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Management of Heavy Metals in Ground Water- A Case Study

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Abstract

The paper describes the studies conducted on heavy metals in ground water with conventional data supplemented with GIS based DRASTIC model analysis and Tools for effective ground water management.

The study area has been identified for investigation is a sub-watershed of the main (South Pennar) watershed. Study area covers a geographical area of 190 sq.kms covering part of Bangalore north, Bangalore east, Devanahally and Hoskote areas in Bangalore district. The laboratory work consisted in collecting samples from 60 selected groundwater locations and analysis of these for heavy metals (for iron, copper, cadmium, zinc, nickel) in the laboratory as per Standard regulations and guidelines. The studies were integrated with a GPS survey which generated a spatial distribution of the ground water stations. The vast volume of water quality data (with respect to heavy metals in ground water) is made effective with a high quality geographic data about the study area. Methods and processes of data analysis in Remote Sensing enabled extracting meaningful spatial information from remote sensed data which become direct input into the studies on GIS based DRASTIC model analysis and generation of an Decision Support tool. Based on the studies DRASTIC index map was generated on a minute grid. This provides a broad assessment to be used in identifying areas with different pollution potentials.

Introduction

Urbanization, industrialization and over-emphasis on development, has led to over-exploitation of groundwater leading to excessive stress on groundwater quality. Hence pollution of groundwater with special characteristics like heavy metals is drawing a great deal of attention. In addition to this need for data-ware housing of groundwater quality and decision support systems for a sustainable development is playing and will continue to play a greater role in the days to come. As per the Central Ground Water Board report on groundwater status in Karnataka, the four taluks of Bangalore namely Anekal, Bangalore North, Devanahally and Hoskote are overexploited blocks (>100%) with respect to watersheds (CGWB Report, 2005). The state government invoked the Karnataka Groundwater (Regulation and Control of Development and Management) Bill 2006 and declared the above taluks as over exploited. From the year 1999 onwards watersheds have replaced taluks as the unit for categorizing groundwater extraction (Water Resources of Karnataka, 2001). As per the present status based on the 1999 classification of watersheds, the four taluks above mentioned falls under the dark over-exploited category (with declining ground water level).

Study Area

The study area that has been identified for investigation is a sub-watershed of the South Pennar watershed. South Pennar is a tributary of South Pennar river system which originates at Nandi hills of Kolar District. Study area covers a geographical area of 480 sq.kms (77°36’0” to 77°54’0”E longitude and 13°9’0” to 13°8’0”N latitude) covering part of Bangalore north taluk, Bangalore east taluk, major part of Devanahalli taluk and minor part of Hoskote taluk. The field studies and secondary data collection consisted of collecting data about meteorology, population, distribution of industries, statistics of health, soil classification, pattern of crops harvested, occupation, presence of health facilities like PHC/hospital, polluting sources and other supporting Meta data. Methods and processes of data analysis in Remote Sensing enabled extracting meaningful spatial information from remote sensed data which become direct input into GIS. Different thematic maps/layers have been generated for geology, landforms, land-use, lineaments, lithology, geomorphology and hydrology (Figures 1-7). The maps have been prepared on a scale of 1:50,000 using IRS1C and PAN + LISS III 2000 data. Drainage density and slope maps have been prepared from SOI topo sheets. Analysis of data and integration

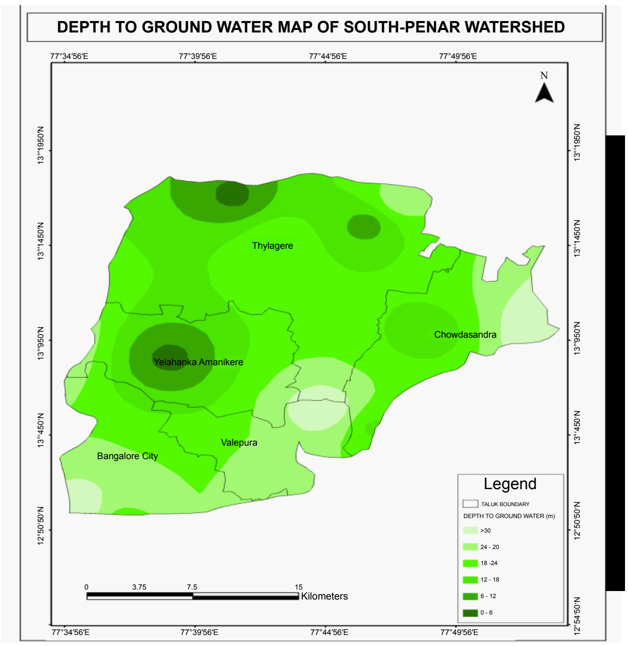

Figure 1: GIS based Depth to ground water map.

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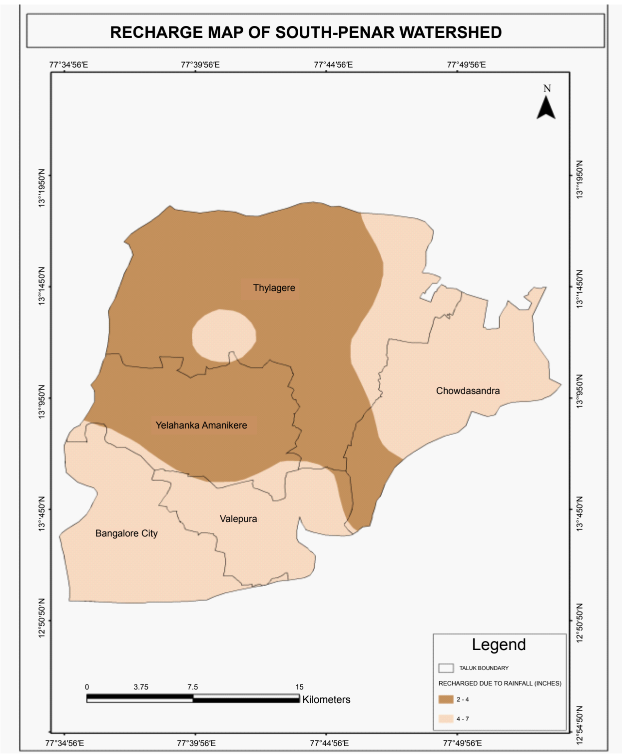

Figure 2: GIS based recharge map of study area.

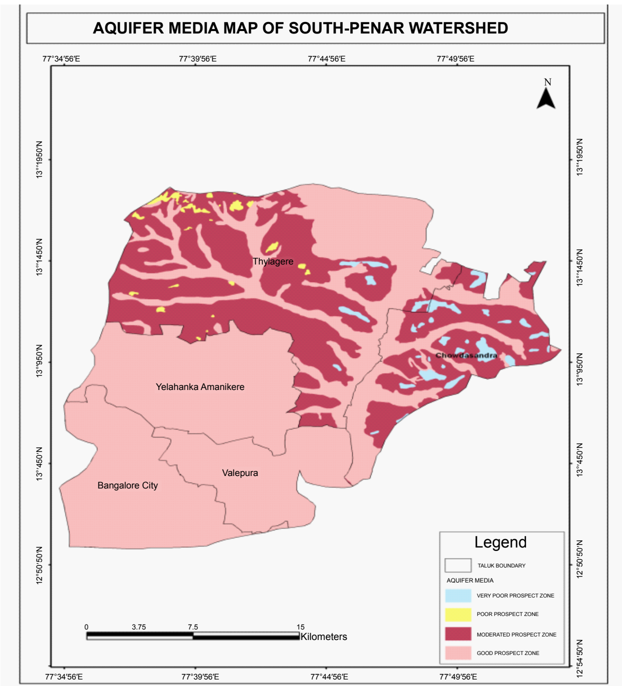

Figure 3: Aquifer media map of study area.

of maps performed by GIS using Arc view, Arc info, Arc map and Auto cad 2004 software.GIS based DRASTIC analysis has been carried out by using super GIS software.

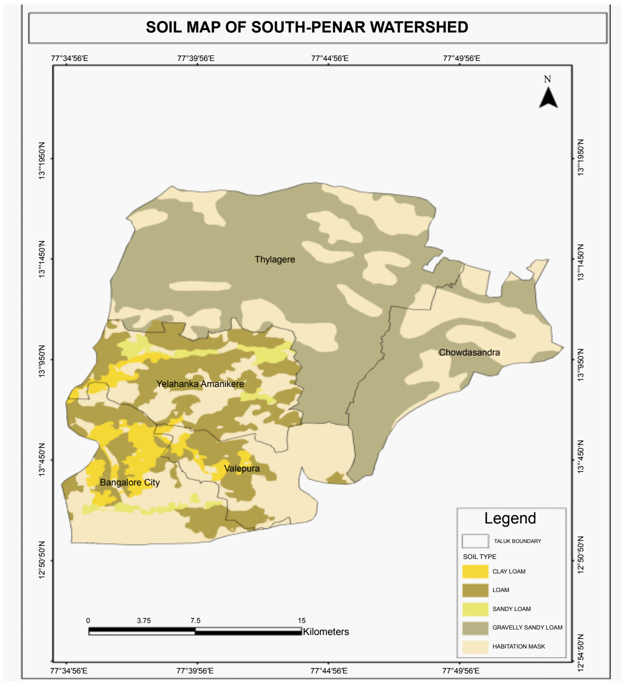

Figure 4: Soil map of study area.

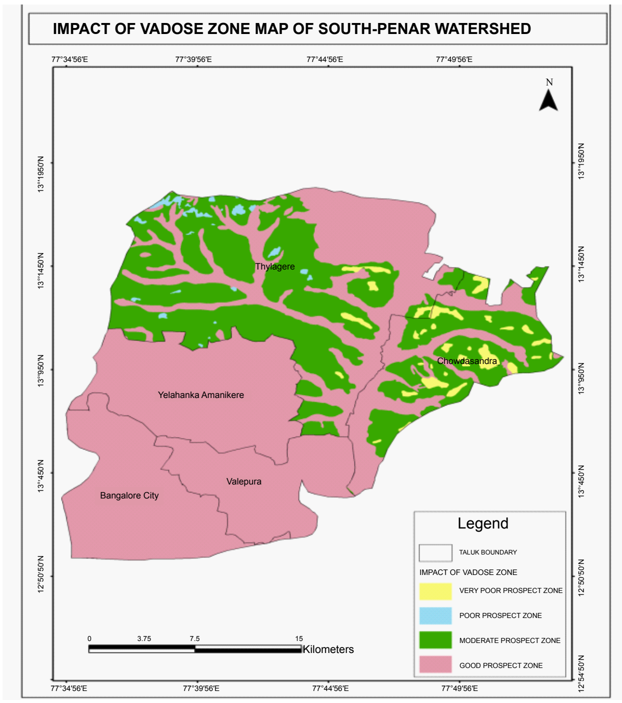

Figure 5: Impact of vadose zone on study area.

Methodology

In the DRASTIC method, spatial data sets on depth to ground water, recharge by rainfall, aquifer type, soil properties, topography, impact of the vadose zone and the aquifer's hydraulic conductivity are combined. DRASTIC is an acronym for the above seven parameters

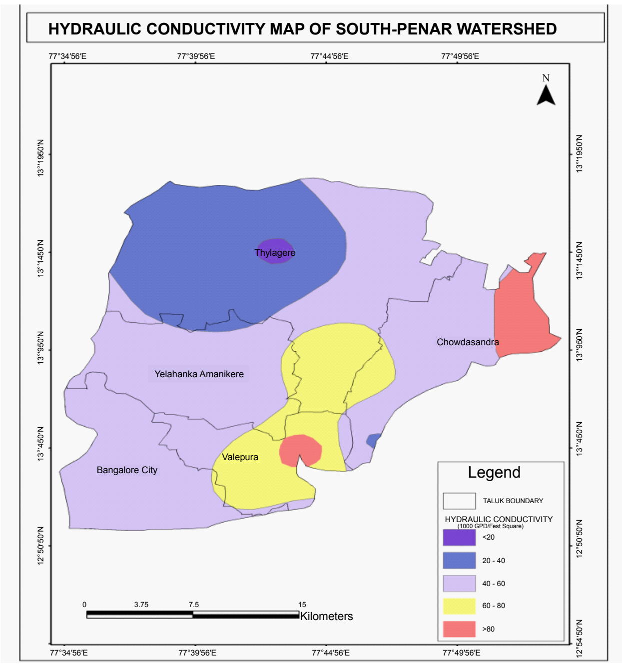

Figure 6: Hydraulic conductivity map of study area.

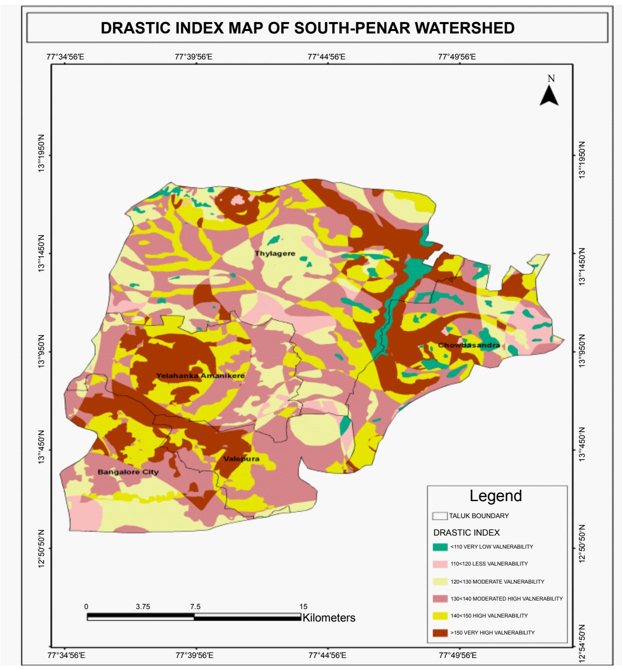

Figure 7: Drastic index map of the study area.

considered in this method. Each of the mentioned hydrologic factors is assigned a rating from 1 to 10 based on a range of values. The ratings are then multiplied by a relative weight ranging from 1 to 5. Tables 1-7 indicates the relative weights. The most significant factors have a weight of 5 while the least significant have a weight of 1.The resulting DRASTIC represents a relative measure of ground water vulnerability to contamination. The higher the DRASTIC index, the greater will be the vulnerability of the aquifer to contamination. A site with low

Factors	weight
Depth to water	5
Net Recharge	4
Aquifer media	3
Soil media	2
Topography	1
Impact of vadose zone	5
Aquifer conductivity	3

Table 1: Assigned weight for Drastic parameterws.

Range (m)	Ratings
0-6	10
6-12	8
12-18	7
18-24	5
24-30	3
>30	1

Table 2: Range and Ratings to depth to ground water table.

Range (inches)	Ratings
0-2	1
2-4	3
4-7	6

Table 3: Range, ratings to recharge due to rainfall.

Range	Ratings
Valley fills and weathered pediplains	9
Shallow weathered pediplains	8
Denudational hills	3
Pediment and pediment inselberg	4

Table 4: Ranges and rating for aquifer media.

Range (%)	Ratings
0-1	10
2-6	9
6-12	5
13-18	3
>18	1

Table 5: Range, ratings for slope media.

Range	Category	Ratings
Valley fill, moderately	Good prospect	9
weathered pediplain	Moderate prospect	8
Pediment inselberg	Poor prospect	4
Denudational hills	Very poor	3

Table 6: Range, ratings for impact of vadose zone.

Ranges(1000PD/sq. ft)	Ratings
<20	2
20-40	4
40-60	6
60-80	8
>80	9

Table 7: Ranges, Ratings for hydraulic conductivity.

DRASTIC index is not free from ground water contamination but it is less susceptible to contamination when compared with the sites having high DRASTIC indices. Based on the reconnaissance surveys and detailed survey of the area 120 groundwater stations (sampling stations) were selected which was distributed in the study area of South Pennar

Category	Range (mg/l)	Fe	Cu	Cd	Zn	Ni	Monsoon Season
Urban (30 samples)	Min	0.8	0.1	0.6	0.05	0.3	Pre
	Max	1.9	0.25	1.3	0.21	1.5	Post
Semi-Urban (30 samples)	Min	0.5	0.08	0.08	0.04	0.4	Pre
	Max	1.5	0.19	0.9	0.1	1.5	Pre
Rural (I) (30 samples)	Min	0.7	0.1	0.1	0.06	0.4	Pre
	Max	1.3	0.25	0.96	0.45	1.1	Post
Rural (II) (30 samples)	Min	0.6	0.09	0.4	0.1	0.4	Post
	Max	1.3	0.19	0.95	0.65	0.8	Post

Table 8: Laboratory analysis (summary sheet) of study area.

sub-watershed having an area of 480sq.kms.The collected samples were analyzed in the Laboratory as per the standard methods prescribed (Standard methods for examination of water and wastewater, 2002) by using Double beam Atomic Absorption Spectrophotometer (GBC, Avanta PM 10) using Acetylene and Air combination. Laboratory analysis of Iron, Nickel, Cadmium, Zinc, and Copper has been tabulated (Table 8).

Conclusions

1. The results of this study shows that of the total 480 sq.kms an area of about 28 sq.km is in the low vulnerable zone with a DRASTIC index range between 110 and 120, about 94 sq.kms are in the moderately vulnerable zone with a DRASTIC index ranging between120-130, about 114 sq.kms are in the high vulnerability zone with a DRASTIC index ranging between 140 and 150 and about 244 sq.kms are in the very high vulnerability zone with a Drastic index of more than 150.
2. The villages that are in the high vulnerability zone are in northern parts of Bangalore taluk Southern parts of Devanahalli taluk, western parts of Bangalore east taluk and Central parts of Hoskote taluk.
3. This study produced a very valuable tool for those who are in management position because it gives a very comprehensive indication of vulnerability to ground water contamination. The high vulnerability of ground water contamination makes it absolutely necessary to local authorities for managing ground water resources, monitoring this problem closely and to act accordingly.
4. Infiltration of storm water runoff with respect to ground water protection showed that the risk of ground water pollution can only be minimized by using infiltration systems with a passage through the top soil and planning, construction, and operation of infiltration systems.