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Characterization of irrigation water of Gurgaon canal command area using geospatial techniques

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Abstract
There are four major irrigation systems and two minor/ micro irrigation systems available in the state for irrigating the crops. Gurgaon canal flowing through Gurgaon, Rewari and Palwal districts in NCR has been chosen for analysis. Gurgaon canal takes delivery of millions of industrial and domestic waste matters. The objective of the study is to characterize the water quality of Gurgaon canal for irrigation suitability and using geospatial techniques to generate of interpolation maps of individual parameters to find out points of maximum concentration and likelihood of probable agricultural land being affected by pollutant concentration beyond prescribed limit in nearby agricultural land area.

The discharge of untreated industrial effluents into the surface water bodies is a major source of surface as well as groundwater pollution. The analysis of canal water samples collected from different locations in the study area were polluted with industrial effluents and resulted in high concentration of soluble salts and exchangeable cations which may create degradation of soil and groundwater quality while making it unsuitable for irrigation purpose. The Gurgaon canal water at different locations were found high in electrical conductivity, TDS, Bicarbonates and RSC which are the indicators of presence of soluble salts and exchangeable sodium which ultimately create salinity and sodality in the soils and these are also responsible for continuous degradation of soil. The high electrical conductivity value of water samples indicates that the discharge of chemicals as cations and anions were higher in canal water which may be due to the mixing of industrial effluent discharged from industrial areas. The higher values of residual sodium carbonate are due to high concentration of bicarbonate which is responsible to create hardness of soil and water logging conditions in the area due to clogging of soil pores. Use of geospatial techniques help to predict and prevent the further extent of loss and deterioration of soil, plant human health, quality of irrigation and drinking water through satellite image interpretation and other tools. This study is focused to mitigate the deteriorating effect of industrial effluent being mixed with irrigation water which may in turn effect soil health and crop production.

Keywords: EC, TDS, bicarbonate, RSC, Cl, irrigation water suitability interpolation method

Introduction

Haryana is located in the northwest India between 27^{0} 37'N to 30^{0} 35'N latitude and between 74^{0} 28'E to 77^{0} 36'E longitude and with an altitude between 700-3600 ft above sea level. Haryana is a landlocked state in northern India. The total geographical area of the state is 4.42 mha, which is 1.4% of the geographical area of the country. Most of the state sits atop the fertile Punjab Plain, a subsection of the Indo-Gangetic Plain. The Yamuna, tributary of Ganges, flows along the state's eastern boundary. The geographical and natural boundaries are flanked by Shivalik Hills in the north, the river Yamuna in the east, Aravalli Hills in the south-west and river Ghaggar in the west, The climate is arid to semi-arid with average rainfall of 354.5 mm. Around 29% of rainfall is received during the months from July to September as a result of the monsoon, and there remaining rainfall is received during the period from December to February as a result of the western disturbance.

About 70% of Haryana's farmers are engaged in agriculture. The Green Revolution in Haryana of the 1960s combined with completion of Bhakra Dam in 1963 and western Yamuna command network canal system in 1970s resulted in the significantly increased food grain production. As a result, Haryana is self-sufficient in food production and the second largest contributor to India's central pool of food grains. The total culturable command area of the state is 3.664 mha, of which 3.102 mha is served by different means of irrigation like canals, wells, public & private tube wells, etc.

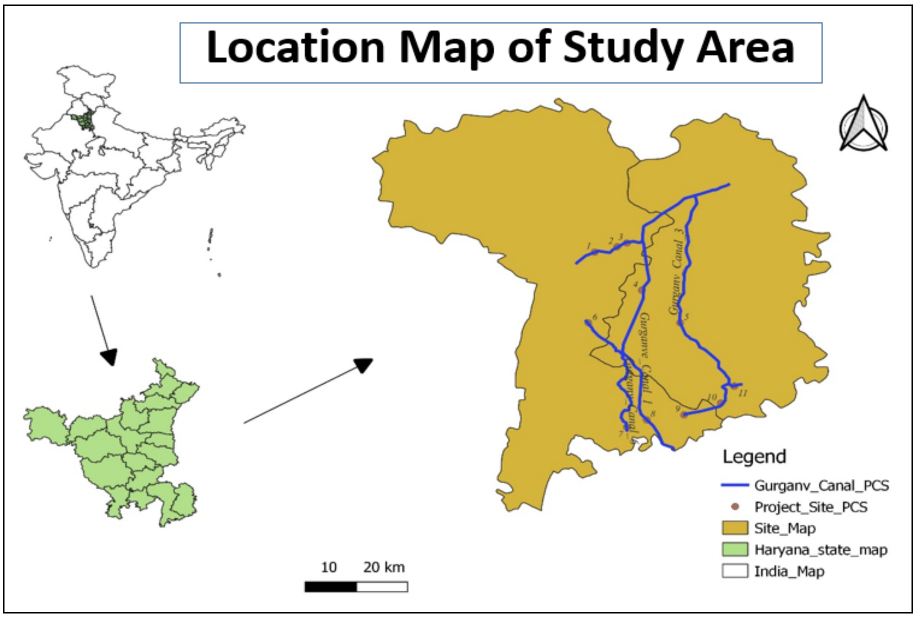


Fig 1: Location map of the study area

As Haryana state is having well developed network of canals, it is capable of primarily meant for meeting the irrigation and industrial water demand of the state. There are four major irrigation systems (*viz*. Western Yamuna canal system, Bhakra canal system, Lift irrigation system and Agra canal & Gurgaon canal systems) and two minor/ micro irrigation systems (*viz*. Sprinkler irrigation system and Drip irrigation system) available in the state for irrigating the crops. Gurgaon canal being one of the major canal system flows flowing through Gurgaon, Rewari and Palwal districts in NCR has been chosen for analysis. It initiates from one of the main branches of the Okhla drain and Yamuna River, in close proximity to NCR at an elevation of 199 m above MSL. Gurgaon Canal traverses a length of 70 km. It caters for catchment of 259 sq miles before out falling in river Yamuna in tehsil Palwal. Its discharge is maximum during monsoon seasons. The floods in the district are mainly due to heavy rains and over flow of Yamuna River (Fig 1). Gurgaon Canal network takes delivery of million volume of industrial and domestic waste matter and untreated waste water is being falling in the canal without pre-treating resulting in unmanageable supply of waste water. In this study, efforts have been made to provide an overview of the existing quality issues of canal irrigation system of Gurgaon canal systems in Haryana which may have adverse effect on crop yield in terms of quality and quantity along with land being degraded by subsided irrigation water in peripheral agricultural lands.

Statement of Problem

Uncontrolled anthropogenic activities are pressurising the resources towards continuous deterioration. These activities have sick effect on soil, human health and ultimately deteriorating quality of food. This study is focused to mitigate the deteriorating effect of industrial effluent being mixed with irrigation water which may in turn effect soil health and crop production.

Objective of the study

The objective of the study is to characterize the water quality of Gurgaon canal for irrigation suitability and using geospatial techniques and to generate of interpolation maps of individual parameters to find out points of maximum concentration and likelihood of probable agricultural land being affected by pollutant concentration beyond prescribed limit in peripheral agricultural land area.

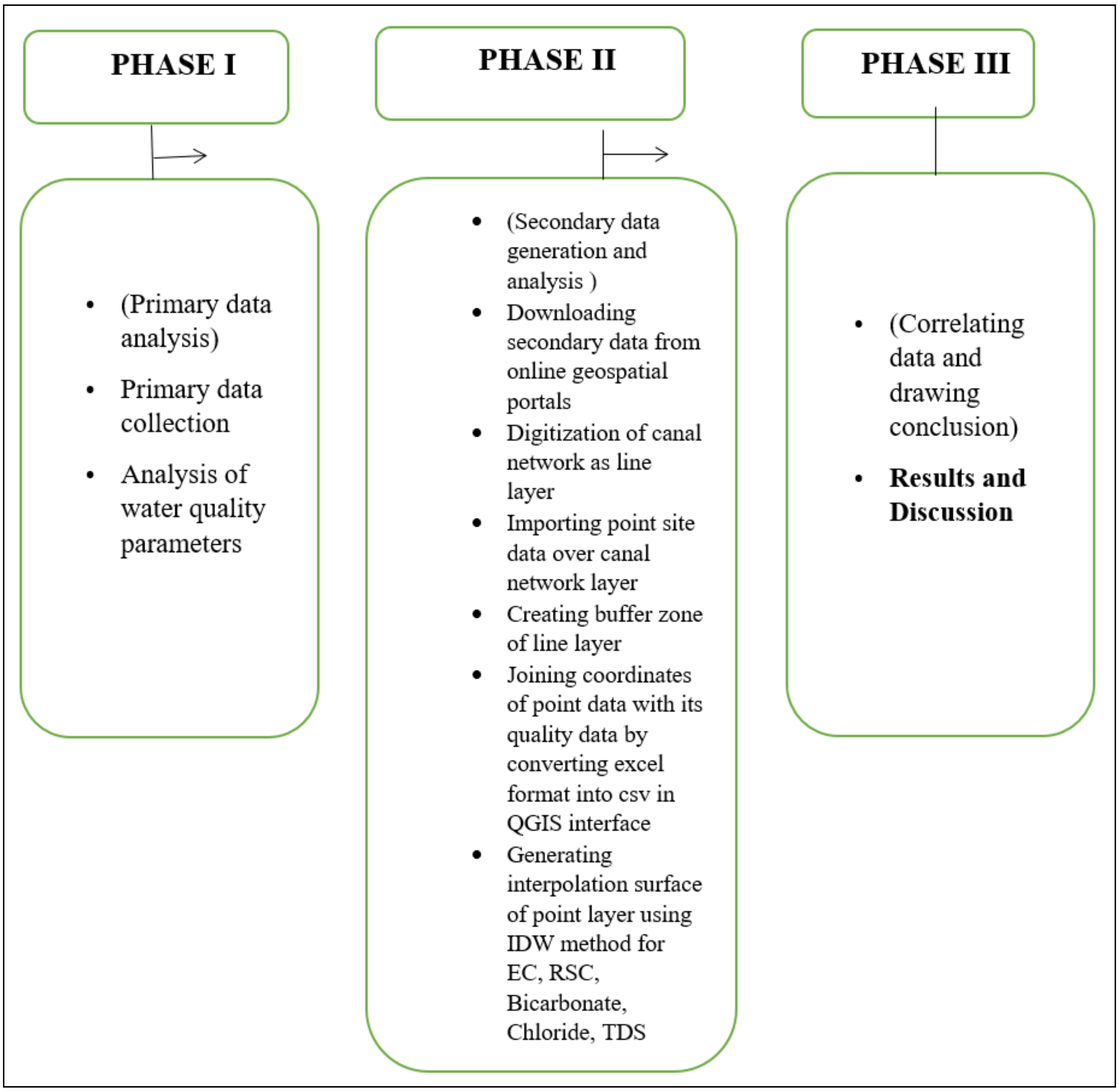
Data sets

Eleven Primary data sets of canal water parameters were used and processed to complete this project. Location map is derived from google earth by plotting the coordinal points of the samples. Guidelines for interpretation of water quality parameters for irrigation were used as given by FAO, 1985 [1] and text book of soil science. Secondary data is acquired from Geospatial portals like Google Earth and BHUVAN and was processed in QGIS and SAGA software.

Methodology.

Phase I of the study involved primary data collection from field at canal periphery for water quality parameters analysis during Rabi season of 2021-22 followed by procurement of primary data from research experiment of selected study area and analysed for different chemical characteristics (Flow Chart 1). Phase II involved downloading of secondary data in raster form was done from geospatial online portals like Bhuvan (ISRO) and Google Earth. Digitizing canal network over the downloaded imagery in QGIS to get vector layer of the canal network.11 site locations as point vector data were imported in QGIS interface over canal network layer. Thereafter a buffer zone was created around line layer to get an idea of the likely area to get effected by polluted canal water.

Joining of attribute table of point coordinates and water quality parameters for each site were done using join operator in QGIS to get geotagged meta data. Lastly generating Interpolation layers of point layer using IDW (Inverse Distance weighting) interpolation method to generate water quality surface for EC, RSC, Bicarbonate, Chloride, TDS of canal water. Lastly phase III involved water quality Interpolation map production as conclusive study to infer about pollution index of the study area.



Flow Chart 1: Methodology followed in the study

Results and Discussion

Table 1: Guidelines for interpretation of water quality for irrigation (FAO, 1985) [1]

Sr No.	Water Constituents	Severity of Problem		
		No Problem	**Slight to Moderate**	**Severe**
1	pH	6.5-7.5	--	>8.4
2	EC	<0.7	0.7-3.0	>3.0
3	TDS	<450	450-2000	>2000
4	Bicarbonate	<1.5	1.5-8.5	>8.5
5	RSC	<1.25	1.25-2.5	>2.5
6	Chloride	<4	4-10	>10

Source: FAO (1985) [1]

1. Characterization of canal water

The canal water samples were collected from 11 sites from peripheral area of the Gurgaon canal in Haryana state during Rabi season of 2021-22 and were analysed for different chemical characteristics as summarised in table 2. This water is utilized to irrigate different crops in rabi and kharif seasons mainly for cereals and vegetables crops. The variation was observed in the different parameters of waters in the peripheral region at different location.

pH

The pH of canal water ranged from 7.5 to 7.8 with mean value of 7.7 and presented in table 2. The minimum pH (7.5) was recorded at site-1whereas maximum pH (pH 7.8) at site 3, 9 and 10. All the values of PH were found to be in compliance with the FAO (1985) [1] limit for irrigation water.

Table 2: Characterization of Gurgaon canal water

Site	Latitude	Longitude	pH	EC (dSm^{-1})	T.D.S. (mgl^{-1})	Bicarbonate ($meql^{-1}$)	RSC ($meql^{-1}$)	Chloride ($meql^{-1}$)
Site 1	28.213056	77.0761111	7.46	1.50	960.00	12.00	11.00	15.00
Site 2	28.224444	77.1202778	7.67	1.20	760.00	5.00	3.85	12.00
Site 3	28.2325	77.1391667	7.77	1.22	780.00	5.50	4.37	11.50
Site 4	28.131111	77.1686111	7.63	2.00	1280.00	10.00	8.90	18.00
Site 5	28.060833	77.2444444	7.65	5.40	3450.00	10.00	7.05	45.00
Site 6	28.060556	77.0633333	7.56	1.60	980.00	12.50	11.43	14.00
Site 7	27.836944	77.1391667	7.62	2.60	1660.00	8.40	7.05	19.00
Site 8	27.8525	77.1783333	7.56	2.00	1280.00	6.00	4.75	15.00
Site 9	27.863056	77.2522222	7.78	1.40	890.00	3.00	1.95	17.00
Site 10	27.888333	77.3244444	7.84	3.10	1980.00	7.00	5.55	20.00
Site 11	27.925	77.3513889	7.63	4.40	2810.00	7.00	4.90	42.00

Electrical conductivity

The electrical conductivity (EC) is another important factor that determine the water quality for irrigation in terms of salinity. The data pertaining to electrical conductivity (dSm-1) of Gurgaon canal water were collected along the canal sites in Gurgaon, Palwal and Mewat district are presented in table 2. The mean value of EC recorded as 2.40 dSm-1. The EC values of the canal water were differed as per the location. The EC of canal water ranged from 1.20 to 5.40dSm-1 and it was recorded highest in 5.40 dSm-1 in the canal water collected from site-5 figure 2 whereas it was recorded minimum in water sample collected from site-2 of the canal area.

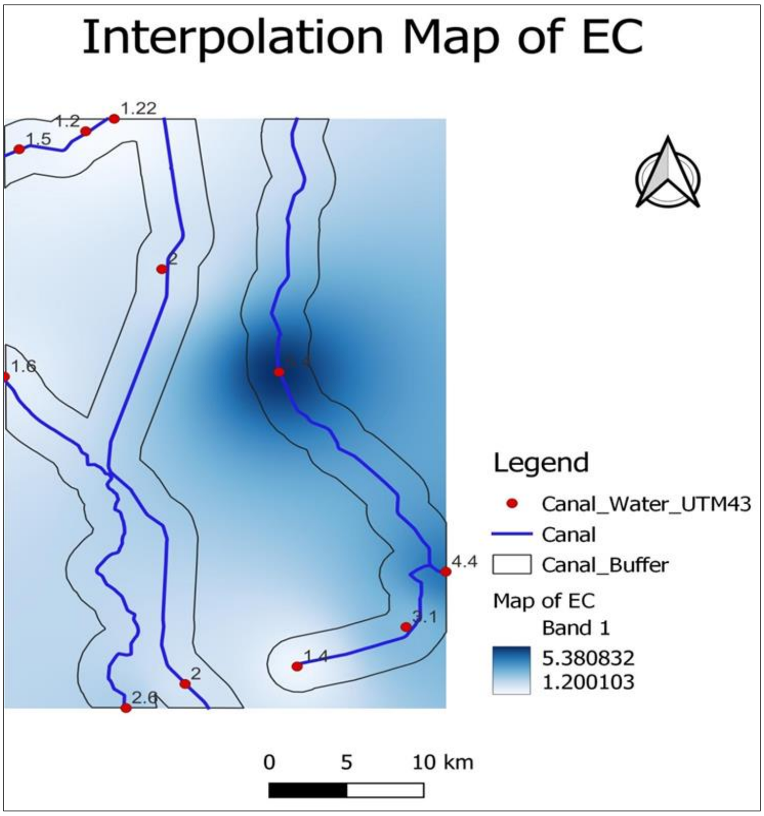


Fig 2: Interpolation map of EC

The Ph and EC value of effluents depends upon on the chemicals beings used and discharged by different industries (Kumaravelu *et al*, 2000) [6]. As per the FAO (1985) [1] irrigation water quality guidelines (table 1), the EC values recorded in the water samples of site-5, 10 and 11 have severe problem and are not suitable for irrigation purpose for very sensitive crops

Total dissolved salts (TDS)

The mean total dissolve solids (TDS) value was recorded 1530 mgl-1 and ranged from 760 to 3450 mgl-1 in the study area (Table 2). The highest value (3450 mgl-1) of TDS was observed in the water sample collected from site-5 figure 3 and the lowest concentration (760 mgl-1)was found in the water sample collected from site-2. As per the FAO (1985) [1] irrigation water quality guidelines (table 1), the TDS values recorded in the water samples of site-5, 10 and 11have severe problem and are not suitable for irrigation purpose for very sensitive crops. The TDS values of the water were differed as per location and nature of effluents discharged. The discharge of effluents from industries increased TDS of the water and depends upon the nature of the chemicals being used and discharged by different industries. The results are supported by Bhat *et al.* (2011) [2] and Kharche *et al*. (2011) [5].

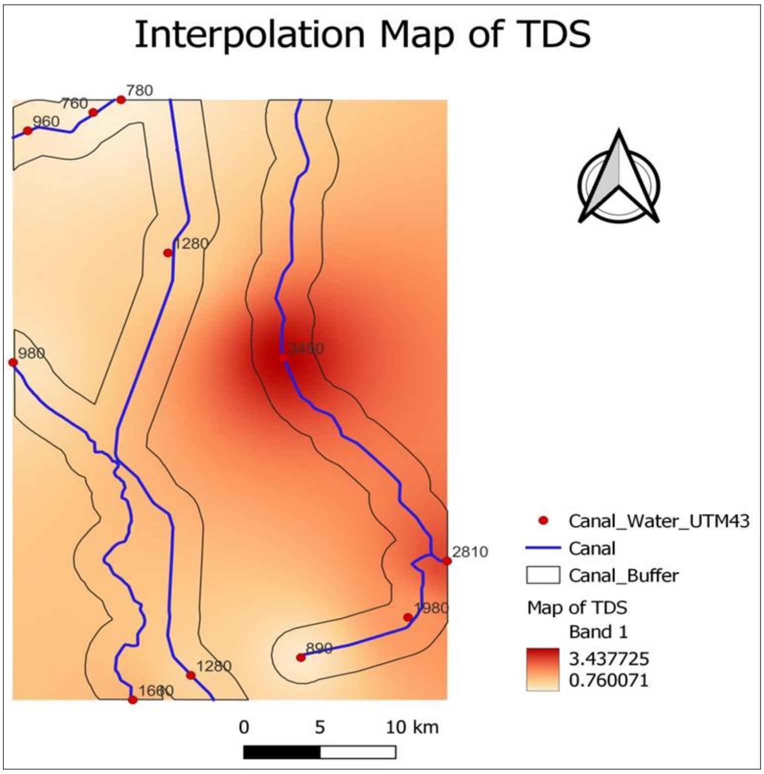


Fig 3: Interpolation map of TDS

Biocarbonate

The mean total bicarbonate value was recorded 7.85 meql-1 and was ranged from 3 to12.5 meql-1 in the study area (Table 2). The highest value (12.5 meql-1) of bicarbonate was observed in the water sample collected from site-6 figure 4 and the lowest concentration (3.0 meq l1) was found in the water sample collected from site-9. As per the FAO (1985) [1] irrigation water quality guidelines the TDS values recorded in the water samples of site-1, 4, 5, and 6 have severe problem and are not suitable for irrigation purpose for very sensitive crops (table 1).

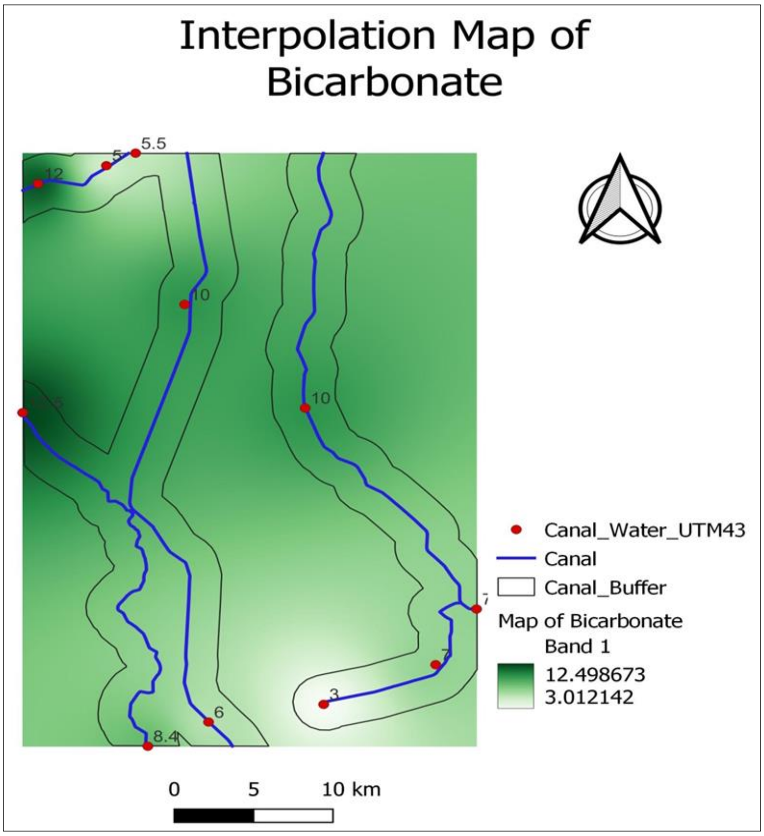


Fig 4: Interpolation map of Bicarbonate

Residual Sodium Carbonate (RSC)

The residual sodium carbonate is also important factor that determine the water quality for irrigation in terms of hardness of water. The data pertaining to residual sodium carbonate (dSm-1) of Gurgaon canal water collected along the peripheral sites in Gurgaon, Palwal and Mewat district are presented in table2. The mean value of residual sodium carbonate recorded as 6.44meql-1. The residual sodium carbonate values of the canal water were differed. The residual sodium carbonate of canal water ranged from 1.95 to 11.43 meq-1 and it was recorded highest as 11.43 meql-1 in the canal water collected from site-6 figure 6 whereas it was recorded minimum in water sample collected from site-9 of the canal area. As per of the standard irrigation water quality guidelines (table 1), the EC values recorded in the water samples of all the sites except site-9 have severe problem and are not suitable for irrigation purpose for very sensitive crops.

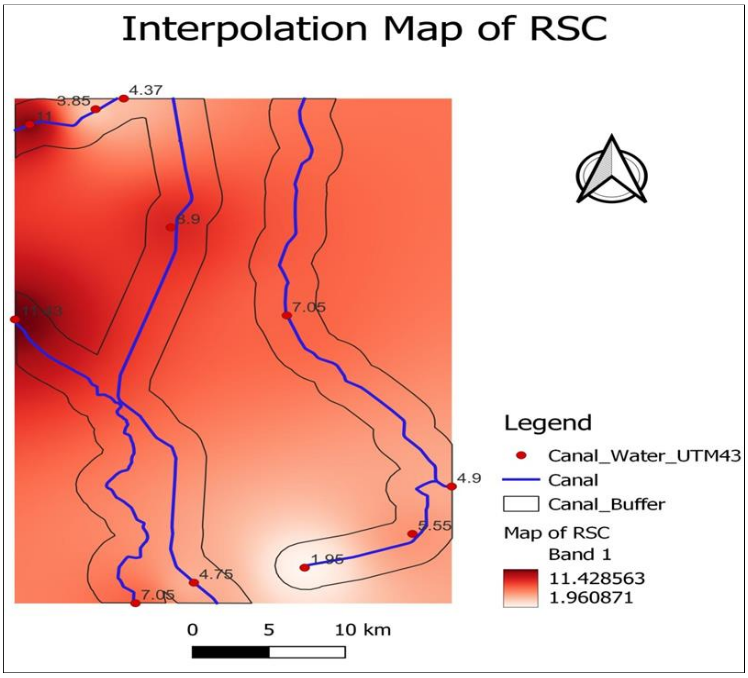


Fig 5: Interpolation map of RSC

Chloride

The mean value of chloride (mgL-1) in canal water were observed as 20.77 (Tables 2) and it ranged from 11.5 meql-1 to 45.0 meql-1 in the study area of the Gurgaon canal. The highest chloride content (45.0 meql-1) was recorded in the water sample collected from site-5whereas it was recorded lowest (11.50 meql-1) in the water sample collected from site-3. The chloride content of canal water was observed higher than the recommended levels 4.0 meL-1of FAO, 1985 [1] (Table2). Similar chloride content was also resulted by Maiti *et al*., 1992 [7]; Bhardwaj *et al*., 2009 and Kharche *et al*., 2011 [5] and Hanumant Singh *et al*., 2019 [11].

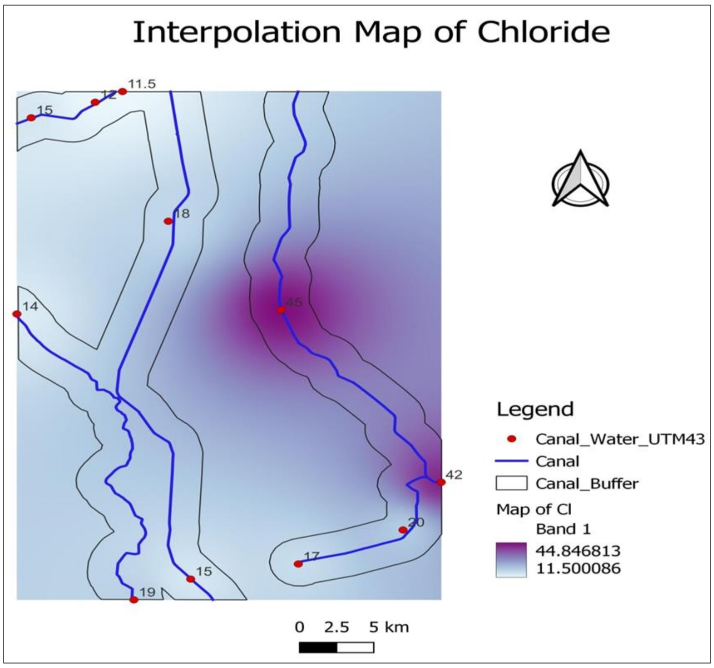


Fig 6: Interpolation map of chloride

Geostatistical Analysis

Using QGIS tool a geostatistical surface map of EC, TDS, Bicarbonate, Residual Sodium Carbonate (RSC) and Chloride concentration were created using the EC, TDS, Bicarbonate, Residual Sodium Carbonate (RSC) and Chloride concentration values of water samples collected from different locations of the study area using IDW method of interpolation. Figure 2, 3, 4, 5, 6 shows the output surface map of the concentration of EC, TDS, Bicarbonate, Residual Sodium Carbonate (RSC) and Chloride respectively. The IDW map allows estimating the spatial pattern of distribution of chemical constituents of water figure 2. shows that the highest electrical conductivity in canal water mostly mapped on the site5 which affect the 2 km buffered area of the site. The spatial distribution pattern of TDS shows (figure 3) that the most affected areas are directly correlated with concentration of chloride which was highest in the buffer zone of site-5.

Conclusion

The discharge of untreated industrial effluents into the surface water bodies is a major source of surface as well as groundwater pollution. The analysis of canal water samples collected from different locations in the study area were polluted with industrial effluents and resulted in high concentration of soluble salts and exchangeable cations which may create degradation of soil and groundwater quality while making it unsuitable for irrigation purpose. Use of geospatial techniques help to predict and prevent the further extent of loss and deterioration of soil, plant human health, quality of irrigation and drinking water through satellite image interpretation and other tools.

Suggestions

Proper treatment of effluent discharged from industrial area is desired before mixing with irrigation water of canal. Furthermore, the groundwater in the vicinity of industrial estate may immensely get polluted by industrial effluents and considered as unsuitable for drinking in the coming future.

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