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An analysis of water quality by using WQI method for domestic use in shallow and deep aquifers of Ambala city and Ambala cantonment, Haryana, India

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Abstract
Water is not only the very necessity of our life but it is the cradle of life on the earth. Bearing the title of "Blue Planet" the inhabitants of earth should be entitled to no scarcity of this very basic element, but still, the earth cries for more water to fulfill the ever increasing need and greed of its people. Not only the scarcity, but the quality of water is also an important aspect of a better quality of life. All these factors i.e. industrialization, urbanization and population explosion, are inter-related, where one problem leads to another. All these are not only leading to over exploitation but also causing contamination of ground water resource. In the present paper we are trying to ascertain the quality of water in an urbanized area which is very near to the state capital. Study area which includes two major cities of Haryana i.e. Ambala City and Ambala Cantonment, a study was made to determine the water quality in the area. Results from most of the sampling locations indicate towards a good quality of water in both cities.

Keywords: Water quality index, urbanization, groundwater, aquifer

Introduction

The Indian scriptures attach great importance to the rivers and water bodies. One of the hymns in the Atharvaveda is as follows:

"May the waters of desert be for our well-being; also for well-being the waters of the low lands. May the waters dug out from earth be for our well-being; also be beneficial for us (joy-giving to us)". The quality of groundwater varies from place to place depending upon the seasonal changes and depth to water table. The chemical composition of groundwater has been changing continuously due to its dynamic nature. It is primarily governed by the extent and composition of dissolved solids present in it. Groundwater quality depends on number of complex processes inter-related with hydro geological, environmental and anthropogenic activities. According to Rao and Abbulu (2013) [1], high concentrations of hardness, sulphates and calcium observed in the groundwater in Duvvada, may be attributed to the increased usage of groundwater for domestic and industrial purposes as well as the degradation of its quality due to the improper disposal of industrial wastes. Recharge to the groundwater is dominantly dependent upon precipitation and it begins to interact with various chemical constituents present in the soil, there by altering the quality of the groundwater. A positive correlation between urbanization and high levels of pH, nitrate and faecal coliform in the sub surface water of Calabar town, Nigeria was found (Devalsam *et al*. 2011) [2]. The quality of the groundwater varies with depth of the aquifer and its proximity to the canals. In addition, rainfall distribution influences the hydrochemical nature of the groundwater. A detailed data has been acquired from field as well as laboratory investigation keeping in view the established and standard parameters of the water quality. Suitability of the groundwater for different purposes is a matter of discussion and makes a good theme of the present investigations.

Description of study area

Ambala is a city and a municipal corporation in Ambala district in the state of Haryana, India, located on the border to the state of Punjab. Politically, Ambala has two sub-areas: Ambala Cantonment (Ambala Cantt) and Ambala City, approximately 3 kilometers apart from each other, therefore it is also known as "Twin City".

Methodology

For performing the present study, a systematic, well tested and technically sound methodology was adopted. The field and laboratory investigations carried out for the present study are discussed below.

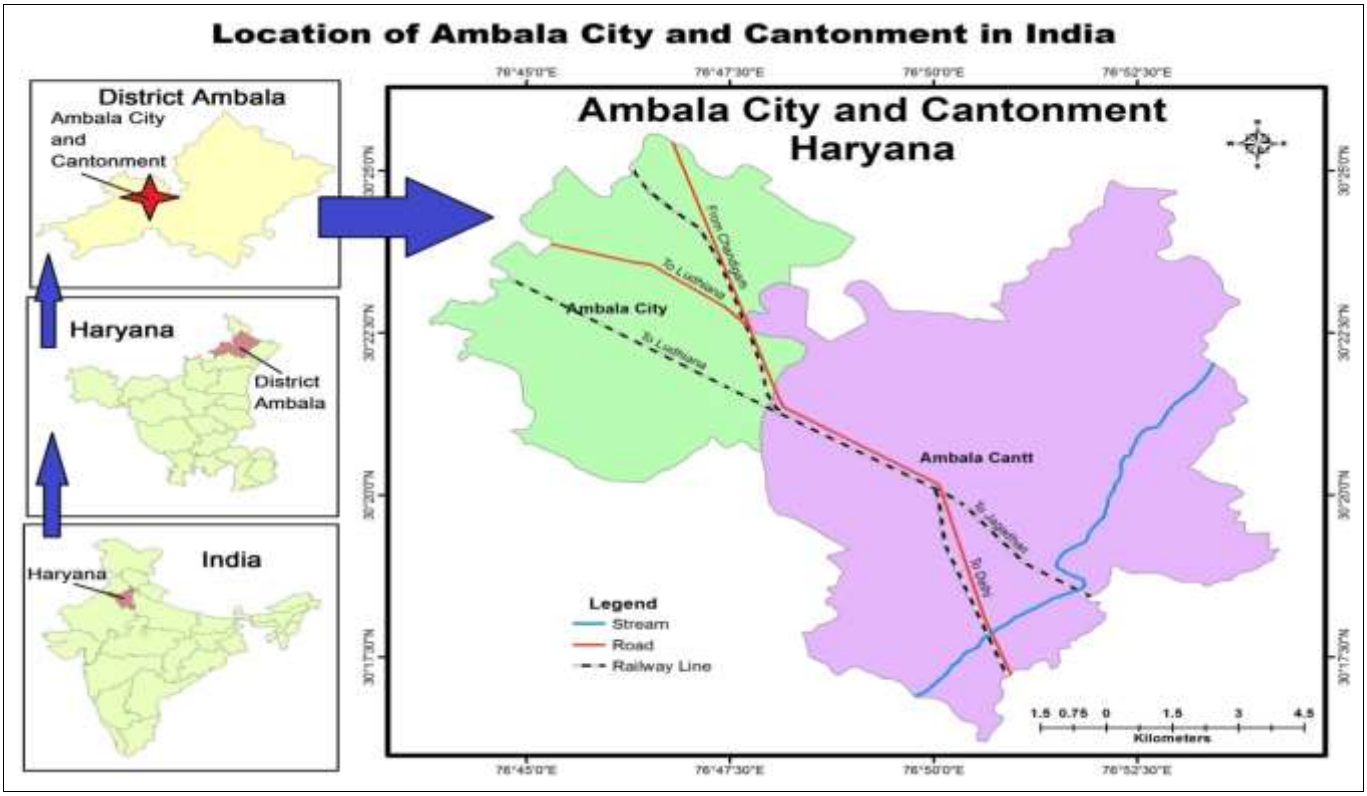

Fig 1: Base map of Study Area

Field Investigations

Reconnaissance survey of the area was carried out to get familiarize with the research area and to collect the preliminary baseline data pertaining to groundwater resources and meteorological parameters.

- A systematic random sampling was done to collect the groundwater samples from the area selected. The locations of the groundwater samples are shown in Fig 4.1.
- Water samples were then collected in hard polythene bottles of two litre capacity, which were thoroughly rinsed with distilled water to ensure compositional originality of water samples from hand pumps (HP) and tube wells (TW) in the months of May (pre monsoon) and October (post monsoon), 2014 and 2015.
- A total of 61 samples were collected from different locations from the Ambala city and Ambala Cantonment area.
- To ensure that the representative water samples were collected from the respective aquifer, tube wells and hand pumps were initially pumped for 10-15 minutes so that the water in contact with the metallic well casing could be removed.
- The sampling bottles were washed and rinsed three times with the water samples and thereafter, filled to the capacity, sealed and labeled accordingly.
- The physical parameters like temperature, pH, electrical conductivity (EC) and total dissolved solids (TDS) were measured in the field with the help of soil and water analysis kit. To ensure accuracy in the data the values were repeated thrice and mean value was taken in case of variation.

Sample collection and digital data base creation

The sites of water sources from where water samples were collected in terms of latitude and longitude were used for generating point location map, using MapInfo Professional 6.5 (Fig. 2). Each source of water sample was assigned with the serial number and structured field data was linked to their respective locations. The sites marked by A1 to A30, C1 to C31 in the figure 2 are the sampling sites in Ambala City, Ambala Cantonment respectively.

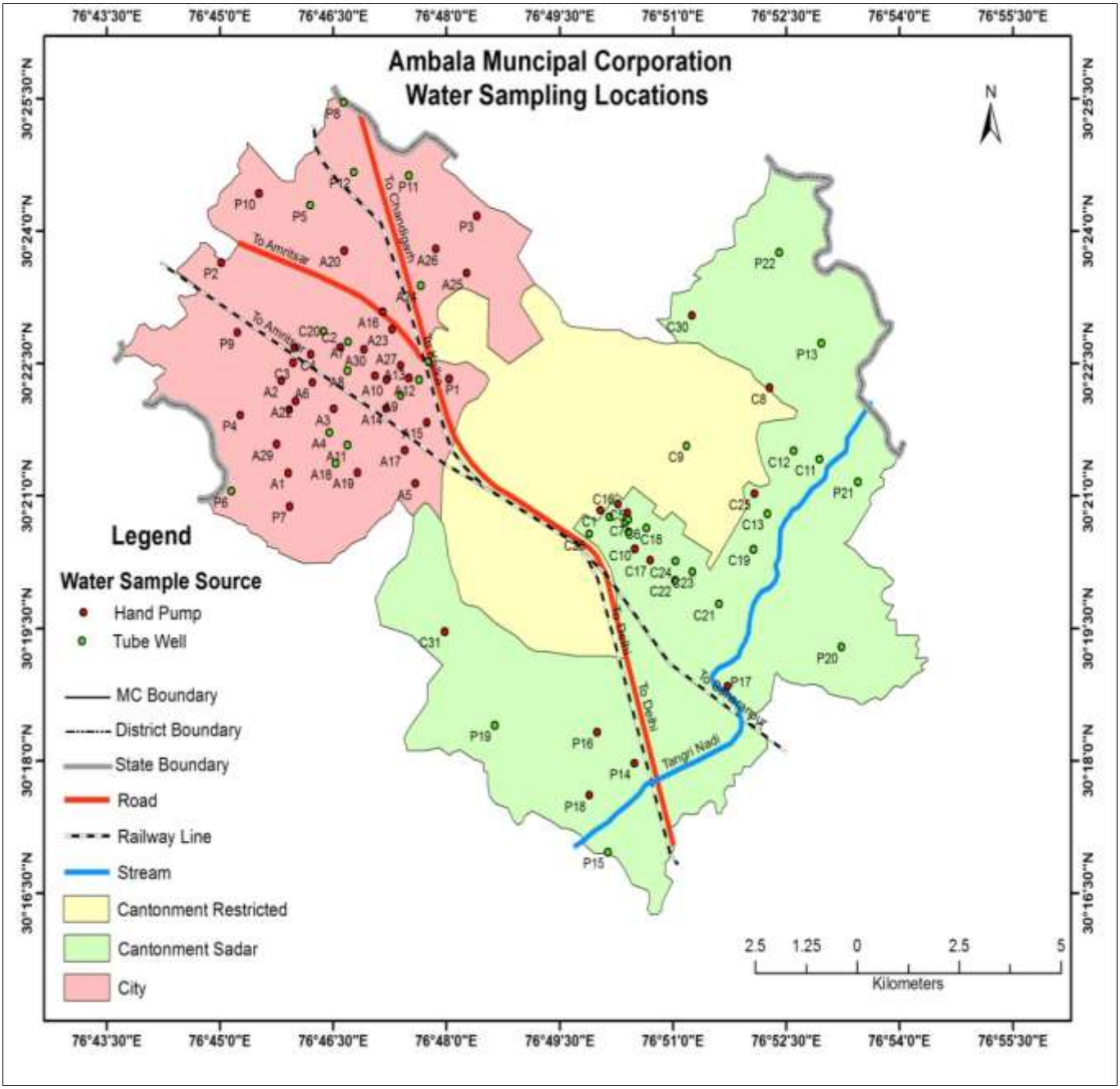

Fig 2: Location of sampling points in the study area

Laboratory Investigations

The water samples so collected were analyzed in the geochemical laboratory of the Department of Geology, Panjab University, Chandigarh according to the standard methodology outlined by APHA, 2005. The analytical methods used and their description is briefly stated in Table 1.

Results and Discussion

Water Quality Index (WQI) provides a comprehensive picture of the quality of groundwater for most domestic uses. WQI is defined as a rating which reflects the composite influence of different water quality parameters (Sahu and Sikdar, 2008) [3]. It involves three steps to compute the WQI of a water sample. In the first step, each of the chemical parameters is assigned a weight (w_i) based on their perceived effects on primary health (Table 1). The highest weight of five was assigned to parameters, which have the major effects on the quality of water.

The second step involved computing the relative weight (W_i) of each parameter using the formula:

$$W_i = w_i / \sum_{i=0}^{n} wi$$

Where, W_i is the relative weight

w_i is the weight of each parameter

n is the number of parameters. Calculated relative weight (W_i) values of each parameter are given in Table 2. In the third step, a quality rating scale (q_i) for each parameter is assigned by dividing its concentration in each water sample by its respective standard according to the guidelines laid down in the BIS 10500 (2012) and the result is multiplied by 100:

$q_i = (C_i/S_i) \times 100$

Where q_i is the quality rating,
C_i is the concentration of each chemical parameter in each water sample in mg/l
S_i is the Indian drinking water standard for each chemical parameter in mg/l according to the guidelines of the BIS 10500(2012).
For computing the WQI, the sub index (SI) is first determined for each chemical parameter, which is then used to determine the WQI as per the following equation:

$SI_i = W_i x\ q_i$

$WQI = \sum_{i=0}^{n} SIi$

Where,
SI_i is the sub-index of i th parameter
q_i is the rating based on concentration of i th parameter
n is the number of parameters
Water quality types, were determined on the basis of WQI (Table 4.12).

Table 1: Relative weights of chemical parameter

Chemical Parameters	BIS Standards(mg/l)	Weight W_i	Relative weight $W_i = \frac{wi}{\sum_{i=1}^{n} wi}$
Total dissolved solids	500	5	0.15625
Bicarbonates	600	1	0.15625
Chloride	250	5	0.15625
Sulphate	200	5	0.15625
Nitrate	45	5	0.15625
Fluoride	1	5	0.093
Calcium	75	3	0.03125
Magnesium	30	3	0.093
		∑wi= 32	∑wi =0.09985

Table 2: Water quality range and category

Range	Categories
<50	Excellent water
50-100	Good water
100-200	Poor water
200-300	Very Poor water
>300	Water unsuitable for drinking purpose

(Source: CCME, 2005)

Table 3: Calculation of WQI for individual water samples, Ambala City

S. No.	Location	WQI	Category
A1	Satsang Bhawan	112.9771	Poor Water
A2	District Court	63.14144	Good Water
A3	Sector 8	68.65049	Good Water
A4	Sector 8	54.1927	Good Water
A5	Patel Nagar	60.17798	Good Water
A6	New Grain Market	54.14886	Good Water
A7	ITI Chowk	22.52194	Excellent Water
A8	Peer Baba, Sector 7	47.007	Excellent Water
A9	Sector 1	40.33197	Excellent Water
A10	Sector-1	74.32127	Good Water
A11	Sector 9	53.78716	Good Water
A12	Jail Campus	48.18515	Excellent Water
A13	Jail Campus	47.6572	Excellent Water
A14	Prem Nagar	50.7611	Good Water
A15	Model Town	32.78704	Excellent Water
A16	Kalka Modd	45.18659	Excellent Water
A17	Laxmi Nagar	57.18852	Good Water
A18	Sector 10	43.44654	Excellent Water
A19	Sector 10	76.40864	Good Water
A20	Manmohan Nagar	76.6759	Good Water
A21	Kapda Market	58.18782	Good Water
A22	Manav Chowk	43.64364	Excellent Water
A23	Near Church	40.19191	Excellent Water
A24	Baldev Nagar	38.05468	Excellent Water
A25	Baldev nagar	63.51911	Good Water
A26	Baldev Nagar	68.80343	Good Water
A27	Police Lines Chowk	71.94438	Good Water
A28	Police Lines Chowk	61.96559	Good Water
A29	Durga Nagar	75.24881	Good Water
A30	Civil Hospital	52.20019	Good Water

Table 4: Calculation of WQI for individual water samples, Ambala Cantonment

S. No.	Location	WQI	Category
C1	Ram Nagar Colony	76.70505	Good Water
C2	Alaxandra road	53.61055	Good Water
C3	Railway Road	92.55575	Good Water
C4	Bus stand	57.3595	Good Water
C5	BC Bazar	68.57398	Good Water
C6	Gandhi Ground	61.15447	Good Water
C7	Rangia Mandi	52.84712	Good Water

C8	Anand Nagar	75.75917	Good Water
C9	Patel Park	38.30444	Excellent Water
C10	Dalipgarh	62.69949	Good Water
C11	Babiyal	59.3197	Good Water
C12	Babiyal	43.74716	Excellent Water
C13	Dayal Bagh	63.68897	Good Water
C14	Indira Park	51.4282	Good Water
C15	PWD office	54.40845	Good Water
C16	P.W.D. Office	65.35271	Good Water
C17	Grain Market	77.98264	Good Water
C18	Supply Depot	74.46848	Good Water
C19	Mahesh Nagar	65.92742	Good Water
C20	Dushehra Ground	57.7363	Good Water
C21	Aggarsain Nagar	46.25833	Excellent Water
C22	Housing Board	64.44674	Good Water
C23	Subhash Nagar	56.46153	Good Water
C24	Subhash Park	35.71365	Excellent Water
C25	Shyam Nagar	98.99463	Good Water
C26	MES	81.99053	Good Water
C27	Mall Road	71.38062	Good Water
C28	Guru Nanak Marg	83.57657	Good Water
C29	Preet Nagar	54.4124	Good Water
C30	Harinagar	66.86482	Good Water
C31	Town park	62.58409	Good Water

Calculation of WQI for individual samples is represented in table 3 and 4 for Ambala City and Ambala Cantonment respectively. In Ambala City, 36% samples indicate excellent water, 60% samples indicate “good water”, 3.3% samples shows “poor water” (Table 3) whereas in Ambala Cantonment, 12% sample show “excellent water”, and remaining 87.09% of samples show good water quality (Table 4). In Ambala Cantonment, none of the water sample exhibited poor quality while in Ambala City; only one sample fell in poor water category.

Conclusion

The water quality seems suitable for domestic use in both shallow as well as deep aquifers in the study area. The results indicate that the water quality is good in general in the both cities. Haphazardly grown Ambala city exhibited poor water category at a few places while in well planned city i.e. Ambala Cantonment exhibited water quality from good to excellent. The reason might include less part of Ambala City covered under sewage treatment in comparison to Ambala Cantonment.

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