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Groundwater quality Mapping using hydrogen chemistry and Geostatistical Analyst of Mahesh River Basin, Akola and Buldhana District, Maharashtra, India.

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Abstract

The aim of this present study was to evaluate groundwater quality in the Mahesh River Basin of Akola and Buldhana district, Maharashtra, India. A detailed geochemical study of groundwater region is described, and the origin of the chemical composition of groundwater has been qualitatively evaluated, using observations over a period of one seasons premonsoon (June) in the year of 2014. To attempt this goal, samples were analysed for various physico-chemical parameters such as temperature, pH, salinity, Na^+, Ca^{2+}, K^+, Mg^{2+}, Cl^-, HCO_3^- and SO_4^{2-}. The abundance of major cations concentration in groundwater is as Na>Ca>Mg>K, while that of anions is Cl>SO4>HCO3. Irrigation status of the groundwater samples indicates that it was moderately suitable for agricultural purpose. Arc GIS 10.1 software was used for the generation of various thematic maps and the final groundwater quality map. An interpolation technique inverse distance weighting wasused to obtain the spatial distribution of groundwaterquality parameters. The final map classified the ground quality in the study area. The results of this research show that the development of the management strategies for the aquifer system is vitally necessary. There was no significant change inpollution parameters in the selected seasons. Comparison of groundwater quality with Indian standards proves that majority of water samples are suitable for irrigation purposes but not for drinking.

Keywords: - GIS; Groundwater quality; IDW; Hydro-geochemistry

Introduction

Groundwater quality is mainly affected by the geological formations that the water passes through its course and by anthropogenic activities (Kelepertsis 2000;Siegel 2002;Stamatis 2010;Sullivan et al. 2005). The hydrogeo chemical study with GIS reveals the zones wherethe quality of water is suitable for drinking, agricultural and industrial purposes. In any area around the world, groundwater quality and risk assessment maps are important as cautionary indicators of potential risk environmental health problems. GIS has been widely used in risk mapping(Daniela 1997; Bartels and Beurden 1998; Hong and Chon1999; Anbazhagan and Nair 2005; Singh and Lawrence2007; Machiwal et al. 2011).As a result, the naturally existing dynamic equilibrium among the environmentalsegments get affected leading to the state of polluted rivers. Hence monitoring of surface water quality has becomeindispensable. On the Surface water quality depends onvarious parameters such as pH, Electrical Conductivity(EC), Total Dissolved Solids, Ca, Mg, Nitrate etc. A similarapproach was adopted by Khadri, ChaitanyaPande andKanak Moharir (2013) where GIS was used to preparelayers of maps to locate promising well sites based on waterquality and availability. Babiker et al. (2007) proposed aGIS-based groundwater quality index method whichsynthesizes different available water quality data (forexample, Cl, Na, SO4) by indexing them numericallyrelative to the WHO standards. Water quality assessmentinvolves evaluation of the physical, chemical, and biological nature of water in relation to natural quality, human effects, and intended uses, particularly uses which may affect human health and the health of the aquatic system itself(WHO1996). The use of GIS technology has greatly simplified the assessment of natural resources and environmental concerns, including groundwater. In groundwater studies, GIS is commonly used for site suitability analyses, managing site inventory data, estimation of groundwater vulnerability to contamination, groundwater flow modelling solute transport and leaching, and integrating groundwater quality assessment models with spatial data to create spatial decision support systems. The present study attempts to the map the spatial variation of surface water quality parameters for Mahesh River Basin using Spatial Interpolation. GIS is an effective tool for water quality mapping and essential for monitoring the environmental change detection. The water samples were collected from 35 locations randomly distributed in the study area. Considering the above aspects of groundwater contamination and use of GIS in groundwater quality mapping, the present study was undertaken to map the groundwater quality in Mahesh River Basin in the Akola district of Maharashtra, India. This study aims to visualize the spatial variation of certain physicochemical parameters through GIS and also GIS is used to assess the existing condition of surface water quality and the contaminated areas can be identified for further monitoring and management. Interpolation is an estimation of Z values of a surface at an unstapled point based on the known Z values of surrounding points. There are two maininter potation techniques: deterministic and geostatistics. Deterministic interpolation techniques create a surface from measured points, based on their extent of similarity [e.g. inverse distance weighted (IDW) or the degree of smoothing (e.g. radial basis functions). Geo statistical interpolation techniques(e.g. kriging) utilize the statistical properties of the measured points (ESRI 2001).In the present study is based on the analysis of ground water samples collected from different source like open well, tube well, hand pump and water supplied by Agriculture land and drinking purpose.

Study Area

The Mahesh River basin is situated in Akola and Buldhana Districts of Maharashtra which is located between 76° 46’11’’ E and longitude 20°40′ 36” N latitude covered by survey of India Toposheets no. 55 D/9, 55 D/7, 55D/11,55D/13,55D/14and 55 D/15on 1:50,000 scale. It can be approached from Amravati by road transport which is about 120 Km. The Mahesh River basin which is a major tributary of Man River lies towards the western and southern part of Akola and Buldhana district. The total area covered by Mahesh River Basin is 328.25 Sq. Kms in fig. 1.

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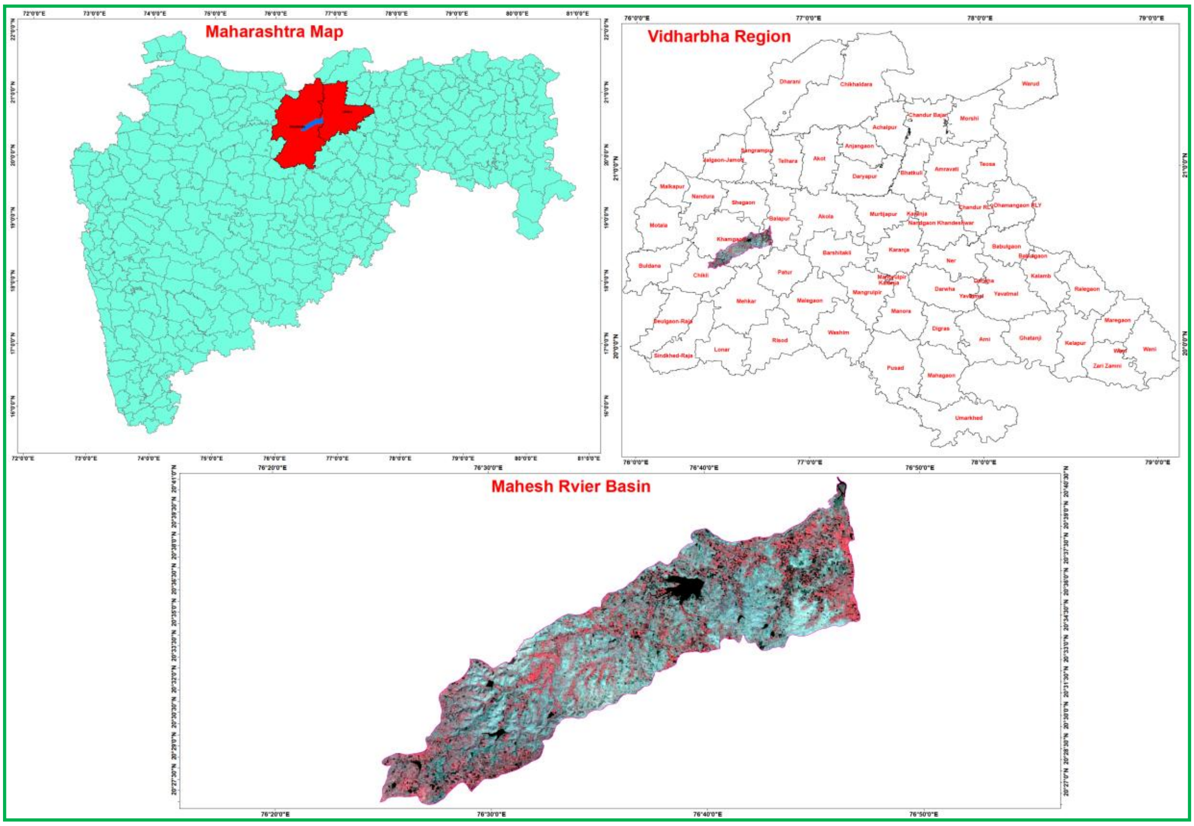

Fig.1 Location Map of Mahesh River Basin

Geology

The study area is occupied by alluvium and Deccan basalts which are horizontally disposed and is traversed by well-developed sets of joints. The Ajanta hill ranges are bordering the district in the Southern with their slope towards Western. The starting part of Akola district is plain whereas the Western part is again elevated with its general slope towards Sothern. The Mahesh River Basinflows in the Southern to Western direction having westernslope and meets the Mun River near Balapur village in Akola district. Purna is the major river of the Akola andBuldhana district. The important tributaries of Purna River are Katepurna, Morna, Man, Vidrupa, Shahanur, Van and Nirguna. Most of the watershed area was covered by unconsolidated sediments, black cotton soil, Red soils and basaltic rocks of Deccan Traps. The study area was drained by Mahesh River Basin flowing south to western with almost dendrite to sub-dendritic drainagepattern.

Methodology

A detailed field study was carried out in Mahesh River Basin area during June 2014. Samples were collected from 35 wells. Thirty five samples were collected from each location. The samples were collected during the pumping operation. Samples were collected in cleaned polythene bottles (500-ml capacity) and were properly labelled, indicating the source, date, and time of collection. All of the samples were analyzed using standard procedures (APHA 1995). Electrical conductivity (EC) and pH were analyzed using a field kit. Major ions like chlorides, bicarbonates, calcium, and magnesium were analyses in the chemical laboratory. The geostatistical analyst tool of ArcGIS10.1 software was used to create the spatial distribution map of different water quality

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parameters; statistical variations of the data arenot considered in this operation, but in geostatistics, these statistical variations are effectively utilized to predict the unknown values from a limited number of known values. Spatial distribution maps of the groundwater quality parameterswere created using geostatistics tool in Arc GIS 10.1 software. Geostatistics methods depend on both statistical and mathematical functions that include autocorrelation. The basic assumption is that the sample points close to the unknown points will have more or less similar value. In this study, ordinary kriging was selected as the inter potation method. In kriging method, a semi radiogram will be created and which will evaluate the average degree of dissimilarity between the unknown point and nearby known value. Geographical information system (GIS) software utilities are used to spatially represent data sets for the purpose of generatingmaps and making spatial comparisons of data. Arc GISspatial analyst was the primary tool used to produce maps that aided analysis. The maps spatially integrated and the analytical results of hydrological parameters show the study area water quality. The spatial analysis of various physicochemicalparameters was carried out using the Arc GIS 10.1software.The concentrations of major anions (Cl)were analyzed in the laboratory according to the methods given in the standard methods (WHO (1996). Analytical results of the groundwater sample interpreted in the software Arc GIS 10.1 software and the spatial distribution map was prepared. The results of the physiochemical analysis are presented in table 1

Table1.Showing Values of Various Physic-Chemical Parameters.

Sr. No.	Village Name	Ec µS/cm	pH	TDS meq/I	Cameq /I	Mg meq/I	Clmeq /I	CO3 meq/I	HCO3 meq/I	SO4 meq/I	Na meq/I	k meq/I
1	Balapur	879	7.6	378.35	4.44	3.13	1.55	0.13	2.61	0.65	1.48	1.02
2	UmraLasura	476	6.9	501.81	6.09	3.95	2.57	0	5.87	1.33	2.91	0.31
3	Sambhapur	1396	7.2	492.5	4.09	5.76	12.86	0	7.47	0.52	3.7	0.1
4	Shendri	867	7.8	392.66	4.14	3.71	7	0.79	7.51	0.85	1.83	0.64
5	HingnaUmra	1587	7.5	451.91	5.09	3.95	24.03	0.13	5.26	2.27	2.09	0.38
6	Ambikapur	934	7.2	364.73	3.59	3.7	3.47	0	5.83	1.12	1.83	0.1
7	Koregaon Bk.	986	7.4	426.91	3.89	4.65	1.35	0.23	2.41	0.83	2.09	0.38
8	Hingna	678	6.5	597.82	4.14	7.84	12.86	0.54	5.83	0.92	0.52	0.43
9	Nilegaon	745	7.6	447.87	4.09	4.87	11.02	0.18	5.26	1.6	1.96	0.26
10	Ramnagar	960	7.1	464.53	5.59	3.7	25.22	0.38	7.47	0.52	2.09	1.02
11	Wihigaon	789	6.5	309.7	2.25	3.95	11.71	0	4.23	2.91	3.87	0.38
12	Kherdi	869	6.1	509.99	5.09	5.11	11.71	0.31	5.87	3.14	3.39	0.26
13	UmraAtali	845	6.2	675.1	7.09	6.42	16.62	0	1.07	2.27	1.74	1.05
14	Naidevi	896	6.8	357.6	3.19	3.96	7.31	0	1.39	1.6	2.35	0.23
15	Lokhanda	845	6.3	387.54	3.79	3.96	15.63	0.18	4.23	3.93	1.52	0.26
16	Pala	845	6.9	587.14	7.78	3.96	1.95	0.23	1.39	3.14	3.87	1.92

17	Sirala	978	6.8	411.99	4.29	3.95	16.31	0	5.83	3.93	1.96	0.64
18	Ganeshpura	876	6.8	342.19	2.54	4.3	16	0.31	1.39	2.52	1.48	1.1
19	Wairagad	968	7.1	519.97	5.29	5.11	9.99	0	1.39	2.08	1.48	1.36
20	Undri	987	7.3	402.51	4.09	3.96	11.62	0.1	1.39	3.93	1.96	1.15
21	Dasala	987	6.3	379.7	3.89	3.7	12.86	0	8.36	3.93	1.96	0.38
22	Kinhi	812	7.1	514.96	4.54	5.76	9.06	0	1.39	2.52	1.48	0.23
23	Pimpri	945	7.1	412.21	4.54	3.7	3.55	0.31	5.87	2.58	1.96	0.26
24	Nirod	645	6.5	526.76	6.59	3.95	9.17	0	2.61	3.08	2.35	0.23
25	Gharod	605	6.3	476.86	5.59	3.95	4.32	0.13	1.39	3.93	1.96	0.38
26	Akoli	645	7.3	487.53	4.64	5.11	11.57	0.23	4.11	0.83	1.48	0.36
27	Atali	521	6.9	668.29	5.14	8.23	13.68	0.1	5.26	2.52	1.52	0.31
28	Patunda	548	7	620.88	4.19	8.23	12.86	0	1.39	2.94	3.31	0.26
29	Pedka	451	6.3	554.49	6.14	4.95	5.02	0	5.87	0.52	1.74	0.38
30	Kadmapur	354	6.8	307.34	2.45	3.7	11.62	0	7.47	2.58	2.83	0.36
31	Palsi Bk.	345	7	545.64	6.29	4.63	3.39	0.05	5.83	1.33	1.96	0.61
32	PalshiKh.	456	6.9	373.36	4.34	3.13	4.49	0	4.11	0.65	2.83	0.36
33	UmraLasura	345	6.3	469.66	4.44	4.95	1.27	0	5.87	3.08	1.74	0.23
34	Takarkhed-1	387	6.5	409.05	3.64	4.54	12.72	0	1.07	3.19	1.48	0.31
35	Takarkhed-2	412	6.9	409.78	3.24	4.95	20.9	0	1.97	0.83	1.48	0.26

Preparation of well location point feature

In this paper was followed to develop a groundwater quality classification map from thematic maps based on the WHO (1993) and ISI (1991) standards for drinking water. We obtained the location of 8 wells all over the study area by using a handheld GPS instrument GARMIN GPS-60 receiver. GPS technology proved to be very useful for enhancing the spatial accuracy of the data integrated in the GIS. We utilized Arc GIS 10.1 software in our study. Based on the location data we obtained, we prepared point feature showing the position of 35wells (Table 1 and Fig.1). From these wells, we collected and analyzed groundwater samples for the study area. The water quality data thus obtained forms the non-spatial database. It is stored in excel format and linked with the spatial data by join option in Arc Map 10.1 software. The spatial and the non-spatial database formed are integrated for the generation of spatial distribution maps of the water quality parameters. For spatial techniques approach in GIS has been used in the present study to delineate the locational distribution of groundwater pollutants. Other spatial interpolation techniques include Cokriging, Spline etc. Kriging isbased on the presence of a spatial structure where observations close to each other are more alike than those that are far apart (spatial autocorrelation). In this method the experimental variogram measures the average degree of dissimilarity between unsam pled values and a nearby data value and thus can depict autocorrelation at various distances. From analysis of the experimental variogram, a suitable model (for example spherical and exponential) is derived by using weighted least squares and the parameters (for example range nugget and sill). Some advantages of this method are the incorporation of variable interdependence and the available error surface output. A disadvantage is that it requires substantially more computing and modeling time and spatial techniques requires more input from the user.

Results and Discussion

Groundwater Quality Map

Groundwater quality map Spatial maps of pH, EC, TDS, Na and Cl, and integrated maps of groundwater quality were produced using the inverse distance weighted (IDW) interpolation method of ArcGIS (ver.10.1) software. IDW is an algorithm to inter polate data spatially or estimate values between measurements. Estimates of IDW interpolation are the weighted averaged values of surrounding sample points. Weights are computed by the inverse of the distance from an observation to an estimate. The best results from IDW are obtained when sample points are sufficiently dense to represent the local variation. If the sample points are sparse or very uneven, the estimates may not adequately represent the desired variations (Khadri, Chaitanya Pande and Kanak Moharir (2013), Khadri and Kanak Moharir (2014), Khadri and Chaitanya Pande (2015). Groundwater quality maps were generated based on the WHO (2004) drinking water standards.

Major ion chemistry

The pH values of the groundwater ranges from 6.1 to 7.8 in 2014 (premonsoon).For Pre monsoon2014 Minimum pH (6.1) was observed in Kherdi and Umra Atali villages while Maximum pH (7.46) value was observed in Balapur, Shendri and Nilegaon villages in fig. 2.These variations are slightly higher than thepermissible limit of drinking water standard. The generalincrease of pH in a sedimentary terrain relates to weathering of plagioclase feldspar in the sediments, aided by dissolved atmospheric carbon dioxide resulting in the release of sodium and calcium which progressively increases the pH and alkalinity of the water. The electrical conductivity average values were found between 345 to 1587 in 2014 (premonsoon) μS/cm at 25°C in the fig.3. The concentration of total dissolved solids average ranged from 307.14 to 675.1 in 2014 (premonsoon)mg/l in the fig.4. Normally, total dissolved solidsin water may originate from natural sources and sewagedischarges. Calcium concentrationranged from 2.25 to 7.78 mg/l in 2014 premonsoon in fig.2. The high concentration ofNa in the groundwater can be attributed to the cationexchange and to the human activities. High concentration ofNa^+ in irrigated area is also the result of the repeated use of water. Bicarbonate ion ranged from 1.07 to 8.36 mg/l in the groundwater samples during 2014 premonsoon seasons in fig. 6. Chloride concentration of groundwater samples in the study average ranged between 1.27to 25.22 in 2014 pre monsoon mg/l in fig. 7.Sulphate ion varied from 0.52 to 3.93 mg/lduring the study period and nitrate ion varied from 0.52 to 3.87 mg/l in the fig. 12. The observation of the Mg in the study area maximum value (9.07) were observed in Atali and Pedka in villages while minimum value (2.88) were observed in Balapur, Dasala, Ramanagr, Undri and Kadampur villages show for pre monsoon 2014 in fig.9. The observation of the K in the study area maximum value (1.92) were observed in Pala villages while minimum value (0.1) were observed in Kadampur, Palshi Kh., Umra Lasura, Shendri, Koregaon Bk., Nilegaon, Atali, Pedka, Akoli, Kherdi, Naidevi, Gharod, Nirod and Pimpri villages for pre monsoon 2014 in the fig.8. The conspicuousvariation observed for this parameter was mainly bythe influence of agricultural activity and by theinfluence of Purna alluviam into the shallow aquifer system. To ascertain the suitability of groundwater for drinking and public health purposes, hydrochemical parameters of the study area are compared with the guideline recommended by world health organization(WHO, 1993) which shows that groundwater has partial suitability for drinking purposes.

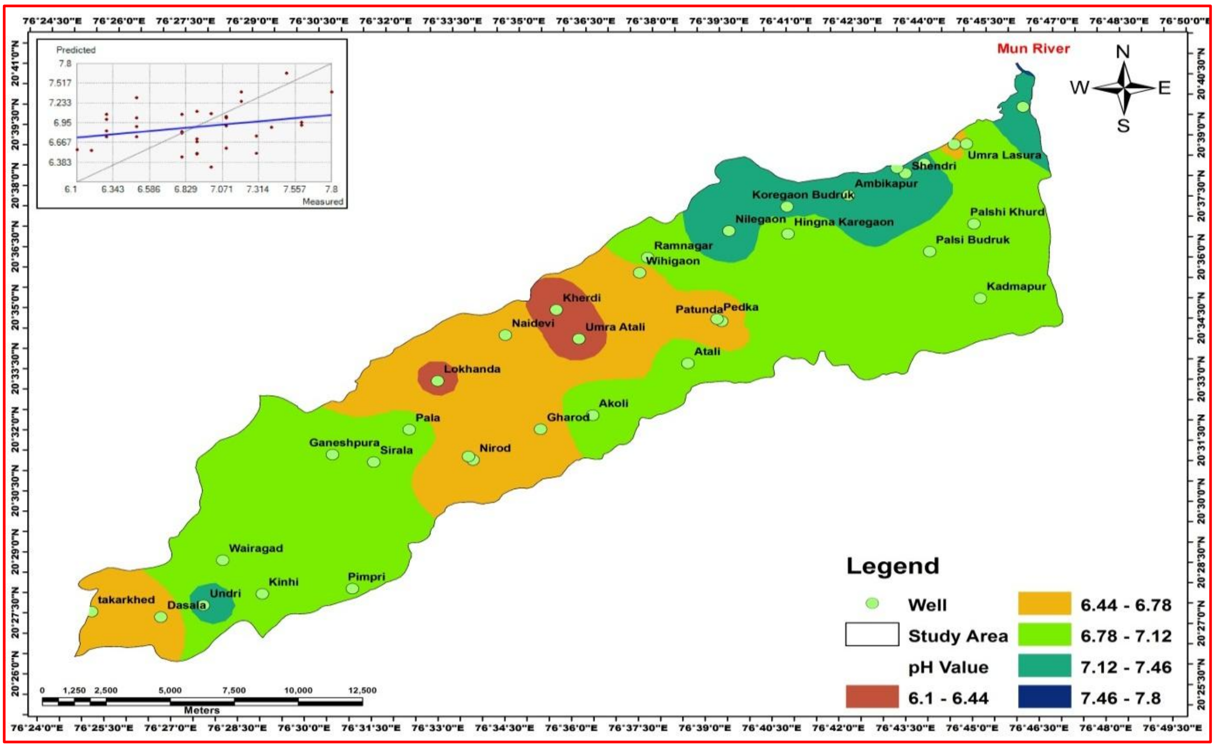

Fig.2 Spatial distribution of pH value map of 2014 pre monsoon

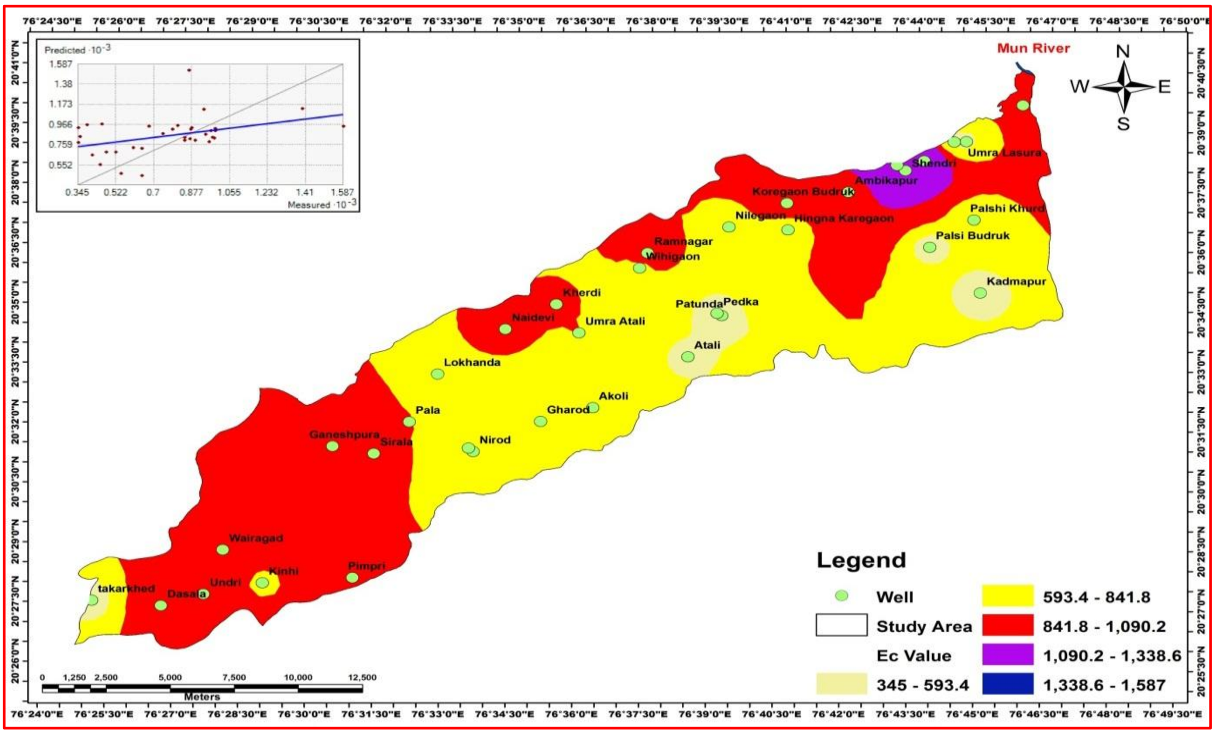

Fig.3 Spatial distribution of EC value map of 2014 pre monsoon

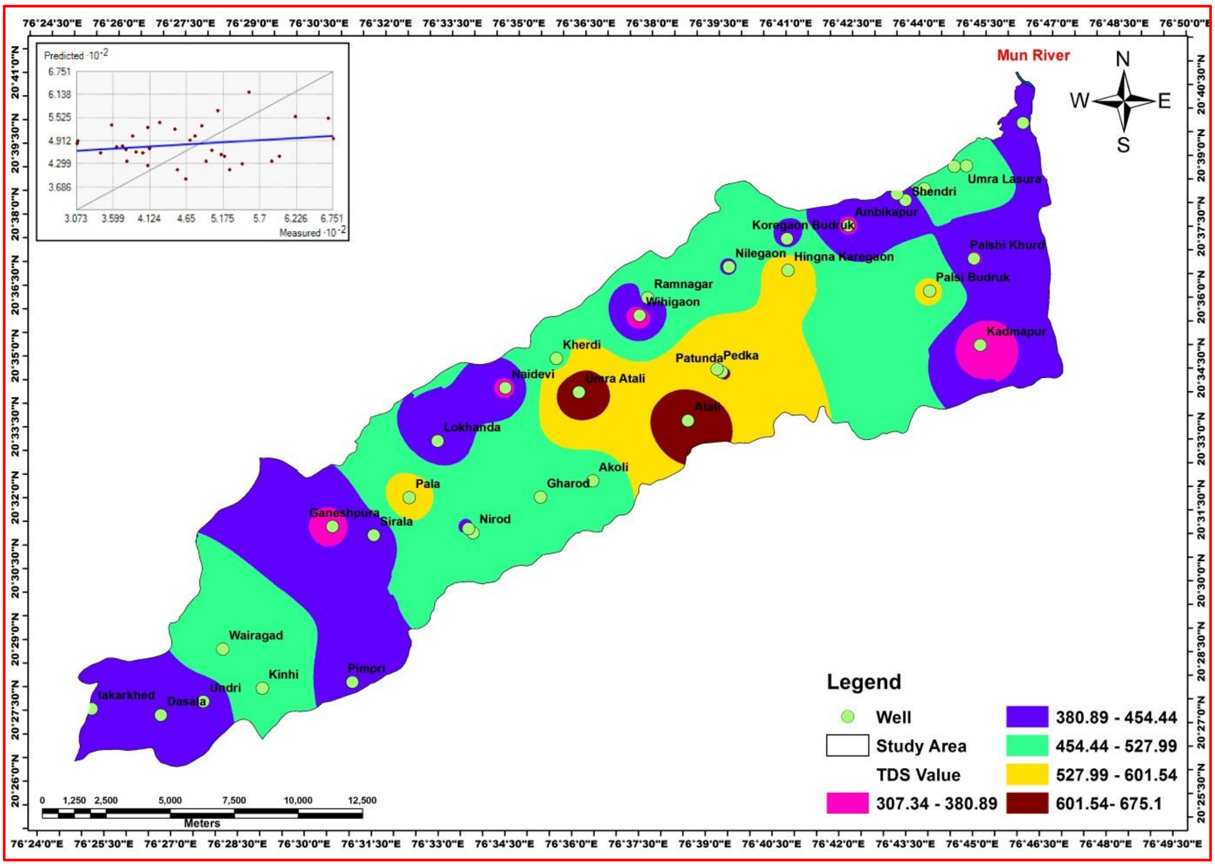

Fig.4 Spatial distribution of TDS value map of 2014 pre monsoon

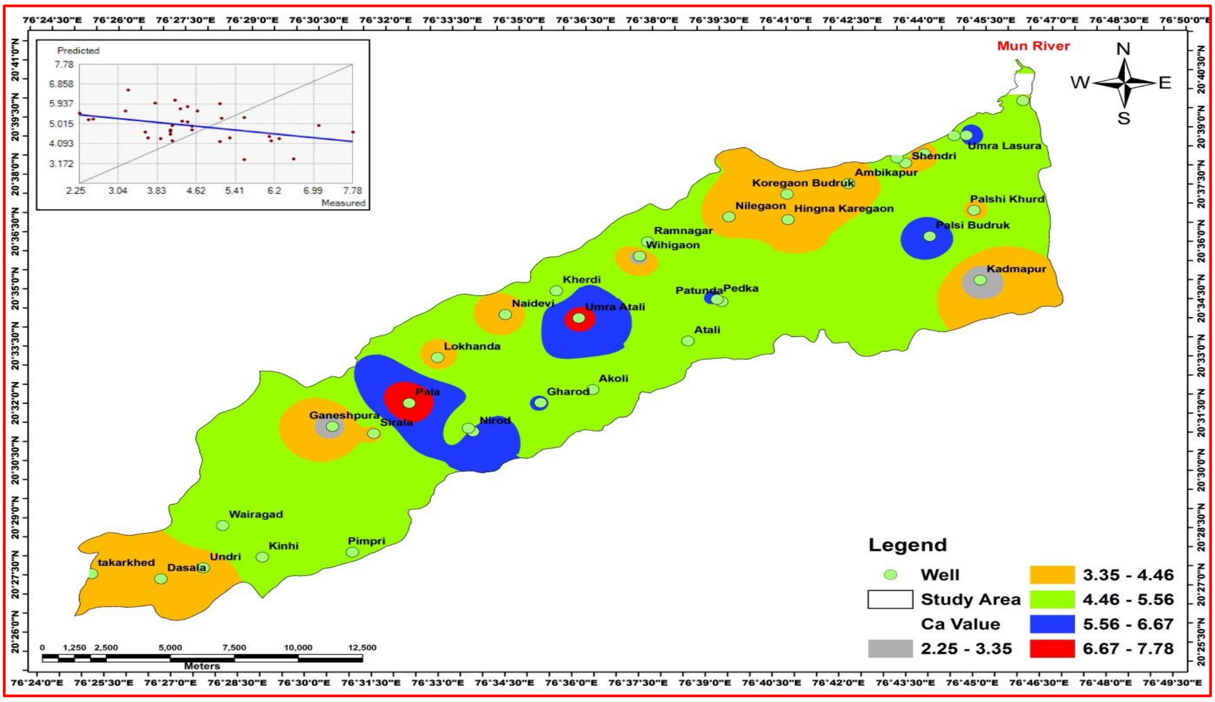

Fig.5 Spatial distribution of Ca value map of 2014 pre monsoon

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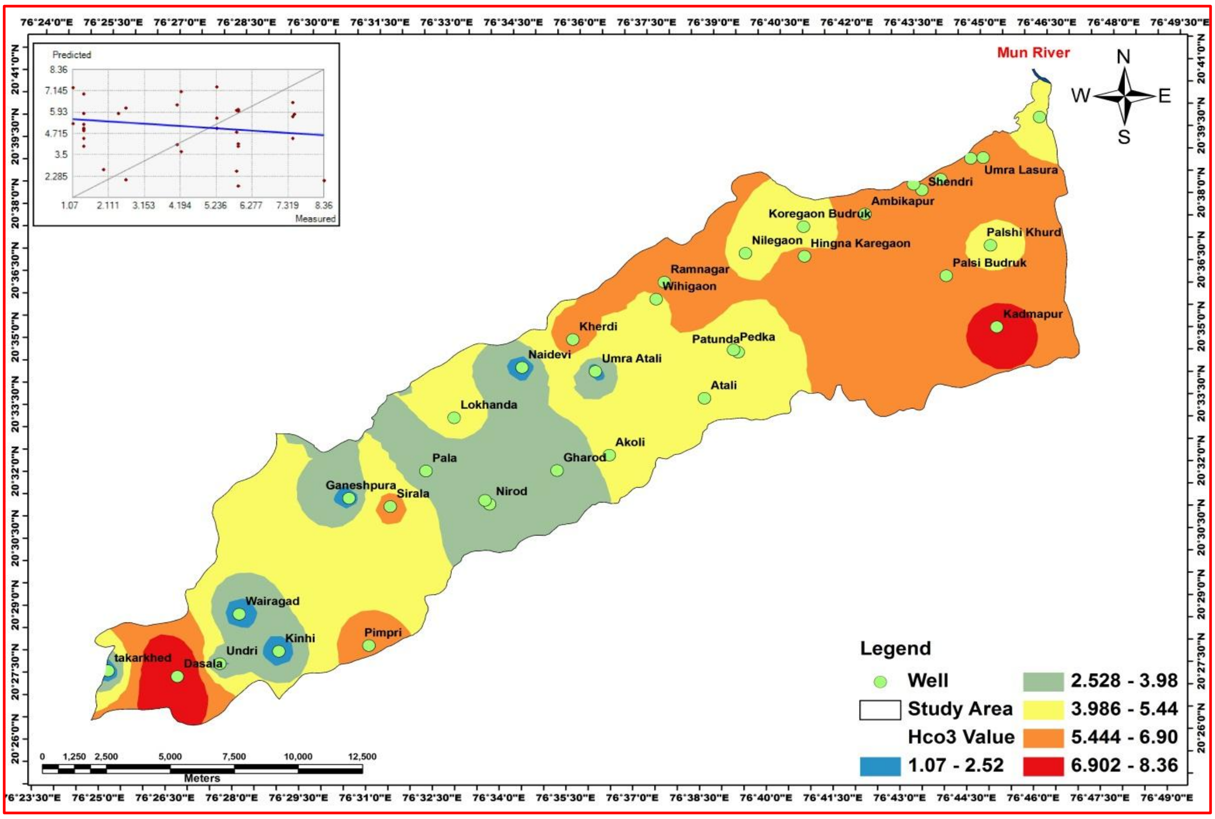

Fig.6 Spatial distribution of HCO_3 value map of 2014 pre monsoon

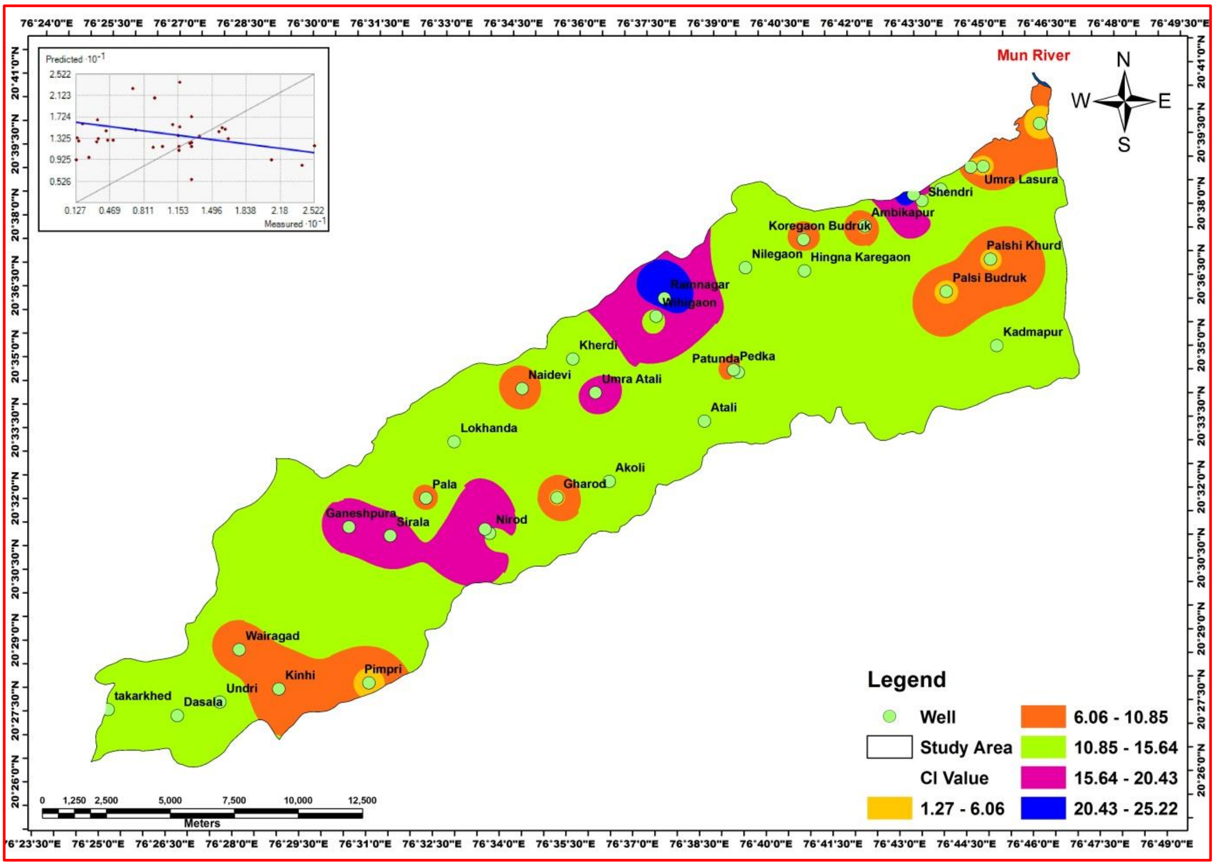

Fig.7 Spatial distribution of Cl value map of 2014 pre monsoon

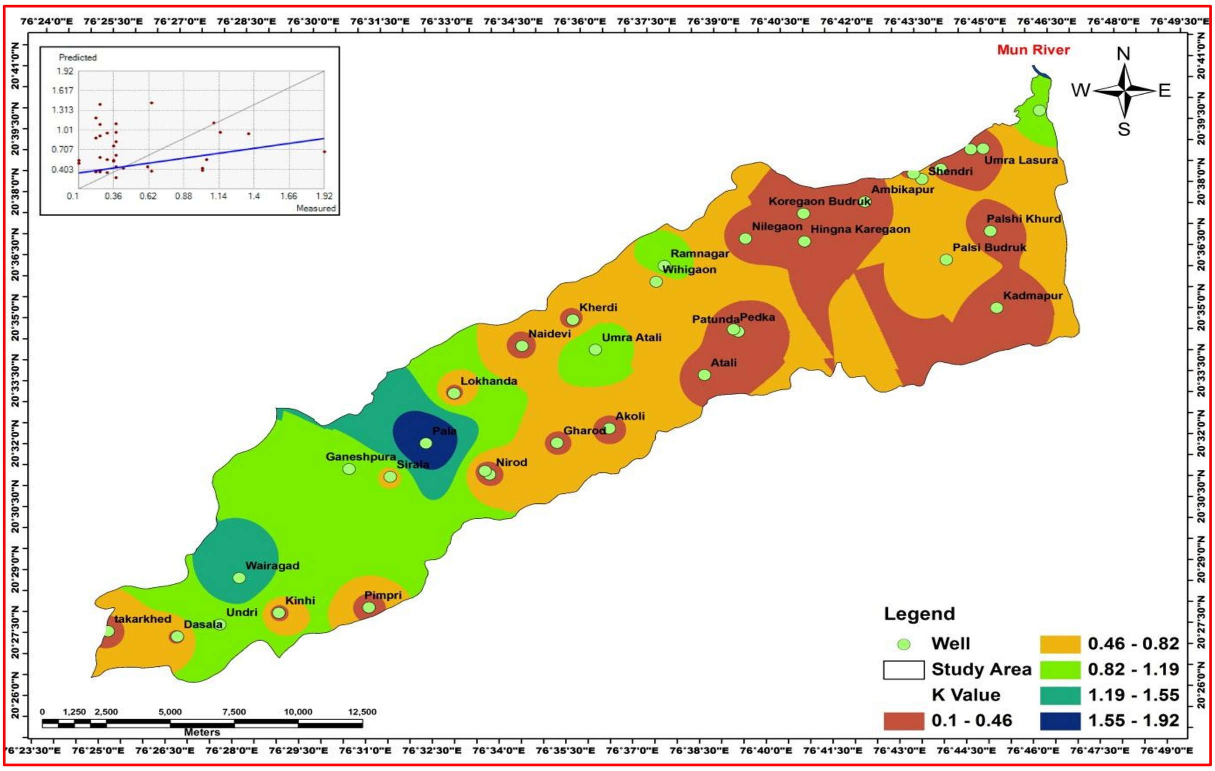

Fig.8 Spatial distribution of K value map of 2014 pre monsoon

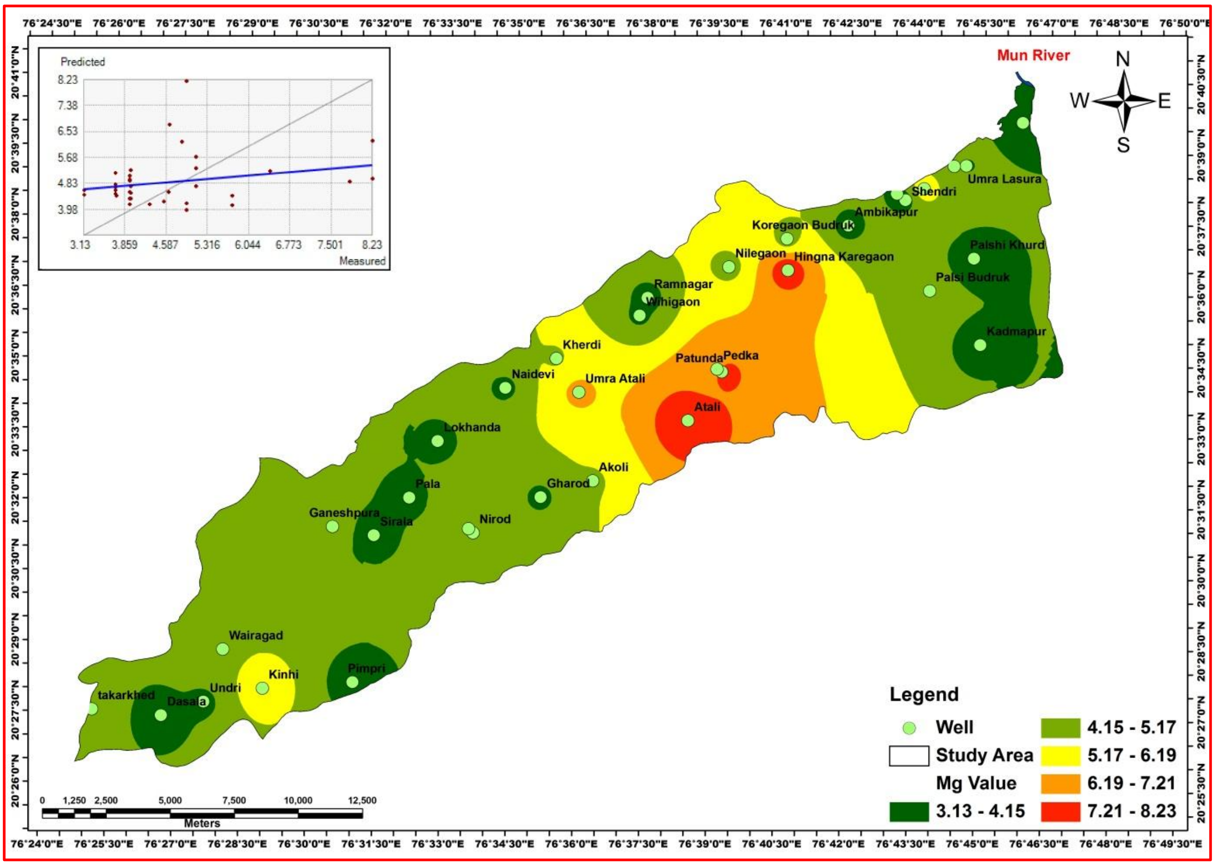

Fig.9 Spatial distribution of Mg value map of 2014 pre monsoon

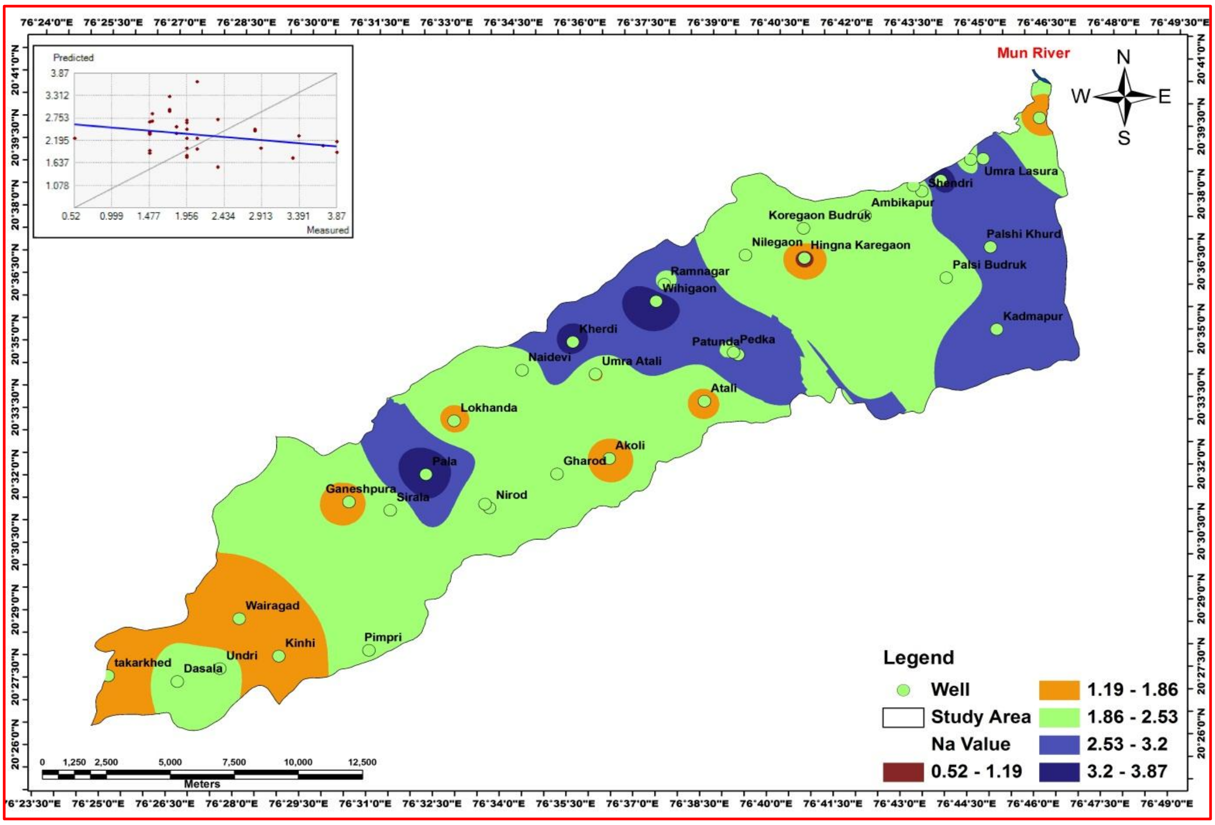

Fig.10 Spatial distribution of Na value map of 2014 pre monsoon

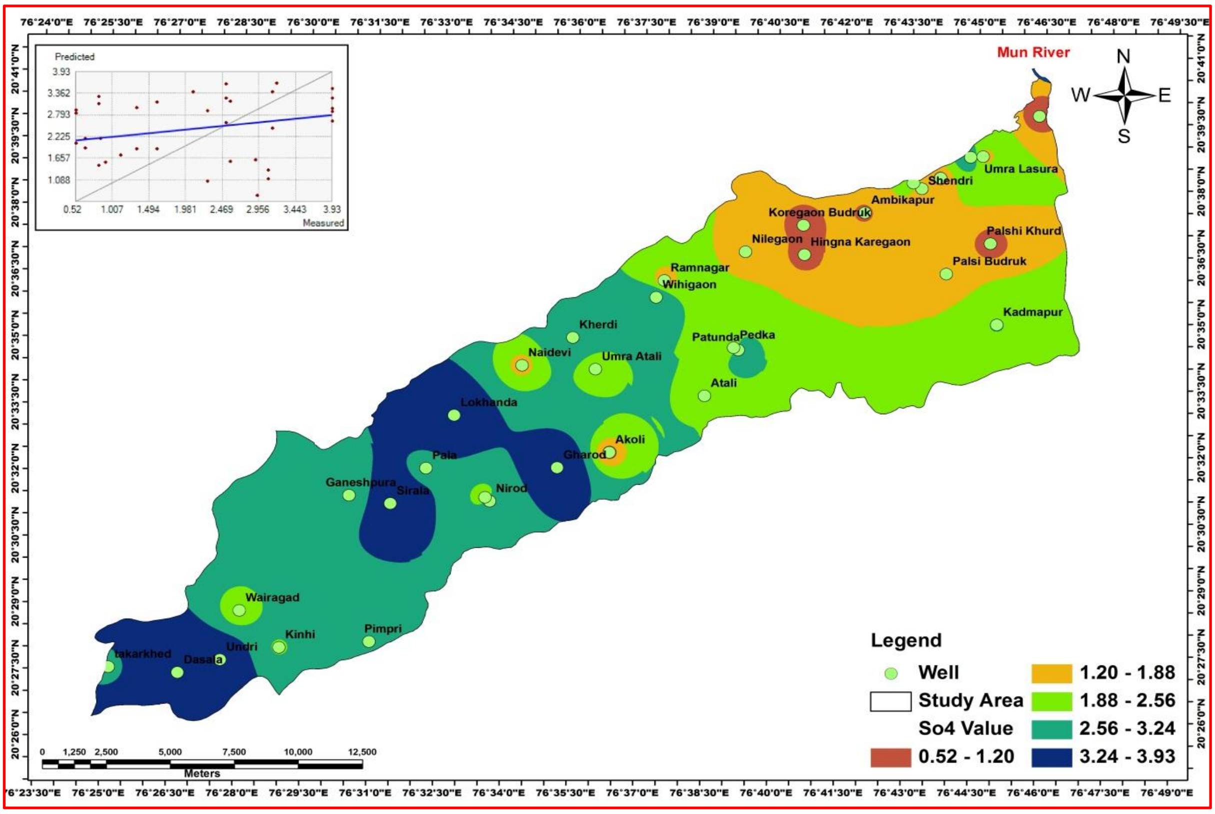

Fig.12 Spatial distribution of SO_4 value map of 2014 pre monsoon

Conclusion

Groundwater is an important source for drinking water and its quality is a critical issue around the world. Groundwater quality is affected by different natural as well as anthropogenic processes. As no significant work appears to have been done in hydrogeochemistry of ground water in different villages of Mahesh River Basin, Akola and Buldhana District, Maharashtra prompted us to undertake a systematic study of the area. Interpretation of hydrogeo chemical analysis reveals that the groundwater of study area is Balapur village and western side villages slightly saline and alkaline in nature because this part affected in Purna alluvium and other part of basin totally Deccan basalt. Hence, the study hashelped to improve understanding of hydrogeochemical characteristics of the area for effective management and proper utilization of groundwater resources for better living conditions of the people. A continuous monitoring program of the water quality will avoid further deterioration of the water quality in the coastal region.

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