# Water quality index of groundwater in different geomorphological units in Bist-Doab, Punjab, India

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***Abstract*—** In the present paper, an attempt has been made to work out water quality index (WQI) to assess the groundwater scenario of different geo-morphological units of Bist-Doab, Punjab, India. Data of 51 groundwater samples collected from piezometers, dug wells, bore wells are used. The WQI is computed using seven parameters viz. pH, Total Dissolved Solids, Total Hardness, Fluoride, Chloride, Sulfate and Nitrate. However, the WQI results show that the overall water quality class is 'good' and water is acceptable for domestic use but continuous monitoring of groundwater is required to protect water from any possible contamination in future due to growing agricultural activities in the area.

***Keywords*—***water quality index; groundwater; geomorphological units; Bist-Doab; Punjab; India*

## I. INTRODUCTION

Government of India is giving high priority to provide pure and safe drinking water by implementing various programmes like Rajiv Gandhi National Drinking Water Mission, Drinking Water Security Programme, National Rural Drinking Water Programme etc. through the Ministry of Drinking Water and Sanitation. Less availability of surface water makes people to look for groundwater resources to fulfill their needs. In Punjab, the groundwater is highly used in agricultural, domestic and industrial sectors. As a result of this, its sustainability is under threat due to its continuous depletion and deterioration of quality [1-11]. Although, the groundwater quality was assessed by various researchers but the water quality index was not developed earlier in the study area. Keeping this in view, the present work was carried with the overall objective of computing Water Quality Index (WQI) tool to assess the suitability of groundwater for drinking purpose, as reported by Singh et al. [12], in Bist-Doab, Punjab, India.

## II. STUDY AREA

The study was carried out in Beas-Satluj Doab area of Punjab having a total area of 9060 km$^2$ covering Hoshiarpur, Nawanshahr, Jalandhar, Kapurthala districts. The area lies between 30$^0$51'N and 30$^0$04'N latitude and 74$^0$57' and 76$^0$40'E longitude. It is bounded by Shivaliks in the north-east, the river Beas in the north east-south west and the river Satluj in south east-south west.

The entire study area was divided into 3 geo-morphological units viz. (1) Kandi region (2) Undisturbed flood plains (3) intensively cultivated plains. In the Kandi region, north-east portions of Hoshiarpur and Nawanshehr, there are deeper groundwater tables, due to the change in topography, and this region considered the recharge area for the deeper aquifer system in plain areas. Some parts of Nawanshahr and Jalandhar districts are irrigated using canals from the Satluj river, however, most of the area of Bist-Doab is irrigated using shallow groundwater [8-9]. In the plain area the gradients are low, with a regional gradient of around 0.4 m/km towards the southeast direction [13]. The climate of the Bist-Doab is semi-arid and possesses continental type of climate. High rainfall and poor vegetation cover are responsible for soil erosion in the Shivalik foot hill zone [14]. The economy of the study area is primarily agro based and the farmers shifted the cropping pattern due to various farming encouraging schemes by the government from the Maize-Wheat or Sugarcane-Maize-Wheat to Wheat-Rice cropping pattern [5, 15].

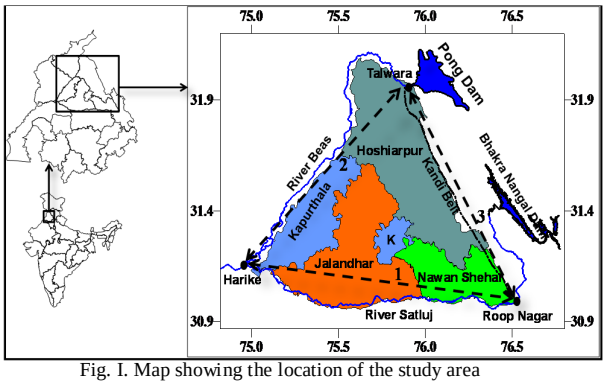


Fig. I. Map showing the location of the study area

## III. METHODOLOGY

For assessing the groundwater quality, the water samples were collected at shallow (<50 m) and intermediate depths (50-100 m) from peizometer, dug wells, bore wells during 2007-2009 from 51 sites covering the entire Bist-Doab area as shown in Fig. II.

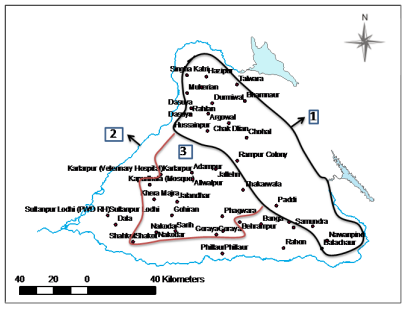


Fig. ii. Sampling points marked in the study area

The samples were analysed by Central Ground Water Board (CGWB), Chandigarh using the standard procedure described by APHA [16].

Water Quality Index (WQI) is a mathematical tool to integrate the complex water quality data into a numerical score and has been developed for surface water by Singh et al [12] but could be used for groundwater Stigter et al. [17]. For calculating the Water Quality Index (WQI), the methods followed by Singh et al. [12] have been employed using the 7 parameters viz. pH, Total Dissolved Solids, Total Hardness, Fluoride, Chloride, Sulfate and Nitrate. The quality rating scale and accordingly the weight values have been assigned to the selected parameters to estimate the overall water quality index. The standards of the water quality parameter are governed by as per BIS: 10500-2012 and Central Pollution Control Board (CPCB) standards and their respective weight used in the present study are highlighted in Table I. The status of water corresponding to different OWQI values is presented in Table 2.

More weights are given to the parameters like TDS, nitrate and fluoride as these are known to be more harmful to human health compared to other water quality parameters. Water quality qualifies as the best which meet out the drinking water standards prescribed by BIS standards. Overall, the samples are classified into 5 classes as given in Table II.

TABLE I. ASSIGNMENT OF SIGNIFICANT WEIGHT TO THE WATER QUALITY PARAMETER

| Sr. No. | *Parameter* | *Weight Factor* | *Standards (IS-10500)* |
|---|---|---|---|
| 1 | pH | 1 | 6.5-8.5 |
| 2 | Total Dissolved Solids (TDS) (mg/l) | 3 | 500-2000 |
| 3 | Total Hardness (mg/l) | 1 | 300-600 |
| 4 | Fluoride (mg/l) | 3 | 1.5-2.0 |
| 5 | Chloride (mg/l) | 1 | 250-1000 |
| 6 | Sulphate (mg/l) | 2 | 25-1000 |
| 7 | Nitrate (mg/l) | 3 | 10-100 |

Singh et al., [12]

TABLE II. OWQI AND CORRESPONDING CLASS AND STATUS OF WATER QUALITY

| Class | OWQI Value | Status of Water |
|---|---|---|
| Heavily Polluted | 0 - 24 | Unsuitable for All Purposes |
| Poor | 25 - 49 | Special Treatment (Special Treatment) |
| Fair | 50 - 74 | Needs Treatment (Filtration & Disinfection) |
| Good | 75 - 94 | Acceptable |
| Excellent | 95 - 100 | Pristine Quality |

Singh et al., [12]

## IV. RESULTS AND DISCUSSION

The average value of physico-chemical parameters and WQI of 51 samples are given in Tables-III, IV and Fig. III, respectively. The variation in physico-chemical parameters in 3 geomorphological units is presented in Table-IV. It is evident from Table-4 that the maximum variation in TDS, fluoride, chloride, nitrate, total hardness and water quality index is in zone-3 which is intensively cropped plain area and the comparatively less variation is found in zone-1 and zone-2 represented by Kandi and undisturbed flood plains, respectively. However, more variation in zone-2 as compared to zone-1 is due to the setting up of some industries in these areas.

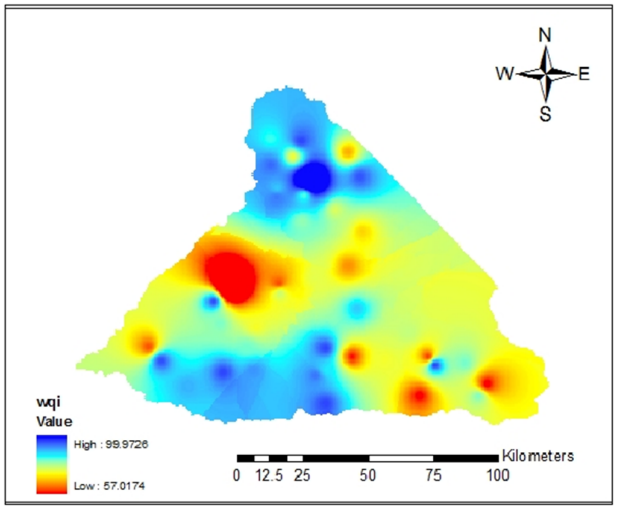


Fig. iii. Spatial variation in wqi in bist-doab, punjab

The maximum values of WQI to the tune of 100 were found in Jalandhar and Durmiwal in Hoshiarpur district and minimum value of 57 in Kartarpur, Jalandhar district delineated as per the Table II which fall under 'Excellent' and 'Fair' categories, respectively. In the present study it is observed that majority of groundwater samples i.e. 80% qualify in the 'Good' category and are acceptable for domestic use and 6% samples qualify in 'Excellent' category which are of pristine quality (Nakodar, Jalandhar and Durmiwal) and 14% samples collected from Garhshankar in Hoshiarpur district, Adampur and Kartarpur in Jalandhar district, Sultanpur Lodhi in Kapurthala district and Nawanpind, Behrampur and Rahon in Nawanshahr district qualify in the 'Fair' category which need 'Filtration and disinfection' treatment. These results also reflected that the parameters particularly chloride, sulphate, nitrate and hardness are found to be higher compared to the permissible level resulting TDS value at higher order owing to anthropogenic contribution which might take place due to high agricultural as well as industrial activities in the area. Almost similar results are found for water quality evaluation of groundwater of Haridwar district of Uttarakhand by Krishan et al [18-19].

Fig. III depicts the spatial variation in WQI in study area and it can be noticed that the values of WQI are very low in central plains of study area and this trend found to extend in other parts mainly eastern and south-eastern parts of the study area. Therefore, the continuous monitoring of groundwater is required in Bist-Doab, Punjab to protect water from any possible contamination in future due to growing agricultural activities in the area

TABLE III. STATISTICAL SUMMARY OF PHYSICO-CHEMICAL PARAMETERS OF GROUNDWATER SAMPLES IN BIST-DOAB, PUNJAB

| Par. | pH | mg/l | | | | | | WQI |
|---|---|---|---|---|---|---|---|---|
| | | TDS | $F^-$ | $Cl^-$ | $SO_4^{2-}$ | $NO_3^-$ | TH | |
| Min. | 7.40 | 169 | 0.1 | 7 | 2 | 0 | 35 | 57 |
| Max. | 8.75 | 1105 | 1.3 | 514 | 105 | 104 | 722 | 100 |
| Av. | 7.95 | 398 | 0.3 | 44 | 25 | 23 | 180 | 82 |
| SDev | 0.25 | 163 | 0.2 | 74 | 23 | 26 | 101 | 7 |

Par.= Parameter; TH= Total Hardness

TABLE IV. VARIATION OF PHYSICO-CHEMICAL PARAMETERS OF GROUNDWATER SAMPLES IN 3 GEOMORPHOLOGICAL UNITS IN BIST-DOAB, PUNJAB

| Par. | pH | mg/l | | | | | | WQI |
|---|---|---|---|---|---|---|---|---|
| | | TDS | $F^-$ | $Cl^-$ | $SO_4^{2-}$ | $NO_3^-$ | TH | |
| Zone 1 (n=20) | 7.4-8.2 | 169-618 | 0.1-0.7 | 7-82 | 2-54 | 0-104 | 131-250 | 73-100 |
| Zone 2 (n=11) | 7.7-8.8 | 241-663 | 0.1-0.6 | 8.5-150 | 2-105 | 0-77 | 35-300 | 74-86 |
| Zone 3 (n=20) | 7.5-8.2 | 176-1105 | 0.2-1.3 | 7-514 | 5-80 | 0-64 | 44-722 | 57-100 |

Par.= Parameter; TH= Total Hardness

## V. CONCLUSIONS

WQI has been computed based on seven different quality parameters to assess the suitability of groundwater for drinking purpose in Bist-Doab, Punjab. The results show that 86% groundwater samples qualified in the category of 'good to excellent' and rest 14% groundwater samples require treatment. This study concludes that 44 groundwater samples can be treated as per drinking standard and remaining 7 groundwater samples are not fit for drinking due to obtaining lesser WQI value i.e., WQI $\leq$ 75. The continuous monitoring of groundwater is required in Bist-Doab, Punjab to protect water from any possible contamination in future due to growing agricultural activities in the area.

In future, the work is required to be focused on seasonal (pre monsoon, monsoon and post monsoon) and long term change in groundwater quality index and its variations according to land use pattern in the study area. In the present study, E. coli and other bacteriological parameters, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) etc. which are equally important could not be taken into consideration in assessing the WQI due to lack of sufficient data. The Central/State groundwater departments and pollution controlling authorities should include these important parameters in their routine analysis.

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