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Research Article

SPATIAL VARIABILITY OF GROUND WATER QUALITY FOR IRRIGATION OF MANSA DISTRICT, PUNJAB

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Abstract: In the present study, suitable geostatistical approach is used for mapping different water quality parameters and generate water quality map for Mansa district, Punjab. Georeferenced ground water samples were collected and analysed for different quality parameters *i.e.* pH, Electrical Conductivity (EC), Carbonate and Bicarbonate (CO_3^{2-}, HCO_3^-), Chloride (Cl-), Calcium + Magnesium (Ca^{2+}+Mg^{2+}) (Total Hardness), Sodium (Na+), Residual Sodium Carbonate (RSC), Potassium (K+) and SAR. Different geostatistical approaches such as ordinary kriging, simple kriging, Radial Basis Functions (RBF) and Inverse Distance Weighting (IDW) were compared on the basis of root mean square error to select the best technique for a particular parameter. EC and RSC variability maps were integrated to generate water quality map in GIS environment. Water quality maps were broadly categorized as Good, Marginal and Poor on the basis of EC and RSC values. Change detection was conducted using previous year water quality map and water quality generated in this study.

Keywords: *Geostatistical interpolation techniques, Water quality mapping, Spatial variability, Irrigation water*

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Introduction

Punjab has witnessed a tremendous increase in crop production during the last thirty years. This has been possible by using irrigation facilities in conjunction with fertilizer use in high consumption crops. During this period, irrigated area has increased from 71% to 94%, out of which 62% area is irrigated through underground water resources and during this period irrigated area of Mansa district has increased from 71% to 98.9% and Mansa district area is irrigated though both underground water and canal resources. Groundwater plays an important role in agricultural Production. The suitability of irrigation water depends upon many factors including the quality of water, soil type, salt tolerance characteristics of the plants, climate and drainage characteristics of the soil. Groundwater always contains small amount of soluble salts dissolved in it.

The quality of underground water is subjected to deterioration from many sources as soluble salts present in soil mantle and other underground formation. The development and utilization of ground water resources could be planned judiciously only when the chemical composition of ground water is fully known.

Shamsudduha, (2007) [1] used different statistical methods to interpolate the spatial variability arsenic in groundwater of Bangladesh. The degree of spatial variability was predicted by variogram analysis. Various interpolation methods were applied and the most appropriate method was selected from cross validation. It was found that ordinary kriging produced better prediction models for arsenic concentration. Askari, *et al*., (2009) [2] while dealing with spatial variations of groundwater quality in Qazvin plain by Geostatic analysis and GIS, concluded that RBF approach has reached much better results than others interpolation methods. Rawat, *et al.* (2012) [3] studied different kriging methods that were used for predicting spatial distribution of some groundwater quality parameters such as: Ca^{2+}, Mg^{2+}, Na+, K+, TDS, EC, F^-, HCO_3^-, NO_3^-, Cl^-, $SO_4^{2-}$and PO_4^{2-}. They used experimental semi-variogram, residual sum of squares (RSS) Value for selecting the best suitable model. They found high values of NO_3^- (=104.77 mg/l), K+ (=141.51 mg/l), PO_4^{2-} (=2.99 mg/l) and high F^- value with a maximum of 4.6 mg/l (at Shahpur) in ground water samples. A suitable model for fitness on the experimental variogram was selected based on less root sum of square value and the best method for interpolation was selected, using cross-validation, mean error and root mean square error. Remote Sensing and GIS are effective tools for water quality mapping for irrigation. Remote Sensing and Geographic Information System (GIS) has added a new dimension in the field of ground water investigations. Knowledge of spatial variability for different ground water quality parameters is very important for proper management. Among pH, EC, Ca^{2+}+Mg^{2+}, CO_3^{2-}, HCO_3^-, Cl-, Na+, Electrical Conductivity (EC) and Residual Sodium Carbonate (RSC) are use full assessing the ground water quality for irrigation purpose for particular area and demarcation of ground water prospective zones, using Remote Sensing and GIS is much more precise and effective. The objectives of the present study are to (1) To compare different Geo-statistical technique for mapping ground water quality; and (2) To map variability of ground water quality for irrigation in spatial domain.

Study Area

It lies between the latitude of 29˚32'19" to 30˚13'00" north and longitude of 75˚09'49" to 75˚47'00" east and is spread over 2,171 sq. Kms, having a total population of 6,88,630 as per 2001 census amounting of 2.9% of the total population of Punjab. The district is roughly triangular in shape, and is bounded on the northwest by Bathinda, on the northeast by Sangrur, on the north by Barnala district of Punjab and on the south by Haryana State. [Fig-1] is showing the study area.

Material and Methods

Collection of Georeferenced Irrigation water samples

The water samples from running tube-wells representing shallow aquifers were collected following standard procedures.

Before collecting the water sample, the tube-well was run for half an hour and samples collected in an air tight plastic bottle of good quality with cover lock.

The location of water sampling sites was marked using Global Positioning System (GPS) [Fig-2]. The point file was created for the locations (x,y coordinates) of tube wells in Arc GIS and analytical data of each well point were attached as data base file.

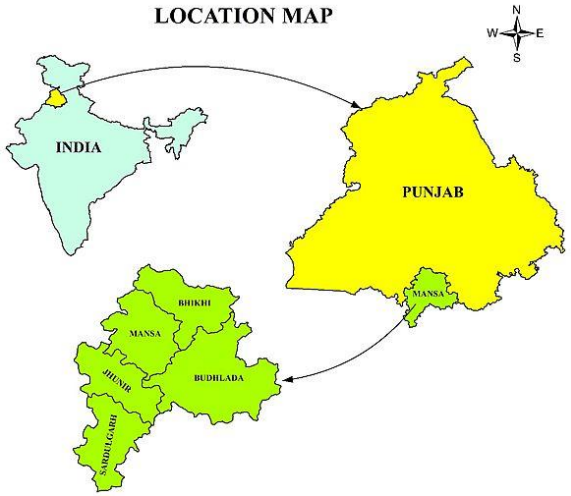

Fig-1 Location map of the study area

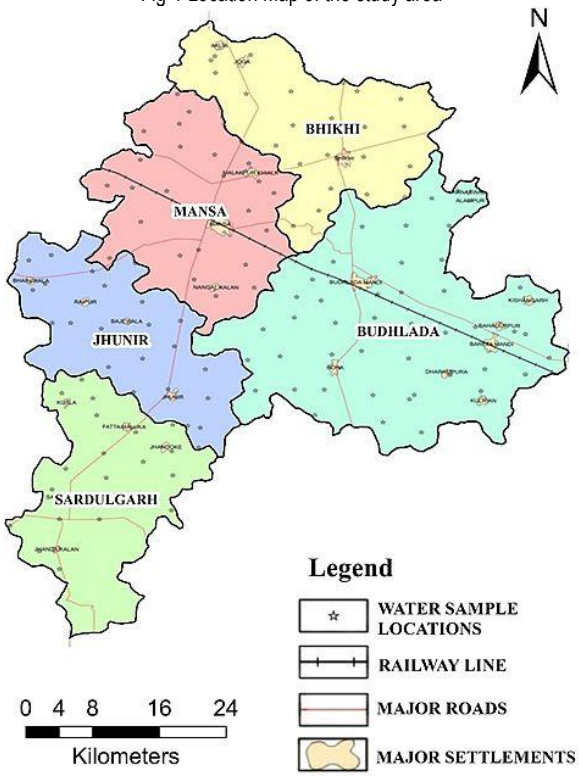

Fig-2 Location of water sampling sites with Global Positioning System (GPS)

Laboratory Analysis for water quality parameters

The sample were analyzed for EC, CO_3^{2-}, HCO_3-, and Ca^{2+}+Mg^{2+}, and following standard Procedures [APHA, (1992), Richards (Ed.), (1954)] which are summarized in [Table-1].

Table-1 *Methodology used for the assessment of ground water quality parameters*

Parameters	Method/Procedures
Electrical Conductivity (EC)	Electrical Conductivity Method, EC Meter
Carbonate and Bicarbonate (CO_3^{2-}, HCO_3-)	Titrimetric Method
Calcium + Magnesium (Ca^{2+}+Mg^{2+}) (Total Hardness)	EDTA – Titrimetric Method

Categorization of Water Samples

The EC and Residual Sodium Carbonate (RSC) values were used for categorization of water samples. The RSC was computed as follows:

$$RSC\ (me\ L\text{-}1) = [CO_3^{2-}+HCO_3^{-}] - [Ca^{2+}+Mg^{2+}]$$

Depending upon the EC and RSC values, the ground water samples have been grouped into three broad categories, *viz*. (a) Good (b) Marginal and (c) Poor. The marginal and poor quality categories have been further subdivided based on the level of salinity, sodicity or both [Table-2]. The ground water sampling sites were assigned the category (I, II, or III) or sub category (IIa/b/c/d/e or IIIa/b/c/d) symbol as per the criteria outlined in table. The extent of each category/ sub category in a district was delineated.

Quality Mapping was generated: on the basis of EC and RSC water quality map was generated in arcGIS with tool analysis tool.

Results and Discussions

Selection of suitable interpolation technique for mapping different water quality parameters

Spatial variability maps for different irrigation water quality parameters *i.e.*, EC, and RSC were generated using various interpolation techniques *i.e.*, Inverse Distance Weighting (IDW), Simple Kriging, Ordinary Kriging, Radial Basis Function (Spline). Comparison of different interpolation techniques was done on the basis of root mean square errors (RMSE) and co-efficient of determination (R_2) for selecting the best suited technique for spatial variability mapping of a particular water quality parameter. Values of R_2 and RMS errors of different interpolation techniques for each of the quality (as mentioned in the methodology) parameters are presented in [Table-3]. In case of EC and RSC, Spline interpolation technique showed lowest RMS error value and therefore was selected for mapping those parameters.

Spatial variability mapping

Spatial variability mapping of different water quality parameters was performed with best suited interpolation techniques as stated in the previous section.

Electrical Conductivity (EC)

A remarkable variation in Electrical Conductivity (EC) was observed in Mansa District. The value of Electrical Conductivity (EC) Ranged from 0.3-8.530 me/l with an average of 2.68 me/l. Irrigation water with Higher amount (4.2-8.5 me/l) of Electrical Conductivity (EC) was found mostly in middle part of Jhunir block whereas in north-eastern part of Budhlada and south-eastern part of Bhikhi irrigation water was found to be nonsaline (0.3-1.5 me/l). Highly saline irrigation water covered 45% (983.13 Sq. Km.) area of Mansa and in only 4% (89.25 Sq. Km.) area irrigation water found to be nonsaline [Fig-3].

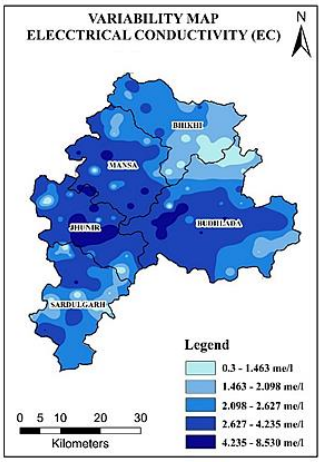

Fig-3 Spatial variability map of Electrical

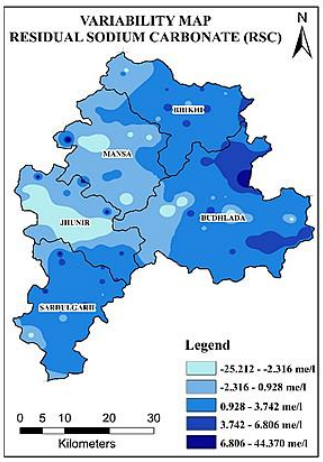

Fig-4 Spatial variability map of RSC Conductivity

Residual Sodium Carbonate (RSC)

A remarkable variation in Residual Sodium Carbonate (RSC) was observed in Mansa District [Fig-4]. The value of Residual Sodium Carbonate (RSC) Ranged from -25.2-44.3 me/l with an average of 1.1 me/l. Irrigation water with Higher amount (6.8-44.4 me/l) of Residual Sodium Carbonate (RSC) was mostly found in

Table-2 *Rating limits for evaluating suitability of ground water for irrigation in Punjab*

Category	Sub-Category		EC (dS m^{-1})	RSC (me L^{-1})	Suitability for Irrigation
I. GOOD	I	Good Non-Saline and Non-Sodic	<2.0	<2.5	Suitable for all conditions
	II a	Slight to Moderately Saline	2.0 - 4.0	<2.5	Suitable for coarse textured soil/salt tolerant crops with periodic monitoring of salt accumulation in soils.
	II b	Moderate to highly Saline	4.0 - 6.0	<2.5	Suitable after mixing with canal water.
II. MARGINAL	II c	Slight to moderately Sodic	<2.0	2.5 - 5.0	Suitable with recommended gypsum application
	II d	Moderate to highly Sodic	<2.0	5.0 - 7.5	
	II e	Slight to Moderately Saline-Sodic	2.0 - 4.0	2.5 - 5.0	Suitable after mixing with canal water and recommended gypsum application
	III a	Slight to Moderately Saline-Moderate to highly Sodic	2.0 - 4.0	5.0 - 7.5	Unsuitable for irrigation
	III b	Extremely Sodic	<4.0	>7.5	
III. POOR	III c	Extremely Saline	>6.0	<2.5	
	III d	Highly Saline-Sodic	>4.0	>5.0	

Table-3 *Comparison of different interpolation techniques for each of the quality parameters*

Parameters	Interpolation Methods							
	IDW Method		Ordinary Kriging Method		Simple Kriging Method		Spline Method	
	R^2 Value	RMS Error Value	R^2 Value	RMS Error Value	R^2 Value	RMS Error Value	R^2 Value	RMS Error Value
EC Value	0.08	1.88	0.11	1.78	0.10	1.78	0.19	1.56
RSC Value	0.05	8.31	0.01	8.46	0.05	8.29	0.01	8.13

north-eastern part of Budhlada block whereas in Jhunir irrigation water was found to be non-saline (-25.2- -2.3 me/l). Highly saline irrigation water covered 55% (1195.61 Sq. Km.) area in Mansa and in only 1% (10.63 Sq Km) area irrigation water found to be non-saline [Fig-4].

Conclusion

The following conclusions are inferred from the present study. On the basis of least root mean square value spline method was found to be the most suitable interpolation techniques for spatial variability mapping of EC and RSC. On the basis of EC and RSC values the samples were categorized in Good, Marginal and Poor and the respective sub categories and area under each of the was commuted block wise and also the whole district. Overall, Good, Marginal and Poor quality of irrigation water covered 5.2 (11139.84 ha), 87.5 (189953.29 ha) and 2.9 (6354.93 ha) % of total geographical area of Mansa district.

Application of research: Ground water (for irrigation purpose) quality map was generated and different water management zones were identified.

Research Category: Remote Sensing

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Institute: Haryana Space Applications Centre (HARSAC), Hisar, 125004, India
Research project name or number: Research station study

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Mansa district, Punjab

Cultivar / Variety / Breed name: Nil

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

References

[1] Shamsudduha M. (2007) *Journal of spatial hydrology*, VII(2), 33-46.
[2] Askari M., Mosaedi A., Dehghani A.A., MeftahHalghi M. (2009) *International Conference Water Recourses. Summer 2009. University Ferdusi Mashhad.*
[3] Rawat et al. (2012) *International Journal of Remote Sensing Applications*, 2 (1), 1-9.
[4] Chaudhary B.S., Manoj Kumar, Roy A.K. and Ruhal D.S. (1996) *International Archives of Photogrammetry and Remote Sensing*, XXXI, part B-6, 18-23.
[5] Balachandar D., Sundararaj P., Murthy K.R., Kumaraswamy K. (2010) *International Journal of Environmental Sciences*, 1(2), 176-190.
[6] Ishaku J.M., Ahmed A.S. & Abubakar M.A. (2011) *Journal of Earth Sciences and Geotechnical Engineering*, 1(1), 35-60.
[7] Camberato James (2001) *Irrigation Water Quality. Turfgrass Program, Clemson University.*
[8] Marko K., Al-Amri N.S., Amro M. & Elfeki M. (2014) *Arabian Journal of Geosciences*, 7(12), 5239-5252.
[9] Minakshi D.M., Sharma P.K., Tur NS., Singh H., Kang G.S. (2006) *Journal of Environmental Science and Engineering*, 48 (2), 91-96
[10] Asadi S. S., Vuppala P. and Anji Reddy M. (2007) *Int. J. Environ. Res. Public Health*, 4(1), 45-52.
[11] Venkateswaran S. and Vediappan S. (2013) *International Journal of Innovative Technology and Exploring Engineering*, 3(2), 180-187.
[12] Tejdeep Singh (2013) *Ground Water Information Booklet Ludhiana District, Punjab, Central Ground Water Board, Chandigarh*