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Fluoride, Iron and Nitrate affected areas of Punjab

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Abstract

The inorganic chemicals present naturally or due to human activity in soils, sediments and rocks enter, as point sources or non-point sources, into groundwater system and degrade its quality thus making it unusable for drinking and irrigation. Identifying the areas affected by these contaminants help in treating the groundwater in such areas. In the present study, the fluoride, iron and nitrate affected areas are mapped in Punjab so that the remedial measures can be taken for making the water utilizable for drinking and irrigation. The concentrations of fluoride, iron and nitrate have been found up to 11.30 mg/l, 25 mg/l and 1180mg/l, respectively. Among the three pollutants nitrate is more intense and widely spread due to unplanned and uncontrolled human activities. The source of fluoride lies deep in Central Himalayas and it is released into water as a result of weathering, deforestation, road construction, fast developing settlements and hill-blasting. The overgrazing, unplanned and unscientific deforestation off the unconsolidated rocks have deleterious effects of high proportion on the soil and water environment and triggers the iron release into water transporting the sediments downslope. It is recommended that these activities should be controlled by mass awareness and legislation in combination.

Keywords: Fluoride, nitrate, iron, contamination, Punjab, Indo-Gangetic basin

Introduction

Groundwater sustainability has been in jeopardy as a result of rapid pace of agricultural development, industrialization and urbanization which have resulted in the overdevelopment and contamination of groundwater resources (Chopra and Krishan, 2014a; Banks et al., 1995; Frengstad et al. 2001; Krishan et al, 2013b, 2014a; Lapworth et al., 2014a,b; MacDonald et al., 2013, 2014; Rao et al., 2014). In India, the available groundwater is generally potable but localized occurrence of various chemical constituents exceed the permissible limits given in the guidelines of Bureau of Indian Standards (IS: 10500, 2012) for drinking water. It is observed that the concentration of few constituents exceed the permissible limit at places in Punjab. The groundwater contaminants like arsenic, fluoride and iron are of geogenic origin whereas nitrates, phosphates, heavy metals are the result of human activities.

Study area

Punjab state (Fig. 1) is one of the most productive agricultural regions in the country and for the same reason this state is called the ‘Bread Basket of India’. Punjab state is bounded by Jammu & Kashmir in the north-east, Himachal Pradesh in east and south-east, Haryana in south and by Rajasthan in south and west and shares the international boundary with Pakistan on the western side. Three perennial rivers namely Beas, Satluj and Ravi along with their tributaries drain the

state. The major canals systems in Punjab are Sirhind Canal system, Bist Doab Canal system, Bhakra Main Line (BML) Canal System, Upper Bari Doab Canal system, Kashmir Canal, Ferozepur Feeder/Sirhind Feeder system, Eastern Canal system, Makhu Canal System, Shahnehar Canal system and the Kandi Canal system. The water table in the central districts of Punjab has been decreasing whereas in south western parts it is rising resulting into the problem of water logging (Krishan and Chopra, 2015). Most of the centrifugal pumps have been replaced by the submersible pumps leading to additional expenditure and cultivation of high water demanding crops particularly paddy is an important factor contributing towards decline of underground water levels in Punjab (Chopra and Krishan, 2014b; Krishan et al., 2015a,b; 2014b-h; 2013a-c).

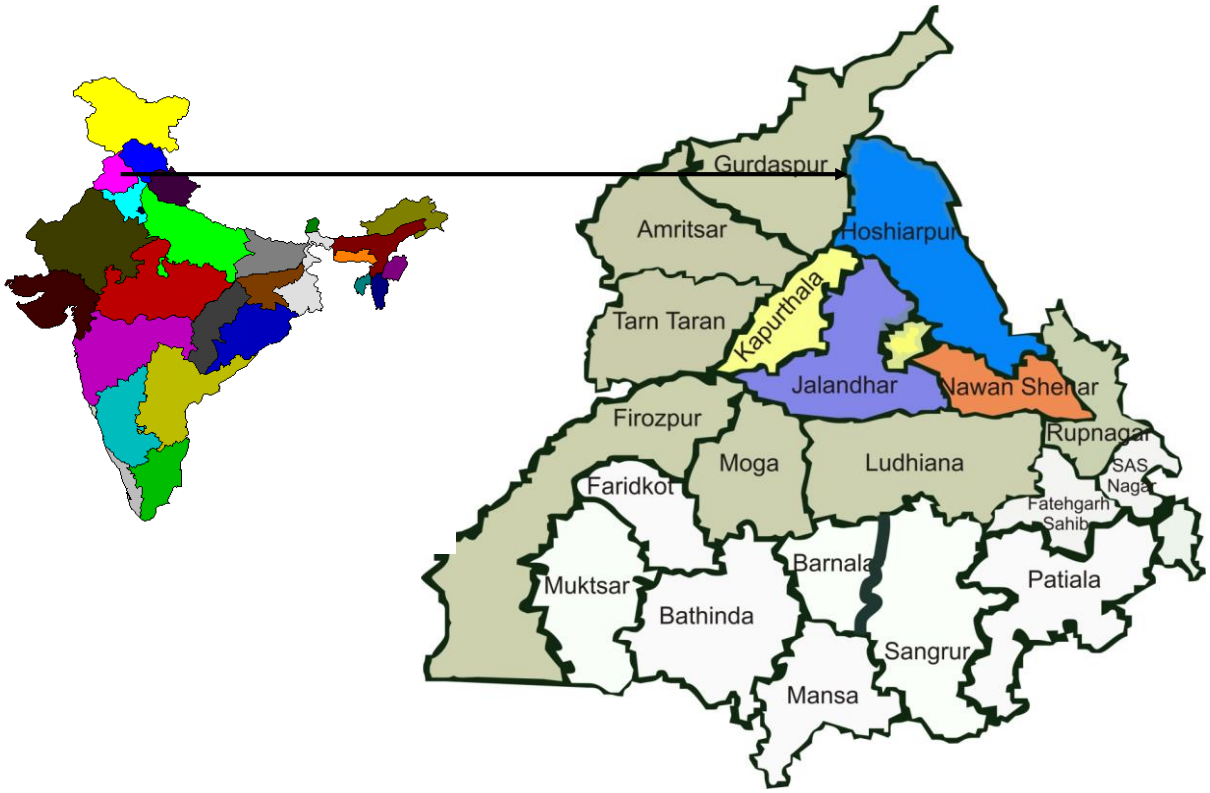

Fig. 1. Study area

Results and Discussion

The areas having concentrations of fluoride, nitrate and more than permissible limits are shown in Fig. 2.

Fluoride

Fluorine is the most electronegative and reactive of all elements that occur naturally in many rock types. The fluorine, in rocks, occurs as fluorides. The most common fluoride bearing minerals are fluorspar, cryolite, fluorite and fluorapatite. Type of rocks, climatic conditions, nature of geological formation and the time residence time of moving groundwater are

responsible factors for its occurrence in groundwater. The permissible limit of fluoride is 1.0 mg/l as desirable concentration in drinking water, which can be extended to 1.5 mg/l (BIS, 2012) and high concentrations of more than 1.5 mg/l of fluoride result in fluorosis. Low concentration of fluoride damages the muscles and high concentration damages the teeth and bones. The areas, in Punjab, having concentration of fluoride more than the permissible limit of 1.5 mg/l have been shown in Fig.2.

Fluoride is found more than the permissible limits in parts of Amritsar, Gurdaspur, Faridkot, Firozepur, Bhatinda, Mansa, Muktsar, Patiala, Fatehgarh Sahib and Sangrur districts (Table 1). Fluoride concentration, in Punjab, ranges up to 11.30 mg/l which is much beyond the toxic limits. Fluoride bearing mineral generally occur in granites, granite-gniesses, augen – gneisses etc. The state of Punjab has its geographic spread on the Indo- Gangetic Alluvium on a basement formed by the rocks of Siwalik System. The alluvium inherently doesn't form the source of fluoride. **It's** quite plausible that the Pre Cambrian and Eocene granites along with the gneisses occurring in the Central Crystallines form the source of fluoride.

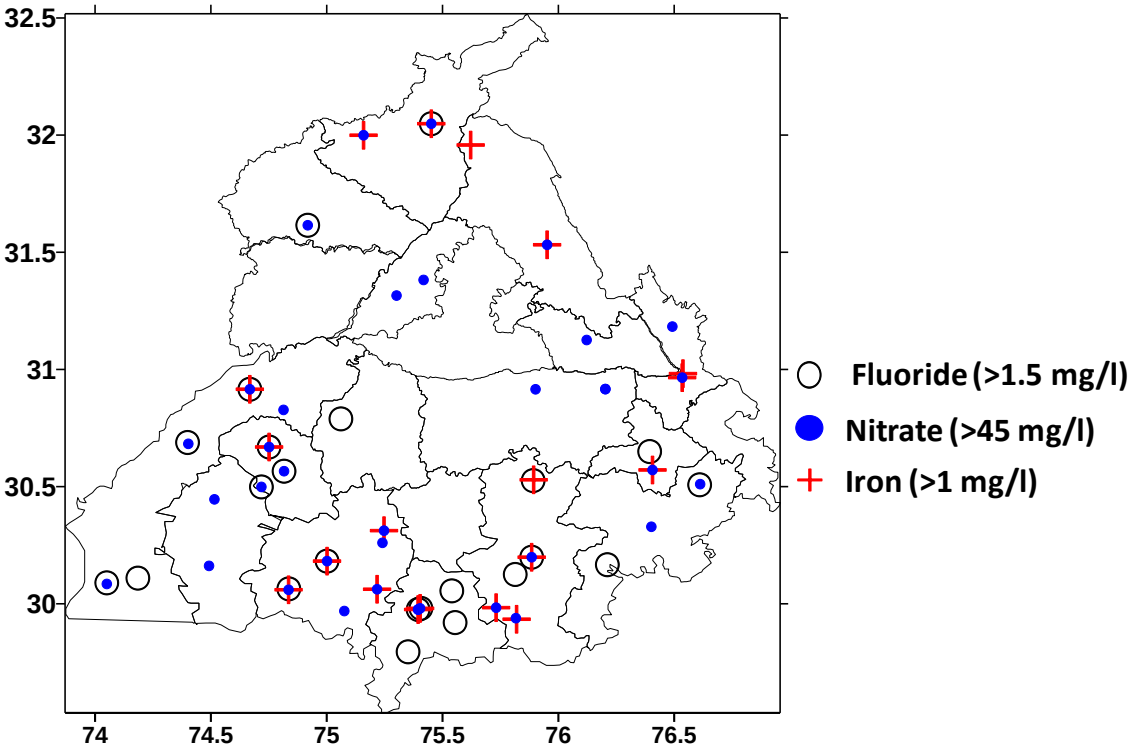

Fig. 2. Fluoride, Nitrate and Iron affected areas in Punjab

Iron

Iron is a common constituent in soil and groundwater which is present in groundwater as soluble ferrous iron controlled by physico-chemical, microbiological environments. On its exposure to air the water turns cloudy due to oxidation of ferrous iron into reddish brown ferric oxide. The main sources, of iron are weathering of ferruginous minerals like hematite magnetite and sulphide of iron prominent of which is pyrite FeS_2. As per BIS (2012), the permissible

concentration of iron in groundwater is less than 1.0 mg/l for drinking and its occurrences beyond permissible limit (> 1.0 mg/l) are shown in Fig. 2.
Iron is found more than the permissible limits (upto 25mg/l) in parts of Gurdaspur, Hoshiarpur, Rupnagar, Fatehgarh, Sangrur, Mansa, Bhatinda, Faridkot and Firozepur districts (Table 1.) The mighty rivers draining along the southern slopes of Himalayas flows across the rocks of Siwalik System. The rocks of Siwalik System are unconsolidated and easily release iron in the water transporting the sediment load carried by these rivers. It is observed that the iron is inherently high in the groundwater occurring in Siwalik aquifers.

Nitrate

Nitrate is of atmospheric origin, it forms an important part of Nitrogen Cycle. The nitrogen fixing bacteria helps fixing the nitrogen in the plants and formation of nitrates. The atmospheric nitrogen is converted into organic form after fixation into the plants and nitrate in the soil has its access in the combination of nitrogen and oxygen. Nitrate is the most common contaminant of groundwater and considered to be an indicator of anthropogenic pollution. Its contamination is generally as a result of human activity and it reached groundwater from leaching of chemical fertilizers, animal manure, human excreta. Leakages from septic tanks and sewer pipes are the common causes of nitrate additions in subsurface water. As per the guidelines of Bureu of Indian Standards (BIS, 2012), the maximum permissible limit of nitrate concentration in ground water is 45 mg/l with no relaxations. The occurrences of nitrate above the permissible limit of 45 mg/l in groundwater have been shown in Fig. 2 and found in parts of districts of Amritsar, Gurdaspur, Kapurthala, Nawanshahr, Rupnagar, Ludhiana, Fatehgarh, Patiala, Sangrur, Muktsar, Mansa, Bhatinda, Faridkot and Firozepur. Nitrate pollution, in Punjab ranges, is very common and it ranges up to 1180 mg/l.

Table1. Fluoride, Iron and Nitrate concentrations in Punjab (Source: CGWB, India)

Sr. no.	District	Concentration range (mg/l)		
		Fluoride	Iron	Nitrate
1	Amritsar	1.58-1.99	-	95-286
2	Bhatinda	1.93-4.70	1.02-25.00	54-621
3	Faridkot	2.64-3.67	1.86-3.10	60-287
4	Fatehgarh Sahib	1.54	1.00-2.58	52-85
5	Firozepur	1.63-3.46	1.82	69-241
6	Gurdaspur	3.55	1.37-3.62	55-521
7	Hoshiarpur	-	1.00-1.36	64
8	Jalandhar	-	-	105
9	Kapurthala	-	-	105
10	Ludhiana	-	-	57-104
11	Mansa	1.58-8.33	1.76-1.82	70-348
12	Moga	1.96	-	45
13	Muktsar	5.36	-	83-944
14	Nawanshahr	-	-	77
15	Patiala	2.05-2.80	-	47-52
16	Rupnagar	-	1.07-3.40	60-64
17	Sangrur	1.71-11.30	1.07-1.37	110-1180

Desirable limit (BIS, 2012)	**0.6-1.2**	**0.3**	**45**
Permissible limit (BIS, 2012)	**1.5**	**1.0**	**No relexation**

Conclusion

Punjab is a state where agrarian economy is prevalent and industrial development is going on at a rapid pace. In the third phase of green revolution from 1988 onwards, the advent of new seeds, excessive use of fertilizers, insecticides, pesticides and application of modern technology have made the agriculture more water and cost intensive. The groundwater abstraction is going on at an unprecedented rate. The cumulative effect of the human activities is manifested in the quantity and quality of groundwater resources in Punjab. This study shows that groundwater quality of 11 districts of Punjab is affected by Fluoride, 9 districts are affected by Iron and 17 districts by nitrate. Among the three pollutants nitrate is more intense and widely spread too. Since it is related to human activities and can be checked by taking suitable measures. The source of fluoride lies deep in Central Himalayas. The release of fluoride into water has a direct bearing with weathering, deforestation, road construction, fast developing settlements, hill-blasting. Such activities should be controlled. Siwaliks are lush green hill ranges with comparatively low altitude which are in close proximity with the Indo-Gangetic plains where the population is thick. The overgrazing, unplanned and unscientific deforestation off the unconsolidated rocks is a very serious matter where it creates deleterious effects of high proportion on the soil and water environment and triggers the iron release into water transporting the sediments downslope. It is recommended that these activities should be controlled by mass awareness and legislation in combination.

This study will be helpful for better understanding of the quality aspects of groundwater resources in Punjab and will prove to be a valuable guide to researchers, engineers, planners, policy makers, administrators and all other stakeholders for best possible development and management of this worthless resource.

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