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Mapping the Spatial Distributions of Water Quality and Their Interpolation with Land Use/Land Cover Using GIS and Remote Sensing in Noyyal River Basin, Tamil Nadu, India

Geetha Selvarani Arumaikkani[1*], Sivakumar Chelliah[2], Maheswaran Gopalan[3]

[1]Department of Civil Engineering, K.S.R. College of Engineering, Namakkal District, Tamil Nadu, India
[2]Department of Mechanical Engineering, K.S.R. College of Engineering, Namakkal District, Tamil Nadu, India
[3]VSA Group of Institutions, VSA School of Engineering & Management Salem, Tamil Nadu, India
Email: *geethacivil1201@gmail.com

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Abstract

Noyyal River is historically, ecologically and culturally significant river in Kongu region of western Tamilnadu. More than 100 villages are situated along the banks of the Noyyal River and it's the was the best site of inhabitation on both the sides of the river up to 3 km from the river before the emergence of the issue of industrial pollution. But now river Noyyal was highly polluted by domestic and industrial growth by discharging of both domestic and industrial are discharged without any treatment. So methodology was proposed to identify the suitable zone for groundwater quality by using land use/land cover data along with groundwater quality in analytic hierarchy process. Suitability of groundwater for drinking was identified in the study area by collecting 63 samples in both postmonsoon and premonsoon as per Indian standards. To evaluate the land use pattern of the study area, land use/land cover map was prepared from satellite images of LISS III by using supervised classification according to National Remote Sensing Agency (NRSA) using Erdas imagine 8.4 software. Using ArcGIS software, weighted overlay analyses were carried out to identify the suitable zones for groundwater quality in postmonsoon and premonsoon and finally these two thematic maps were integrated with land use/land cover map to identify the suitable zone for quality of water. The interpretation shows that groundwater in most of the locations were unsuitable for drinking purposes.

Keywords

Noyyal River, Drinking Water Quality, Total Dissolved Solids, GIS, Land Use

1. Introduction

Groundwater is a vital natural resource and it is used for drinking, irrigation and industrial purposes. Nowadays the quality of groundwater is deteriorating day by day due to over exploitation of groundwater and improper methods of solid waste disposal and untreated effluents into the water bodies [1] [2] [3]. And also the temporal changes in the origin and constitution of the recharged water, hydrologic and human factors may cause periodic change in groundwater quality. And this water pollution not only affects water quality but also threatens human health, economic development, and social prosperity. Hence, evaluation of groundwater quality status for human consumption is important for socio-economic growth, development and also for establishing a database for planning future water. Mapping the spatial distributions of major elements and their interpolation with the geology and land use/land cover maps in GIS environment [4] [5] have contributed for the better understanding of the chemical processes of water and the methods of their acquisition. Several studies were carried out in the past two decades for identifying the groundwater quality zones using GIS and remote sensing data and the methodology proposed in the literature are [6]-[18]. Noyyal River is one of the tributaries of the river Cauvery, which originates from the hills of Vellingiri, also termed as southern Kailayam in Western Ghats and flows towards the southwest of Coimbatore district in Tamil Nadu, and finally it ends in river Cauvery at Kodumudi in Karur district. It flows through Coimbatore, Tiruppur, Erode and Karur districts with its catchments in seven taluks (Coimbatore, Tiruppur, Avinashi, Palladam, Dharapuram, Erode and Karur). It flows over a length of about 180 Kms covering an area of 3510 km^2. Out of the total area in the basin, 1752 km^2 (49.9%) of the area is under cultivation and 178 km^2 (5.1%) is covered by forest and wetland growing teak and eucalyptus and the rest 1580 km^2 (45%) is barren land [19]. The boundary of the river basin is between north latitude 10˚54'00" to 11˚19'03" and east longitude 76˚39'30" to 77˚55'25" which is shown in **Figure 1**. More than 100 villages are

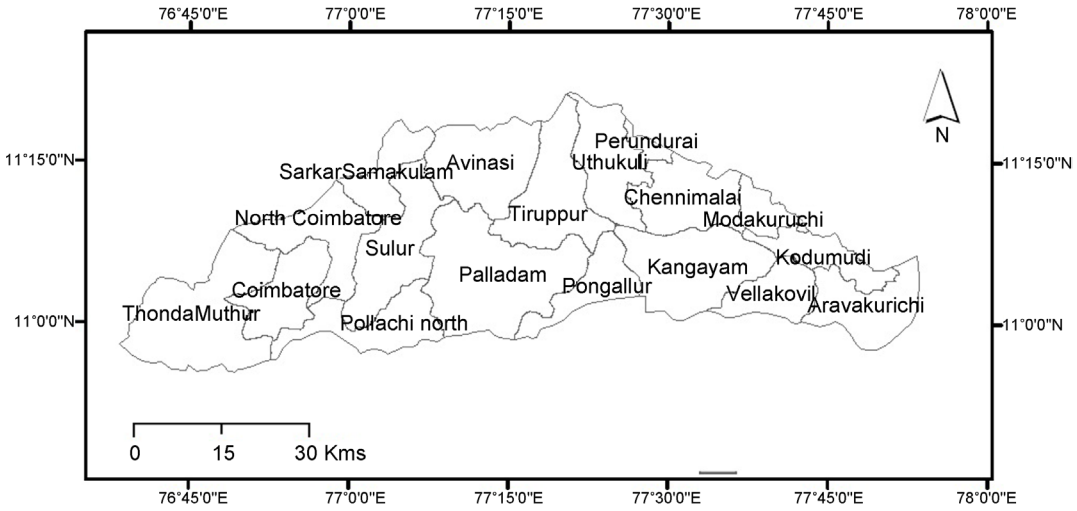

Figure 1. Key plan showing the study area details.

situated on both sides of the banks of river Noyyal. Nearly 6000 acres of cultivable land in Coimbatore district is irrigated by using river water [20].

The average rainfall in the basin is about 700 mm. The river flows from west to east and its maximum elevation is around 1600 m above mean sea level and the minimum elevation is 100 m above mean sea level [21]. It is also believed that water contains natural medicine and therefore it is good for health. Noyyal is a seasonal river which has good flow only for short periods during the northeast and southwest monsoons. Occasionally flash floods occur when there is heavy rain in the catchment areas [22]. Apart from these periods, there is only scanty flow in most part of the year. Generally, a subtropical climate condition prevails in the river basin. It is divided into, winter from January to February, summer from March to May and it is followed by southwest monsoon from June to September and from October to December constituting the postmonsoon season [21]. The rainfall in western parts is comparatively more during the southwest monsoon season while the eastern parts get more rainfall during the northeast monsoon season [23]. The precipitation is unevenly distributed throughout the year and often completely lacking of rainfall during dry period [23]. The present study is to evaluate the physico-chemical characteristics of groundwater in and around a Noyyal River basin and integrated with land use/land cover data for the assessment and suitability of groundwater for drinking purposes.

2. Materials and Methods

The base map of the study area was created by using Survey of India (SOI) toposheets of 58A/12, 58A/16, 58B/9, 58B/13, 58E/3, 58E/4, 58E/7, 58E/8, 58E/12, 58E/16, 58F/1, 58F/5, 58F/9, 58F/13 (1:50,000). Sixty three groundwater (bore well) samples were collected in a cleaned polythene bottle in and around the catchments of the basin during the month of January 2015 (postmonsoon) and June 2015 (premonsoon) to know the status of various physico-chemical parameters and their impacts. The sampling locations were marked in the base map which is shown in **Figure 2** and its corresponding names are given in the **Table 1**. Standard procedure and methods were followed for preservation and analysis of the groundwater samples [24]. The analysed results were compared with Indian Standard (IS) 10,500-1991 [25]. The suitability of groundwater for drinking was identified based on Total Dissolved Solids (TDS), chlorides, calcium, hardness and alkalinity for both postmonsoon and premonsoon.

Using ArcGIS software, weighted overlay analyses were carried out to identify the suitable zones for groundwater quality in postmonsoon and premonsoon and finally these two thematic maps were overlaid to identify the suitable zones for Drinking purposes. This analysis has categorised the study area into three zones (good, moderate and poor), which would enable the user to locate the potable water without any problem which is shown in **Table 2**. Each class in every thematic map was assigned a weight. Highest weight was assigned to the class that was most favourable for the drinking and the lowest weight was assigned to the class that was least favourable/unfavourable class. To evaluate the

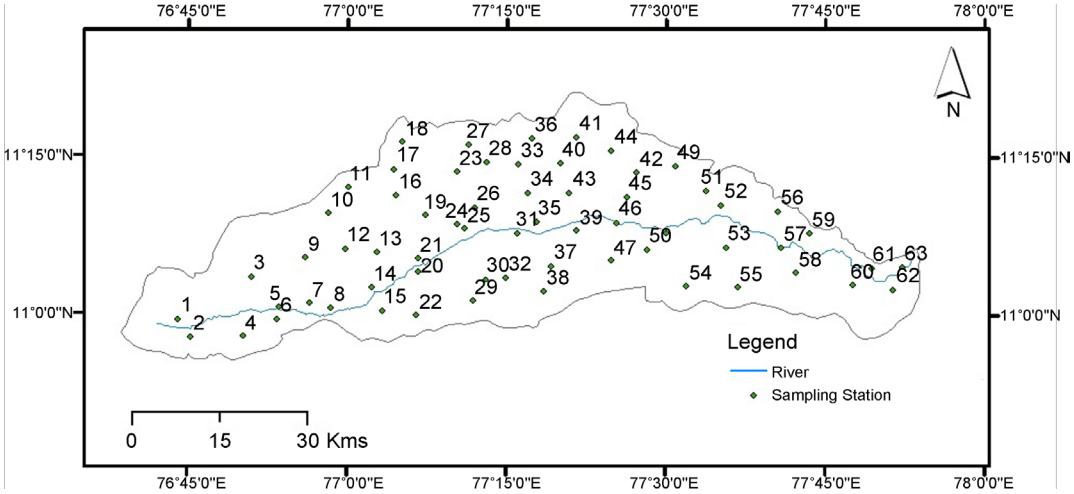

Figure 2. Key plan showing sampling stations.

Table 1. Details of the sampling locations.

Sl.No	Name of Habitation	Sl.No	Name of Habitation
S1	Iruttupallam	S2	Perumalswamykovil
S3	Thimmekavanporam	S4	Mathipalayam
S5	Perur	S6	Ramachattipalayam
S7	Ukkadam	S8	Nanjundapuram
S9	Varadayyampalayam	S10	Kalappatti
S11	Karaiyampalayam	S12	Irugur
S13	Pattanampudur	S14	Kariyampalayam
S15	Indiranagar	S16	Alampalaiyam
S17	Sulur	S18	Muttukavundampudur
S19	Rasipalayam	S20	Apanayakkanpattipudur
S21	Uppilipalayam	S22	Puduppalayam
S23	Karumattampatti	S24	Senniyandavarkovil
S25	Semmandampalayam	S26	Vellandipalayam
S27	Periyakattupalayam	S28	Arangattupalayam
S29	Ayyampalayam	S30	Rasakkaundampalayam
S31	Mangalam	S32	Rasakavundanpalayam
S33	Nallikavundapalayam	S34	Tirumuruganpundi
S35	Murugapalayam	S36	Karuvampalayam
S37	Chennimalaipalayam	S38	Krishnapuram
S39	Nallur	S40	Perumanallur
S41	Uttukkuli	S42	Molakavundampuam
S43	Velampalaiyam	S44	Aruvangattupuram
S45	Periyakunnampalayam	S46	Manur
S47	Kariyampalayam	S48	Ramakkaranpalayam
S49	Kavundanpalayam	S50	Moskuttivalasu
S51	Chennimalai	S52	Puchchakkattuvalasu
S53	Pallakkatupudur	S54	Uttamapalayam
S55	Palanikavundanvalasu	S56	Vettukattuvalasu
S57	Sengodampalayam	S58	Subramaniyapuram
S59	Valliyampalayam	S60	Velliyankattupudur
S61	Murugampalayam	S62	Adiyappakaundanvalasu
S63	Velaiyampalayam		

Table 2. Criteria for the classification of thematic maps of groundwater quality and land use/land cover for drinking purpose.

S.No	Parameters	Descriptive scale	Score	Weightage
1)	Hardness (mg/l)	Good	3	20
		Moderate	2	
		Poor	1	
2)	TDS (mg/l)	Good	3	30
		Moderate	2	
		Poor	1	
3)	Calcium (mg/l)	Good	3	5
		Moderate	2	
		Poor	1	
4)	Alkalinity (mg/l)	Good	3	10
		Moderate	2	
		Poor	1	
5)	Chlorides (mg/l)	Good	3	5
		Moderate	2	
		Poor	1	
6)	Land use/Land cover	Land with scrub	3	30
		Crop land	3	
		Fallow land	3	
		Scrub forest	2	
		Built up land	1	
		Water bodies	3	
		Land without scrub	3	
		Forest blank	2	
		Open forest	2	

land use pattern of the study area, land use/land cover map was prepared from satellite images of LISS III by using supervised classification according to National Remote Sensing Agency (NRSA) [26] with Erdas imagine 8.4 software. Finally land use/land cover map was integrated with quality map to identify the suitable zone for quality of water.

3. Result and Discussion

By means of ArcGIS superimpose was prepared by adding up the weights of the classified themes of postmonsoon, premonsoon and land use/land cover map were used to prepare a map of groundwater quality zone for drinking purpose of the study area.

Overlaying was done by adding the weights of the classified themes of hardness, TDS, alkalinity, chlorides and calcium were used to prepare a map of groundwater quality for drinking purpose in ArcGIS platform. This analysis has categorized in the study area into three zones (good, moderate and poor). The

spatial variation of suitable zones for drinking purposes based on groundwater quality for both postmonsoon and premonsoon are shown in Figure 3 and Figure 4. GIS analysis, reveals that the quality of groundwater was predominantly poor category in both premonsoon and postmonsoon, while the good category water found in Thondamuthur block during premonsoon period. The suitable quality found in southwestern, western and southeastern side of the river basin. The discharging of industrial and Drinking effluent on either side of the river were ultimately polluting the groundwater of the study area and this reflects in the downstream of Tiruppur during premonsoon period and also the potable ground water was found in larger area than during the postmonsoon period.

Land is a prime natural resource and the mapping of land use/land cover is essential for planning and development of land and water resources [27]. But anthropogenic and natural forces modify the landscape. So it is important to monitor and assess these alterations to avoid the misuse of usable land into wastelands. Timely and accurate information on the existing land use/land cover

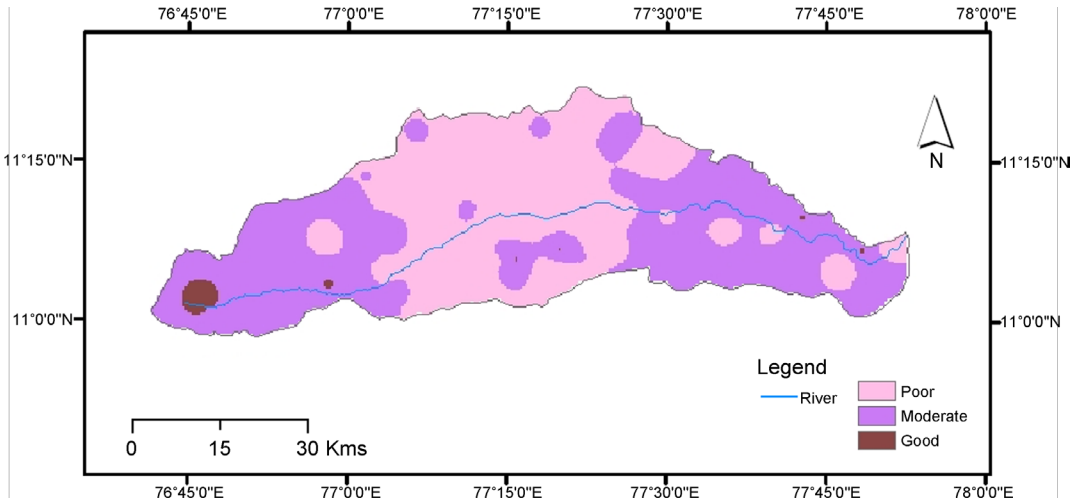

Figure 3. Spatial distribution of groundwater quality for drinking in postmonsoon.

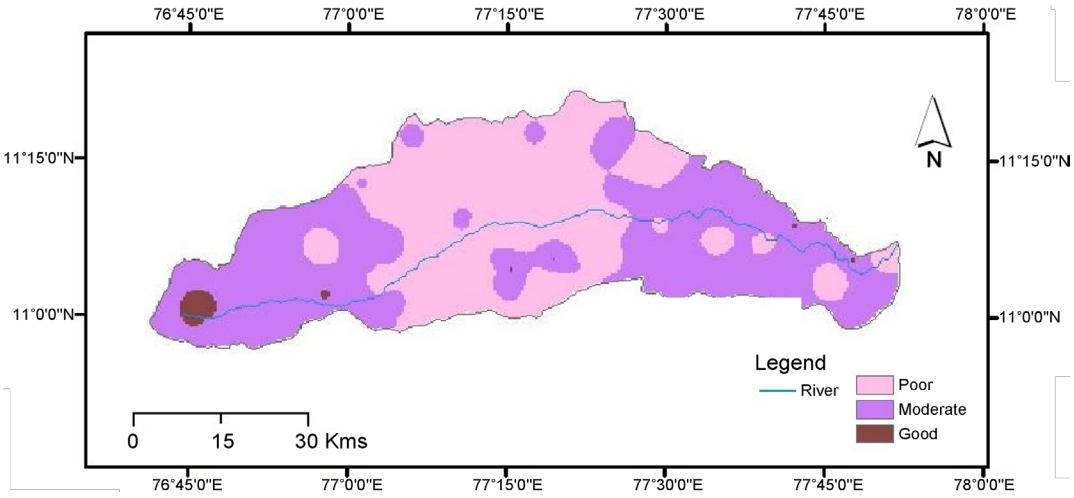

Figure 4. Spatial distribution of groundwater quality for drinking in premonsoon.

pattern and its spatial distribution and changes is a prerequisite for planning, utilisation and formulation of policies and programmes for making micro and macro-level developmental plan [27]. Remote sensing technology along with GIS is cost-effective and best utilised solutions for integration of various data sets for both macro and micro level analysis which helps in identifying the problem areas and suggest conservation measures [6] [7]. The mapping and monitoring of the land use/land cover requires land use classification system. One of the most widely used classification scheme was developed by National Remote Sensing Agengy (NRSA 1995) [26]. Land use/land cover change detection mapping of the study area has been done by using software ERDAS Imagine 8.4 from Landsat TM and IRS LISS III data. The ten major levels of land use/land cover categories were interpreted in the image of the study area and is shown in **Figure 5** namely built up land having poor sanitary conditions and anthropogenic activities, groundwater quality is deteriorating significantly in the city area as compared to water fields so it has poor groundwater quality zone, fallow land and agriculture land, land with scrub, land without scrub, water bodies fields facilitate the recharge of groundwater during monsoon periods and also provide the water supply to city through production wells [6] [7]. So it has very good groundwater quality zone, dense forest, scrub forest, forest blank and open forest having moderate groundwater zone.

In the study area, groundwater quality map was prepared by overlaying and adding a weightage of classified themes from postmonsoon, premonsoon and land use/land cove map. This analysis has categorized the study area into three zones (good, moderate and poor). The spatial variation for drinking purpose (**Figure 6**) based on the thematic map was found under moderate category in south western, eastern and north eastern side of the study area, while good category water was found in Thondamuthur block in south eastern side of the study area. Poor category was found in southern, centre and northern parts of the study area. The highly polluted blocks were Annur, Avinashi, Tiruppur, Sulur,

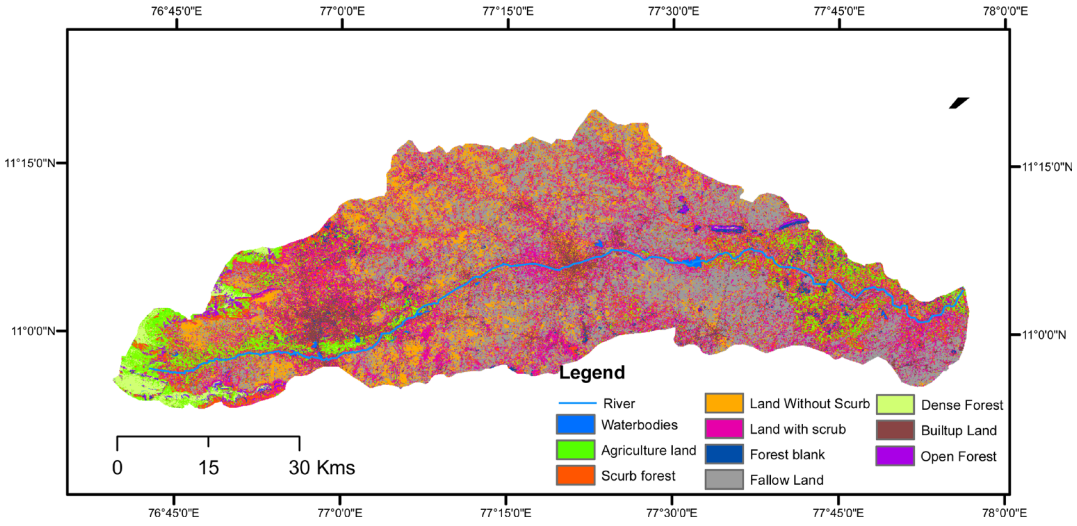

Figure 5. Land use classification.

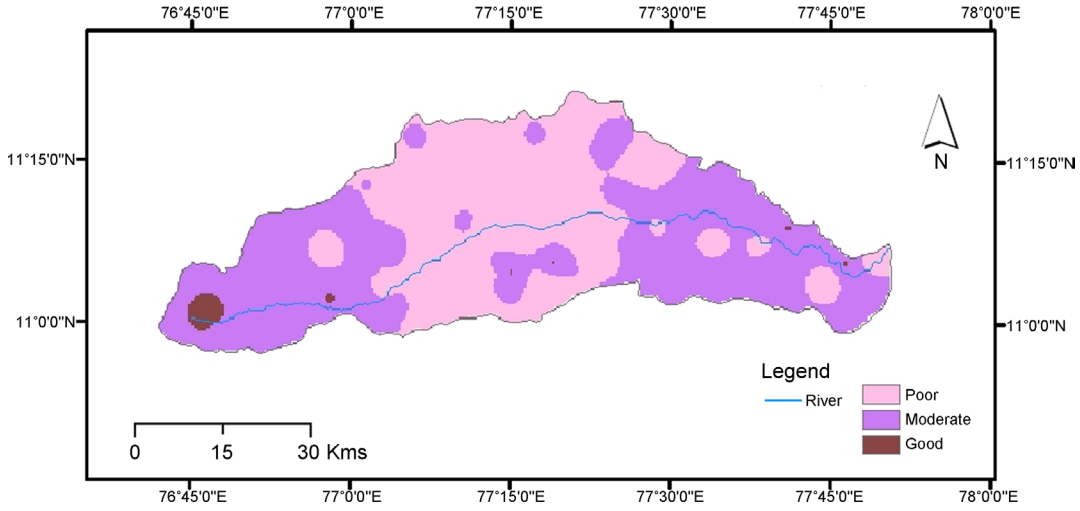

Figure 6. Spatial distribution of groundwater quality showing suitable zone for drinking.

Sultanpet, Palladam, Pongalaur, Uthukuli and few isolated parts of Kangeyam and Perundurai blocks.

4. Conclusion

Geospatial techniques are applied to identify and assess the groundwater quality zones for drinking purposes. The quality zone is assessed by integrating water quality map and land use/land cover map with categorized into good, moderate and poor. The spatial distribution shows that the percentage of suitable zones for drinking is higher in postmonsoon as compared to premonsoon due to high recharge and dilution of contaminants during monsoon and postmonsoon. Based on the interpretation, groundwater quality of Noyyal river basin is not suitable in few locations for drinking purposes and also indicates that, the river is heavily polluted only after entering the Sarkar Samakulam area of Coimbatore district and continues till the end of the basin. The drinking water quality is deteriorated at some sites which is indicated by the excess presence of total dissolved solids, hardness, alkalinity and chloride which is due to dense population and discharge of industrial and drinking effluents. So groundwater in these locations can be used for irrigation under special circumstance only. If the improper disposal of municipal and industrial waste is continuously falling in the Noyyal river basin, then there is a chance for over pollution in future, which affects the aquifer system of the basin to a greater extent.

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