Study of groundwater quality parameters in parts of Muktsar district, Punjab, India.

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Abstract

The present study is focused on deterioration of physico-chemical analysis of groundwater quality in parts of Muktsar district with context to human health and agriculture. The district has experiencing the problem of water logging due to introduction of high yielding wheat varieties and introduction of paddy as a second major crop. The hydrochemistry of study area reveals that in many samples pH, EC, Sodium, Nitrate and Fluoride parameters were having values above than the permissible limit, which could be due to the geological sources but aggravated by anthropogenic factors and also some leaching of agricultural fertilizer and chemicals with rainwater to the groundwater. Chadha diagram (1999) explains in Muktsar 49.6% and 45.7% during pre and post-monsoon respectively fall under Ca^{2+}–Mg^{2+}–$HCO3^{-}$ water type. Such observation suggests water has temporary hardness. High values of Kelley's ratio were observed in both pre monsoon and post monsoon of study area. Higher average value of PI was observed in post monsoon than pre monsoon with 34.3% samples fall in class- I during both seasons. 12.8% and 27.08% in class II during pre and post monsoon respectively. In class III 17.6% and 28.09% samples in pre and post monsoon seasons respectively.

Keywords: Agriculture, hydrochemistry, temporary hardness, PI and Kelley's ratio.

1. Introduction

Punjab is having geographical area of about 50,362 sq. km. is predominantly an agricultural state with cropping intensity 190% (Statistical Abstract of Punjab, 2013).During 'Green Revolution' the district has achieved new heights in agriculture production mainly due to introduction of high yielding wheat varieties and introduction of paddy as a second major crop (Chadha et al, 2004). The poor quality of water is also attributed to activities like tannery, textile and dyeing (Umamaheshwari, 2016).The district has an area of 2596 sq.km and is located between North latitudes 29º 54' 20" to 30º 40' and East longitude 74º 15' to 74º 49" as shown in Fig.1. Muktsar district has been experiencing the twin problem water logging and salinity. Groundwater needs to be carefully managed (both quantitatively and qualitatively) if its use is to be sustained for future generations (Central Ground Water Board, 2013).

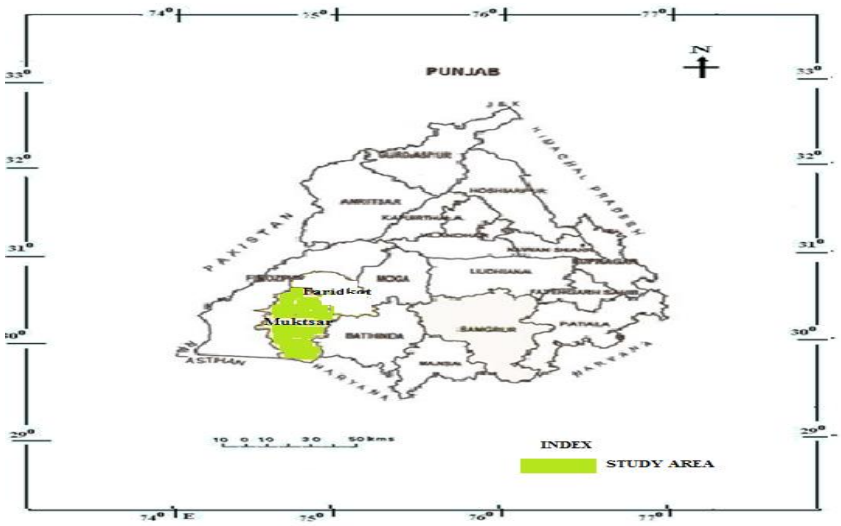

Fig. 1 Map showing location of the study area

2. Hydrochemistry and Groundwater Quality

Understanding the quality of groundwater is equally important as its quantity owing to the suitability of water for various purposes (Matthess, 1982).For assessing the quality of Groundwater for drinking and irrigation purposes groundwater samples from 45 different locations were collected from Muktsar for both pre monsoon and post monsoon seasons in 2015. The chemical analysis was done in the laboratory as per (BIS, 2012) as shown below in Table 1.

3. Results and Discussions

Table: 1. Descriptive analysis of groundwater during pre and post-monsoon

Parameters	Range during Pre monsoon	Range during Post monsoon	Result	Reason
pH	6.5-8.5	6.9-8.1	**Alkaline in nature**	Brackish in taste due to leaching of agricultural fertilizer and chemicals with rainwater
EC	398 to 6898µS/cm	479 to 7769µS/cm	**High value**	high mineralization of groundwater
TDS	148 to 2498 mg/l	176 to 2758 mg/l		
Calcium	16.9 to 305.9 mg/l	17.1to 207.5 mg/l	**High value**	presence of dissolved calcium and magnesium from soil and aquifer minerals containing limestone or dolomite. Calcium and magnesium normally maintain the equilibrium in most of the water ecosystems. More of the magnesium, more effect on the crop yield (Sundary et al, 2009).
Magnesium	0.75 to 191.8 mg/l	0.96 to 169.6 mg/l		
Sodium	3.6 to 881mg/l	7.6 to 987 mg/l	**High value**	agricultural activities

Potassium	2.3 to 863 mg/l	1.4 to 859 mg/l		
Nitrates	1.4 to 594.7 mg/l	1.6 to 597.2 mg/l	**High Value**	Sources like: fertilizer, livestock facilities, septic systems, manure lagoons and household waste water deposits.
Fluoride	0.1 to 11.6 mg/l	0.07 to 12.9 mg/l	**High Value**	geogenic sources but aggravated by anthropogenic factors

Correlations of pH, EC, TDS, Na^+, K^+, Ca^{2+}, Mg^+, Cl^-, HCO_3^-, CO_3^{2-}, NO_3, SO_4^{2-} and F^- of District Muktsar (Pre and Post monsoon)

➢ A strong correlation between EC and total dissolved solids (TDS)(0.85), SO_4^{2-} -K (0.75), NO_3^-- K (0.80), SO_4^2 - HCO_3(0.69) exhibiting a strong uphill (positive) linear relationship. Overall, in the study area for pre monsoon Na^+ - pH, CO_3^- - Cl, CO_3^- - SO_4^{2-} exhibited correlation of more than 0.5 exhibiting a moderate uphill (positive) relationship.

➢ A strong correlation between EC and total dissolved solids (TDS)(0.83),Na^+ - EC (0.71), Na^+ - TDS(0.70), NO_3 – K(0.67)exhibiting a strong uphill (positive) linear relationship. The common fertilizers that are used in the field are potash, nitrogen–phosphorous–potassium (NPK), ammonium sulfate, urea, and zinc sulfate. Application of these fertilizers may account for the increased nitrate content in the groundwater of this area. The positive relation between nitrate andpotassium in groundwater confirms this factor as NPK fertilizers are used in this area for agriculture.Overall, in the study area for post monsoon Cl – TDS, HCO_3 - Ca^+, SO_4^{2-} –TDS, $SO4^{2-}$ – Na, SO_4^{2-}– Clexhibited correlation of more than 0.5 exhibiting a moderate uphill (positive) relationship.

4. Groundwater Quality Index with respect Drinking and Agricultural use

Groundwater quality for drinking purposes was assessed by parameters mentioned above and calculating various classifications like Chadha's, which is a modified version of Piper diagram (Piper, 1994) and the expanded Durov diagram (Durov, 1948), Kelley's Ratio and Permeability Index (PI).

4.1Chadha diagram(1999) explains in Muktsar 49.6% and 45.7% during pre and post-monsoon respectively fall under Ca^{2+}–Mg^{2+}–$HCO3^-$ water type. Such observation suggests water has temporary hardness as shown in Fig.2.

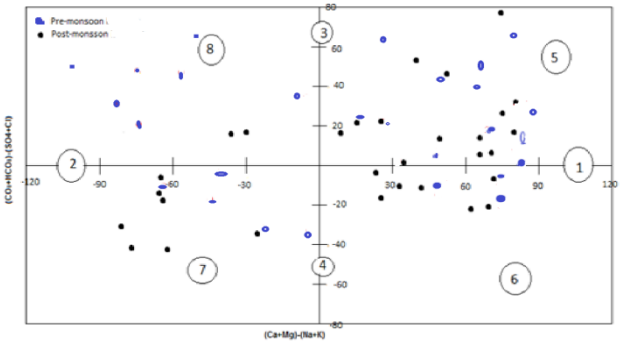

Fig.2: Chadha diagram showing water samples during pre and post-monsoon of Muktsar District

4.2 Kelley's index(1963) is used for the classification of water for irrigation purposes. Sodium measured against calcium and magnesium is considered for calculating this parameter.

$$KI = \frac{\text{Na}}{(\text{Ca} + \text{Mg})}$$

Waters with KI <1 is suitable for irrigation, while those with greater ratio are unsuitable (Kelly, 1940). High values of Kelley's ratio were observed in both pre monsoon and post monsoon. In Muktsar32.9% samples in both the seasons were having value of Kelley's ratio above 1 which means not suitable for irrigation as shown in Table 2.

S.No.	**Kelley's index (KI)**	Pre and post monsoon	Result
1.	Ratio above 1	32.9% water samples	Not suitable for agriculture

Table 2: Results of KI of water samples during per and post monsoon in parts of Muktsar District, Punjab

4.3 Permeability index (PI) is a significant parameter for the suitability of irrigation water and it indicates that the soil permeability is affected by long term use of irrigation water as influenced by Na^+, Ca^{2+}, Mg^{2+}, and HCO_3^- contents of the soil. The permeability index (PI) values also indicate the suitability of groundwater for irrigation. It is defined as (Doneen, 1964).

$$\text{PI} = \frac{(\text{Na}^+ + \sqrt{\text{HCO}_3}) \times 100}{(\text{Ca}^{2+} + \text{Mg}^{2+} + \text{Na}^+ + \text{K}^+)}$$

The concentrations are expressed in meq/l. Water can be classified as Class I, II and III. Class I and II water are categorized as good for irrigation with 25%-75% or more of maximum permeability. Class III water is unsuitable with 25% of maximum permeability. According to the permeability index values, in Muktsar, higher average value of PI was observed in post monsoon than pre monsoon with 34.3% samples fall in class- I during both seasons. 12.8% and 27.08% in class II during pre and post monsoon respectively. In class III 17.6% and 28.09% samples in pre and post monsoon seasons respectively as shown in Table 3.

S.No.	Limiting value of **Permeability Index (PI)**	Class	Water samples Pre-monsoon	Water samples Post-monsoon	Interpretation of results
1.	**>75**	Class I	34.3%	34.3%	Water is good for agriculture
2.	25-50	Class II	12.8%	27.08%	Water is marginally good for agriculture
3.	<25	Class III	17.6%	28.09%	Water is not suitable for agriculture

Table 3: Results of PI of water samples during per and post monsoon in parts of Muktsar District, Punjab

5. Recommendations

Lessening in canal allowance, sustainable use of ground water for irrigation and social awareness at all levels, effectual on farm management practices, boosting tolerant crops like barley, wheat, cotton, sun-flower, instituting water user societies for effective management of available water resources and implementation of organic farming to maintain soil fertility.

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