A study of groundwater quality of Ambala city and Ambala Cantonment area, Haryana, India

Ritu Sarsoha, Madhuri, S. Rishi and Naval Kishore*

Dept. of Environment Studies, Dept. of Geology*

Panjab University, Chandigarh

Email: madhuririshi@gmail.com

Abstract: *Groundwater is an essential commodity for the survival of human race. Urbanization coupled with population and industrialization has caused incomplete interaction between various flow compartments of the aquifer. Drinking water is an internationally accepted human right (WHO, 2001),and has been enlisted as one of the ten targets in the Millennium Development Goals (MDGs).In the present study, the physicochemical characteristics of groundwater of Ambala city and Ambala cantonment area were assessed for its suitability for drinking purpose. The water samples were collected from deep aquifer based tube wells and shallow aquifer based hand pumps from different parts of Ambala city and Ambala Cantonment area. In order to assess the ground water quality, the water samples were analyzed for different physicochemical parameters, e.g., pH, electrical conductivity (EC), total dissolved solids (TDS), calcium, magnesium, total hardness (TH), sodium, potassium, carbonate, bicarbonate, chloride, fluoride , nitrate, sulphate and phosphate concentrations. The results were compared with the standards prescribed by World Health Organization (WHO) and Bureau of Indian Standard (BIS). pH value at several locations shows that the ground water of the study area is alkaline in nature. Except at some locations, other physiochemical parameters in the entire area were found to be in the prescribed permissible limit.*

Keywords**:** *Drinking water, fluoride, De-ionized Water, WHO, BIS, Physicochemical*

1. Introduction

Earth is known as "Blue Planet" as 74% of the earth's surface is covered with water, yet when it comes to availability of freshwater for human use it becomes a scarce resource. Groundwater is the main source of drinking water for more than 98% of the population in Haryana, India. Being a basic need of human development, health and wellbeing, safe drinking water is an internationally accepted human right (WHO, 2001), which has been enlisted as one of the ten targets in the Millennium Development Goals (MDGs) [6].As a decentralized source of drinking water and myriads of other services for millions of rural and urban families, groundwater as a natural resource plays a crucial role which, accounts for nearly 80 per cent of the rural domestic water needs, and 50 per cent of the urban water needs in India [13].Today Groundwater has become much vulnerable to contamination due to population explosion and industrialization. Endemic fluorosis has become a common problem in many parts of Haryana. [10]. [12] studied the groundwater quality in some parts of Haryana including Hisar, the areas of Fridabad and Rohtak were studied [13].) ,the water quality of Jind region was studied by Meenakshi *et al., (*2004), and it was found that the water quality in the villages of Jind district contains fluoride content above permissible limits. Therefore, the primary objective of this investigation is to find out the physicochemical parameters in deep aquifer based tube wells and shallow aquifer based hand-pump water in order to explore their suitability for human consumption and domestic use by the Ambala city and Ambala Cantonment population. Ambala district of Haryana lies between 30° 10'31° 35' N latitudes and 76° 30' 77° 10' E longitudes. Total geographical area of the district is around 1574 km2 . The district area falls in the Yamuna sub basin of Ganga basin and is mainly drained by three nonperennial streams such as The Markanda & its tributaries, The Dangri (Tangri) & its tributaries and The Ghagghar & its tributaries. The ground water exploration revealed the presence of three aquifer groups down to a depth of 450 meters comprising fine to medium grained sand, clay, silt and kankar with occasional gravel. The height from the sea level is 900 feet. The average gradient of the water table is of the order of 1m/km. The overall flow of ground water is from northeast to southwest direction. The administration has constructed tube wells of varying depths ranging from 175m to 400m for drinking water supply to Ambala city and Ambala Cantonment.

2. Materials and Methods

2.1 Sample Collection

Total 45 ground water samples were collected, from deep aquifer based tube wells and shallow aquifer based hand-pumps covering the entire (Ambala City and Ambala cantonment) area, from 45 different locations. Water samples were collected directly from the tube wells and hand-pumps after running the water for about 10-15 minutes. Samples were collected in May 2011, during pre monsoon period. Water samples were collected in precleaned, sterilized, polyethylene bottles of one liter capacity. The first sample was collected from the tube well of Alaxandra road and the last sampling was done from the tube well of Satsang Bhawan, Ambala Cantonment.

2.2 Method of Analysis

The water samples were analyzed at the Chemical Laboratory of Advanced Centre for Geology at Panjab University, Chandigarh. The water samples were analyzed for pH, electrical conductivity (EC), dissolved solids (TDS), total calcium (Ca 2+), magnesium (Mg 2+), total hardness (TH), sodium (Na +), potassium (K+), chloride (Cl -), fluoride (F) and sulphate ($SO4^{2}$),nitrate(NO3-) and phosphate(PO4-). All the reagents used in the present study were of analytical reagent grade and deionized water was used for experimental purpose. All the precautions were taken as given in APHA, AWWA, WPCF (2003), for sampling and analysis. The details of the sampling sites and results are presented in Table 1and Table 2.

Table1: Sampling locations of Ambala City and Ambala Cantonment Area

Sample No.	Sampling Locations	Sample No.	Sampling Locations
1	Alaxandra Road	24	Gandhi Ground
2	Railway Road	25	Model Town
3	Bus Stand	26	Kalka Mod
4	Indira Park	27	Sector-1
5	Mata Mandir	28	Sector 10
6	Subhash Nagar	29	District Court
7	Mahesh Nagar	30	Manav Chowk
8	Shyam Nagar	31	Sector-8
9	MES	32	Baldev Nagar
10	Babiyal 3	33	Police Lines Chowk H.P.
11	Mall Road	34	Police Lines
12	Subhash Park	35	ITI Chowk
13	Housing Board	36	Jail Campus
14	PWD Office	37	Sector-10 H.P.
15	Dayal Bagh	38	Near Curch
16	Babiyal Village	39	Kapda Market
17	Baldev Nagar	40	Sector-8
18	Patel Park	41	Peer Baba
19	Guru Nanak Marg	42	PWD Office
20	Dalipgarh	43	Sector-1
21	New Grain Market	44	Manmohan Nagar
22	Baldev Nagar	45	Inside Satsang Bhawan
23	Supply Depot		

Table 2: Comparison of water quality parameters of groundwater of Ambala Cantonment Area and Ambala City with drinking water quality standard (Indian and WHO)

Parameters	Range of samples		BIS Standards		WHO Limit
	Minimum	Maximum	Acceptable limit	Maximum limit	
pH	7.0	9.8	6.5-8.5	6.5-9.2	6.5-9.2
EC	192	3724	300	-	-
TDS	121	1556	500	2000	500
TH	28	560	300	600	100
Na^{+}	3.4	431.1	50	-	-
K^{+}	0.8	108.0	-	-	-
Ca^{+2}	4.2	227.1	75	200	75
Mg^{+2}	1.7	129.7	30	100	150
CO_3^{-}	0.0	175.0	75	200	75
HCO_3^{-}	0.0	1000	30	-	-
Cl^{-}	21.3	582.2	200	1000	200
F^{-}	.25	1.5	1.0	1.5	1
SO_4^{2-}	10.7	28.47	200	400	200
NO_3^{-}	0	9.64	45	-	-
PO_4^{-}	0	0.7	-	-	-

*Units of all the parameter are in mg/l except EC (µS cm 1) and pH.

3. Results and Discussion

Hydrogen Ion Activity (pH)

pH is a term used to express the intensity of acidic or alkaline conditions. It is the expression of hydrogen ion concentration, more precisely, the hydrogen ion activity. pH is an important parameter in assessing the water quality. Acidic conditions will prevail as pH value decreases and alkaline conditions will prevail as the pH value increases. The BIS limit for drinking water is 7.0-8.5 shown in Table 2. pH value in analyzed water samples varied from 7 to 9.8 .The low pH does not cause any harmful effect (Boominathan and Khan, 1994). The highest value was observed at location no. 38. The results show that groundwater of the study area is slightly alkaline in nature.

Electrical Conductivity (EC)

The ability of a solution to conduct an electrical current is governed by the migration of solutions and is dependent on the nature and numbers of the ionic species in that solution. This property is called electrical conductivity. It is a useful tool to assess the purity of water. The permissible limit for electrical conductivity (EC) is 300 µS cm 1. EC of the collected samples ranged from 192 to 3724 µS cm.

3.3 Total Dissolve Salts (TDS)

The electrical conductivity of water samples correlates with the concentration of dissolved minerals or with what is commonly known as the total dissolved salts of water samples. The acceptable range of TDS is 500 mg/l. The range of TDS of analyzed water samples during pre monsoon period varied between121 to 1556 mg/l . Out of total 45 samples 12 samples were found slightly saline while 33 of the samples were found non-saline as per the salinity classification (Table 3). So, it can be concluded that in case of non-availability of any other water source, groundwater of studied areas is suitable for drinking purposes from salinity point of view.

Table 3: Classification of groundwater on the basis of salinity values (Robinove et al., 1958)

TDS (ppm)	**Description**	**No. of Samples**
<1000	Non-Saline	33
1000-3000	Slightly saline	12
3000-10,000	Moderately Saline	0
> 10,000	Very Saline	0
	Total	45

3.4 Calcium (Ca^{2+}) and Magnesium (Mg^{2+})

The calcium and magnesium are the most abundant elements in the groundwater. Calcium may dissolve readily from carbonate rocks and lime stones or be leached from soils. However, dissolved Mg^{2+} concentration is lower than Ca^{2+} in the groundwater. Other sources include primarily industrial and municipal discharges. Calcium is an essential nutritional element for human being and aids in maintaining the structure of plant cells and soils. Mg^{2+} is a constituent of bones and is essential for normal metabolism of Ca^{2+} . Its deficiency may lead to protein energy malnutrition.

The acceptable limits of Ca^{2+} and Mg^{2+} are 75 mg/l and 30 mg/l respectively. The estimated Ca^{2+} content from collected water samples ranged from 4.2 to 227.1 mg/l and Mg^{2+} concentration ranged from 1.7 to 129.7 mg/l as shown in Table 2. Only 2 percent of the total water samples showed Ca^{2+} concentration above the acceptable limit while in case of Mg^{2+} , all samples were below the acceptable limit. Higher concentration of Ca^{2+} was observed at location no. 10. Higher concentration of Mg 2+ was observed at location no.8, 10,11,18,20,23,24,28,29,30,34 and 37.

3.5 Total Hardness (TH)

In groundwater hardness is mainly contributed by bicarbonates, carbonates, sulphates and chlorides of calcium and magnesium. So, the principal hardness causing ions are calcium and magnesium. The acceptable limit of total hardness is 300-600. mg/l(BIS Standards). The hardness of analyzed water samples varied from 28 to 560 mg/l as CaCO3 during pre monsoon period .All of the samples were found within allowable limit. In ground water, in case of non-availability of alternate water source, Ca^{2+} and Mg^{2+} up to 200mg/l and 400mg/l respectively, can be accepted (Ministry of Rural Development, India). If these components are present in high concentration, than this leads to encrustation in water supply structure and adversely affect use of water. Durfor and Becker (1964) have classified water as soft, moderate, hard and very hard as given in Table 4. As per this classification most of the samples comes under moderate to hard category. On the basis of this classification it has been observed that no water samples are soft, 23% are moderately hard, 73% are hard in nature.

Table 4: Classification of water on the basis of total hardness [7]

Total Hardness (mg/l)	**Nature of water**
0-60	Soft
61-120	Moderate
121-180	Hard
>181	Very Hard

3.6 Sodium (Na^+) and Potassium (K^+)

Practically all sodium compounds are water soluble and tend to remain in aqueous solution. Water in contact with igneous rocks will dissolve sodium from its natural source. Higher concentration of Na + ion in drinking water may cause heart problems. Higher Na^+ ion in irrigation water may cause salinity problems. Excessive amount of Na^+ ion in groundwater normally affects the palatability of water. The permissible limit of sodium in drinking water as prescribed by BIS is 50 mg/l. The range of Na^+ ions in water samples varied from a minimum of 3.4 to 245.49 mg/l (concentration in excess of 200 mg/l give rise to unacceptable taste). At room temperature, the average tastes thresh Guideline sodium is about 200 mg/l. No health base guideline values have been prescribed (WHO, 2006). On comparison with BIS standards, Na + concentration of all samples was found to be high at locations 13, 17,32,33,34 and 41. Potassium is an important cation and plays a vital role in intermediately metabolism. K^+ is an essential nutrient for both plant and human life. However ingestion of excessive amounts may prove detrimental to human beings. The K^+ concentration of analyzed water samples was found to be within permissible limits except at location no. 19.

3.7 Carbonate ($CO3^-$) and Bicarbonate (HCO_3^-):

Carbonates and Bicarbonates in water are present mainly in association with Ca 2+ and Mg 2+ .The acceptable limit of CO3 2– and HCO3 – is 75 mg/l and 30 mg/l respectively. The carbonate content of analyzed water samples varied from 0 mg/l to 175 mg/l and HCO3 –content varied from 0 mg/l to 1000 mg/l as shown in Table 2.

3.9 Chloride (Cl^-)

Chloride is an anion found in variable amount in groundwater. Chloride may present naturally in groundwater and may also originate from diverse sources such as weathering, leaching of sedimentary rocks and infiltration of seawater etc. The maximum permissible limit of chloride in potable water is 250 mg/l. It produces salty taste at 250mg/l to 500mg/l (Trivedy and Goel, 1984). In the analyzed water samples, the concentration of chloride varied from 21.3 to 582.2 mg/l. The chloride content of the water sample when compared with BIS standard then it was found that all samples showed concentration within the permissible limit. More than 200 mg/l Cl – concentration was observed at location no.1,10,13,8,21,32,33,34,37,38,39.

Fluoride (F^-)

The sources of fluorides are mainly, industries of iron, steel production, petroleum refining and phosphate fertilizer. Higher concentration of fluoride causes bone and dental fluorosis. The BIS permissible limit for fluoride in groundwater is 1mg/l as given in Table 2. However, in temperate region this limit is 1.5 mg/l, where, water intake is low. Varied from permissible limit for F concentration is 1 mg/l according to WHO (2003). Fluoride concentration less than 0.8 mg/l leads to dental caries. Hence it is essential to maintain fluoride concentration between 0.8 to 1.0 mg/l in drinking water. The concentration of fluoride in groundwater samples varied from 0.25 to 1.5 mg/l . Fluoride concentration in all these samples found to be well within permissible limit. Khaiwal and Garg (2006) reported relatively high ranges of fluoride contamination, i.e., 0.03–16.6 mg l1 in groundwater of Hisar region of Haryana.

Sulphate (SO_4^{2-})

Sulphur in groundwater is normally present in sulphate form. Sulphate may enter into groundwater through weathering of sulphide bearing deposits. The acceptable limit of sulphate is 200 mg/l. The sulphate content in analyzed water samples varied from 10.7 to 28.4 mg/l as shown in Table 2. All the samples found to be well within permissible limit. High concentrations of fluoride (up to 46 mg/l) in villages of Haryana) in ground water has been reported [4]. Similar study in Kohdasht city of Lorestan, Iran showed water quality parameters were within the permissible limits of the WHO [9]. The water quality varies depend on type of soil, climate and human activities. Compare to other studies in another part of the world this water has good property for drinking. Study in Ghana, Africa showed low pH in some ground water sources [1].Luckily, with reference to analyzed parameters during this research, all harmful components for human health were in a good state.

Nitrate (NO_3^-)

The value of nitrate in all the groundwater sampling locations is found between 1-11.6. The acceptable limit of nitrate is 45 mg/l according to WHO. The presence of nitrate in groundwater may be due to leaching of nitrate with the percolating water. The contamination of groundwater may be due to sewage and other wastes rich in nitrates. Toxicity of nitrates in infants causes methaemoglobiaemia.

Phosphate (PO_4^{2-})

The value of phosphate in the groundwater samples lie between 0 to 0.7 mg/l. Highest value (0.7 mg/l) is recorded at location no. 7 and minimum value (0.01 mg/l) is recorded at location no. 1, 9 and 39. In this present study, the phosphate values are found within the permissible limit (0.1 mg/l) of WHO. Normally groundwater contains only a minimum phosphorus level because of the low solubility of native phosphate minerals and the ability of soils to retain phosphate. The phosphate values of all the groundwater samples do not pose any water quality problem.

Conclusion

The present study shows that ground water in Ambala city and Ambala cantonment area is alkaline in nature. The values of all the groundwater samples were compared with the standard permissible value. The pH values ranges from7.0 to 9.8 indicating that the ground water is neutral to alkaline (weak base type in nature). Specific conductivity is a measure of total dissolved solids present in water and it ranges from192 to 3724 micro/mhos at 250C which shows the presence of low chloride level .High value of sodium were observed at some of the locations. The phosphate, nitrate and sulphate values were found within the permissible limit. Groundwater is the only potable source in many areas of Ambala city and Ambala cantonment area Thus the ground water of the area is well within the permissible limits set by the BIS: 10500: 1991 and is categorized as fresh and is suitable for domestic /drinking purpose. It may be said that water in Ambala is though fit for domestic and drinking purposes but need treatment to minimize the contamination especially alkalinity. Thus it is suggested to monitor and assess the groundwater quality periodically in this study area due to increase in population and industrialization.

References

[1] O. Akoto and J. Adiyiah,"Chemical analysis of drinking water from some communities in the Brong Ahafo region", International Journal of Environmental Science and Technology, 4(2), pp 211-214,(2007).

[2] O.V. Akpoveta B.E. Okoh and S.A. Osakwe, "Quality assessment of borehole water used in the vicinities of Benin, Edo State and Agbor, Delta State of Nigeria", Current Research in Chemistry, 3, pp 62-69,(2011).

[3] APHA, AWWA, WPCF, "Standard Methods for Examination of Water and Wastewater", 20th Edition, American Public Health Association, Washington, DC (2003).

[4] R. Boominathan, and S.M. Khan, "Effect of distillery effluents on pH, dissolved oxygen and phosphate content in Uyyakundan channel water", Environmental Ecology, 12 (4), pp 850-853(1994)

.

[5] Central Ground Water Board Report: Our vision" water security through ground water management", pp1-17,(2007)

.

[6] R. Chadetrik, A. Sharma, "Assessment of drinking water quality: A case study of Ambala cantonment area, Haryana, India" ,International Journal of Environmental Sciences Volume 2, No 2, pp 933-945,(2011).

[7] C.N. Durfor, and E. Becker, "Public water supplies of the 100 largest cities in the United States", In Geological Survey Water Supply, U.S. Government Printing Office, Washington, Paper No. 1812, pp. 364(1964).

[8] M.J Islam, S.M.H Uddin, Zaman,., M.W Mahmood. and M.S. Rahman, "Toxicity assessment of ground water in different aquifers of Khagrachari in Bangladesh", Asian Journal of Plant Science, 2, pp 257-260,(2003).

[9] A. Jafari, H.Mirhossaini, B. Kamareii, S. Dehestani, "Physicochemical analysis of drinking water in kohdasht city lorestan, Iran", Asian Journal of Applied Science, 1, pp 87-92,(2008).

[10] A .Kaushik, K. Kumar, Kanchan, Taruna, H.R. Sharma, "Water quality index and suitability assessment of urban ground water of Hisar and Panipat in Haryana", Journal of Environmental Biology, 23, pp 325-333,(2002).

[11] A. Kaushik, K .Kumar, I.S. Sharma, H.R .Sharma, "Groundwater quality assessment in different land use areas of Faridabad and Rohtak cities of Haryana using deviation index", Journal of Environmental Biology, 25(2), pp 173-180,(2004).

[12] R. Khaiwal, and V.K. Garg, "Distribution of fluoride in groundwater and its suitability assessment for drinking purposes", International Journal of Environmental Health Research, 16, pp 163–166 (2006).

[13] R. Kumar, R.D. Singh, K.D.Sharma, "Water Resources of India", Current Science, 89(5), pp 794-811,(2005).

[14] M. Garg, V.K., Kavita, Renuka, A Malik, "Groundwater quality in some villages of Haryana, India: focus on fluoride and fluorosis", Journal of Hazardous Material, 106B, pp 85–97,(2004).

[15] M. Hanipha Mohamed, A. Hussain Zahir, Study of Groundwater Quality at Dindigul Town, Tamilnadu, India, International Research Journal of Environment Sciences,Vol. 2(1), 68-73,(2013).

[16] P.Singh, J.P.Saharan. K. Sharma, S. Saharan, Physio-Chemical & EDXRF Analysis of Groundwater of Ambala, Haryana, India Researcher pp. 68-75,(2010).