbidity (NTU) | 1 | 5 |

**Table 3: Results given as Mean ±Standard Deviation**

| Sample No | Acidity | Ca (mg/L) | $Cl^-$ (mg/L) | Conductivity (µS) | $F^-$ (µg/L) | K (mg/L) | Mg (mg/L) | Na (mg/L) |
|---|---|---|---|---|---|---|---|---|
| 1[a] | 252.7 ±0.57 | *104.7 ±2.08 | 227.7 ±0.57 | 1.90 | *3.10 | 21.52 | *243.4 ±0.71 | 135.5 |
| 2[b] | 307.9± 0.31 | *76.43± 0.40 | 209.0± 6.08 | 1.99 | *2.30 | 28.34 | *165.9± 0.82 | 143.6 |
| 3[a] | 192.7± 2.52 | *84.47± 0.41 | 66.00± 2.64 | 1.13 | *1.65 | 26.29 | *158.9± 0.88 | 216.1 |
| 4[b] | 201.0± 1.00 | *44.73± 1.41 | 153.0± 3.00 | 1.54 | *3.40 | 23.70 | *201.4± 0.54 | 195.4 |
| 5[a] | 170.2± 0.27 | *78.97± 0.89 | 126.2± 2.00 | 1.42 | 1.35 | 19.56 | *175.4± 0.62 | 189.7 |
| 6[a] | 214.6± 0.56 | *53.40± 2.42 | 236.7± 1.52 | 1.00 | 1.49 | 14.04 | *212.5± 0.45 | 157.8 |
| 7[a] | 122.6± 0.55 | *164.5± 2.73 | 121.0± 1.00 | 1.59 | *3.35 | 17.97 | *138.9± 0.55 | 175.4 |
| 8[b] | 184.7± 0.57 | *98.67± 3.05 | 76.67± 1.15 | 1.31 | *3.33 | 20.71 | *144.4± 0.44 | 193.8 |
| 9[b] | 217.7± 2.08 | *81.63± 0.83 | 51.00± 1.73 | 1.19 | *3.40 | 22.23 | *102.5± 0.46 | 198.5 |
| 10[a] | 204.1± 0.10 | *66.03± 0.23 | 127.7± 0.57 | 1.64 | *3.10 | 20.26 | *167.8± 0.76 | 165.1 |
| 11[a] | 212.3± 0.34 | *105.7± 1.60 | 80.00± 4.00 | 1.42 | *3.30 | 21.39 | *314.2± 0.75 | 164.1 |
| 12[b] | 367.5± 0.41 | 80.00± 1.60 | 220.0± 2.00 | 1.81 | *1.60 | 22.84 | *312.5± 0.49 | 141.1 |
| 13[a] | 138.4± 0.46 | *83.20± 2.44 | 126.7± 4.16 | 1.90 | 1.30 | 22.63 | *287.2± 0.52 | 139.7 |
| 14[a] | 217.5± 0.50 | *108.3± 3.20 | 134.7± 5.77 | 1.00 | 1.15 | 19.55 | *287.0± 0.97 | 132.6 |
| 15[b] | 166.3± 1.46 | *94.40± 0.92 | 243.3± 4.46 | 1.89 | 1.00 | 19.16 | *247±1.00 | 141.3 |
| 16[a] | 197.8±0.32 | *131.7±2.44 | 146.7±4.16 | 1.54 | *3.10 | 16.39 | *286.2±1.42 | 163.7 |
| 17[a] | 142.7± 0.58 | *106.1± 1.60 | 110.0± 10.00 | 1.00 | *1.80 | 18.56 | *258.7 | 184.2 |
| 18[a] | 198.0± 0.79 | *92.80± 0.92 | 86.67± 3.05 | 1.11 | *2.60 | 19.53 | *275.3± 0.53 | 183.5 |
| 19[a] | 185.8± 0.32 | *213.9± 0.92 | 108.7± 3.05 | 1.25 | *3.15 | 21.96 | *312.9± 1.00 | 173.6 |
| 20[a] | 187.0±1.73 | *290.7±2.08 | 112.7±1.15 | 1.34 | *2.10 | 16.27 | *301.7±1.12 | 176.0 |

**[a] indicates the samples from submersible pump.**
**[b] indicates the samples from hand pump.**
*** indicates the samples exceeding permissible limits.**

**Table 4: Results given as Mean ±Standard Deviation**

| Sample no. | pH | $PO_4^{3-}$ (mg/L) | $SO_4^{2-}$ (mg/L) | Total Alkalinity | Total Hardness | TDS (ppm) | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|
| 1 | 7.30 | 0.042 | 0.750 | *252.7 ±3.05 | 296.7 ±1.52 | *1140 | 0.50 |
| 2 | 7.34 | 0.029 | 0.220 | *232.7± 1.15 | 225.3± 2.08 | *1194 | *10.80 |
| 3 | 7.42 | 0.022 | 0.012 | 182.6± 0.50 | 191.3± 1.52 | *678 | *8.10 |
| 4 | 7.29 | 0.031 | 0.060 | 200.6± 0.51 | 257.3± 1.52 | *924 | *16.00 |
| 5 | 7.36 | 0.042 | 0.050 | 186.5± 0.50 | 212.0± 1.00 | *852 | *9.50 |
| 6 | 7.28 | 0.250 | 0.420 | *222.7± 1.15 | *326.7± 0.57 | *600 | 0.50 |
| 7 | 7.39 | 0.026 | 0.750 | *228.0± 0.99 | 206.3± 1.52 | *954 | 3.00 |
| 8 | 7.40 | 0.028 | 0.010 | 197.8± 0.78 | 203.3± 1.52 | *786 | 2.80 |
| 9 | 7.42 | 0.032 | 0.009 | 198.0± 0.05 | 147.0± 2.64 | *714 | 2.70 |
| 10 | 7.31 | 1.480 | 0.026 | *210.4± 0.43 | *372.3± 2.00 | *984 | *17.70 |
| 11 | 6.77 | 0.150 | 0.130 | *247.9± 0.17 | *370.7± 2.30 | *852 | 1.92 |
| 12 | 6.78 | 0.230 | 0.320 | 185.3± 1.52 | *364.0± 2.00 | 106 | *19.20 |
| 13 | 6.75 | 0.290 | 0.380 | 186.1± 0.11 | *351.3± 2.30 | *1140 | 1.84 |
| 14 | 6.80 | 0.009 | 0.002 | *232.2± 0.72 | *342.0± 2.00 | *600 | *18.00 |
| 15 | 7.31 | 0.230 | 0.320 | 186.0± 1.00 | *360.0± 2.00 | *1134 | *22.20 |
| 16 | 6.87 | 0.020 | 0.012 | 186.3± 0.46 | *321.7± 1.52 | *924 | 1.84 |
| 17 | 7.05 | 0.058 | 0.057 | *221.0± 0.93 | *343.3± 1.52 | *600 | *19.10 |
| 18 | 6.83 | 0.070 | 0.057 | 190.2± 0.74 | *347.3± 1.15 | *666 | *18.90 |
| 19 | 6.70 | 0.120 | 0.150 | 188.1± 0.11 | *355.7± 1.15 | *750 | 1.93 |
| 20 | 6.80 | 0.160 | 0.190 | 172.3±1.15 | *323.3±2.08 | *804 | 1.89 |

**Table 5: Correlation analysis**

| | Acidity | Ca | $Cl^-$ | EC | $F^-$ | K | Mg | Na | pH | $PO_4^{3-}$ | $SO_4^{2-}$ | Alk | TH | TDS | Turibidity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acidity | 1 | | | | | | | | | | | | | | |
| Ca | -.245 | 1 | | | | | | | | | | | | | |
| $Cl^-$ | **.446*** | -.226 | 1 | | | | | | | | | | | | |
| EC | .306 | -.122 | **.539*** | 1 | | | | | | | | | | | |
| $F^-$ | -.020 | .135 | -.372 | .035 | 1 | | | | | | | | | | |
| K | .412 | -.327 | -.094 | .373 | .092 | 1 | | | | | | | | | |
| Mg | .129 | .378 | .193 | .020 | -.261 | -.236 | 1 | | | | | | | | |
| Na | -.376 | .036 | **-.712**** | **-.536*** | .344 | .074 | **-.492*** | 1 | | | | | | | |
| pH | -.091 | -.432 | .091 | .098 | .144 | .176 | **-.917**** | .366 | 1 | | | | | | |
| $PO_4^{3-}$ | .017 | -.160 | .073 | .204 | .054 | -.087 | -.073 | -.159 | .053 | 1 | | | | | |
| $SO_4^{2-}$ | .029 | .119 | .550* | .488* | -.004 | -.137 | .027 | -.482* | .123 | -.080 | 1 | | | | |
| Alk | .159 | -.238 | .219 | .057 | .244 | .050 | -.082 | -.372 | .162 | -.018 | .390 | 1 | | | |
| TH | .073 | .142 | .325 | .083 | -.261 | -.333 | **.837**** | **-.584**** | **-.724**** | .404 | .051 | .037 | 1 | | |
| TDS | -.358 | .005 | .138 | **.554*** | .205 | .157 | -.231 | -.186 | .313 | .118 | .271 | .216 | -.126 | 1 | |
| Turbidity | .178 | -.363 | .208 | .025 | -.385 | .147 | .088 | -.111 | -.008 | .244 | -.306 | -.112 | .304 | -.243 | 1 |

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