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Comparison of Spatial Interpolation Techniques - A Case Study of Anantnag District J&K, India

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Abstract: *Groundwater is used for a variety of purposes, including irrigation, industrial, drinking, and manufacturing. Assessment and mapping of quality of groundwater is an important because the physical and chemical characteristics of groundwater determine its suitability for agricultural, industrial and domestic usages. The present study area i.e, District Anantnag lies in southern part of Jammu and Kashmir and is characterized by undulating topography, rugged mountains. The habitants of the study area mainly depend on ground water resources viz; springs and tube wells. The present study attempts to explore the best spatial interpolation technique that will best represent the actual ground water quality of district anantnag. In the present study various maps representing various physio-chemcial properties of ground water quality were generated using spatial interpolation techniques viz; Inverse Distance Weighted (IDW) and Nearest Neighbor (NN). Out of total 92 ground water samples, 8 points were preserved for cross validation between the two interpolation techniques using Root Mean Square Error (RMSE) test. Finally it can be conclude that IDW is the most preferable technique for spatial interpolation measurement of ground water quality data.*

Keywords: *Root mean Square error, IDW interpolation, NN interpolation, Anantnag,*

I. Introduction

The continuous circulation of water between ocean, atmosphere, and land is called the hydrologic cycle The hydrologic cycle can be viewed as a major machine on the planet, controlling distribution of water on the earth. Groundwater is one of the major links in the hydrologic cycle. Groundwater forms the invisible, subsurface part of natural hydrological cycle. Inflow to the hydrologic system arrives as precipitation, in the form of rainfall or snowmelt. Outflow takes place as stream flow or runoff and as evapo-transpiration, a combination of evaporation from bodies of water, evaporation from soil surfaces, and transpiration is delivered to streams both on the land surface, as overland flow tributary channels; and by subsurface flow routes, as inter flow and base flow following infiltration into the soil (Freeze & Cherry, 1979). Excluding the freshwater that is locked up in the form of polar ice caps and glaciers, about 97 percent of the worlds freshwater exist in aquifers. The present study has been carried out in district Anantnag of Jammu & Kashmir state. In the present study the available physio-chemical data of 92 locations of the various tehsils of district Anantnag, was used, the data was obtained from PHE and Central ground water authorities of concerned districts. The physio-chemical data contained the information about various water quality determining factors. The data was digitized and put up in Arcgis Software for Spatial Interpolation and based on previous experience most commonly used interpolation methods viz; Inverse Distance Weighted (IDW) and nearest Neighbor were applied to the above data for generation of continuous raster surface for studying the influence of each interpolation technique and best judging which interpolation technique is best. Finally the results obtained were Cross Validated for RMSE Error, as this error test is used to know which Spatial interpolation technique is best based on the value of RMSE Error. This was achieved by keeping 12 points reserved from total 92 sample points and later was used to study deviation if any. Finally the interpolation technique which showed the lowest value for RMSE error was found to be IDW interpolation method. Through this study it is hoped that basic Interpolation method needed to study the water quality of this area further in future has been generated.

II. Study Area

Anantnag district is southernmost district of Kashmir valley separated from the Jammu Province by the mighty Pir- Panjal Range & connects both the regions by the famous Jawahar Tunnel. The districtwith its headquarters at Anantnag forms the southern part of Kashmir valley and is located between $33^0$17'20" and 34^o15'30" North latitude and between 74^o30'15" and 74^o35'00" East longitude and is covered by SOI Degree sheet no. 43 K, N, O. The district is bounded by Poonch district in the west, Srinagar district in the North & Kargil district in the North East and Doda district in the East, by Pulwama district in the North West and Rajouri & Udhampur districts in the South & South East. The district is approachable NH IA and is interconnected by metalled roads from all parts of the Valley. The district is also famous for Holy Amarnath Cave situated in Pahalgam tehsil where Lacs of pilgrims visit every year from all over the country. The district has a total geographical area of 3,984 sq km, comprising of 605 villages (605 inhabited). Administratively, the district is divided into 05 tehsils (Anantnag, Kulgam, Bijbehra, Pahalgam & Dooru) and 12 blocks (Achabal, Breng, Dachnipora, D. H. Pora, Kulgam, Khovripora, Qazigund, Qaimoh, Shahabad, Shangus, Devsar & Pahloo). Hydro-geologically, the district is divided into two distinct and well-defined aquifer systems, viz., hard rock or fissured aquifer constituted mainly by semi-consolidated to consolidated rock units and soft sedimentary or porous aquifer constituted mainly by unconsolidated sediments. The study site location is shown in Figure 1 below.

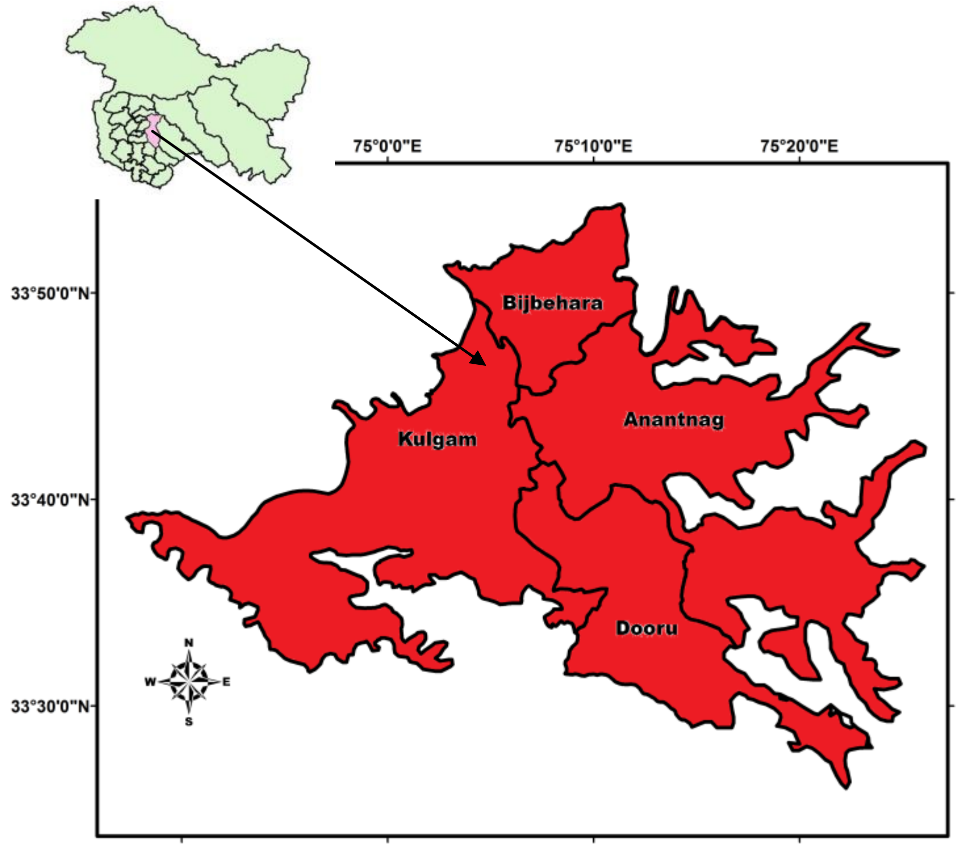

Figure 1: Location of Study Area

III. METHODOLOGY

In order to carry out the research the 92 groundwater quality samples were collected and out of these 12 sample points were kept reserved for cross validation in order to explore which interpolation is best. Ancillary data containing various water quality parameters such as pH, and other physio-chemical parameters like concentration of Na, Fe, SO_4, NO_3etc were collected from the department of the Public Health Engineering Srinagar and central groundwater board Jammu. Later field work to various locations was organized to collect the co-ordinates (lat/long) of the locations of the ancillary data, with the help of Global Positioning System (GPS) pertaining to the water quality parameters collected from the two respective departments. Figure 2 below shows the methodology in flowchart below. Physio-Chemcial Data of water Quality Determining factors obtained from J&K PHE department and Central Ground water Board. IRS-LISS image of October 2005. For ground truthing Trimble GPS was used for validating and locating the various water resources sites of the study area. The further step was to digitize groundwater ancillary data using the MS Excel and assigning of GPS locations to each points which was otherwise without locations for the creation of the database Then the groundwater ancillary data and the spatial data (co-ordinates) which were collected with the help of GPS were joined in the ArcGIS 9.2 software.

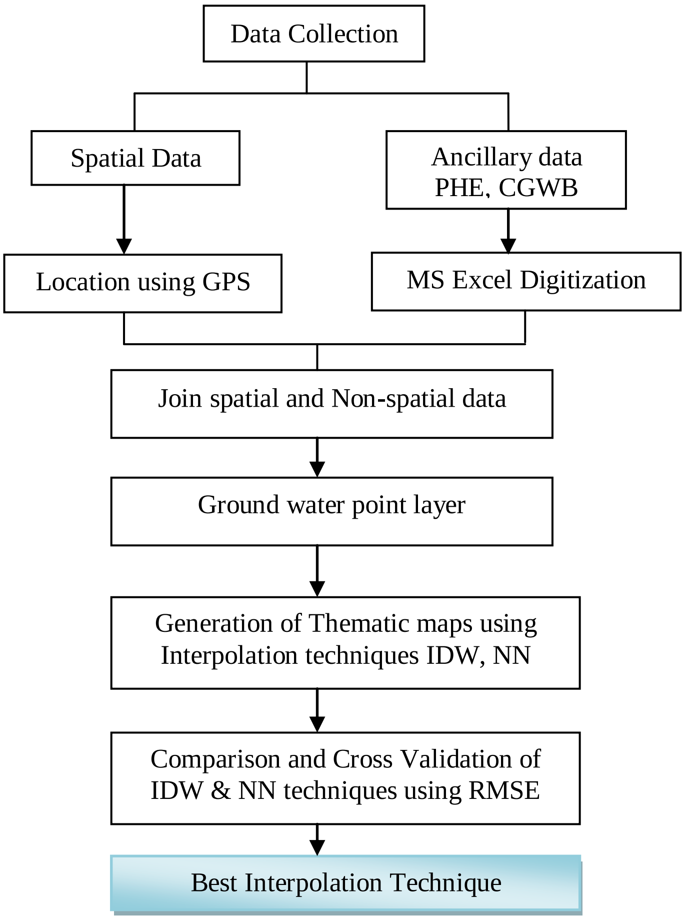

Figure 2.Overall Methodology Adopted

After linking the spatial and non-spatial data the groundwater quality point layer was generated for further analysis. Later on the other analysis was carried out using the IDW (Inverse Distance Weighted) Interpolation and Nearest Neighbor (NN) in Geographic information system environment using the Arc Map software. Interpolation creates a continuous (or prediction) surface from sampled point values. The continuous surface representation of a raster dataset represents height, concentration, or magnitude—for example, elevation, pollution, or noise. Interpolation makes predictions from sample measurements for all locations in a raster dataset whether or not a measurement has been taken at the location. In the present data analysis we used IDW (Inverse distance weighted) interpolation technique and nearest neighbor. Later on Root mean square error and absolute error was used to cross validate the two different interpolation techniques and select the best interpolation techniques.

IV. RESULTS & DISCUSSIONS

Two interpolation methods were implemented in this study Inverse Distance Weighted (IDW) and Nearest Neighbor (NN). These interpolation techniques were compared to get the best interpolation techniques i.e., to see which of the interpolation technique gives the result which is more acceptable. The interpolation results are presented in a tabular form below in table 1. The table shows different water quality determining factors which are acceptable with the regulating agencies like Bureau of Indian Standards (BIS), Indian Council of Medical Research (ICMR) and World Health Organization (WHO). The results are given with the ranges of values for two interpolation techniques. From the table it is apparent that some parameters show increase in value and some show decrease. The values are inferred using Bureau of Indian standards as Desirable, Permissible Limit and Non-potable. In addition to this various thematic layers of interpolation have been generated using the above parameters as input to Arcgis spatial analyst module for interpolation. The interpolation maps generated shows the influence of each water quality factor in the study district. Water quality interpolation results are generated for various layers like hardness, pH, Nitrates, sulphates, iron calcium, fluorides, sodium, chlorine and magnesium. The interpolation maps generated have been shown from Figure 3-14 below.

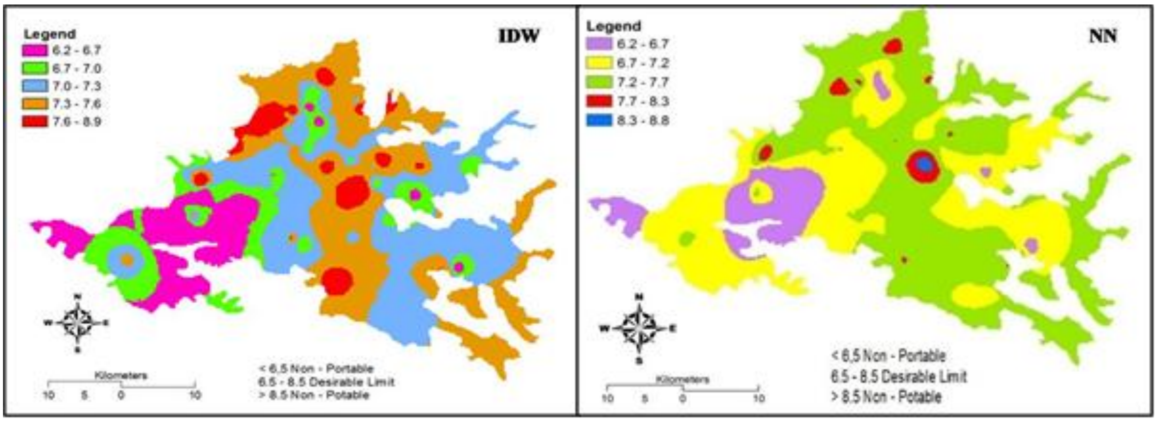

FIGURE 3**:** Interpolation Results for pH

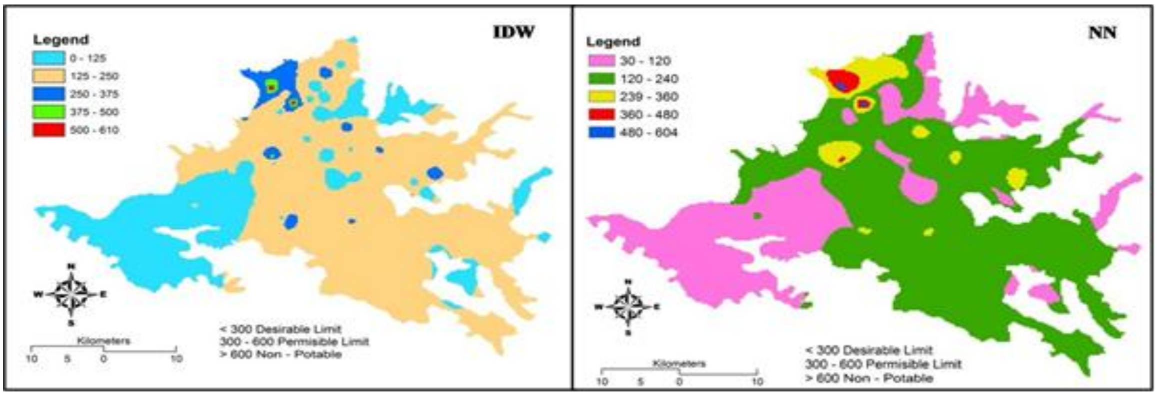

FIGURE 4: Interpolation Results for Total Hardness

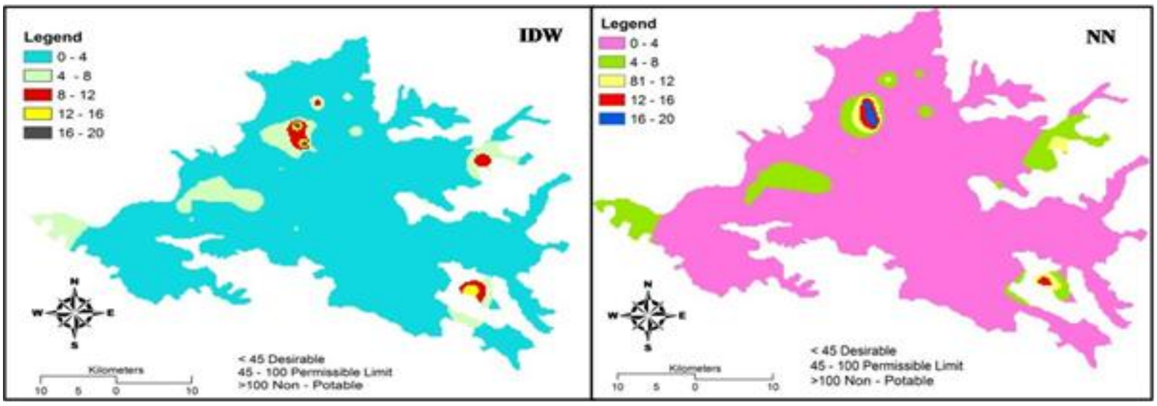

FIGURE 5: Interpolation Results for Nitrates

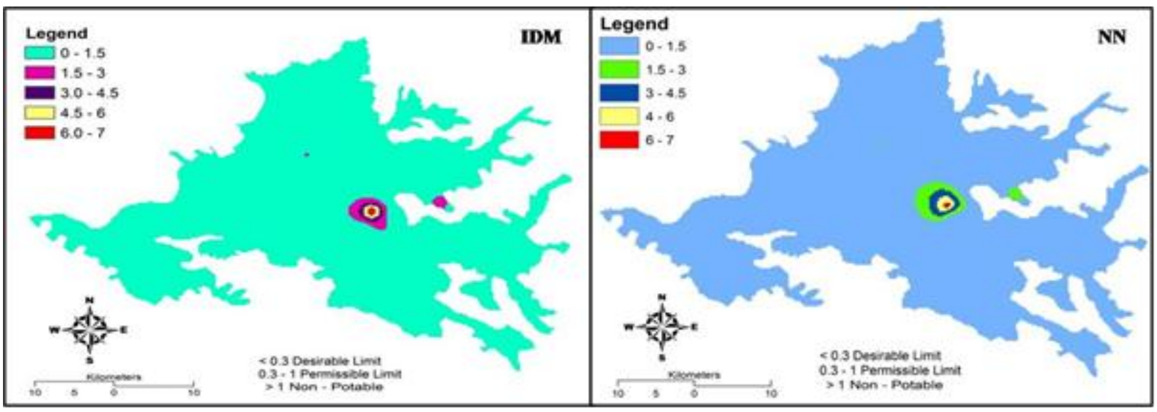

FIGURE 6: Interpolation Results for Iron

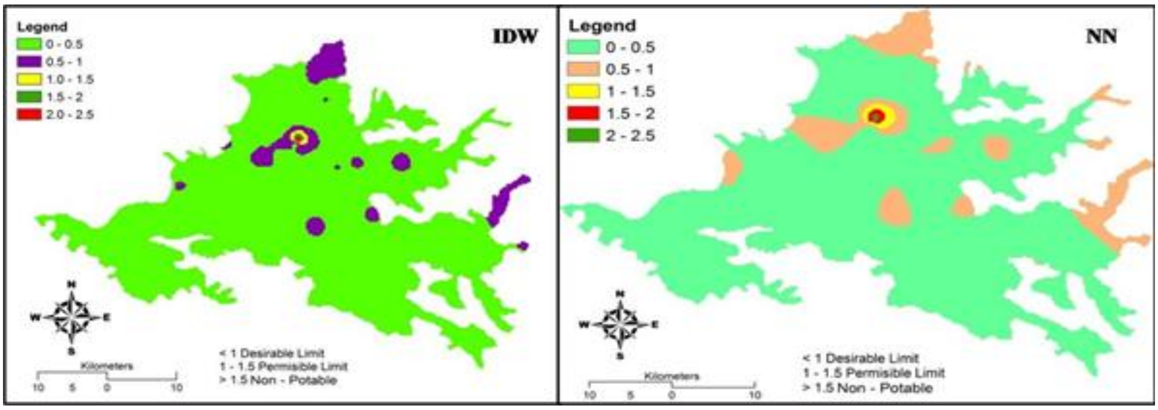

FIGURE 7: Interpolation Results for Fluorides

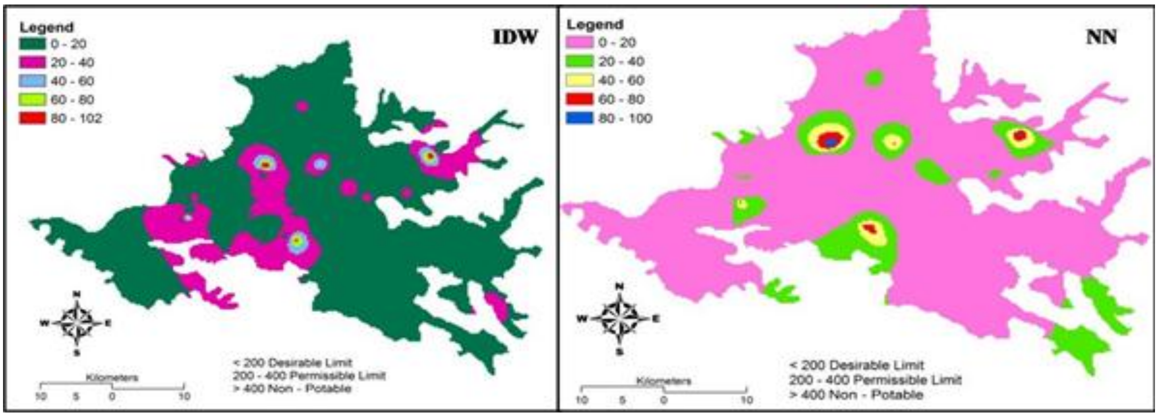

FIGURE 8: Interpolation Results for Sulphates

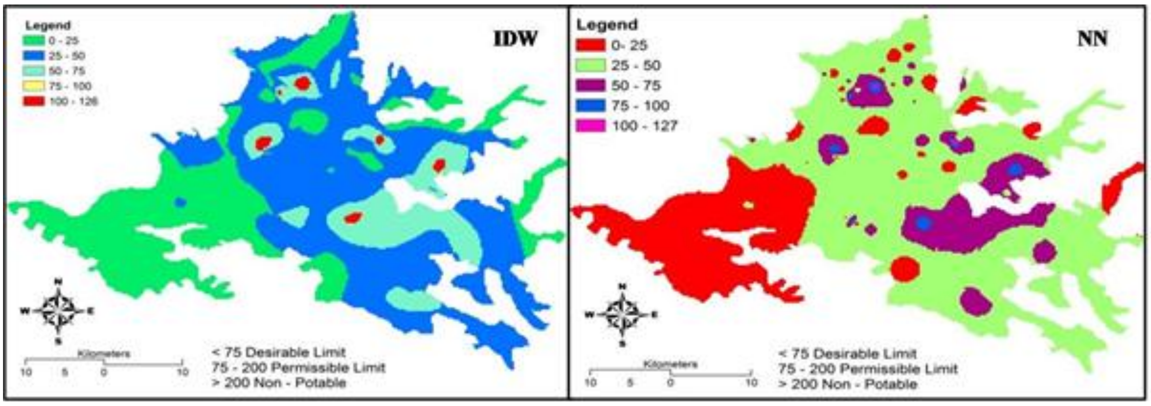

FIGURE 9: Interpolation Results for Calcium

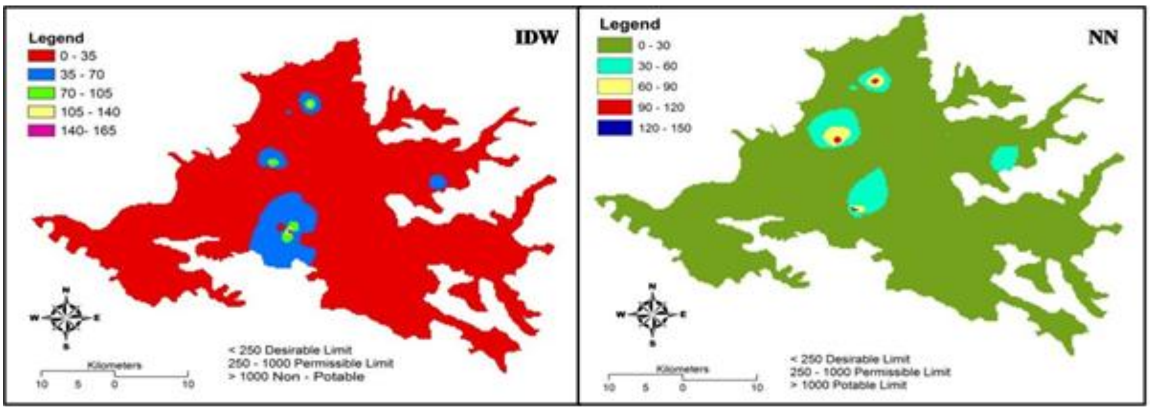

Figure 10: Interpolation Results for Chlorides

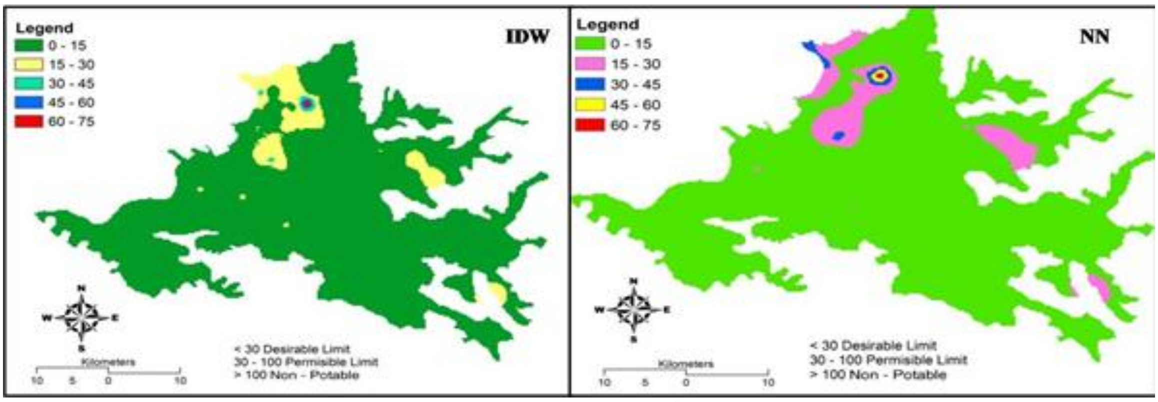

Figure 11: Interpolation Results for Magnesium

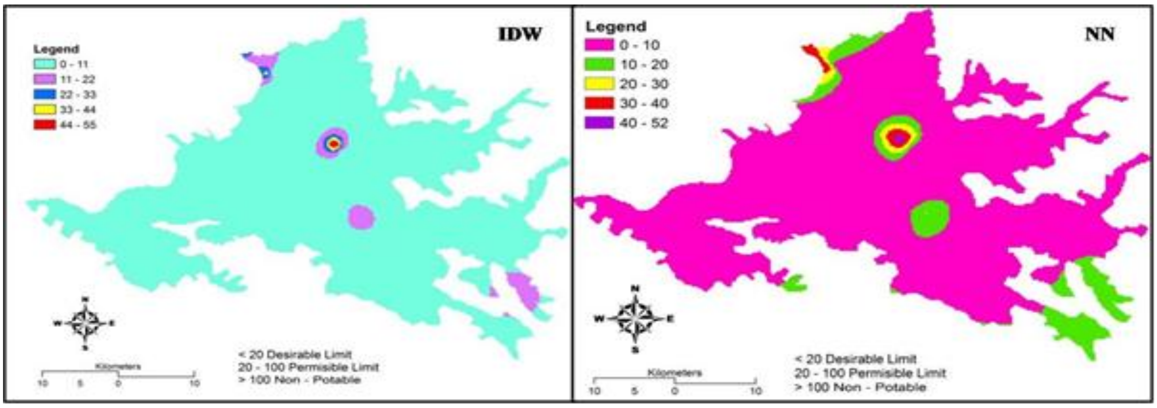

Figure 12**:** Interpolation Results for Sodium

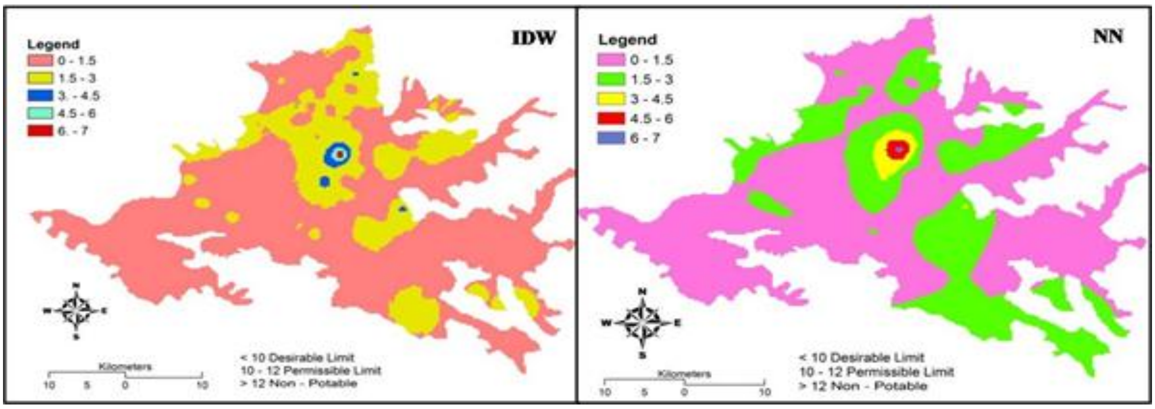

Figure13: Interpolation Results for Potassium

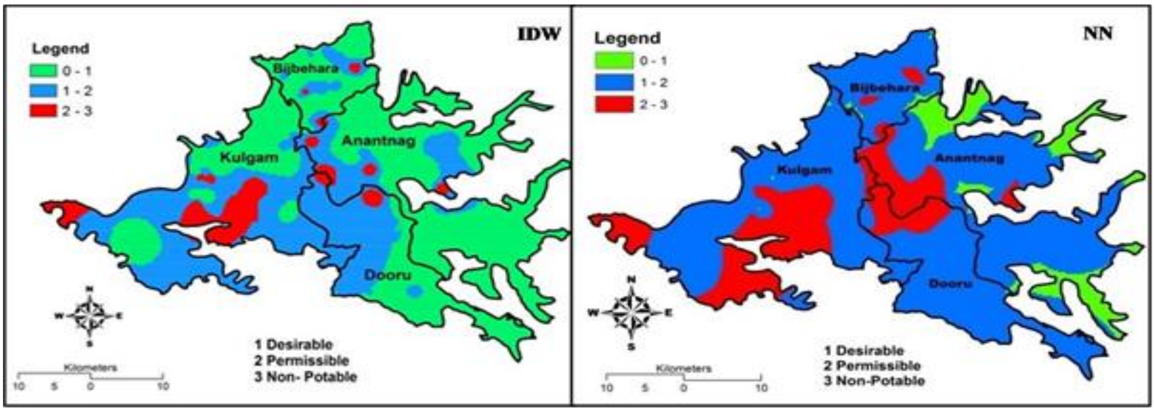

Figure 14: Interpolation Results for Ground Water Quality Map

Table 1: The Overall Water Quality (Element Wise) Obtained Using Two Different Interpolation Techniques.

S.NO	Element	IDW-Interpolation	Results IDW	NN-Interpolation	Results NN	BIS Standards
1	pH	6.2-8.9	High for Sond village	6.19-8.183	8.83 at Sond village	<6.5 NP 6.5-8.5D >8.5 NP
2	TH	14-610	High at Kareiteng	331-603.47	Kraiteng	<300 D 300-600 P >600 NP
3	Nitrates	0.1-20	-	0.001-19.34	-	<45 D 45-100 P >100 NP
4	Iron	0.001-7	Exceed at Damhal, Nowshera, Kareiteng,Tokerpura	0.001-6.74	Damhal	<0.3 D 0.3-1 P >1 P
5	Fluorides	0.002-2.5	Tokerpura	0.002-2.39	Tokerpura	<1 D 1-1.5 P >1.5 P
6	Sulphates	0.01-104	Botachloo	0.09-99.30	Botachloo	<200 D 200-400 P >400 NP
7	Calcium	0.1-127	Rembalpura	0.22-125.099	Rembalpura	<75 D 75-200 P >200 NP
8	Chlorides	0.03-184.3	Supat	0.18-149.35	Supat	<250 D 250-100 P >1000NP
9	Magnesium	0.1-75	Wupzan,Botathchloo	0.0047-71.75	Wupzan	<30 DL 30-100 P >100 NP
10	Sodium	0.001-53.6	Maliknag	0.085-51.56	Maliknag	<20 D 20-100PL >100 NP
11	Potassium	0.0015-68	-	0.0023-6.63	Maliknag	<10 D 10-12 PL >12 NP

*****D= Desirable Limit, P = Potable, PL = Permissible Limits, NP = Non Potable

Also for two interpolation technique viz; IDW and NN, the RMSE error test was applied to see which interpolation technique best suits and is more efficient. Evaluation of the accuracy of spatial interpolation techniques. The cross-validation technique was achieved by removing data from one observation point at a time (j), taken from all of the available observation points in the data set and then estimating the value of the removed observation point data using the data from the remaining (n − 1) observation points. This technique is used to evaluate how well the neighboring stations estimate the missing value. The accuracy of spatial interpolation techniques was evaluated by using the following two statistical indicators. Several researchers (e.g. Chang 2004; Kane ski & Malignant 2004; Ahrens 2006) have recommended these two measures for comparison of spatial predictions of interpolation models for testing data. Formula of RMSE is given bellow.

$$RMSE = \frac{\sqrt{\sum_{j=1}^{n}(y_j - \hat{y}_j)^2}}{n}$$

Where, y_j is the measured value
$\hat{y}_j$ is the estimated value of the dependent variable,
n is the number of observations.

From the results obtained from Root mean square error (RMSE). The root mean square error for IDW is 0.011while as Root mean square Error (RMSE) for Nearest Neighbor analysis comes out to be 0.172 thus it is quite evident that IDW inverse Distance weighted interpolation is the best interpolation technique than Nearest Neighbor analysis. The value Lower RMSE values indicate greater central tendencies and generally smaller extreme errors. In this comparative study the best suitable spatial interpolation techniques were determined based on Root Mean Square error.it is hoped that through this study basic data and technique needed for studying the water quality of the study district in great detail in future has been generated.

V. Conclusions

From the current study it has been found that Inverse distance weighted interpolation techniqueis the best way of determining the water quality, As in this technique the chances of error are minimized to a great extent and chances of deviation of original value are extremely low.

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