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Groundwater Pollution Vulnerability in Relation to Topography and Land use/Land cover: RS and GIS aided case study for Bangalore District, India

Mrs.Shwetha A[1]*, Dr.Sampath Kumar M C*[2]*, Dr.Rajyalakshmi M*[3]

[1]*Faculty, Department of Civil, Presidency University, Bengaluru, Karnataka 560064.*
[2]*Faculty, Department of Civil, BMS College of Engineering, Bengaluru, Karnataka 560019.*
[3]*Faculty, Department of Civil, BMS College of Engineering, Bengaluru, Karnataka 560019.*

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***Abstract*:**
The main objective of this study was to obtain the relationship oftopography and Land Use/Land Cover (LU/LC) classes ongroundwater pollutionvulnerability using RS and GIS for Bangalore District. Here ArcGIS software and ERDAS IMAGINE software are used withAnalytical Hierarchy Process (AHP) to process different layers such as drainage map, a relief map, a Digital elevation map, and drainage network map. Topographic features like drainage network and relief likely have a substantial impact on groundwater pollution with Land Use/Land Cover classes which was divided into seven categories water bodies, forest land, grass, wasteland, wetlands, agriculture built-up, built-up area with very low, low, medium and high density. The urbanization index map was developed by overlaying all the maps to explain topographic impacts on groundwater contamination.Our research shows that due to urbanization, industrialization, and anthropogenic activities, topography has a major effect on groundwater pollution.

Water distribution in the study region showed a falling drift with a 59 p ercent decrease. The vegetation distribution also showed a declining tre nd with a 49 percent fall. The combined distribution showed a significa nt 109 percent rise. Other areas decreased by 40 percent in total. The d evelopment of form land and open spaces into developed areas on the o utskirts of the city demonstratesan unsustainable growth of the town, which must be resolved, and there must be immediate action taken by the concerned authorities and eradicating the future damages at the earliest.

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1. Introduction

Environmental issues relating to freshwater (GW) typically focus on the effect of pollution and quality depletion on domestic uses, especially local supplies (Rahman 2008; Sophocleous 2002).

Due to increased overpopulation and urbaniz ation, more domestic and industrial harmful by-products are dumped, which leads to groundwater pollution in shall ow aquifers(Rahman 2008; Bazimenyera and Zhonghua 2008). Water contamination is a significant problem in India, as nearly 70% of its groundwater re serves were polluted with microbial, chemica l, and artificial contaminants.(Rao and Mamatha 2004; Shekhar, Pandey, and Tirkey 2015). Water supply is a critical problem for humanity, as it is directly related to human well-being (Balakrishnan, Saleem, and Mallikarjun 2011). Land use applies to the object, for example, in which the land serves recreation, reforestation, or agriculture. Implementations for land use include both simple modeling and subsequent surveillance (Nobi et al. 2009; Sreenivasulu et al. 2014). Land cover and land use lead to impact the ecology and environment system of any region, so it must be appropriately regulated (Parker et al. 2003). For other parts of the world, however,expanding development and building projects is being carried out in a haphazard and poorly managed manner, thereby creating an unfavorable shift in the land cover and land use circumstance (Varnakovida 2010).Therefore, this transition needs to be researched and viewed, and that can be achieved with maps of land cover and land usage. A detailed image of a specific region is given by thematic maps of land use and land cover.For other governments, this data is a central component in planning and statement-making processes, since it helps them to identify which areas can be prepared for development and which regions need to be maintained.

MATERIALS AND METHODOLOGY

Study area

The region chosen for this investigation is Bangalore which covers Devanahalli, Hoskote, Bangalore East and AnekalTaluk (**Figure 1**) is situated between 12.40°N–13.20°N latitude and 77.30°E–78.00°E longitude. The field studies and supplementary data collection consist of gathering meteorological data, population, industry distribution, soil status, crop patterns harvested, employment, polluting sources, and many other information supporting data. Remote Sensing technologies and data processing methods allowed meaningful spatial evidence to be extracted from remotely sensed data, which is directly entered into a GIS. Differentmaps have been generated for drainage maps, depth to the groundwater table, relief map, Digital elevation map, and drainage network map. Topographic features like drainage network and relief likely have a substantial impact on groundwater pollution with Land Use/Land Cover classes.

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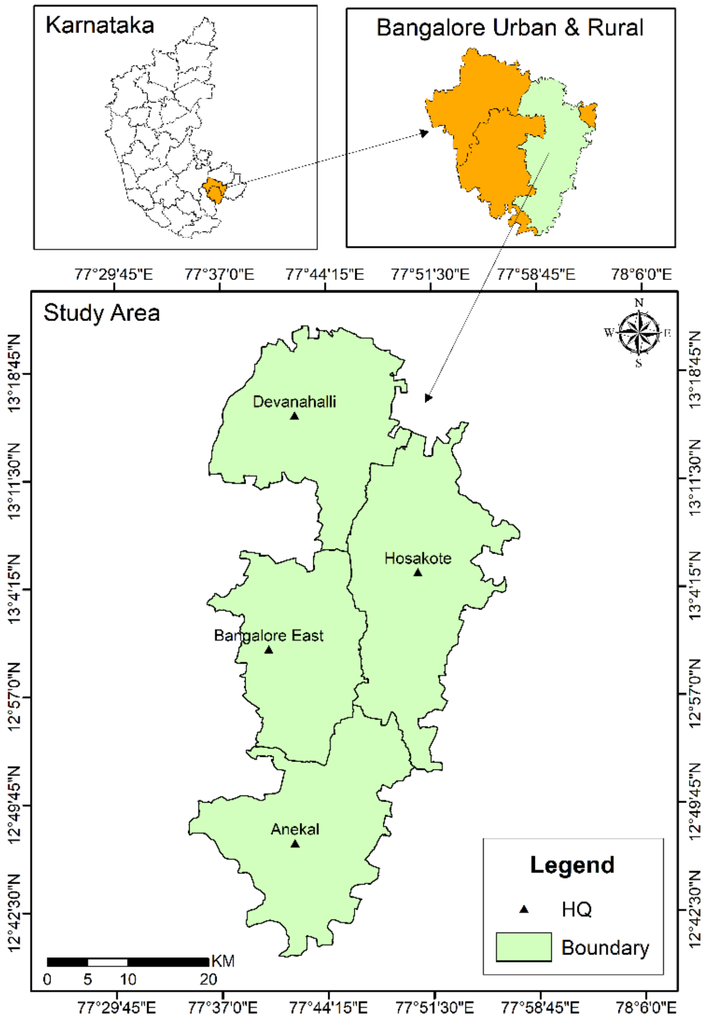

Figure 1.Location map of study the area

Methodology

In the present research, the vulnerable map was developed using RS and GIS techniques, which allows the determination of vulnerable groundwater contamination zone from anthropogenic activities.Several researchers and scientists conducted quality assessments of groundwater based on the above description(Secunda, Collin, and Melloul 1998; Shirazi, Imran, and Akib 2012; Gogu and Dassargues 2000). The approach used essential data on land use and analytical means to explain the vulnerability of aquifers (Al-Adamat, Foster, and Baban 2003; Collin and Melloul 2001; Hill et al. 2008)Also develop groundwater vulnerability and study area risk maps using GIS and Remote Sensing with Analytical Hierarchy Process (AHP)(Neshat, Pradhan, and Dadras 2014; Sener and Davraz 2013; Sar, Chatterjee, and Adhikari 2015). Vulnerable map obtained is studied with topographical maps, and Landuse/Landcover maps to develop a relationship in terms of sources for groundwater pollution(Ozdemir 2011; Akbar, Lin, and DeGroote 2011; Ghosh and Parial 2014).These models are intended to test zones with major groundwater pollution potential that are geared towards their hydrogeological and environmental impacts (Lowe and Butler 2003; Awawdeh and Jaradat 2010; Andreo et al. 2006).

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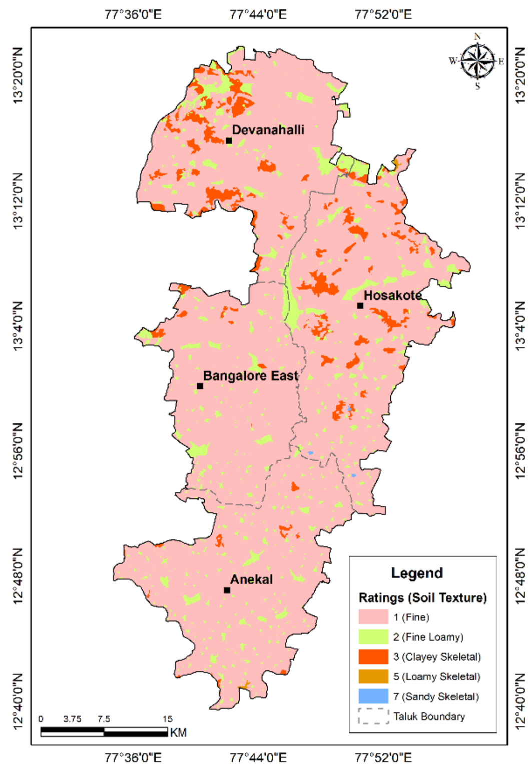
3. Results and Discussion

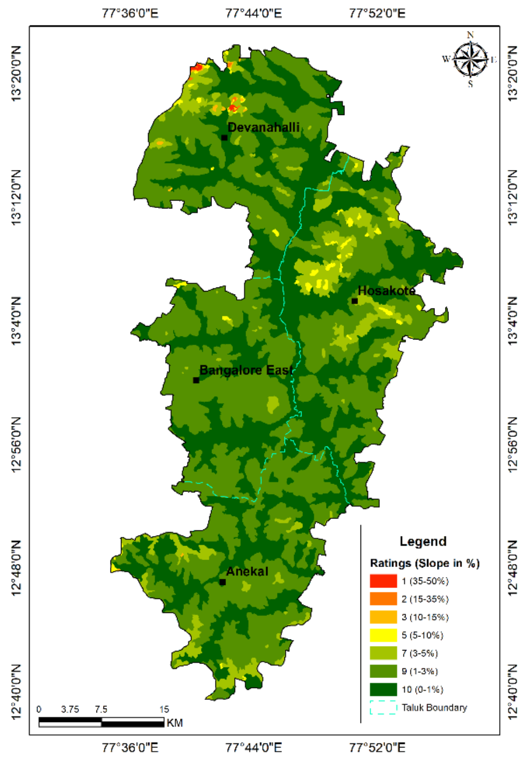
The existence of granular substances such as clay, peat, or silt and the proportion of organic matter in the surface cover can lower intrinsic permeability and delay or eliminate contaminant migration through physical-chemical processes such as penetration, ion exchange, oxidation, and biodegradation.A soil map was extracted from the "National Bureau of Soil Survey and Land Use" District soil map. Soil does not differ considerably in the field of analysis; it is (i) Fine soil (ii) Fine Loamy soil (iii) clayey skeletal soil (iv) Loamy skeletal soil and (v) Sandy skeletal soil**(Fig. 2a).**Sandy skeletal soil leads to a high degree of groundwater contamination, and Fine Soil characterizes a large portion of the study area.

3.1 Groundwater pollution vulnerability in relation to Topography (drainage and painted relief) and Land use/Landcover

The topography is the elevation of a region. Low sloping areas try to hold water for more extended periods(Montgomery 2001).It allows for greater water absorption and more significant potential for contaminant movement (Rahman 2008). Zones with steep slopes have a substantial runoff, so minor infiltrations are even less vulnerable to groundwater contamination **(Fig. 2b).**Areas with relatively low topography are susceptible to contamination because the water in these areas can accumulate and penetrate into the soil strata. The topographic map was drawn from the 1981 "Surveyof India" (SOI) toposheet on a scale of 1:50,000, and contours of 20 m were digitized, and the "Digital Elevation Model" (DEM) was developed in the Arc GIS software**(Fig. 2c).**With "Digital Elevation Model"three classes of the slope were extracted. The type of topography will determine whether a contaminant runs off or stays on the ground to reach the groundwater(Lynch, Reynders, and RE 1994). An interpretation of the existence of primary stores, secondary stores, and the possible storage capacities of various types of drainage basins with relief is essential in recognizing groundwater contamination capacity in the study area**(Fig 2d).**The range in the slope of the research area very between 757 and 1099 m **(Fig. 2e).**Flat areas areconsidered to be more vulnerable to groundwater pollution since the amount of runoff in flat areas is low, and hence more impurity percolation to groundwater.The land use map was superimposed on the groundwater vulnerability map **(Fig 2f)** to determine if there was a spatial connection between land use and groundwater vulnerability of the study area.This was a significant step to find out if there are possible sources of contaminants within the low or medium vulnerable zone.The "Land use Land cover" map is categorized into eight groups, including "village, road, farming, industry, drainage, lake, open land and vegetation".


77°36'0"E
77°44'0"E
77°52'0"E
13°20'0"N
13°12'0"N
13°4'0"N
12°56'0"N
12°48'0"N
12°40'0"N
Devanahalli
Hosakote
Bangalore East
Anekal
Legend
Ratings (Soil Texture)
1 (Fine)
2 (Fine Loamy)
3 (Clayey Skeletal)
5 (Loamy Skeletal)
7 (Sandy Skeletal)
Taluk Boundary
0 3.75 7.5 15
KM

(a)


77°36'0"E
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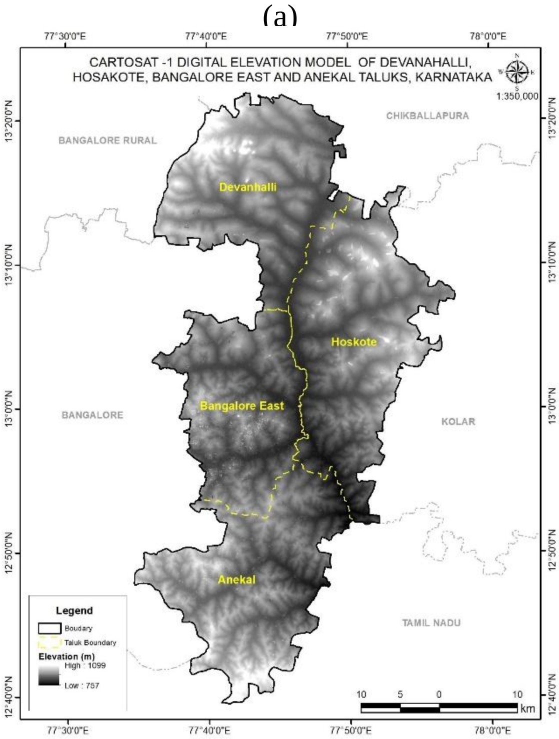
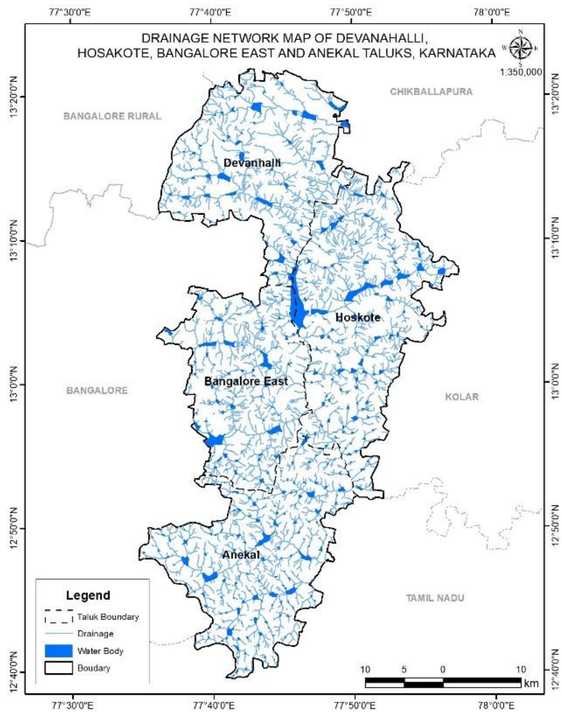
13°12'0"N
13°4'0"N
12°56'0"N
12°48'0"N
12°40'0"N
Devanahalli
Hosakote
Bangalore East
Anekal
Legend
Ratings (Slope in %)
1 (35-50%)
2 (15-35%)
3 (10-15%)
5 (5-10%)
7 (3-5%)
9 (1-3%)
10 (0-1%)
Taluk Boundary
0 3.75 7.5 15
KM

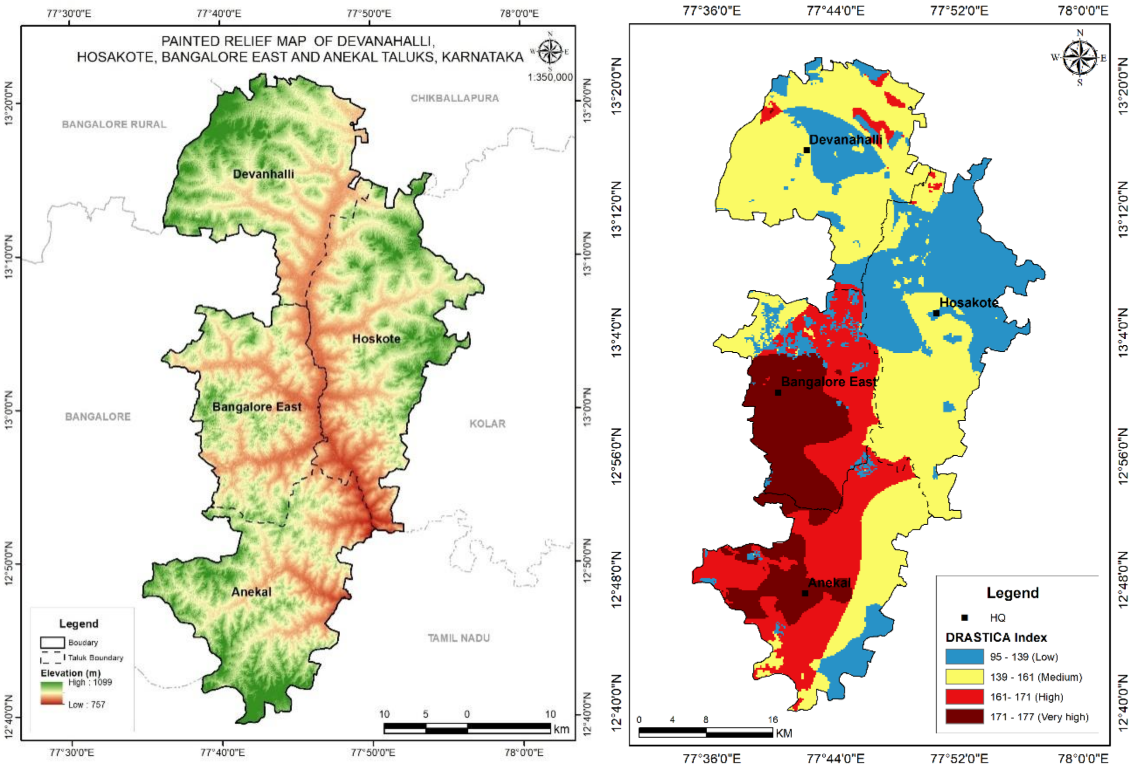
(b)


77°30'0"E
77°40'0"E
77°50'0"E
78°0'0"E
CARTOSAT -1 DIGITAL ELEVATION MODEL OF DEVANAHALLI,
HOSAKOTE, BANGALORE EAST AND ANEKAL TALUKS, KARNATAKA
1:350,000
13°20'0"N
13°10'0"N
13°0'0"N
12°50'0"N
12°40'0"N
CHIKBALLAPURA
BANGALORE RURAL
Devanhalli
Hoskote
Bangalore East
BANGALORE
KOLAR
Anekal
TAMIL NADU
Legend
Boudary
Taluk Boundary
Elevation (m)
High : 1099
Low : 757
10 5 0 10
km

(c)


77°30'0"E
77°40'0"E
77°50'0"E
78°0'0"E
DRAINAGE NETWORK MAP OF DEVANAHALLI,
HOSAKOTE, BANGALORE EAST AND ANEKAL TALUKS, KARNATAKA
1:350,000
13°20'0"N
13°10'0"N
13°0'0"N
12°50'0"N
12°40'0"N
CHIKBALLAPURA
BANGALORE RURAL
Devanhalli
Hoskote
Bangalore East
BANGALORE
KOLAR
Anekal
TAMIL NADU
Legend
Taluk Boundary
Drainage
Water Body
Boudary
10 5 0 10
km

(d)



(e) (f)

Figure 2: a)Soil map b)Topography c) Digital elevation model(DEM) d) Drainage network e) Painted relief and f) Vulnerability map

4. Summary and conclusions

The present study has attempted to assess groundwatervulnerability for Bangalore District using ArcGIS software, and ERDAS IMAGINE software is used with Analytical Hierarchy Process (AHP) to process different layersCoverage of anthropogenic contamination of groundwater in the past couple of years has stressed the consequences to integrate topographical parameters and LULC aspects into management issues and also to consider the vulnerability of groundwater as a prerequisite for preventing/minimizing such contamination. The roleof land use I addition to topographic parameters such as drainage map, relief map has alsobeen assessed.This research used an“Arc GIS” model to define groundwater’s risk to pollution in the District of Bangalore and its neighboring areas. The findings show that groundwater all across the study area is less vulnerable to low to high pollution. It appears from this analysis that Groundwater coverage in the study region showed a declining drift with a decrease of 59 percent. Vegetation coverage also revealed a decreasing tendency with a reduction of 49 percent. Built-up Coverage showed an unprecedented 109% growth, and other areas decreased by 40% in total.

Type of soil, drainage network, painted relief, and “Land-use Land-cover” plays anessential role in the assessment of groundwatervulnerability.The soil media, by comparison, and groundwater velocity are also more important in the assessment of pollution potential in soil strata. This solidifies the importance of extensive and representative evidence on these factors.Taking into account (LULC) vulnerability in groundwater, the vulnerability map production provides additional spatial data for local decision-making. It is the most suitable for effective groundwater resource management and land-use development.

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