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Geomorphological Study of Vrishabhavathi River Basin, Karnataka, India

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Abstract:- Vrishabhavathi river is a minor river that flows through the south of Bangalore city. The river was once so pristine that the water from it was used for drinking. It is a tributary of the Arkavathi river and a stark example of river pollution. Earlier the river was a grand source of pure drinking water to villages all along from Bengaluru to Ramanagaram has turned into a cesspool polluted by industrial, agricultural and municipal solid waste thrown directly to the river. The river has been the carrier of all sorts of industrial toxic waste and domestic waste water for the past few decades now. Sometimes, the Pattanagere bridge crossing is blocked with solid waste during rains, causing the river to overflow and scatter all the plastic waste and dirt on the roads create several problems to the road users. The entire area gets dirtier and the smell is intolerable at several times. In the present study geomorphological aspects of the basin has been discussed.

Keywords*: Landuse, Rainfall, Pollution, Geomorphology, DEM*

1. Introduction

The Vrishabhavathi river is a minor river that flows through the south of Bangalore city. The river was once so pristine that the water from it was used for drinking and used by the famous Gali Anjaneya Temple at Bapuji Nagar of Bangalore metropolitan city. Currently it is highly polluted due to pollutants from industrial, agricultural and domestic sources. According to Yellappa Reddy (2015) the river was in perspective state with pure and pristine water flow and has the opinion that there is need of extra-ordinary commitment and vision to recover its glory. The area around the river on Mysore road has several factories which discharge effluents via their drainage systems. There were not many factories in the sixties, but by the 1980's many came up along the Mysore road, a few kilometers from Bangalore University. Reddy (2015) explains that in the early stages of the river formation, Vrishabhavathi had a wealth of aquatic plants, which would purify waste water. The plants had in-built properties to purify water. All waste that would come from the storm water drain from the upward area of the river would get destroyed by the aquatic plants, which had the capacity to generate oxygen. But as time passed, the quantity of waste coming into the river was so high that the aquatic plants were unable to handle the heavy flow. It would be accurate to say now that the river has lost its aquatic wealth and its capacity to naturally purify waste water. The absence of aquatic plants is a sign that the river has been invaded totally by waste. The plants would also pump oxygen into the water to resist concentration of waste, but now the oxygen levels have come down, reflecting the rise in population and consequent waste from industries discharge into the river. Lake Development Authority (LDA) has reported the high percentage of mercury levels in the Vrishabavathi river water. LDA declared that mercury levels in the river water is 500 times than permissible limits and it is very dangerous if this water is used for the drinking or for agricultural activities. In milk and crops grown on the river banks of Vrishabavathi have shown traces of lead, mercury, metal dust and all of them are poisonous. The river now flows with all these pollutants into the Byramanagala lake off Mysore road which has a command area of 200 acres. There have been reports of yields of paddy and sugarcane going down year by year. Residents along the river face serious problems - shortage of clean drinking water and health hazards like asthma, skin and heart diseases. This problem is particularly acute in Byramangala, Chowkahalli and Gopalli. Concentrations of nitrate and total hardness are higher than normal and bacterial contamination in the groundwater too is well beyond the WHO standards.

2. Objectives

The objective of this study is to evaluate the geomorphological aspects like geology and soil types, rainfall analysis and to prepare the various maps related rainfall, drainage, soil, geomorphology and DEM. It is also planned to find reason for pollution of water in the river and its impact on the life existing in the study area. Groundwater is

an important component in the Vrishabavathi valley where there is a lot of demand for the surface water to the day to day needs. People in the river basin have drilled innumerable number of bore wells to tap the groundwater for various requirements. The present study is aimed to study how much encroachment has happened in the Vrishabavathi valley which will in turn reduced the flow space during the rainy season in the river system and during the summer periods the polluted water will pollute the groundwater aquifers in the adjacent area. Land use and Land cover pattern study will help to find out the changes happened in recent years in the study area. It is also aimed to study the seasonal variation in the chemical components of the groundwater in the Vrishbhavathi basin.

3. Methods and Materials

By using the Survey of India toposheets different types maps have been prepared relating to the geology, drainage, soil, rainfall (Annual normal rainfall, Pre-monsoon, Post-monsoon), DEM and slope maps. In addition to this land use and land cover map by using Arc GIS software for the present study has also been prepared.

4. Physiography and Climate

Bangalore is situated at the altitude of over 915 meter above sea level. Lying to the east of the major north-south trending Tumkur-Closepet Granite Hill range, the city is located on the watershed of two river basins, the Arkavathi to the west and south, and the Pennar to the east. The topography of the Bangalore is also characterized by the well-defined radiating valleys and gradual fault towards the wide belt of flat land. The three principle valleys are known as Vrishabavathi, Koramangala and Chellagatta. The naturally undulating terrain of hills and valleys, lends itself to the development of lakes that can capture and store rain water. A series of tanks of having varying sizes are also developed (Figure 1). The streams between ridges and valleys were dammed at suitable location creating the cascade of reservoirs in each of the three valley systems serving as a source of water for the inhabitants. The gentle topography has also well for potential groundwater development. But the unplanned urbanization has caused the environmental degradation, disruption of natural drainage and robbed the area of its natural topographic advantages for storing water. This is also responsible for floods during spells of heavy rain as natural drainage has been blocked. The mean annual rainfall is 859 mm with the principle rainy season lasting from June to September (south-west monsoon) and the secondary rains takes place in the month of November and December regularly (north-east monsoon).

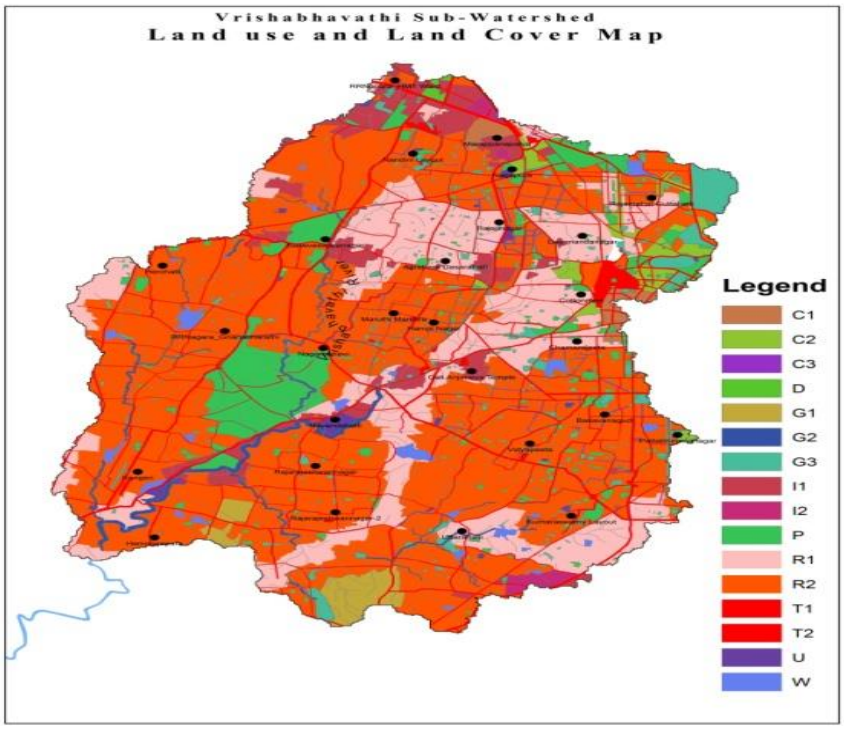


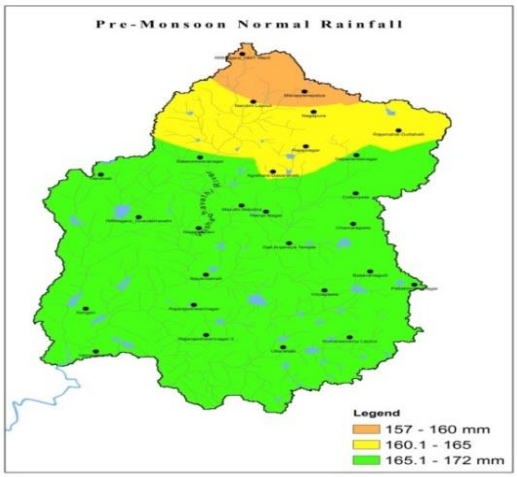
Fig.1: Land use and Landcover map.

5. Rainfall

A detailed study of the rainfall over the catchment is an essential aspect of groundwater study in the present investigation. Rainfall is the main source of both surface and groundwater. Its seasonal distribution will give an idea to know the local recharge by the precipitation and would influence the groundwater body. In the present study data from the rain gauging stations in the Vrishabhavathi valley has been collected and analyzed. There is a variation in the normal rainfall pattern in the area. From the figure 2 it is seen that there is slightly lesser rain fall in the southern part (849 to 865 mm) and medium rainfall in the northern part (865 to 885mm) and slightly high rain fall in the middle and western part of the basin (885 to 916mm). But there is so much variation in the Pre-monsoon and south west monsoon rain fall pattern in the study area (Figures 2 and 3). To understand the effect of rainfall on the agricultural activities and human requirements it is important to know the rainfall pattern in the study area (Kulkarni et al. 2014, Kusre 2016). The distribution of rainfall over different seasons is important and is analyzed by dividing the year into different seasons and the maximum precipitation of 66.72% is recorded in the monsoon season in the study area, there is moderate precipitation of 30.67% recorded during the post monsoon and low precipitation of 2.59% during the pre-monsoon (Table 1).

6. Temperature

The temperature is an important factor hydrological investigation. It is directly influencing the soil moisture and evapo-transpiration of surface water bodies and vegetation in any area. The temperature data has been used to calculate the potential evapo-transpiration in the study area which is an important component of water balance equation (Horton 1932, 1945**,** Langbein 1947, Schumm 1956, Strahler 1953, 1957). The monthly maximum and minimum mean temperature presented in the Table 2.



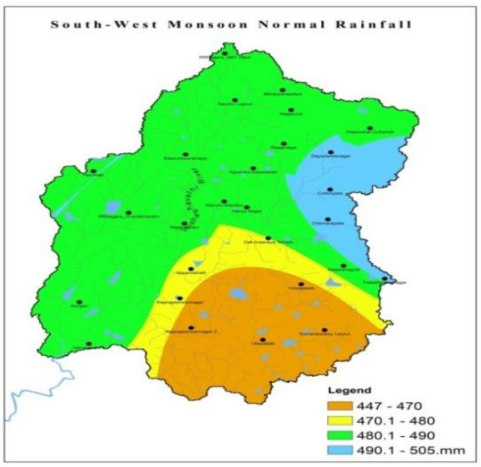


Fig.2: Pre - monsoon normal rainfall pattern map. Fig.3: South-west Monsoon normal rainfall.

7. Relative Humidity and Wind Speed

The monthly maximum relative humidity is 79.04% is noticed in November and minimum relative humidity is 47.22% in the month of February. The minimum wind speed is noticed in the month of September is 1.37km/hour and the maximum are noticed in the month of June is 5.64km/hour.

8. Water Level Fluctuation

The study of groundwater level fluctuation enables us to understand the hydrodynamic characteristics area (Miller 1953, Leopold and Miller 1956). The seasonal water level fluctuation varies from 0.36 to 8.71m during a year (Table 3). The study is very important in planning for a proper utilization of ground water.

9. Geology

The western portion of the Bangalore is composed of the only type rock is gneiss and it belongs to Precambrian age. This rock type is also called as Peninsular Gneiss. The gneisses are exposed in and around the Bangalore city as continuous chain of mounds raising 90 to 150 meters above the normal ground level. In the western portion of the Bangalore city the gneisses are intruded by numerous bodies of quartz and pegmatite veins. Precambrian granites and gneisses are mainly comprised in the Bangalore south. In this region granitic gneisses are exposed as continuous chain of mounds up to 30 to 70 meters. Texturally these gneisses are medium to coarse-grained, hard

and compact, massive in nature. Distinctively banded gneisses are traversed by the vertical and horizontal joints and are intruded by doleritic dykes (Renuka Prasad 2011). The entire study area is underlined by the peninsular gneisses of Precambrian age. The gneisses are prominently exposed as ridge running NNE and SSW. The longitudinal joint exposures on weathered surfaces are very well exhibited as tilted beds. The gneisses are medium and fine grained in nature and are distinctly banded as different shades of grey colour. These gneisses are intruded by dolerite dykes at various places. The dykes are oriented in the N-S direction. Patches of migmatites abundantly exposed in the southern part of the study area (Srikantia 2000). It is also called as granitic gneiss and it abundantly occurs in the study area. The banding pattern of this rock is well exposed near the Sericulture Department in the Jnana Bharathi campus of Bangalore University. The white band comprises quartz, orthoclase, microcline and black bands are composed of hornblende, augite, diopside, magnetite and hematite minerals. The Gneissic rocks near Pattanagere are well exposed as ridges. These are very hard and compact exhibiting Gneissic banding. Soil is a non-indurated material may or may not contain vegetal matter. The weathered rock may be in the form of sand, silt, clay. Pebble etc., In the northeastern part of the study area more settlements have been recorded (Figure 4). In the western part of the study area it is noticed that more gravity clay. A small patch of well drained clayey soil has been noticed in the northwestern part of the study basin.

Table.1: Showing the Rainfall pattern in the study area.

Year	Pre-Monsoon	SW Monsoon	NE Monsoon	Annual Rainfall
2000	156.8	617.5	265.2	1039.5
2001	247.1	548.5	184.4	980
2002	266.8	229.2	165.8	661.8
2003	28.4	366.4	215.9	610.7
2004	223.5	593	274.8	1091.3
2005	180.7	699.2	531.7	1411.6
2006	168	329	92.1	589.1
2007	210.6	573.7	233.9	1018.2
2008	393	534.9	243.3	1171.2
2009	256.2	680.8	104.2	1041.2
2010	211.7	413.3	256.2	881.2
2011	336.5	428.5	186.9	951.9
2012	154	263.5	180.5	444
2013	192	606	234.5	1032.5
2014	33.5	359	191	583.5
2015	150.45	656.05	231.83	1038.33
2016	148.32	625.31	234.10	1007.73
2017	173.20	524.52	180.68	878.40
2018	233.00	623.20	167.54	1023.74
2019	189.34	610.11	110.25	910.12
2020	198.67	643.06	187.45	1029.18
2021	173.30	545.53	183.80	902.63
2022	210.01	603.67	198.67	1012.34
Av.	**181.43**	**512.52**	**168.32**	**2730.55**

Table. 2: Average monthly temperature, relative humidity and wind speed

Month	Temper. (C°)	Relative Humidity	Wind Speed (km/hr)
	Mean	Mean	
JAN	22.53	63.56	1.535
FEB	24.27	47.22	1.978
MAR	26.33	52.62	1.812
APR	27.36	60.39	2.543
MAY	26.47	68.83	3.009
JUN	24.80	76.08	4.343
JUL	24.81	72.15	5.645
AUG	24.66	74.96	1.545
SEP	24.61	74.28	1.370
OCT	25.09	68.06	1.425
NOV	22.47	79.04	1.455
DEC	22.95	68.75	1.670

Table. 3: Water level fluctuation in the study area.

Year	Pre-Monsoon (in mts)	Post -Monsoon (in mts)	Difference (in mts)
2003	28.21	29.91	1.70
2004	25.17	25.53	0.36
2005	20.1	28.81	8.71
2006	26.52	28.7	2.18
2007	26.32	27.3	1.06
2008	20.72	22.86	2.14
2009	27.92	29.88	1.96
2010	32.53	38.9	6.37
2011	30.2	31.2	1.00
2012	26.2	27.65	1.45
2013	26.4	27.69	1.29
2014	27.72	28.97	1.25
2015	28.20	30.10	1.90
2016	26.54	28.25	1.71
2017	27.87	29.34	1.27
2018	28.10	30.05	1.95
2019	27.98	29.91	1.93

2020	28.18	30.01	1.83
2021	27.98	29.17	1.19
2022	28.30	30.10	1.80
Av.	**27.50**	**28.956**	**1.254**

10. Geomorphology

The pediplains constitute low relief area having matured dissected rolling topography with erosional land slope covered by a layer of loamy soil of varied thickness. The pediplains are dissected by streamlets flowing in the southern direction. In the study area the valley fills are developed in gneisses along the main valley of the basin. Figure 6 showing the low laying area of the basin. The low laying areas are mainly concentrated near the Gali AnjeneyaTtemple. In this region several times floods have been reported during rainy season. This area is under investigation to find the solutions for the floods occurring during the rainy season every year in this region. In addition to this it is also observed, near the Nandini layout, Dasarahalli Agrahara, Rajarajeshwari Nagar also comes under low lying area in the study basin. From the figure 7 it is very well seen that several small tanks which were there earlier have now been completely closed due to the settlements or due to the development of layouts by Bangalore Development Authority (BDA) and other Private Layout Developers.

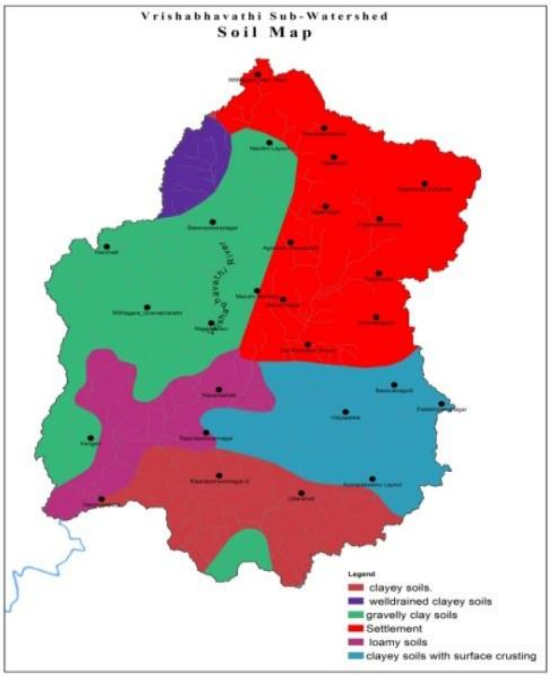


Fig.4: Soil map of the river basin

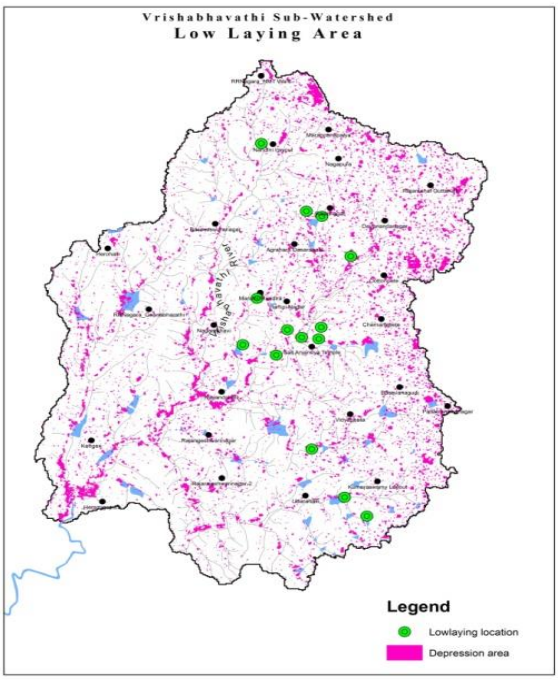


Fig. 5: Low laying areas of the basin.

11. Drainage

From the figure 5 it is very much clear that there is huge difference between the first order streams and the fifth order stream in the basin. The difference in the height (237metre) from the highest point (980m) to lowest point is 743 meters. The granitic ridge running in the study area along NNE to SSE governs the drainage pattern of Bangalore city. Towards the east of the study area the drainage is made up of network of nalas generally flowing from west to east with the storage tanks along the nalas ultimately feeding the Dakshina Pinakini river. In the western side the drainage pattern is made up of network of nalas generally flowing from east to west with storage tanks along the nalas feeding the Arkavathi river. The primary data for the soil map has been taken from the National Bureau Soil Survey and Land Use Planning (NBSSLUP), Bangalore. From the drainage map it is clear that there several ridges made of gneissic rocks are existing in Arkavathi (Yellappa Reddy, 1977). From the figure 1 it very much clear that large part of the basin is occupied by settlements in the north and eastern portion of the basin. In the eastern part the settlements associated with innumerable number of smaller streams which are joining the main stream at Gali Anjaneya Temple. Due to this there were floods several times earlier. To overcome this

Bruhat Bangalore Mahanagara Palike (BBMP) has constructed two main bridges and made provision for the flow of water. In addition to this BBMP has also done de-silting of the streams near the temple so that the flow of water takes place easily.

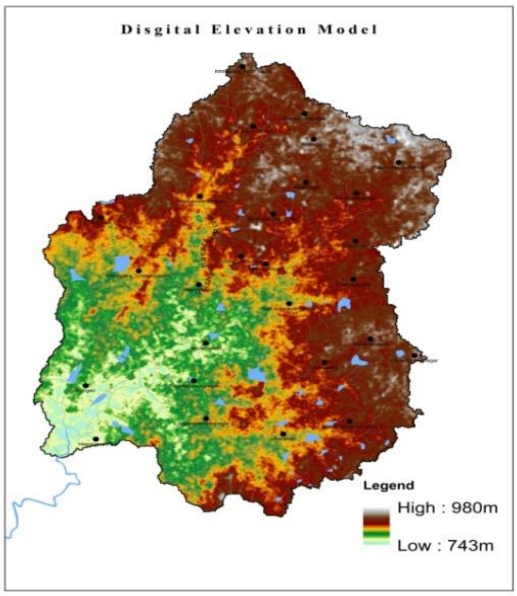


Fig. 6: Digital Elevation Model Map (DEM)

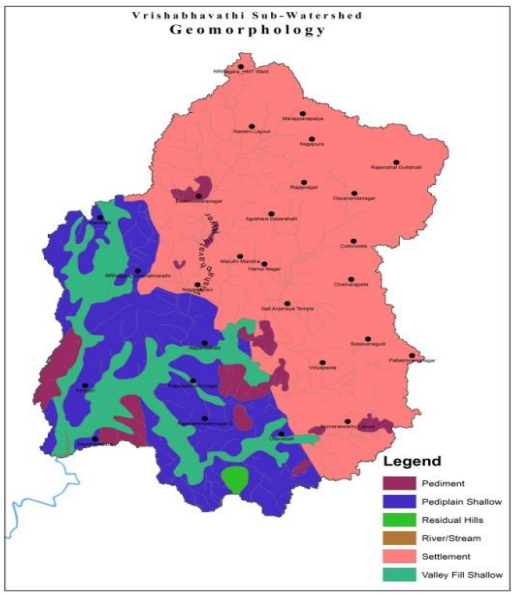


Fig.7: Geomorphological map of the area.

12. Discussion and Conclusion

Groundwater deterioration has major role in affecting hazardous to the health and ecology of the region. Thus, studying the water quality is an important consideration in sustainable management of natural resources. From the rainfall analysis it is very much clear that there is a huge difference in the post monsoon and pre-monsoon rainfall pattern. It has been noticed that there are several areas where flooding takes place especially during south west monsoon. With the help of drainage map low lying areas have identified in the study area. Generally, the flooding takes place in the study area due to huge amount of constructions by encroaching streams and stream segments. This leads to reduction in the width of the streams and causes flooding. With the help of remote sensing data Digital Elevation Model (DEM) has been prepared for the basin and it indicates larger low-lying area around Gali Anjaneya temple. Due to the settlements it is not possible to check the existence of these soils the basin. It indicates that these rocks are not easily weathered out due to the presence of resistant minerals.

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