Object oriented linking of GIS to assess ground water quality in Dharmapuri district, India

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Abstract: The World Health Organisation has identified 'Fluorosis'as a serious bone disease caused by groundwater. Though the fluoride content in groundwater is a natural phenomenon, when the permissible limit of fluoride is exceeded the consequences may be fatal. This study is identified areas of high fluoride content in the Dharmapuri district of India, which is one of the major districts severely affected by fluorosis (WHO). The approach to this problem is by using GIS as a tool to locate areas of high risk. Ground Water samples collected from 35 randomly located wells (open / bore wells) in the district were analysed for fluoride content. The results were compared with the standards of WHO (World Health Organisation), ICMR (Indian Council of Medical Research), BIS (Bureau of Indian Standard) and PHE (Public Health Engineering) and interpolated using IDW and spline methods using Arcview GIS 3.2 a.

A computer based automated information system was developed in Arcview Avenue 3.2a, so as to enable the user to visit the risk areas at his desktop and to remediate measures as and when required.

Key words Fluorosis, GIS, Spatial Interpolation, Automated information system.

1.Introduction

GIS is a computer-based tool, which effectively handles digital geographic data. GIS allows preprocessing, spatial analysis and post processing of data and also modeling of the data according to the user. This tool has been used for various water resources problems to solve the complexity and to evolve best management solutions. This can be accomplished by combining various socio-economic and environmental factors related to the spatial entities of a water resource problem and thus making them available for use in decision-making. The model building capacity in GIS helps the user to take complete control of the data input and manipulation whereby the user dictates the environmental changes allowing the construction of new rules to the problem.

WHO has identified 23 countries for high fluoride content in groundwater and one among them is India. The excess fluoride content in groundwater causes 'Fluorosis' a serious bone disease is mainly caused by the regional and local geological setting and the hydro-geological conditions of the fluoride contamination (Vinodh Agarwal.,1997). In TamilNadu, TWARD Board (Tamil Nadu Water Supply and Drainage Board) has identified the districts of Dharmapuri, Salem, and Erode are the districts under major endemic 'Fluorosis'. Out of these identified areas, the maximum fluoride content was recorded by TWARD Board in Dharmapuri district is 9 mg/L.

With this background, the present study was initiated to develop an operational framework based on the observed fluoride content in groundwater to improve the co-ordination of the geographic information management and mapping activities for health among different sectors to help not only researchers but also bureaucrats to develop decision support systems.

2.Area Description

The area selected for the present study is Dharmapuri district of Tamil Nadu, India, which extends between the geographic location of 11°13' to 78°45'E. The district covers a total area of 9581.26 sq.kms, which comprises of 8 taluks, seven towns and 1168 revenue villages.

Recently, two new taluks have been formed from the existing eight taluks. The district has a vast expanse of hilly and rocky areas with undulating plains. The district is located between the eastern and western ghats having the soil types of forest loamy, red ferrogenous and black soil.

3.Methodology

Groundwater samples from both open and bore wells were collected from 35 stations that are randomly located within the district. The groundwater samples were collected in sterilized containers and analysed in the laboratory for fluoride content, using Calorimetric methods. As the interference of certain ions are present, distillation was done prior to estimation of samples. The groundwater sampling was not concentrated in Pennagaram taluk as this place serves as an entry to the river Cauvery and the major source of drinking water is the river.

A database was created for the results of the estimation using the geographical co-ordinates of each sampling site.

The Survey of India toposheets at 1:250,000 scale were used to digitize the study area using Arcview GIS 3.2a to prepare a base map. The 35 sampling stations were located in the map by database connectivity in GIS. The Arcview enabled Avenue scripting was used to compare the results with the WHO, ICMR, PHE and BIS standards. These areas were selected and IDW and spline interpolation techniques, which are spatial analysis tools, were applied to analyse these specific areas.

4.Results

The water samples collected from the 35 locations of the Dharmapuri district were subjected to statistical analysis and the talukwise mean fluoride content groundwater was tabulated (Table1). The base map identifying the sampling locations were prepared. The located sampling stations were earlier recorded in dbase and merged with the digitized base map. The overall mean fluoride content in the district is 1.80±0.57mg/L which exceeds the WHO permissible limit of 1.5 mg/L in drinking water. In-depth analysis to identify specific areas which exceed the permissible limit is necessary. For such analysis querying capabilities is available in GIS. But complex querying and criterion selection is a multiple step process. On such basis, Avenue script in Arcview GIS is a boon to the user which allows scripting of the model as a one step process.

Table 1. Mean Fluoride value of different taluks in Dharmapuri district

S.No	Taluks	Mean Fluoride mg/L	SD	Variance	Range
1.	Dharmapuri	2.6	1.50	1.97	3.45
2.	Krishnagiri	0.76	0.55	0.31	1.30
3.	Harur	1.45	0.24	0.06	0.65
4.	Hosur	0.88	0.89	0.78	2.30
5.	D.kotta	2.30	0.30	0.09	0.65
6.	Palacode	2.22	0.40	0.16	0.99
7.	Uthangarai	2.42	0.24	0.06	0.65
	Mean	**1.80**	**0.76**	**0.70**	**0.42**

Using these functions, once the user inputs the base map and the additional information, the GIS can extract a node-link network, generate a mathematical model, run the model and finally display the results. For such water resources problems, it is good to link GIS with traditional mathematical models.

Hence, a script was developed in Avenue specifying the permissible limit of fluoride content in drinking water by WHO, BIS, PHE , and ICMR (Table2). Conditions to select the areas above, below or all within the prescribed limits were applied. On such conditions given exactly, Arcview is prompted to select the areas that are within the criterion and retrieves the areas and display the result as a new theme. For example Fig1 shows the 12 areas that fall below the WHO limits which, 5 from Krishnagiri taluk, 4 stations from Hosur taluk , 1 station from Dharmapuri taluk and 2 stations from Harur taluk. Similarly Fig 2 represents the 15 stations that exceed the permissible limit prescribed by WHO. Similar analysis was done to identify areas that exceed and areas that fall within the, BIS, PHE and ICMR standards for drinking water quality.

Table 2.The maximum permissible level of fluoride content (mg/L in Drinking water

S. No	Name of the Organizations	Permissible limit of Fluoride mg/L
1.	World Health organization (WHO) Internal standards for drinking water	1.5
2.	Bureau of Indian Standards (BIS)	0.6-1.2
3.	The committee on Public Health Engineering (PHE) Government of India	1.0
4.	Indian Council of Medical Research (ICMR) Government of India	1.0

Spatial analyst of Arcview GIS 3.2a is an important tool in GIS, which, by using the existing results, can identify other unsampled

areas for their fluoride contents using interpolation techniques. Two available interpolation methods in spatial analyst are IDW (Inverse Distance Weighing) and spline interpolation. The interpolated data were subjected to diagnostic checking. The RMSE (Root Mean Square Error) and MAE (Mean Absolute Error) is less in spline interpolation than the IDW. Therefore spline interpolation was adopted to extend the analysis to the unsampled areas and is presented as Fig 3. This visually represents the risk involved due to excess fluoride content in groundwater if the same conditions persist.

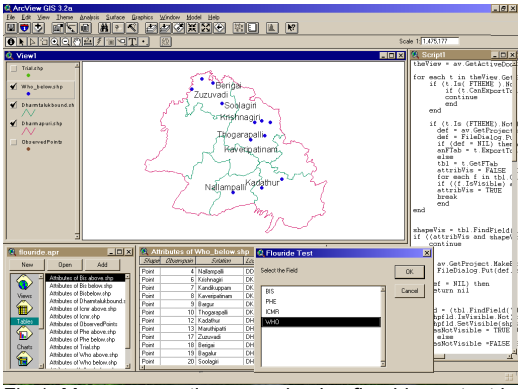

Fig 1. Map representing areas having fluoride content in groundwater below the WHO permissible limit.

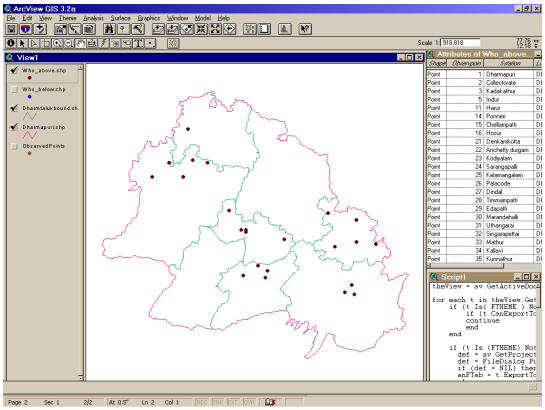

Fig.2.Map representing areas having fluoride content in groundwater above the WHO permissible limit.

5. Discussion and Conclusion

Object oriented linking and tight coupling methods have been adopted in GIS by several authors (McKinney et al., 2002). Sophisticated graphical user interfaces to provide user-defined triggers were constructed by (Crosbie, 1996).

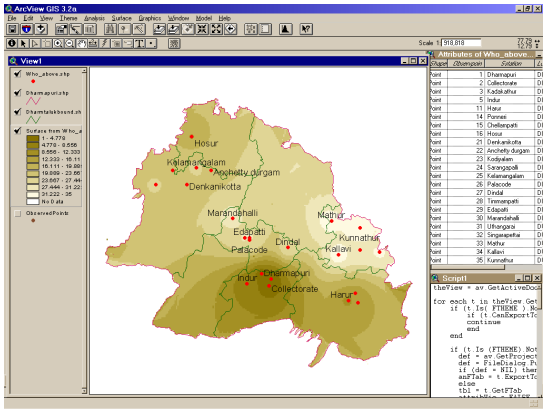

Fig 3. Map representing spline interpolated areas for fluoride content in unsampled locations of Dharmapuri district

Densham and Goodchild (1989) have presented an approach to develop spatial decision support system to integrate spatial data and model builder into an operational framework for water resources problems, distribution related and their management.

A preliminary step towards such a goal is taken to enable not only researchers but also the commoners and bureaucrats who require a one step decision support. This work in particular concentrates on fluoride contamination in groundwater but can be applied to other water quality studies and can be extended to health related problems so as to enable decision-making fast.

References

[1] Vinodh Agarwal, A.K. Vaish and Prerana Vanish et al., 1997 ,Groundwater quality : Focus on Fluoride and fluorosis in Rajasthan,Current Science,Vol.73, 9-10

[2] Crosbie,P., 1996.Object –oriented design of GIS: a new approach to environmental modeling. In: GIS and Environmental Modeling: Progress and Research Issues.GIS World Book,Goodchild M.F. (Eds).Fort Collins, 383-386.

[3] Densham,P.J., Goodchild ,M.F.,1989. Spatial decision support systems: a research agency. In: GIS/LIS'89 Proc., American Congress on Surveying and Mapping, Bethesda, MD. Vol.2

[4] McKinney,D.C., and Ximing Cai., 2002, Linking GIS and water resources management models: an object-oriented method. Environmental modeling and Software17,413-425