Geospatial Variability of Groundwater Depth and Quality Parameters of East Godavari District, Andhra Pradesh-India.

Nathi Ajay chandra[1], Sanat Nalini Sahoo[2]

[1]*Civil Engineering Department, NIT Rourkela, Rourkela-769008, India, Email: nathi.ajaychandra@gmail.com*

[2]*Civil Engineering Department, NIT Rourkela, Rourkela-769008, India, Email: sahoosanat@nitrkl.ac.in*

Abstract

Quality of Groundwater is important for the safe use of water. The motive of this exploration was. (1) To furnish an overview of present groundwater quality of East Godavari district Andhra Pradesh. (2) To govern the geographical distribution of groundwater quality parameters (viz; Depth to water in meters, Mg, Cl-, and Ca). Ordinary kriging to examines the geospatial variability of groundwater quality and depth parameters. (3) To map groundwater quality in the study area by using GIS, Geostatistics techniques, ArcGIS 10.3, and ArcGIS Geostatistical Analysis for generation of various thematic maps.

Keywords: Groundwater quality Parameters, Geostatistical wizard (Ordinary kriging, Indicator Kriging), Spatial Analyst tool, Geostatistics, Drinking water quality standards, and Semivariogram.

1.Introduction

Groundwater is a major source in India for all purposes. Groundwater plays a vital role in India for economic development and Food security. For drinking water More rural population than of urban population depends on groundwater. In the coastal areas of Andhra Pradesh, the majority of the population, rely on groundwater sources for their domestic use of water, agricultural water, and aquaculture purposes. Groundwater contains dangerous organic chemicals and minerals in various concentrations and many dissolved constituents too. The most important quality parameters are Mg, Cl^-, and Ca these are the common constituents. If they are within the permissible limits they are not harmful. Groundwater is less vulnerable to pollution than surface water since the soil and rocks into and out of which groundwater flow separate most of the bacteria. Major chemical elements including Mg, Cl^-, and Ca are very important in classifying and assessing groundwater quality. Previous studies indicated that open seamless drains and contamination deposit locations in the recharge zones behaves as the origin of contamination to the groundwater (Datta, Deb, Tyagi 1997). To know the concentration of pollutants and groundwater depth at unsampled areas, the geostatistical and deterministic approach has been attempted (Sarangi, Madramootoo 2005). Geostatistical interpolation approach has been predicted, to achieve superior

than deterministic approach (Sarangi and others 2006). Comprehensive and extensive clarification of geostatistical conception have been reported in Geostatistical analyst report (2010).

This study was attempted for a better understanding of the present groundwater quality in East Godavari district by using R.S and GIS techniques with present Field data.

2.Study Area

The study area figure:1 having coordinates of 17.3213° N and 82.0407° E. Climate of this area is mild and generally warm, the average temperature of this area is 16.4℃. The district has a population of 5,154,296, the density of population is 477/Km^2 (or) 1240/m^2 and urban population is 25.52%. One of the Largest districts in the state has a total area of 12,805km^2.The annual average rainfall is 1201.1mm. Headquarter of the district is Kakinada covers an area of 10,807km^2. Andhra Pradesh is one of the largest rice producers of India is only because of East Godavari district.

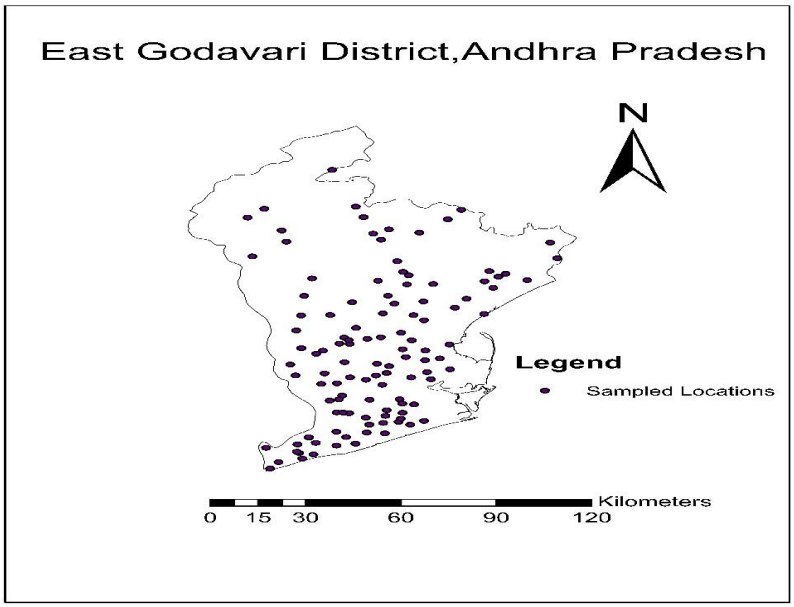


Figure.1 Sampling locations of East Godavari District, Andhra Pradesh.

3.Methodology

3.1 Semivariogram Modeling

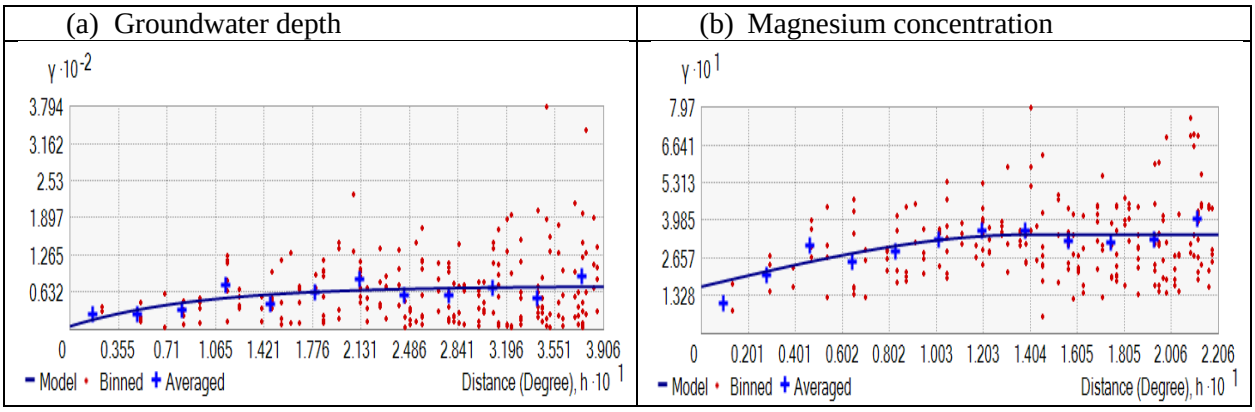
Semivariogram: The change of semi-variance distance between observations in a graph.
The empirical semivariogram is a graphical portrayal of the mean square fluctuation between two nearby points of distance h as shown in below

$$\gamma(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [z(x_i + h) - z(x_i)]^2$$

where, $\gamma(h)$ is the semivariogram expressed as a function of the degree of the lag distance (or) separation vector h, N
(h) is the number of observation pairs detached by distance h, and $z(x_i)$ is regionalized at location x_i.

3.2 Choice of Model, Cross Validation, and Semivariogram Parameters

Lognormal transformation was used to make a normal distribution and identifying the outliner. Eventually, semivariogram criterion for every theoretical model such as linear, Gaussian, circular, spherical, and exponential were generated. The most suited model was selected based on regression statistics such as mean error $\cong 0$ and root-mean-square-standard error $\cong 1$. The corresponding nugget (C_0), the range (A_0), and the sill $(C_0 + C)$, values of the most suited theoretical model were identified.
By selecting the appropriate theoretical model and the corresponding semivariogram parameters, and by using ordinary kriging(OK) method groundwater quality and depth parameter geospatial variability maps were created.



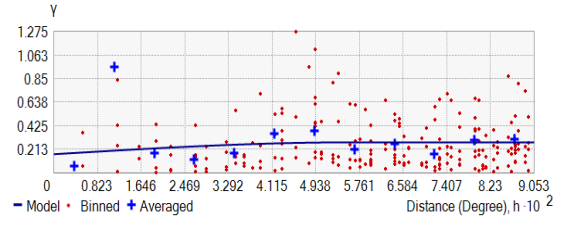
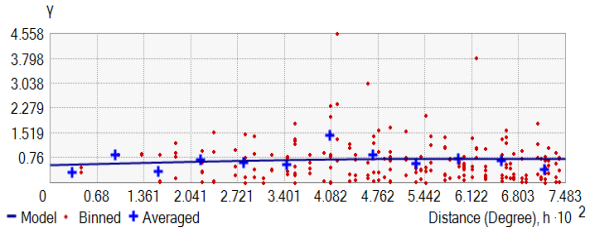
(c) Calcium Concentration	(d) Chloride concentration
	

Figure 2: Most suited semivariograms of Groundwater depth and Quality Parameters

The predictive execution of different models was examined on the basis of cross-validation tests. The values of mean error $\cong 0$, root-mean-square and average standard error difference should be less, mean standardized error $\cong$ minimum, and root-mean-square-standard error $\cong 1$.

4.Results

Groundwater levels in East Godavari district varied from a minimum of 0.45m at Samanthakurru and maximum at Gandepalli 68.35m, The minimum magnesium value is 10 mg/l at Kadium and maximum is190 mg/l at Korukonda, The least chloride value is 10 mg/l at Kundada and high is 104 mg/l at Samanthakurru, minimum calcium value is 8 mg/l at J.Annavaram and maximum is 152 mg/l at Gadala.

Table 1 Bureau of Indian standards (BIS) for drinking water quality

Parameter	Desirable limit	Permissible limit
Magnesium, mg/l	30	100
Chloride, mg/l	250	1000
Calcium, mg/l	75	200

Since, the data sets obtained were not normally distributed hence to make the data distribution normal various mathematical transformations were carried out for the analysis.

Table 2	
Parameter	**Transformation**
Magnesium, mg/l	Lognormal
Chloride, mg/l	Lognormal
Calcium, mg/l	Lognormal

Geospatial structure of groundwater quality and depth parameters

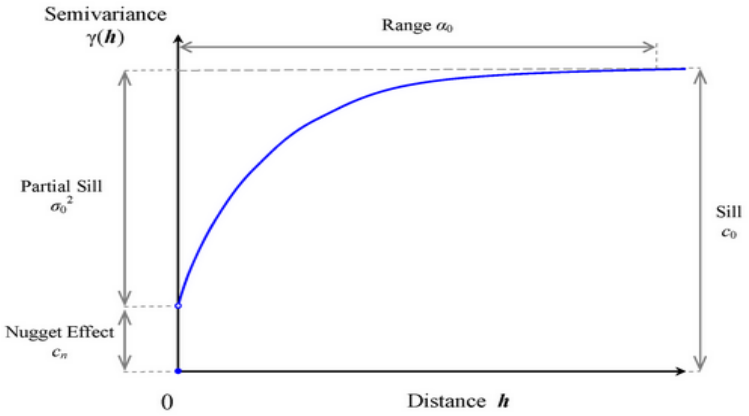


Figure.3 Theoretical Semivariogram model

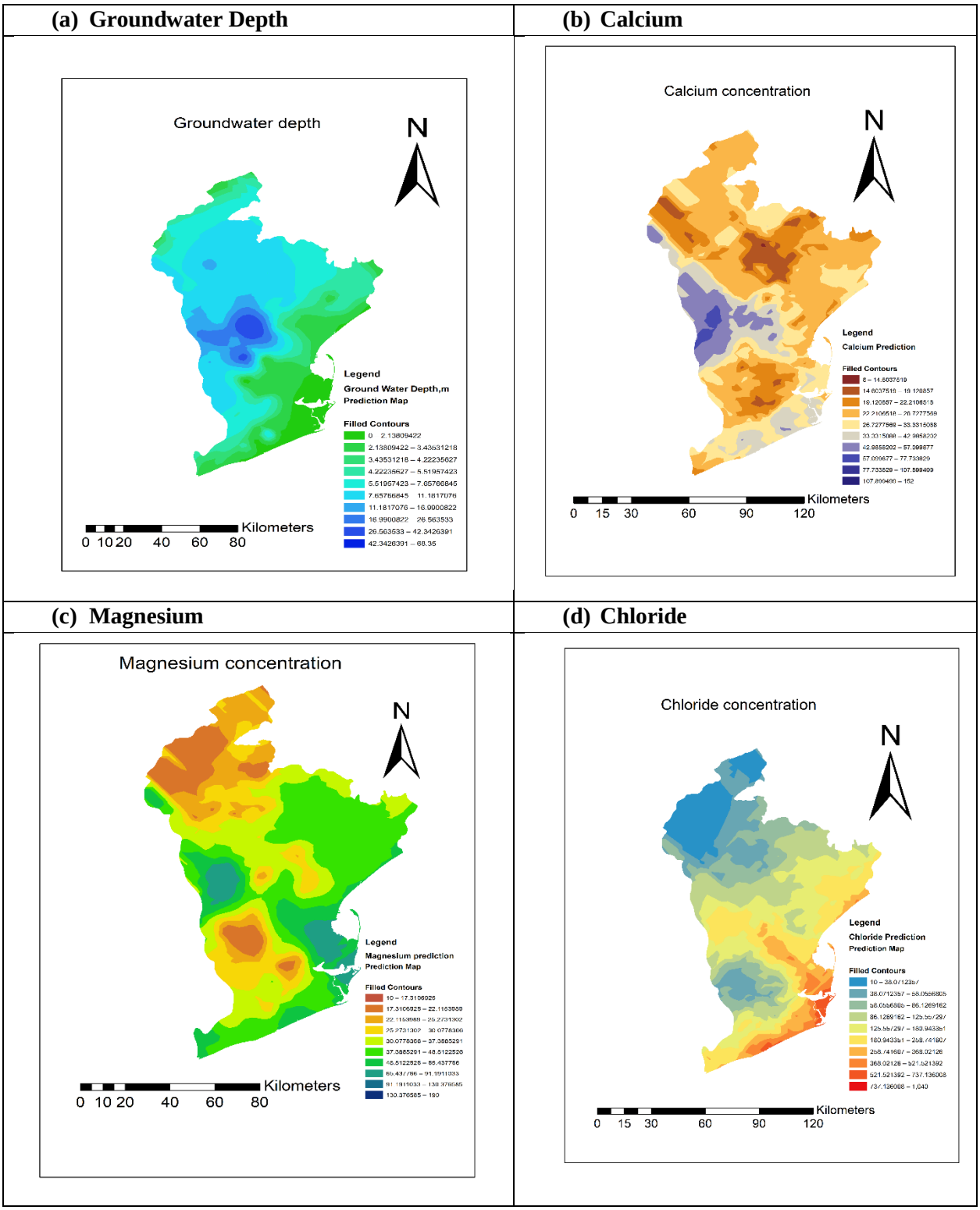
Nugget, Sill, and Range are the measures of a variogram, the most suited theoretical models for groundwater quality and depth parameters are shown in **Table 3**.

Table 3 Most suited models for Groundwater quality and depth Parameters

Parameter	No. of observations	Most suited model	Nugget, (c_0)	Sill, (c_0+c)	Range, (A_0)	ME	RMSSE
Water depth	116	Exponential	5.807	68.277	0.281	0.020	1.216
Magnesium	116	Spherical	0.165	0.182	0.140	-0.45	0.995
Chloride	116	Spherical	0.537	0.192	0.056	-1.712	0.804
Calcium	116	Spherical	0.169	0.106	0.056	-0.430	0.989

The empirical semivariogram could be suited to various theoretical models namely spherical, exponential. The anisotropy in different directions can be examined by the sill, the range, and the nugget.

Figure 4 Geospatial variability maps of Groundwater quality and depth parameters of study area



9.Conclusion

The geospatial variability maps generated by appropriate kriging method revealed that the groundwater depth is less near the coast of the East Godavari district, the SAR values were found to be high near the southern part of the study area which was mainly due to the influence of coastal region and the aqua cultural activities which are predominantly carried out in coastal region. Considering the research objective of this particular study various interpolation procedures were used to map the spatial variability of depth and water quality information. The information in this geospatial variability maps will assist the researchers and the hydrological community in outlining guidelines for effective policy making of groundwater resources.

References

IS 10500 (2012). "Indian Standard Drinking Water Specification (Second Revision)." *Bureau of Indian Standards*.

Chatterjee, R., Tarafder, G., and Paul, S. (2010). "Groundwater quality assessment of Dhanbad district, Jharkhand, India." *Bulletin of Engineering Geology and the Environment*, 69(1), 137–141.

Chen, J., Zhang, H., Qian, H., Wu, J., and Zhang, X. (2013). "Selecting proper method for groundwater interpolation based on spatial correlation." *Proceedings - 2013 4th International Conference on Digital Manufacturing and Automation, ICDMA 2013*, 1192–1195.

Dash, J. P., Sarangi, A., and Singh, D. K. (2010). "Spatial variability of groundwater depth and quality parameters in the national capital territory of Delhi." *Environmental Management*, 45(3), 640–650.

Datta, P. S., Deb, D. L., and Tyagi, S. K. (1997). "Assessment of groundwater contamination from fertilizers in the Delhi area based on18O, NO3/-and K+composition." *Journal of Contaminant Hydrology*, 27(3–4), 249–262.

ESRI. (2010). "Geostatistical Analyst Tutorial." *Electronic Journal of Geotechnical Engineering*, 15 J, 1–22.

Hu, K., Huang, Y., Li, H., Li, B., Chen, D., and White, R. E. (2005). "Spatial variability of shallow groundwater level, electrical conductivity and nitrate concentration, and risk assessment of nitrate contamination in North China Plain." *Environment International*, 31(6), 896–903.

Nas, B., and Berktay, A. (2010). "Groundwater quality mapping in urban groundwater using GIS." *Environmental Monitoring and Assessment*, 160(1–4), 215–227.

Oliver, M. A., and Webster, R. (2014). "A tutorial guide to geostatistics: Computing and modelling variograms and kriging." *Catena*, Elsevier B.V., 113, 56–69.

Sarangi, A., Cox, C. A., and Madramootoo, C. A. (2005). "G m p s v r m r." 48(3), 943–954.

Sarangi, A., Madramootoo, C. A., and Enright, P. (2006). "Comparison of Spatial Variability Techniques for Runoff Estimation from a Canadian Watershed." *Biosystems Engineering*.