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Research article

HYDROCHEMICAL CHARACTERIZATION AND CLASSIFICATION OF GROUNDWATER REGIME FOR SUSTAINABLE AGRICULTURE IN LUDHIANA DISTRICT, PUNJAB, INDIA.

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ABSTRACT: The global population is going to reach a 9 billion mark by 2050 and food production will have to increase 70 percent to meet the demands of a booming population. Today more than 1 billion people around the world depend upon farming for their livelihoods. The water quality is also one of the major factors for the sustainable agriculture. Agriculture must be environmentally, socially and economically sustainable so that they can feed the world. Ludhiana was the first district where the green revolution made its appearance right from the beginning. Rapid industrialization and urbanization lead to depletion of water resources which ultimately cause pollution and contamination through sewage, industrial wastes, domestic wastes and agricultural runoff. The quality of water was made by various parameters like pH, EC, TDS,TH and major cations like (Ca^{2+},Mg^{2+},Na^{+},K^{+}) and anions like (HCO_3^-, Cl^-,SO_4^{2-},$PO_4^{3-}$and NO_3^-) as per BIS standards. The results show that bicarbonate is the dominate anion and calcium along with magnesium is the dominant cation. EC, %Na, SAR, RSC, PI and KI are also analyzed for irrigation purposes. Classification of hydrochemical facies of ground water reveals majority of water belongs to Ca-Mg-HCO_3^- water types i.e. water has temporary hardness.
Key words: Sustainable agriculture, Industrial wastes, Agriculture runoff, Industrialization.

INTRODUCTION

Water is the essence of life. Groundwater contributes only 0.6% of the total water resources on earth, it accounts for nearly 80% of the rural domestic water needs and 50% of the urban needs in developing countries like India [15]. Anthropogenic activities leads to environmental pollution resulting its ill effects on living organisms. Water is the vital natural resource and agricultural sector is the major consumer of water. Rapid industrialization and urbanization increased the demand for water and also leads to the contamination of surface as well as ground water. Increased use of fertilizers in agriculture also leads to groundwater pollution. Overexploitation of ground water depletes the water table and also makes good quality aquifers more contaminated. Burning of nonconventional fuel and resultant emission of greenhouse gases, rice-wheat dominant system and conventional method of sowing not only disturbs the soil environment but also leads to atmospheric pollution. Environmental stability is directly linked to agriculture. The present agricultural system in Punjab has become unsustainable and non-profitable. Over intensification of agriculture over the years has led to water depletion, reduced soil fertility and micro-nutrient deficiency, non-judicious use of farm chemicals and problems of pesticide, reduced genetic diversity, soil erosion, atmospheric and water pollution and overall degradation of the rather fragile agro ecosystem of the state. Easily and regularly available clean drinking water is still a harsh task to achieve not only in deserts but also in most of the small towns and mega cities [13].The United Nations has proclaimed the years of 2005-2015 as the international decade for action on “water for life” [20].

In view of the above mentioned problem, this paper is primarily focused on the various parameters required for the agricultural sustainability in Ludhiana, District.

Study Area

Ludhiana district falls in central part of Punjab. The district is bounded between north latitude30^0 $31^{'}$and $31^0 01^{'}$ and east longitude $75^0 28^{'}$ and76^0 $20^{'}$. The Sutlej forms the border of the district in the north with Jalandhar and Hoshiarpur districts. Ropar and Fatehgarh Sahib Districts marks the eastern and south eastern boundaries. The western border is adjoining Moga and Ferozpur districts. The geographical area of the district is 3790 sq. kms. Administratively, the district has four sub-divisions: Ludhiana, Khanna, Samrala and Jagroan and eleven developmental blocks [19].

The climate of Ludhiana is of tropical steppe, hot and semi-arid with dry hot summer and cold winter except during monsoon season. The hot weather starts from mid-march to last week of June followed by the south west monsoon which lasts upto September. The winter season starts late in November and remains upto first week of March. The normal annual rainfall is 680mm.

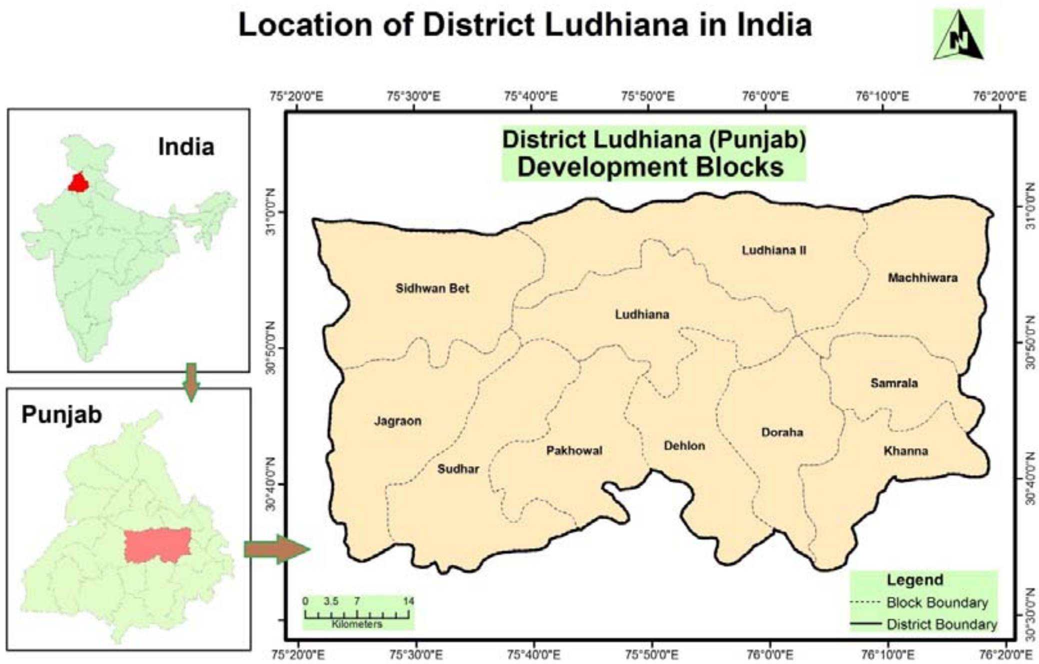


Fig.1 Location Map of Study area

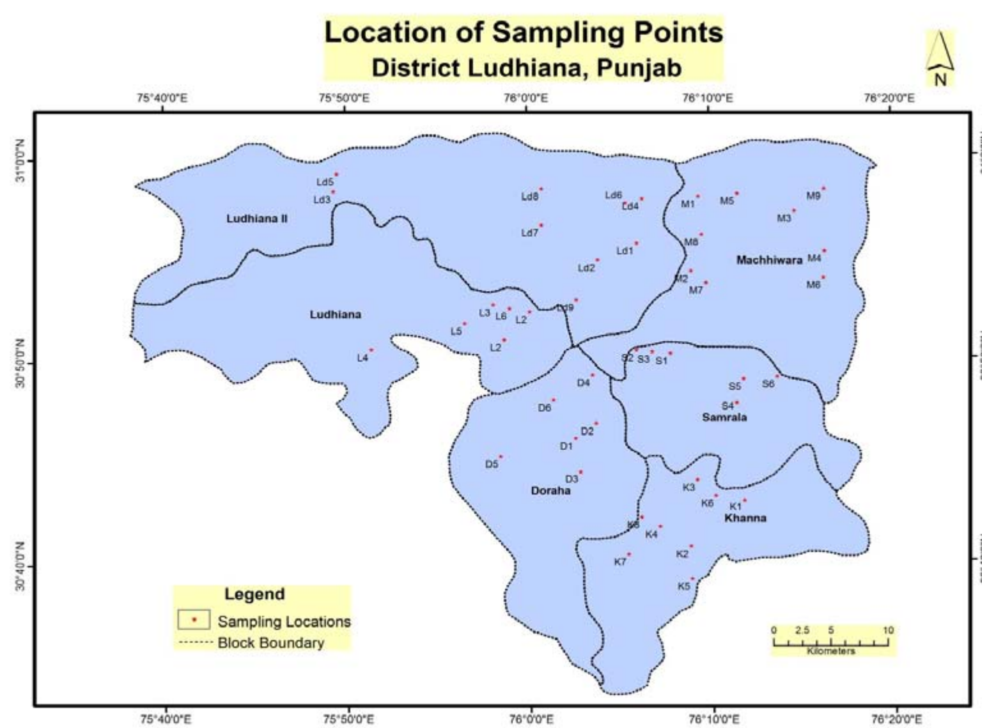


Fig 2: Map showing groundwater sampling locations during pre and post monsoon (2013)

MATERIALS AND METHODS

The hydrochemical analysis of ground and surface water is essential for the evaluation of its suitability for drinking as well as for agricultural use. 44 groundwater samples have been collected from various water sources of Ludhiana district during the Months of May and November 2013. The samples from these areas have been collected from varying depths of 2.5 mtrs to 110 mtrs. Sampling, preservation and analytical protocols were conducted by standard methods. Good qualities, air tight plastic bottles with cover lock were used for sample collection and safe transfer to the laboratories for analysis. The groundwater samples were analyzed to assess various chemical and physical water quality parameters such as (pH, EC, TDS) and major elements such as (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, SO_4^{2-},Cl^{-},NO_3^{-} ,HCO_3^{2-},PO_4^{3-}) were evaluated according to the standard method [1] within a short period of time to get a more reliable and accurate results. Physical parameters like EC, pH, TDS were measured on the spot at the time of sample collection using potable kit. Analysis were done for major cations (Na^{+}, K^{+}, Ca^{2+} and Mg^{2+}) and anions (HCO_3^{2-}, Cl^{-}, SO_4^{2-}, PO_4^{3-} and NO_3^{-}) using APHA method. $Ca^{2+,}$ Mg^{2+}, CO_3^{2-} and HCO_3^{2-} were analysed by titration. Na^{+} and K^{+} were measured by flame photometry and NO_3^{-} and SO_4^{2-} by U.V. Spectrophotometer. Mean value was calculated for each parameter, with standard deviation being used as an indication of the precision of each parameter.

RESULTS AND DISCUSSION

Descriptive statistics for the chemical analysis of ground water samples during (Pre monsoon) PRM and (Post monsoon) POM seasons are shown in table 1 and table 2 respectively.

Table 1: Chemical analysis of ground water samples during pre monsoon

Parameters	MIN	MAX	AVG	STD
pH	6.41	7.58	6.83	0.26
EC	1153	3014	1758.8	409.33
TDS	786	1893	1189.6	269.46
Ca	52.29	95.45	74.10	8.48
K	19.65	42.21	30.73	4.96
Mg	38.27	75.28	58.87	11.27
Na	22.07	35.57	29.32	3.38
HCO	102	110	105.9	2.16
Cl	11.92	15.89	13.88	0.81
SO	7.41	15.09	11.05	2.13
NO	39.21	90.3	59.29	17.88
PO	0.011	0.093	0.034	0.02
F	0.68	1.1	0.84	0.10

Table 2: Chemical analysis of ground water samples during post monsoon

Parameters	MIN	MAX	AVG	STD
pH	5.87	7.12	6.59	0.43
EC	1160	3023	1784.3	403.58
TDS	802	1912	1219.84	262.69
Ca	55.9	88.07	71.63	8.54
K	19.89	48.87	34.46	7.10
Mg	35.89	71.03	53.13	9.74
Na	47.83	62.02	54.72	4.21
HCO	110	145	123.93	7.35
Cl	19.87	32.21	27.32	3.50
SO	7.47	13.86	10.55	1.29
NO	39.12	98.87	53.59	15.90
PO	0.01	0.74	0.091	0.10
F	0.71	1.3	0.89	0.13

All values are in mg/l except pH, EC

Suitability of groundwater for irrigation purpose

The sustainability of agriculture depends principally upon the salinity, soil permeability, toxicity, excessive nitrogen loading or unusual pH of water. Chemical quality of water is a significant factor for evaluating the water suitability for agriculture [7]. Water suitability for agriculture also depends upon the effect of some mineral constituents in the water on both the soil and the plant [23].

It is determined on the basis of Electrical Conductivity (EC) Sodium Absorption Ratio (SAR), Residual Sodium Carbonate (RSC), Percent Sodium (%Na) shown in table 3.

Table 3: Showing agricultural parameters during pre and post monsoon.

S.No.	Parameters	Values	Water Class	No. of Samples (Pre Monsoon)	No.of Sample(Post Monsoon)
1.	EC	<250	Excellent	NIL	NIL
		250- 750	Good	NIL	NIL
		750 - 2000	Permissible	40	40
		2000 - 3000	Doubtful	03	03
		>3000	Unsuitable	01	01
2.	SAR	>10	Excellent	44	44
		10 – 18	Good	Nil	Nil
		18 - 26	Doubtful	Nil	Nil
		>26	Unsuitable	Nil	Nil
3.	%Na	<20	Excellent	23	Nil
		20 -40	Good	21	10
		40 - 60	Permissible	Nil	34
		60 - 80	Doubtful	Nil	Nil
		>80	Unsuitable	Nil	Nil
4.	RSC	<1.25	Water can be used safely	Nil	Nil
		1.25 – 1.5	Can be used with management	Nil	22
		>2.5	Unsuitable for better yields	44	22

Electrical Conductivity (EC)

Electrical Conductivity (EC) is the ability of water to conduct electric current flowed and this is further a function of temperature, types of ion present and their concentration [24]. The excess of salt content is one of the major concerns of water used in agriculture. According to Wilcox Classification [23], 40 water samples under permissible class (750 - 2000µS/cm), 03 water samples under doubtful class (2000-3000µS/cm) and 01 water sample lie under unsuitable class (>3000µS/cm) during pre monsoon and post monsoon.

Sodium Absorption Ratio (SAR)

Excess sodium in water produces undesirable effects of changing soil properties and reducing soil permeability [11]. Sodium hazard of irrigation water can be well understood by knowing SAR. Sodium Absorption ratio (SAR), which is given by the following relation [16].

$SAR= Na^{+}/(Ca^{2+}+Mg^{2+})^{1/2}/2$

Sodium absorption ratio influences infiltration rate of water. So, low SAR is always desirable. In the studied samples, SAR values are varied from 0.51meq/l to 0.61 meq/l. during pre monsoon and 0.1.75meq/l to 2.61meq/l during post monsoon.

US salinity Diagram

The correlation between sodium-absorption ratio and electrical conductivity were plotted on the US salinity diagram [23]. The entire water samples falls under C3-S1 (High Salinity with Low Sodium) i.e ,but only three samples falls under C4-S1 (very High salinity with Low Sodium).

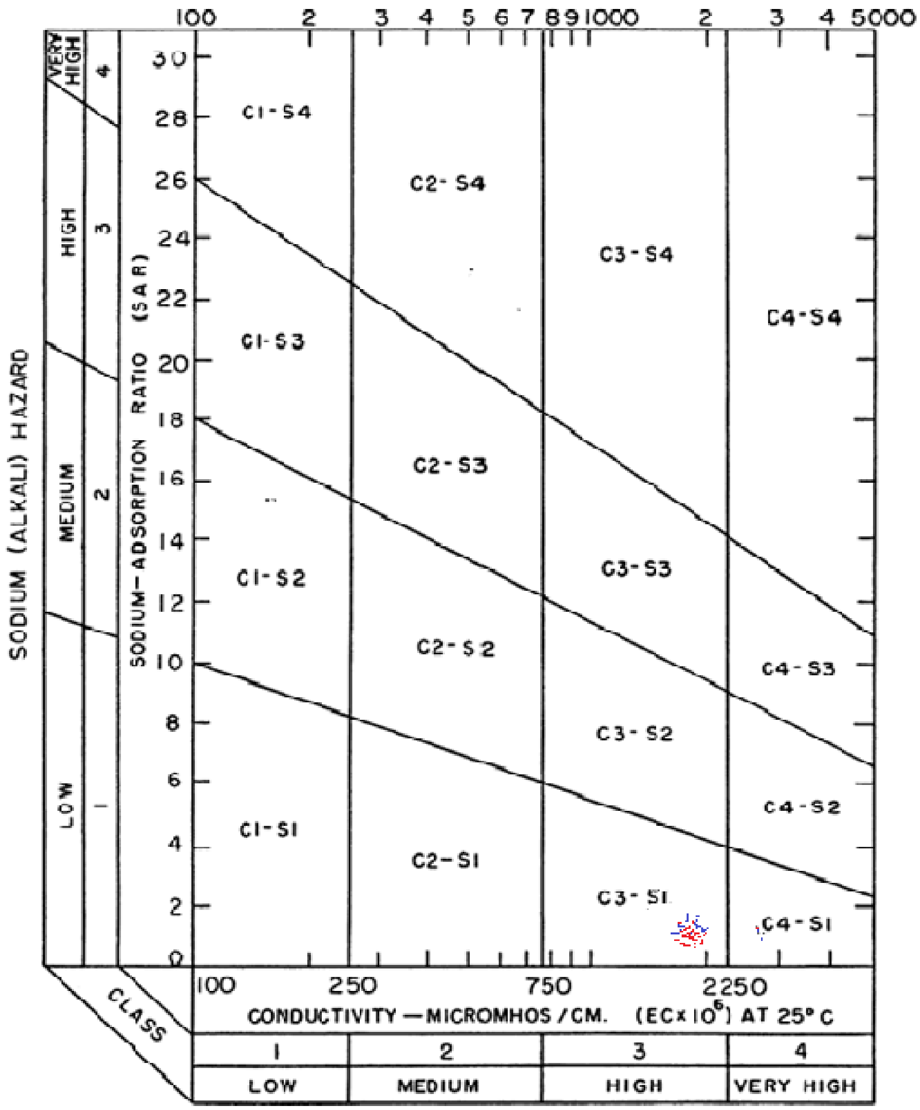
RSC

Eaton (1950) suggested that water having carbonate and bicarbonate ions in excess of calcium and magnesium will lead to alkali formation which is indicated by its SAR and thus decreasing the soil permeability. The sum of carbonate and bicarbonate over the sum of calcium and magnesium in water influences the fit of groundwater for irrigation purposes. An excess sodium bicarbonate and carbonate influence the physical properties of soil that leaves the black stain on its surface on drying [12]. This excess is called RSC and determined by the formula [17].

$RSC = (HCO_3^- + CO_3^-) + (Ca^{2+} + Mg^{2+})$

Where, all ionic concentrations are expressed in meq/l.

In the studied samples, RSC values are varied from-8.67 meq/l to-8.12 meq/l during pre monsoon and -3.55meq/l to -1.80meq/l during post monsoon.



Salinity hazard

Fig 3. USSL classification for pre monsoon and post monsoon

Percent sodium

Sodium percentage values reflected that the water was under the category of 'good' (20-40 Na%), 'permissible' (40-60 Na%) and 'doubtful' (60-80Na%) class [23]. The sodium percentage is calculated by following equation

$Na\% = [Na^+/(Na^+ + K^+ + Ca^{2+} + Mg^{2+}+)]x\ 100$

Here all the concentrations are expressed in meq/l.

When the concentration of sodium ions is high in irrigation water, Na^+ tends to be absorbed by clay particles, displacing magnesium and calcium ions. This exchange process of sodium in water for $Ca^{2+}$and Mg^{2+} in soils reduces the permeability and eventually results in soil with poor internal drainage.

In the studied samples, %Na values are varied from 16.78 % to 20.31%. During pre monsoon and 36.89% to 47.25% during post monsoon. Wilcox classified water for irrigation purposes by correlating percent sodium and electrical conductivity (1948, 1955) shown below:

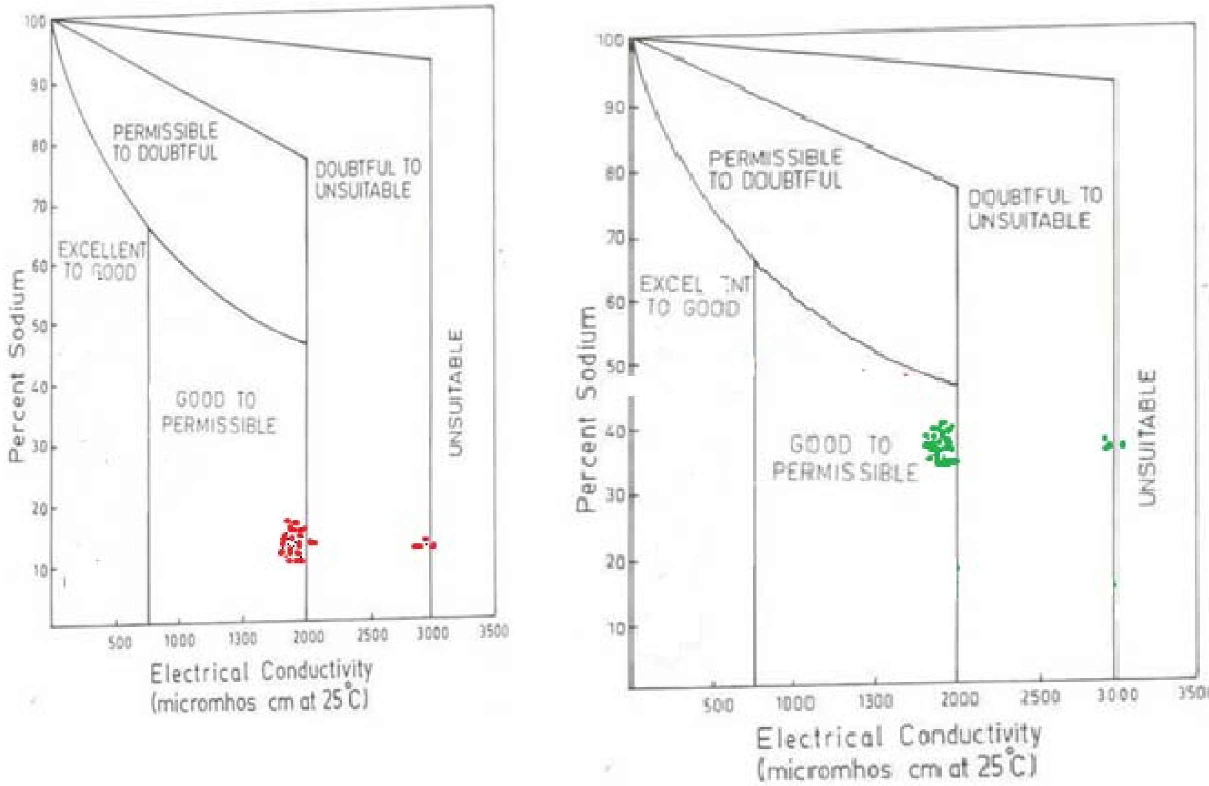


Fig-4: a) Pre monsoon b) Post monsoon

CONCLUSION

The ground water sample collected from the various sources of Ludhiana district were appraised for their chemical composition and suitability for agricultural purposes. The present data of chemical analysis of water shows that water is slightly alkaline in nature and ground water is fresh to moderate saline. The ionic dominance pattern is in the order Ca^{2+}> Mg^{2+}>Na^{+}>K^{+} among cations and HCO_3^->NO_3^->Cl^->SO_4^{2-}>PO_4^{2-} among anions. The results showed that parameters like TDS, Ca^{2+}, Mg^{2+}, NO_3^- were above the desirable limit of BIS gives us caution that in future water will become unfit for human consumption and agricultural use. This may be due to the industrial effluent discharge from industries in the Ludhiana. Water samples assessed for the agriculture purposes on the basis of EC indicate permissible water types. The US salinity diagram illustrates that most of the ground water samples fall in the field of C3-S1i.e. High salinity and low sodium .The RSC value is between -6.13 -2.5 i.e. water should be used with management and in many areas it is not suitable for better yields. The % Na lies under excellent, good category and permissible during pre monsoon and post monsoon.

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