GEOGRAPHICAL ANALYSIS

RESEARCH ARTICLE

Impact Analysis of Urbanization and Industrialization on Water Quality of Vrishabhavathi River

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Abstract

The Arkavathi watershed, Bangalore Urban, and Ramanagara are all parts of the Vrishabhavathi River district. This River, a tributary of the River Arkavathi, which enters the River Cauvery, serves as the primary supply of surface water. It drains a major parts of Bangalore metropolis and is an outlet for domestic and industrial effluent of that area. It is an outlet for the domestic and industrial wastewater of the Bangalore metropolis and drains a sizable portion of the city. Previously, drinking and agriculture were the principal uses for this surface water. Because of the location of this watershed in both urban and rural Bangalore, this water is now solely used for unsafe agricultural purposes. The current study has been conducted to map the geographical variability of the surface water quality in the watershed in order to assess the surface water quality. The results and analysis showed that most sampling sites' water quality is not suitable for drinking water purposes. It is also limited to the usage of other activities because of the degradation of water quality. The Nitrate content is high in a few of the groundwater samples collected. The bicarbonate content is more in all the samples. The study, therefore, emphasized the need for periodic monitoring of water levels, the management of industrial effluents before discharge into the river, and the introduction of appropriate mitigation strategies to resolve problems and deterioration to facilitate the safe state of the river. Only 40 per cent of the industries have got the facility to treat wastewater. They have installed Effluent Treatment Plant (ETP).

Keywords: Industrial effluent; Wastewater; Water quality; Contamination

Introduction

Every body of water has a watershed. The watershed is the area of land that drains or sheds water into a specific receiving water body, such as a lake or a river. As rainwater or melted snow runs downhill in the watershed, it collects and transports sediment and other materials and deposits them into the receiving water body. Watershed management is a term used to describe the process of implementing land use practices and water management practices to protect and improve the quality of the water and other natural resources within a watershed by managing the use of those land and water resources in a comprehensive manner. Watershed management planning is a process that results in a plan

or a blueprint of how to best protect and improve the water quality and other natural resources in a watershed. Runoff from rainwater or snowmelt can contribute significant amounts of pollution into the lake or river. Watershed management helps to control pollution of the water and other natural resources in the watershed by identifying the different kinds of pollution present in the watershed and how those pollutants are transported, and recommending ways to reduce or eliminate those pollution sources. New land development, runoff from already-developed areas, agricultural activities, and household activities such as gardening/lawn care, septic system use/maintenance, water diversion and car maintenance all can affect the quality of the resources within a watershed. Watershed management planning comprehensively identifies those activities that affect the health of the watershed and makes recommendations to properly address them so that adverse impacts from pollution are reduced.

Every city has traditionally grown around sources of water – either natural or man-made. The city of Bangalore belongs to the latter category. Traditionally, water supply to Bangalore was from the various tanks and lakes which dot the landscape of the city. The scenario today, the lakes have become derelict and have lost their relevance as sources of water supply in the face of urbanization. Most of the lakes are turning into an ecological waste.

Study Area

The Vrishabhavathi is a tributary of the Arkavathy River. It is located in southwestern part of Bengaluru. The river is located on 12°59'06"N latitude and 77°25'53"E longitude. Vrushbhavathi Basin is typical of the features of peninsular India in that it is made up of ridges, valleys and undulating terrain. Monsoon rainfall is substantial and the tanks and lakes can receive and contain substantial amounts of water from rains. Only thing is to de-clog the natural water flow routes and to restore the bunds of tanks and repair the spillways and put in place legal and administrative measures to preserve the interiors of tanks; free them from construction activities and launch suitable afforestation programs to contain soil erosion, improve the quality of subsoil water and raise if possible medicinal and ornamental trees so that Bangalore gains in its aesthetic appeal.

Statement of the Problem

Bangalore has grown haphazardly and ill-thought manners turning Vrishabahavathi watershed into filth, overcrowding, polluting, and waste dumping, which are deteriorating human standards of that locality. Market centers, commercial complexes, factories, companies, private and public institutions are producing the waste at a higher level. Inhabitants of Bangalore city are generating plenty of sewage and wastes by adapting western country's way of life and consuming packed

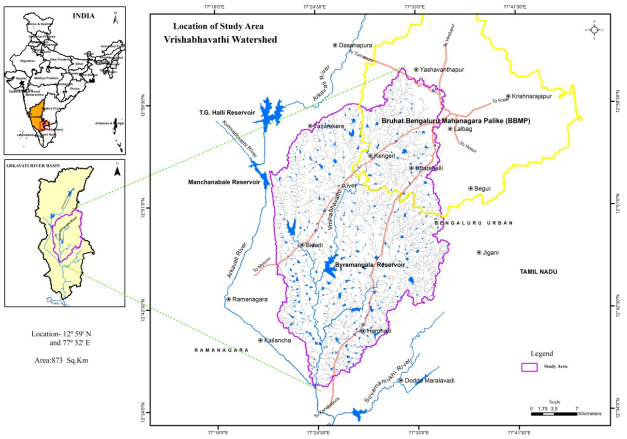

Fig. 1. Location map of Vrishabhavathi watershed

goods. Hence, the detailed study of waste Vrishabahavathi watershed and its model is to be done so as to find solutions for the problems faced by the city. In the name of highlife and western-culture the Vrishabahavathi watershed has been targeted and in the process it has lost its originality. It is now threatening hazardous disease to the localities of the watershed. Hence, Vrishabahavathi has to be studied, planned and monitored so as to avoid possible threat in coming days.

Significance of the study

It is difficult to overstate the practical and scholarly significance of this work. Bangalore is a vital cog in India's engagement with the global economy; yet the pitfalls of its rapid change are obvious. Failure to ensure management of river valleys will harm the very assets which have forged the city's successes; namely, an amenable and attractive cityscape. A widely held view is that Bangalore is fast being transformed from India's 'garden city' to its 'polluted city'. As the city faces the burden of an ever-increasing number of houses, industries and commercial establishments in the process the Vrishabhavathi valley is targeted. Vrishabhavathi Valley is one that affects severely as it falls under industrial areas. The residues of rapid urbanisation can be seen in terms of slums, squatters and ghettoes scattered here and there in the Vrishabhavathi Valley, placing intense pressures on urban management. In the context of further city expansion, failure to deal with these issues will see the problems of central Bangalore migrate to the periphery

Objective

- To understand the impact analysis of urbanization and industrialization on this area
- Identification of dangerous zones of effluents release.
- To analyse the water quality of the watershed

6. Database and Methodology

With the help of geoinformatics & GPS, the spatial data were traced out, that will generate a unique spatial database. A Dimensional Map is also created for the Vrishabhavathi Valley and through a combined methodology involving geoinformatics and on-the-ground survey work ('field analysis'), the key contributing factors to the loss of blue and green spots in the watershed can be identified.

ArcGIS and ERDAS Image Processing software will be used for analyzing and image processing. GPS (Global Positioning system) would be engaged to locate the boundaries of the objects. Following is the flow diagram that depicts the methods of work to be undertaken.

The samples were collected in the polythene bottles of one-liter capacity. Each sample was brought to the laboratory without adding any preservative and used for the determination of chemical parameters like pH, electrical conductivity, Total Dissolved Solids, Total Suspended Solids, Total Hardness, Calcium, Magnesium, Nitrates, Sulphate, Iron, Fluoride, Sodium, Potassium, and Alkalinity. Table shows the analysis results obtained. For the determination of heavy metals like Lead, Copper, Zinc and Nickel, the samples were collected separately in a polythene bottle of one litre capacity and preserved in the field, immediately by adding Concentrated Nitric acid. For the determination of Chemical Oxygen Demand (COD), the samples of about 250 ml were collected separately in polythene bottles and preserved in the field, by adding concentrated Sulphuric acid immediately after collecting the sample. For the determination of Dissolved Oxygen and Biological Oxygen Demand, samples were collected in BOD bottles of 300 ml capacity. The Dissolved Oxygen was fixed in the field itself by adding MnSO4 and Alkali azide Solution. Immediately after collecting the samples, the bottles were covered with black carbon paper to protect from the light. This was done in order to avoid the production of oxygen from photosynthetic reaction. To identify the pollution sources, a field visit was made along the stretch of the stream (15 kms). The volume of water was estimated by measuring the flow, depth and the width of the stream.

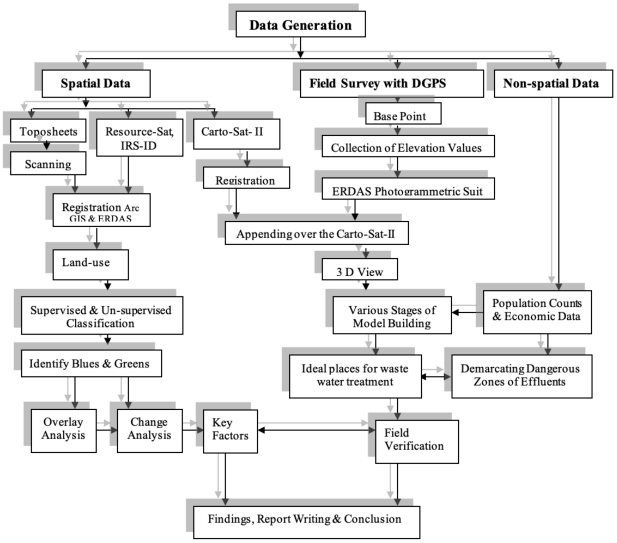

Fig. 2. Methodology: Flow Model

Results and Discussion

Impact Analysis of Urbanization and Industrialization

This study was carried out to find out the water quality and to identify the major pollutant sources in Vrishabhavathi River. This river originates near the Southwestern end of Bangalore city. While the original river has dried up, at present, it is carrying industrial effluents and sewage water from about a hundred small-scale industries of various kinds. It receives improperly treated and/or untreated effluents and domestic waste water from the treatment plant of Bangalore Water Supply and Sewage Board (BWSSB) containing various organic materials, toxic elements and disease causing pathogens. As surface water is accessible for irrigation in the study area it is highly polluted with sewage and effluents groundwater is the most preferred source in the area. A majority of the farmers own both dug wells and deeper bore wells for irrigating crops. In recent years, contamination of groundwater too has emerged as a severe environmental issue in the locality constraining its use.

As revealed from the survey, the types of waste generated in hotels include mainly, left out food items. In one of the hotels, the method adopted for disposal of waste includes collection by the Contract persons. The Contract person visits the Hotel every day in the evening and takes away the wastes. For this purpose he charges about Rs. 150 – 200 /- per month. But in the other Hotel, the wastes are disposed by dumping it in the nearby Dustbins.

In the Meat stall, the type of waste generated includes waste meat. They dispose it by selling to the persons who are having dogs at home. In Beauty parlours and saloon shops, the main waste generated includes hairs, plastic tubes etc. In beauty parlours, usually long hairs are collected for a few days and then sold to other persons who make use of it. But the problem is with short hairs especially in saloon shops. The short hairs are of no use, hence no one purchase it. As seen in the survey, in one of the shops they dispose the waste by dumping it on the sides of the drain.

Water Quality Standards and Significance

The quality of drinking water affects health of the consumers because not only certain diseases and toxic chemical compounds may be transmitted by water, but also the very inher-

ent constituents may not be suitable for consumption. Experience has shown that community health and water quality are directly related to each other and that improvement of water quality of the drinking water supply ensures improvement in the community's health. Therefore, a good water supply is one that provides adequate water of acceptable quality.

Environmental Significance of Water Quality

Water that is clear and colorless gives an expression that it is safe for human consumption. This may not be always true as many of the bacteria and objectionable matter may be present in invisible form. These may be added to water either naturally or due to certain activities and therefore, it is important to understand their environmental significance. Table 1 and Table 2 give the Indian standard drinking water specifications and the ill effects of pollutant on human body.

Cause for Contamination

Out of total number of sample, in 80 per cent of the industries the source of water is the Tube well, and all industries generate wastewater. But the quantity of wastewater generated depends upon the quantity of water consumed in each industry and the production turnover of the industry. Only 40 per cent of the industries have got the facility to treat wastewater. They have installed Effluent Treatment Plant (ETP). The rest 60 per cent of them do not have the ETP.

As observed in the Survey, the main problem for not installing the ETP is, high investment cost, which is not be affordable, and they are of the feeling that, they generate only a small quantity of wastewater; hence the treatment is not necessary. None of the industries is generating any solid waste other than wastewater. The main mode of disposal of untreated wastewater includes.

- To let into the open lands
- For gardening purpose

The treated wastewater is used for gardening purpose-Out of the total number of the samples, 40 per cent of them are treating the wastewater i.e. generated and use the treated wastewater for gardening. The rest 60 per cent of them do not treat the wastewater and they just discharge untreated wastewater on the open lands. There is a regular inspection by the Regulatory Authorities like KSPCB, to check water pollution.

Table 1. Indian Standard Drinking Water – Specification

Sl No	Substance	Desirable Limit	Permissible Limit
1	Color, Hazen units	–	25
2	Odours Unobjectionable	Unobjectionable	—
3	Taste Agreeable	Agreeable	—
4	Turbidity, NTU, Max	5	10
5	pH Value	6.5 to 8.5	No Relaxation
6	Total Hardness (as CaCO3), mg/	300	600
7	Iron (as Fe), mg/l	0.3	1.0
8	Chlorides (as Cl), mg/l	250	1000
9	Calcium (as Ca), mg/l	75	200
10	Sulphate (as SO4), mg/l	200	400
11	Nitrate (as NO3), mg/l	50	No relaxation
12	Fluoride (as F), mg/l	1.0	1.5

Table 2. Major Parameters and Some of the Problems that they Cause

1	Calcium and Magnesium	Major constituents that is present in water. Hardness is largely responsible for the formation of scales in heaters, pipes etc.
2	Iron	One of the troublesome minerals and as low as 0.3ppm is potable-leaves brown stains on porcelain, clothes
3	Fluoride	Dental fluorosis & skeletal fluorosis.
4	Total Hardness	Temporary hardness and permanent hardness
5	Nitrate	Methaemoglobinaemia and carcinogenesis
6	Pathogens	Hepatitis, cholera, typhoid, diarrhoeal, etc.,
7	Cadmium	Cancer, harm kidneys (the Hindu, 10/8/03)
8	Chromium	Liver or kidney failure
9	Copper	Severe renal damage, central nervous system irritation followed by depression.
10	Mercury	Neurological and renal effects
11	Lead	Anemia, tiredness and irritability

7.5 Statistical Analysis and Interpretation

Water Quality across the V rishabhavati Stream

To know the quality of the surface and groundwater, physico-chemical analysis of the both surface and groundwater were carried out. Twelve water samples were collected at random points across the stream. The locations of the sampling stations have been given in Table 3.

Findings based on physical and Chemical parameters

After water Analysis using different chemical parameters the pH of all water samples are in the permissible limits except in the sample collected at Nandini Layout. Hence, the sample is alkaline compared to other samples. The Total Dissolved

Table 3. L ocation of sample stations

Sample station	Location	SW/GW
1	Peenya industrial area Surface water	Surface water - SW1
2	Peenya industrial area Ground water	Ground water - GW1
3	Nandini Layout Surface water	Surface water - SW 2
4	Nandini Layout Ground water	Ground water - GW 2
5	Ka. Palya Industrial Area Surface water	Surface water - SW 3
6	Ka.Palya Industrial Area Ground water	Ground water - GW 3
7	Rajajinagar Industrial Area Surface water	Surface water - SW 4
8	Rajajinagar Industrial Area Ground water	Ground water - GW 4
9	Near Mysore road Surface water	Surface water - SW 5
10	Near Mysore road Ground water	Ground water - GW 5
11	Near Nagarabhavi Surface water	Surface water - SW 6
12	Near – Nagarabhavi Ground water	Ground water - GW 6

Table 4. Water Analysis Results (Chemical Parameters) (Peenya, Nandini Layout and Kamakshipalya Industrial area)

Sl. No	Constituents	Desirablelimits Mg / L	Peenya Industrial Area		Nandini Layout		Kamakshipalya area	Industrial
			SW1	GW1	SW2	GW2	SW3	GW3
1	Ca mg/L	75	67	173	61	51	72	83
2	Mg mg/L	30	20	49	22	36	34	33
3	Na mg/L	–	130	187	549	67	162	117
4	K mg/L	–	17	2	13	1	20	8
5	Fe mg/L	0.3	1.4	0.55	3.00	0.45	0.68	0.698
6	HCO_3 mg/L	200	412	549	436	287	490	456
7	CO_3 mg/L	–	Nil	Nil	83	Nil	Nil	Nil
8	Cl mg/L	250	140	316	372	76	148	98
9	NO_3 mg/L	45	11	54	43	18	25	27
10	SO_4 mg/L	200	10	98	383	64	64	69
11	TDS mg/L	500	630	1190	1780	490	800	700
12	SC μmoths/cm	–	1100	2080	2900	840	1390	1210
13	TH mg/L	300	248	628	240	272	316	340
14	PH	6.5-8.5	7.68	7.03	9.03	7.83	7.81	7.46
15	F mg/L	1.0	0.24	0.24	0.34	0.37	0.26	0.22

Solids is high compared to desirable levels in all the samples which indicate the presence of toxic minerals in the water. Moreover, The Bicarbonate content is also high compared to the permissible limits in all the samples. However, The Alkalinity is more compared to Total Hardness, indicating the presence of basic salts of Potassium and Sodium in addition to Calcium and Magnesium. Total Hardness is more in the permissible limits except in the samples collected at Nagarabhavi and Peenya Industrial Area. The Iron content of all the sample water is high than the permissible limits and heavy metals like Zinc and Nickel are within the permissible limits. The Copper content is found to be high in two of the surface water samples collected at Nandini Layout and Rajajinagar Industrial Area, which indicates that pollution of water by the external sources like industrial effluents. The Zinc content is high in all the samples, except the samples collected at Rajajinagar Industrial Area.

The BOD (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand) content of all the Surface water samples are very high compared to the permissible limits of 2.5 mg/l and 5.0 mg/l respectively. This clearly indicates that the water is highly polluted. The main source of high BOD and COD content in the water samples may be attributed to the flow of industrial effluents from the industries and also the domestic sewage (organic wastes). In groundwater samples, the BOD and COD content is nil as per the permitted level. This clearly shows that the groundwater is not polluted because of the polluted surface water. That means, I can say

Table 5. Water Analysis Results (Chemical Parameters) (Rajajinagar, Mysore Road, Nagarbhavi)

Sl. No	Constituents	Desirablelimits Mg/L	Rajajinagar Industrial Area		Mysore Road		Nagarbhavi I Stage	
			SW4	GW4	SW5	GW5	SW6	GW6
1	Ca mg/L	75	54	94	66	122	78	134
2	Mg mg/L	30	24	24	30	45	41	43
3	Na mg/L	–	161	151	140	125	154	165
4	K mg/L	–	19	1	26	16	23	9
5	Fe mg/L	0.3	1.2	0.25	1.95	0.17	0.38	0.025
6	HCO_3mg/L	200	441	259	466	407	529	508
7	CO_3 mg/L	–	Nil	Nil	Nil	Nil	Nil	Nil
8	$_{CL}$ mg/L	250	123	109	115	190	140	207
9	NO_3 mg/L	45	30	1	26	66	23	71
10	SO_4 mg/L	200	47	69	62	122	74	104
11	TDS mg/L	500	750	750	730	920	830	1020
12	SC μcm/cm	–	1210	1320	1250	1560	1450	1740
13	TH mg/L	300	232	330	284	484	360	508
14	PH	6.5-8.5	7.28	7.78	7.71	7.44	7.81	7.08
15	F mg/L	1.0	0.29	0.37	0.22	0.28	0.25	0.29

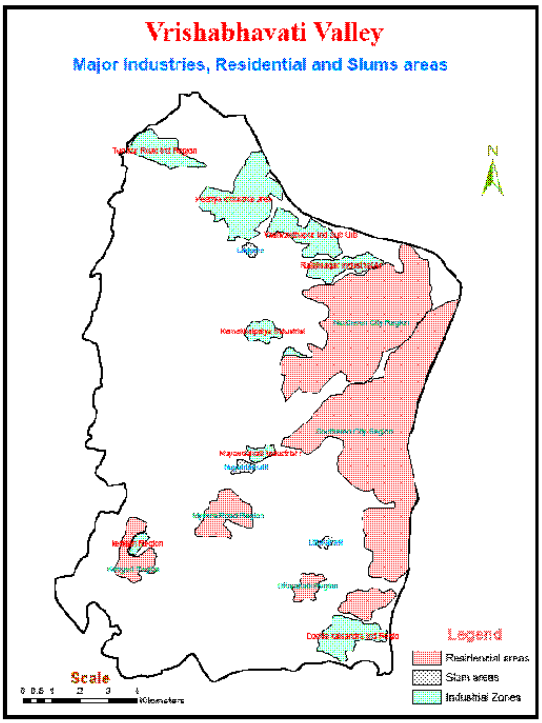

Fig. 3. Vrishabhavati watershed (Major Industries, residence and slum areas)

that there is not much impact of the surface water pollution on the ground water. But in general, the hardness of groundwater is high compared to surface water. This may be attributed to the natural reactions that take place in the geological structures.

Conclusion

The study aims were to evaluate the impact of industrialization and urbanization on the water quality of the Vrishabhavathi River flowing through Bangalore City. The results and analysis showed that most sampling sites' water quality is not suitable for drinking water purposes. It is also limited to the usage of other activities because of the degradation of water quality. It was found from the present and the previous studies that the quality of water is deteriorating day by day. The principal rationale for this is the direct and indirect disposal of industrial effluents and sewage from the city's waste disposal systems. There could be a variation in the test results of the parameters at different test centers because of the lab techniques or methods used. This analysis reveals that the hardness of the groundwater is high compared to the surface water. This may be attributed to the natural reactions that take place in the geological structures. The Nitrate content is high in a few of the groundwater samples collected at Mysore road and Nagarabhavi area and Peenya Industrial area. The bicarbonate content is more in all the samples. The Iron content is more in a few samples collected at Kamakshi Palya, Peenya and Nandini Layout. The heavy metals are all within the permissible limits except Lead, which is little high in the samples collected at Peenya industrial area and Rajajinagar indus-

trial area. The study, therefore, emphasized the need for periodic monitoring of water levels, the management of industrial effluents before discharge into the river, and the introduction of appropriate mitigation strategies to resolve problems and deterioration to facilitate the safe state of the river.

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