Groundwater Quality Analysis of an Industrial Region of Himachal Pradesh

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Abstract—*Groundwater is a major source of fresh drinking water in both the rural and urban regions of India. The groundwater quality, however in recent times has deteriorated due to the percolation of polluted water into the soils from wastewater drains. This study deals with the groundwater pollution in the Baddi Industrial Area in Solan, Himachal Pradesh. Groundwater samples were collected from 8 locations in Baddi-Nalagarh region and tested for heavy metals concentration in water. Groundwater samples were collected from hand pumps and shallow tube wells in the area. The results obtained have been compared with BIS standards for drinking water (IS 10500:2012). During the study a total of 6 heavy metals parameters of water were tested: lead, arsenic, chromium, copper, iron and manganese. Some of the metals were found to be exceeding the limit prescribed in IS 10500:2012. The reason behind the presence of heavy metals could be disposal of untreated wastewater from the industries in the area. The study revealed that due to groundwater pollution in the area the groundwater in the area is not fit to be used as drinking water.*

1. INTRODUCTION

Water is one of the essentials that support all forms of plant and animal life (1). Natural waters are increasingly subject to a variety of pollution sources attributed to urbanization, industrialization, and the proliferation of chemical, products and even natural sources (4). In late 19th centuries health officials from England and France have recognized the importance of soil and groundwater contamination and its effect to human health.

Groundwater is water located beneath the earth's surface in soil pore spaces and in the fractures of rock formations. A unit of rock or an unconsolidated deposit is called an aquifer when it can yield a usable quantity of water. One of the most important environmental issues today is groundwater contamination (7) and there are wide diversity of contaminants affecting water resources, be it industrial effluent or contaminant from any other source. These contaminants affect both physic-chemical and biological properties of groundwater. In addition to this addition of heavy metals in the groundwater render the water toxic to be used as drinking water (8).

According to the UN, Planet Earth's mean annual renewable volume of water is 43,000 cubic kilometres. This is about half of all the fresh water contained in all the Earth's natural lakes and about ten times the volume of all man-made reservoirs. Groundwater recharge accounts for about 10,000 cubic kilometres annually, (i.e. 0.1% of all around water resources). Thus, only a tiny proportion of the total volume of groundwater reserves isrecharged each year, compared to the large volume in stock.

According to Suresh (10) the main factors which affecting ground water pollution are: Rain Fall Pattern, depth of Water Table, and distance from the Source of Contamination and Soil properties such as texture, structure and filtration. In urban areas pollution levels are very high. Due to the concentration of main polluting industries in urban areas these areas have to bear the brunt of pollution even more. Therefore authorities all over the world have made legal as well as administrative provisions to weed out the polluting industries. In India govt. has enacted the water (prevention and control of pollution) act in this regard. Besides this national water policy (2002) is another step that govt. initiated to tackle the problem of groundwater pollution. National green tribunal has also been set up to ensure that no undue harm come to the environment.

Many studies have investigated the occurrence of pollution in groundwater. Ramesh (8) studied the pollution caused by 8 heavy metals in Madras. Study by Suresh (10) highlights the overexploitation of groundwater in the Bangalore city. Garg (3) studied that groundwater quality comprising of physical, chemical, and biological qualities of groundwater of Jind. Mukherjee (6) studied that continuous disposal of industrial effluents on land, which has limited capacity to assimilate the pollution load, has led to groundwater pollution. Momodu (5) studied the heavy metal contamination of the groundwater in Lagos for aluminium, cadmium, lead contamination, and found out that that there is significant toxicity in groundwater due to heavy metals.

2. DESCRIPTION OF STUDY AREA

The present study deals with the groundwater pollution in the Baddi Industrial Region in Solan district of Himachal Pradesh. Nalagarh-Baddi-Barotiwala core area has been declared an Industrial Area by the Govt. of Himachal Pradesh and Govt. of India has given a special industrial package. BBN is the leading industrial area of Himachal Pradesh with an estimated presence of 1477 industrial units. The average elevation of the region ranges between 300 to 3000m above MSL. This region is drained by river Sirsa, a tributary of river Sutluj and lies in Shiwalik belt of Himalayas.

There are four major seasons. The winter season commences from Nov to Feb & ends in March; summer season extends from March to June followed by the monsoon period extending from July to September. Maximum precipitation occurs during the months from July to September. Average annual rainfall in the district is about 1450 mm with average of 64 rainy days. In the winter season precipitation as snowfall also occurs in the higher reaches up to 1000 m elevation and as rainfall in low hills and valleys of the district.

Table 1: Number of Industries (2013)

Electronics	Electricals	Pharmaceuticals	Plastics	Food processing	Packaging	Others
319	266	303	205	106	240	1158

Materials and methods

Samples from 8 different locations were collected and tested for different parameters. Samples were collected from hand pumps and shallow tube wells using good quality standard sampling bottles. A total of 6 parameters were analysed using methods as prescribed in standard methods (18^{th} addition). Parameters analysed are: lead, arsenic, chromium, copper, manganese and iron. All the parameters were analysed in laboratories and the results were compared with the respective acceptable limits as mentioned in IS 10500:2012. Atomic absorption spectrometry was used to analyse the heavy metals concentration in the samples. For this purpose AAS 5EA analytic gena spectrometer was used.

Results and discussions

Samples from 8 locations were tested for 6 heavy metals. Tabulated results are given in table 2.

Lead: Lead is toxic metal whose concentration in drinking water should not be more than 0.01mg/l. Limit for lead was breached at two locations Baddi and Sandholi.

Copper: Although copper was within permissible limit (1.5 mg/l) at all locations but it exceeded the acceptable limit (0.05mg/l) at 3 locations.

Iron: Permissible limit (0.3mg/l) for iron was exceeded at two places Baddi and Nalagarh (0.503 and 0.367mg/l respectively).

Manganese: Manganese concentration exceeded the permissible limit (0.3 mg/l) at two locations: Sandholi and Nalagarh (3.8 and 0.77mg/l respectively).

Arsenic: Arsenic was within the permissible limit (0.05mg/l) at all locations but the acceptable limit (0.01mg/l) for arsenic was exceeded at Nalagarh (0.034mg/l).

Chromium: Chromium was within its acceptable limit at all 8 locations.

Table 2

Parameter	Minimum value	Maximum value	Acceptable limit	Permissible limit
Lead	0.002 (mg/l)	0.046 (mg/l)	0.01 (mg/l)	NR
Iron	0.008 (mg/l)	0.503 (mg/l)	0.3 (mg/l)	NR
Copper	0.012 (mg/l)	1.213 (mg/l)	0.05 (mg/l)	1.5 (mg/l)
Manganese	0.003 (mg/l)	3.8 (mg/l)	0.1 (mg/l)	0.3 (mg/l)
Arsenic	0.001 (mg/l)	0.034 (mg/l)	0.01 (mg/l)	0.05 (mg/l)
Chromium	0.003 (mg/l)	0.02 (mg/l)	0.05 (mg/l)	NR

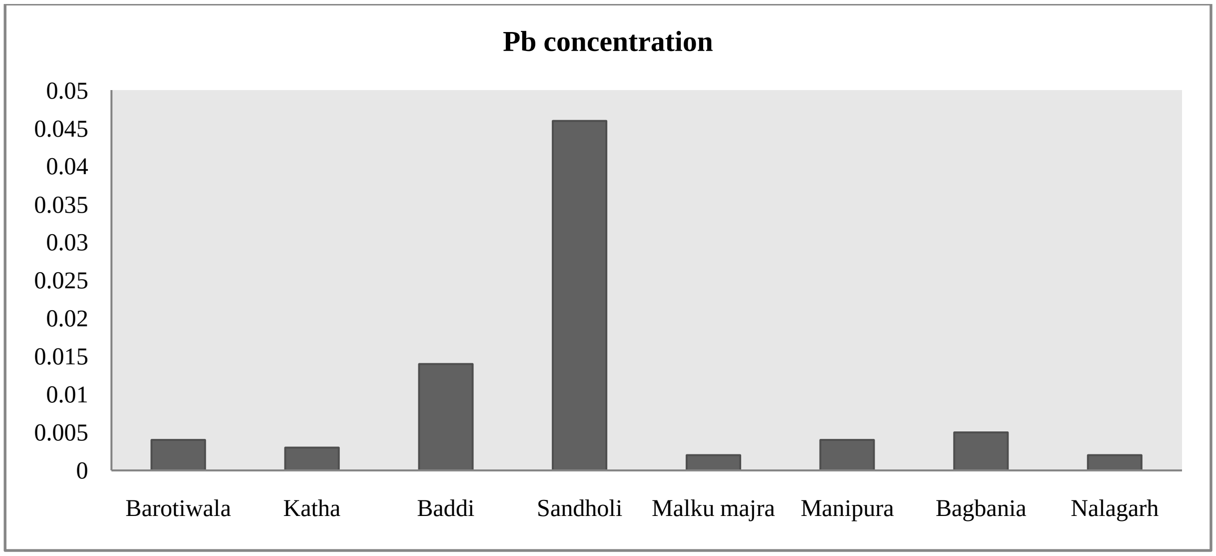

Fig. 1: Concentration of Pb in water samples at different locations

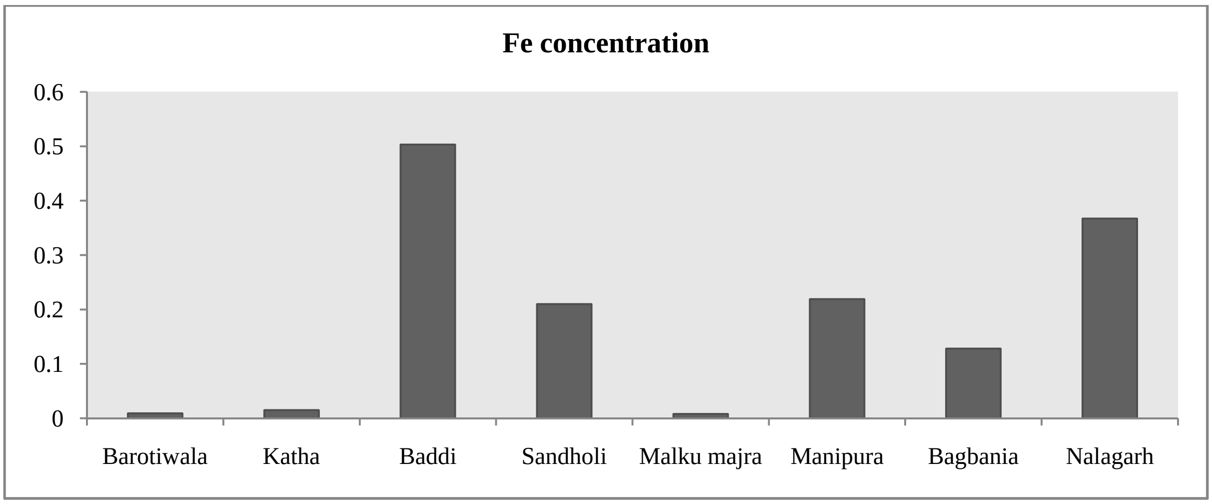

Fig. 2: Concentration of Fe in water samples at different locations

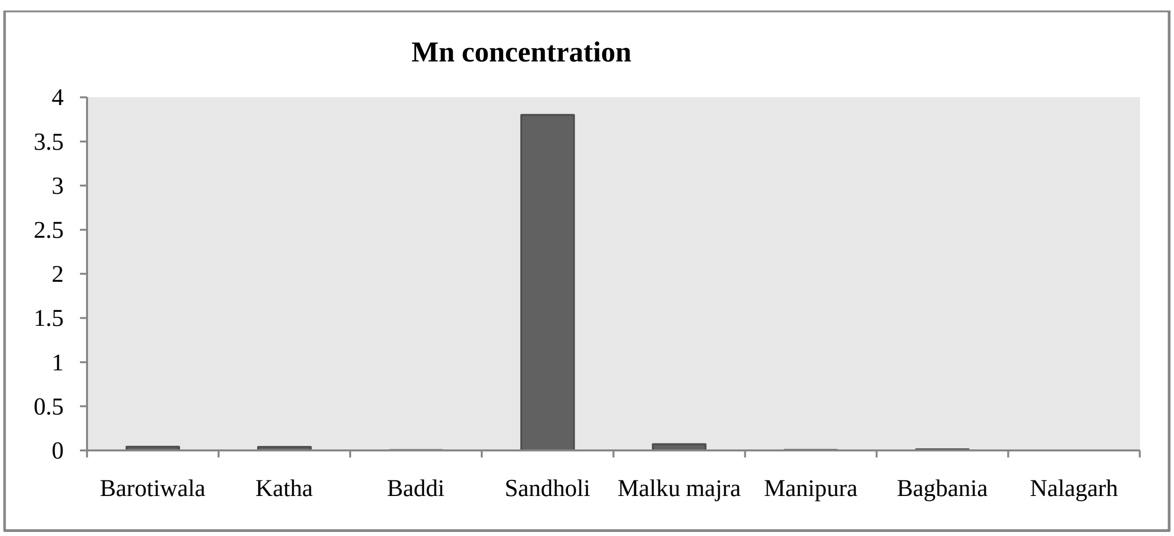

Fig. 3: Concentration of Mn in water samples at different locations

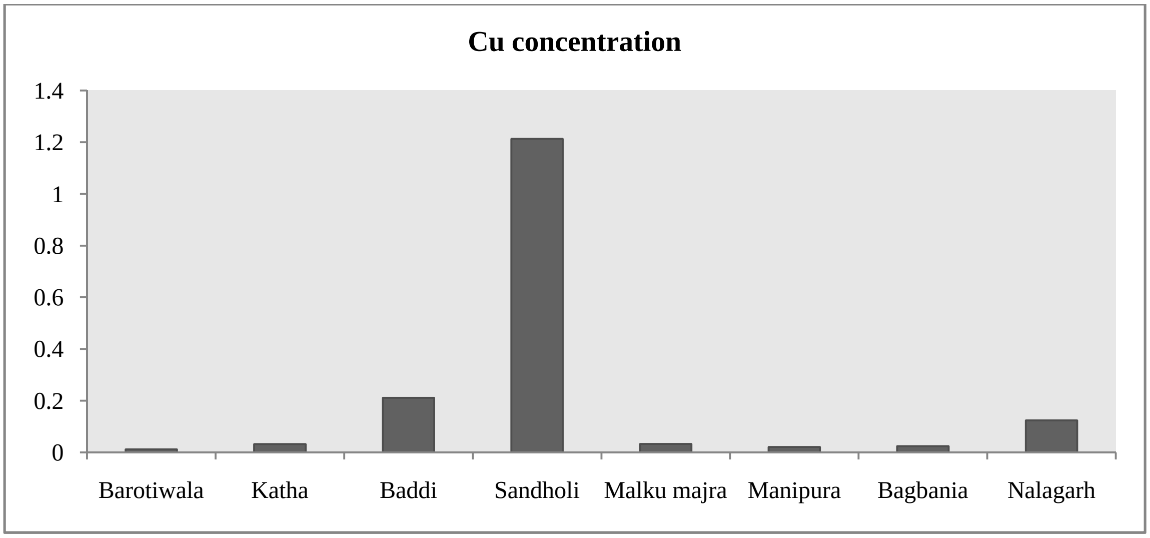

Fig. 4: Concentration of Cu in water samples at different locations

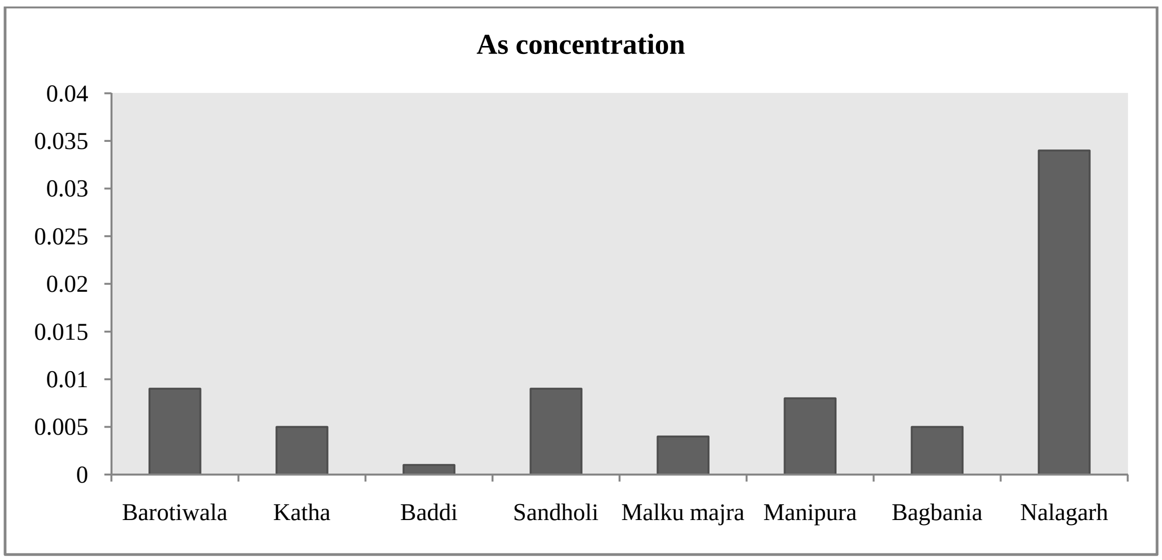

Fig. 5: Concentration of As in water samples at different locations

3. CONCLUSIONS AND RECOMMENDATIONS

Heavy metals were sporadic in their appearance. Heavy metals exceeded the prescribed limits only at 3 sample sites: Baddi, Sandholi and Nalagarh. Each of these sites had some heavy metals breaching the prescribed limits. Manganese and Iron were highest at Sandholi. Arsenic exceeded limit only in Nalagarh. Chromium was found to be within limits at each site.

Therefore, the study reveals that groundwater in the Baddi Industrial area does not conform to the drinking water standards adopted in India. So it is not fit for consumption as drinking water without treatment. This water can be used for any other purpose eg. for irrigation purpose subjected to its fulfilment of standards. The periodic analysis of the hand pumps in the area should be made compulsory and the result of the analysis should be documented properly and published for awareness among people.

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