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Assessment of Ground Water Quality in Punjab, India

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Abstract

In the present study, groundwater quality in respect of native groundwater has been determined in the entire State of Punjab during the installation of observation wells under World Bank aided Hydrology Project Phase II undertaken during 2009-14 by Water Resources and Environment Directorate, Punjab. The results of sampling done during installation of observation wells show that the groundwater quality in the depth range of 45-60 m on the basis of EC and RSC is categorized as: fit in 53% and marginal to unfit in remaining 47%.

Keywords: Groundwater; Quality; Depth; Punjab; EC; RSC

Introduction

Groundwater is well thought-out to be the most vital natural and fresh resource on earth which is used for drinking and irrigation purposes. Groundwater quality studies become unavoidable since its poor quality may badly affect its users [1]. Various processes affecting the water quality may be natural like evaporation and weathering and or anthropogenic like agricultural activities, domestic-industrial effluents and minor amount of atmospheric fallout. Some of the studies on groundwater quality focused on drinking and irrigation carried out in various parts of India are as: Andhra Pradesh [2]; Jharkhand [3]; Pondicherry [4]; Tamil Nadu [5].

Punjab having geographical area of about 50,362 Sq. Km is predominantly an agricultural state where 80% of population is engaged in agriculture and has highest % age of irrigated land compared to total cultivable land in India. About 83% of the State's geographical area is cultivated with cropping intensity of 190% [6]. 98% of net area sown is irrigated. The agriculture in the State is, therefore, dependent on heavy requirement of water. The State's surface water resources are limited and fully utilized. To meet the ever-growing demand for agriculture, urban and rural population and industry, dependency on groundwater has been increasing tremendously. Out of the total irrigated area, 73% of the area is now irrigated by groundwater through tube wells as against 55% four decades ago. Excessive extraction of groundwater has resulted in decline of water table in more than 80% of the State area having fresh/fit quality of groundwater in North-Western, Central and South-Eastern part of the State which has been reported in many studies also [7-11]. On the other hand, groundwater is substantially rising causing waterlogging and salinity/alkalinity problems in South-Western part of the State where ground water extraction is limited due to brackish/saline/alkaline quality [12-14] and water quality for Bist-doab area is also reported [15].

In order to meet the demand of groundwater for diverse purposes, there is a need (1) to ascertain the depth upto which native groundwater is fresh/ fit for use (2) depth/aquifer wise quality of native groundwater. Therefore, in the present study, groundwater quality in respect of native groundwater has been determined in Punjab during the installation of observation wells under World Bank aided Hydrology Project Phase II undertaken during 2009-14 by Water Resources and Environment Directorate, Punjab.

Study Area

The state Punjab extends from the latitudes 29.30° N to 32.32° N and longitudes 73.55° E to 76.50° E and is bounded by Jammu and Kashmir in the north-east, by Himachal Pradesh in east and south-east, by Haryana in south, by Rajasthan in south and west and shares the international boundary with Pakistan on western side (Figure 1). Punjab state is divided into 22 districts which are further divided into 77 tehsils and 141 development blocks [16].

Depth to water level in the area ranges from 1.5 to 31 meter below ground level (mbgl). Water table is at shallow depth at several areas of Muktsar, Ferozepur, Bathinda and Mansa districts where it ranges from 1.5 to 7.5 mbgl causing water logging at many places. The bores drilled in the area up to 60 m depth reveal the presence of predominance of fine sand occasionally associated with 'kankar' and comprising of two main aquifer zones each ranging in thickness from 4 to 25 m separated by clay layers of 3 to 5 m thickness [16]. Water table has been rising in the area comprising blocks of Muktsar, Lambi, Kot Bhai, Khuiyan sarwar, Abohar and Fazilka creating water logging at many places.

There has been erratic rainfall distribution in Punjab for the last two decades during which the annual average rainfall has decreased by 40-50% from 755 mm in 1990 to 385 mm in 2009 and 472 mm in 2010 [16].

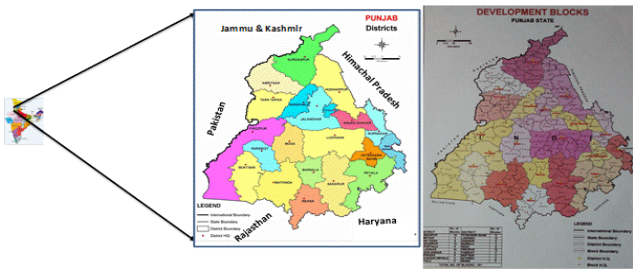

Figure 1: Punjab map.

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Methodology

The representative groundwater samples were collected using the standardized methodology during the installation (2009-14) of each Shallower/Medium Groundwater Observation Well (MGWOW) from appropriate depth ranging mostly between 45 metres and 60 metres and subjected to chemical analysis for its quality for irrigation use. The observation wells were evenly distributed ranging from 5 to 10 in each of 141 development blocks (the development blocks are shown in Figure 1) in the State in regard to their respective area. Results of chemical analysis of one time sampling of groundwater during the installation of MGWOW give first-hand information about the quality of groundwater at specific depth representing the respective aquifer.

Ground Water Quality Map has been prepared on the basis of results of Electrical Conductivity (EC) and Residual Sodium Carbonate (RSC) of ground water samples collected during development of each observation well. EC of each sample has been determined in the laboratory by conductivity Meter through direct reading. Prior to determining EC (in micro mhos/cm at 25°C), the instrument was calibrated through Standard Solution. RSC (meq/l) was determined by the following formula:

$RSC = (CO_3^{--} + H\,CO_3^{-}) - (Ca^{++} + Mg^{++})$.

The above ions were determined volumetrically in the laboratory using titration method [17]. Quality was categorised as Fit, Marginal and Unfit on the basis of criteria of EC and RSC values as mentioned below [18]:

i) EC values (µmhos/cm at 25°C)

a)	upto 2000	Fresh/fit
b)	2000-4000	Marginal
c)	Above 4000	Unfit

ii) RSC values (meq/l)

a)	upto 2.5	Fresh/fit
b)	2.5 to 5.0	Marginal
c)	Above 5.0	Unfit

Results and Discussion

The results of the chemical analysis have been compiled district wise and classification of the groundwater quality is given in Table 1. Relative abundance of sodium with respect to alkaline earths and boron, and quantity of bicarbonate and carbonate in excess of alkaline earths, influences suitability of water for irrigation. Above excess carbonate is denoted by 'Residual sodium carbonate' (RSC). Water with high RSC has high pH and lands irrigated by such water become infertile, owing to deposition of sodium carbonate [19].

The results reveal that groundwater quality between the depth range of 45 and 60 metres of the aquifer in Punjab is categorised on the basis of EC and RSC as: fit in 53%, marginal in 22% and unfit in 25%.

Map showing distribution of groundwater quality in Punjab State has been prepared on the basis of the results of analysis of ground water samples in respect of Electrical Conductivity (EC) and Residual Sodium Carbonate (RSC) and is given in Figure 2. Water chemistry is mainly influenced by water–rock interaction taking place from the recharge area to location of sampling. The water quality is different in different areas of Punjab due to the presence of different types of minerals.

S.No.	District	Total Area (Sq. km)	Fit		Marginal		Unfit	
			Area	%age	Area	%age	Area	%age
1	Gurdaspur	3564	3549	99.59	15	00.41	0	00.00
2	Amritsar	2647	2086	78.81	561	21.19	0	00.00
3	Tarn Taran	2449	632	25.81	1317	53.78	500	20.41
4	Kapurthala	1632	1356	83.09	201	12.32	75	04.59
5	Jalandhar	2632	2331	88.56	276	10.49	25	00.95
6	Hoshiarpur	3365	3365	100.00	0	00.00	0	00.00
7	Nawan Shahr	1267	1242	98.03	25	01.97	0	00.00
8	Ropar	1369	1271	92.84	98	07.16	0	00.00
9	SAS Nagar Mohali	1093	833	76.21	260	23.79	0	00.00
10	Fatehgarh Sahib	1180	872	73.90	308	26.10	0	00.00
11	Ludhiana	3767	3340	88.66	401	10.65	26	00.69
12	Moga	2216	665	30.01	1025	46.25	526	23.74
13	Faridkot	1469	42	02.86	554	37.71	873	59.43
14	Ferozepur	5303	1444	27.23	1296	24.44	2563	48.33
15	Muktsar	2615	0000	00.00	114	04.36	2501	95.64
16	Bathinda	3385	84	02.48	1035	30.58	2266	66.94
17	Barnala	1410	390	27.66	720	51.06	300	21.28
18	Mansa	2171	88	04.05	499	22.99	1584	72.96
19	Sangrur	3610	1194	33.07	1456	40.34	960	26.59
20	Patiala	3218	2063	64.11	880	27.35	275	08.54
Area of State(Sq. km)/%age		50362	26847	53.31 (~53)	11041	21.92 (~22)	12474	24.77 (~25)

Table 1: District wise classification of groundwater quality in Punjab State.

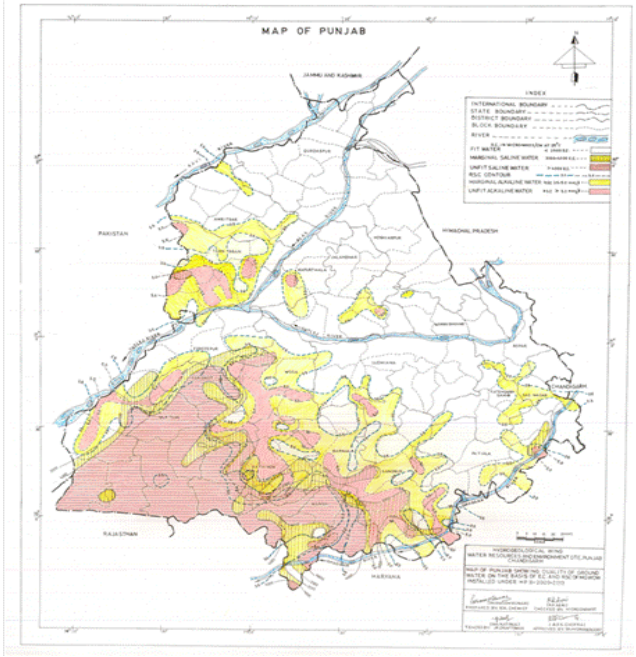

Figure 2: Spatial distribution of Groundwater quality in Punjab.

Upper Bari Doab Canal Tract (UBDC)

Groundwater quality is largely fit for irrigation. Groundwater is not saline in UBDC tract comprising districts of Amritsar and Gurdaspur. Small pockets representing marginal and unfit category are due to alkalinity in parts of Gandiwind, Chola Sahib, Naushahra Panuan, Bhikhiwind, Valtoha and Patti blocks of Tarn Taran district.

Bist Doab Tract (BD)

Groundwater quality in entire area in Bist Doab tract is fresh and fit for agricultural purposes except small isolated pocket in Sultanpur Lodhi block of Kapurthala district and Rurka Kalan block of Jalandhar district where groundwater quality is categorized as unfit due to high alkalinity.

Area on south of Sutlej

Groundwater in large area lying South of Sutlej is affected by native salinity and alkalinity problems. Groundwater quality problem is more acute in South and South-western part. On the other hand groundwater quality is found to be fresh/fit for irrigation in large parts of the State comprising of districts Ropar, SAS Nagar, Fatehgarh Sahib, Patiala, Ludhiana, Northern part of Moga, North and Eastern part of Ferozepur districts. Groundwater between the depth range of 45 and 60 m is found to be unfit for irrigation in district of Muktsar, Faridkot, Bathinda, Mansa and part of Sangrur due to high salinity and or alkalinity. Dominance of Ca^{2+} and Mg^{2+} is mainly due to the presence of calcareous encrustations present in the soil matrix.

The weatherability of rock and release of ions depends on mineralogy of host rock. Hence, knowledge about host rock characteristics will help in understanding water quality of a region.

Conclusions

The study has shown that the groundwater quality in the depth range of 45-60 m on the basis of EC and RSC is categorized as: fit in 53% and marginal to unfit in remaining 47%. The spatial distribution of the groundwater quality shows that most of the parts of UBDC and BD are fall in fit category while most of the south-western part falls in marginal to unfit category indicating high salinity water, which cannot be used for irrigation purposes and require management for salinity control. In such conditions, the soil must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching and salt-tolerant crops/plants should be selected.

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