Progressive deteriortaion of groundwater quality in Vrishabhavathi Valley Basin, Bangalore, India

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Abstract- The present work aims to study the progressive deterioration of groundwater quality over a period of eight years, in and around the Vrishabhavathi Valley, an erstwhile fresh water stream, now carrying huge amounts of industrial, agricultural and domestic effluents from the western part of Bangalore metropolis. Groundwater samples were collected from both the borewells and open wells along the Vrishabhavathi valley watershed during April 2014 from the same sampling sites, that were chosen for the study in 2006 by these authors and subjected to a comprehensive physico-chemical analysis and water quality indices were worked out for the entire study area, both for the 2006 and the present data. The water quality indices have risen alarmingly and it has been found that nearly 67% of the samples are non-potable and it is seen that this number has risen sharply from 50 % non-potability in study 1 conducted in 2006. This clearly shows that there is a massive deterioration of water quality in the study span of 8 years, clearly reflecting the unabated and huge increase in the concentration of pollutants from municipal, industrial and agricultural sources that have been making their way to the groundwaters of Vrishabhavathi valley basin. The results imply that the groundwater of all the affected areas are completely unfit for human consumption and needs elaborate and appropriate treatment for improving its quality.

Keywords- ***Contamination, Groundwater, Pollution, Quality, Water quality index***

I. INTRODUCTION

The urban environmental quality is deteriorating day by day with the largest cities reaching saturation levels and unable to cope up with the increasing pressure on their infrastructure [1].Bangalore city has meager water resource in its neighbourhood, being a part of semi-arid peninsular India. The undulating topography of the city has been meticulously managed in the past, to build a chain of water storage lakes in the Valley areas. But, the city has been heading towards freshwater crisis, mainly due to improper management of water resources and Environmental degradation, which has led to lack of access of safe water supply [2].

The Department of Mines and Geology carried out investigations to evaluate the groundwater quality in Bangalore Metropolis (1995) and based on the analysis, reported that 51 percent of the samples were found to be non-potable due to the presence in excess of one or more water quality parameters .But Nitrate was found to be the major cause, accounting for 45 percent of non-potability [3].

Statement of the problem

The Vrishabhavathi River, once used as a major source of water is now entirely contaminated from household, agricultural and industrial wastes [4]. While the original river has dried up, at present, it is carrying sewage and industrial effluents from more than 100 industries of various kinds. The wastewater flow into the Vrishabhavathi Valley is about 300 MLD. It receives improperly treated and /or untreated effluents and domestic wastewater from the Bangalore Water supply and sewerage board (BWSSB) treatment plant, containing various organic materials, toxic elements and pathogens [5]. As surface water is accessible for irrigation in the study area, it is highly polluted with waste effluents and groundwater is the most utilized source in the area. A majority of the farmers own both dug wells and bore wells for irrigating various crops [5]. In the recent years, pollution of groundwater in the Vrishabhavathi locality has emerged as a severe environmental issue, constraining its use drastically. What is very alarming, is the massive deterioration of the water quality, with every passing day due to huge amounts of pollutants from all three major sources of wastes In this context, the present study, which aims at assessing the present pollution levels and making a comparison with similar studies carried out by the author in 2006, focusing on the drastic deterioration of quality over a given time period, assumes great importance.

Details of the study area

The Vrishabhavathi is one of several tributaries of the river Cauvery. It drains a major part of Bangalore metropolis in the west and is the outlet channel for domestic and industrial effluents in the area. An erstwhile freshwater stream, it has now become the carrier of heavy pollutants [6]. The Vrishabhavathi, a tertiary tributary of the river Cauvery, drains an aerial extent of 545 Sq km before it joins the Suvarnamukhi River at Bhadragundadoddi of Kanakapura taluk, Bangalore district. It is encompassed by North Latitudes 12^0 45^1 to 13^0 03^1 and East Longitudes $77^0 23^1$ to $77^0 35^1$. The topographic coverage of the area is available on the topo sheets 57H/5 and 57H/9 published on scale 1: 50,000.

II. MATERIALS AND METHODS OF ANALYSIS

Thirty water samples were collected from the bore wells and Open Wells in the study area (figure 1) during April 2014 in two litre PVC containers and sealed and were analyzed for the major physico-chemical parameters in the lab [7]. The samples were drawn from the same sources under similar conditions as that in 2006, carried out by the same authors/investigators.

The physical parameters such as p^H and Electrical Conductivity were determined in the field at the time of sample collection. The chemical analysis was carried out as per the standard methods [7] for examination of water and wastewater (APHA, 1995). The results obtained were evaluated in accordance with the standards prescribed under 'Indian Standard Drinking Water Specification IS 10500: 1991 of Bureau of Indian Standards [8]. The water quality indices for these samples were calculated and these values were compared with the water quality indices of the same set of samples analyzed in 2006.

Computation of Water quality Indices

Water quality index is one of the most effective ways to communicate information on the quality of water to the concerned citizens and the policy makers. It thus, becomes an important parameter for the assessment and management of groundwater [9]. A water quality index (WQI) may be defined as a rating reflecting the composite influence of a number of water quality parameters on the overall quality of water. The main objective of WQI is to turn complex water quality data into information that is understandable and useable by the public. WQI based on some important parameters can provide a simple indicator of water quality. It gives the public, a general idea of the possible problems with water in a particular region.

The WOI has been calculated using the formula [10]

$WQI = \text{Antilog} [\sum W^{n}_{n=1} \log_{10} q_n]$ (1)

where, W = Weightage factor (Table 3) computed as follows

$W_n = K / S_n$ (2)

K = Proportionality constant derived from equation

$K = [1 / (\sum n_{n=1} 1 / S_n)]$ (3)

S_n is the recommended drinking water standards as per B.I.S

Quality rating q is calculated using the formula,

$q_{ni} = [(V_{actual} - V_{ideal})/(V_{standard}-V_{ideal}) X 100]$ (4)

$q_{ni} =$ quality rating of i^{th} parameter for a total of n parameters.

V_{actual} = Value of water quality parameter obtained from laboratory analysis

V_{ideal} for p^H = 7 and equivalent to zero for other parameters.

$V_{standard}$ = B.I.S standards of parameters.

Based on the above WQI values, the groundwater is rated as excellent, good, poor, very poor and unfit for consumption (Table 3)

RESULTS AND DISCUSSIONS

Thirty groundwater samples were drawn from the open wells and bore wells which included hand pumps, piped water supplies and mini water supply schemes and were analyzed for twenty physico-chemical parameters including trace metals. The results of the physico-chemical analysis as per study 1 is presented in table 1, which shows the maximum, minimum and average concentrations of critical parameters as per BIS. Table 2 shows the water quality parameters, standards and unit weights and table 3 depicts the water quality index categories. Table 4 clearly depicts the comparison of water quality indices of the (present study with study 1. The diagrammatic interpretations of the results presented in figures 2 and 3. Figure 2 indicates the water quality index contours for the study area while figure 3 depicts the graph showing the variation of water quality index in the two study periods

Based on the results of physic-chemical analyses results, the water quality index has been calculated for both study 1 and the present study to determine the suitability for drinking purposes. WQI values revealed that only 33.33% of the 30 groundwater samples are of excellent – good category and hence can be used for human consumption as against 50 % from study 1. 3 samples are of poor quality (WQI, between 51- 75) as against 5 from study 1, 4 samples of very poor quality (WQI between 76- 100), on par with the result of study 1 and 13 samples, resulting in a whopping 43.33% are totally unfit for Consumption (WQI > 100) as against 6 samples amounting to just 20 % from study 1 under this category.

TABLE 1: MAXIMUM, MINIMUM AND AVERAGE CONCENTRATIONS OF CRITICAL PARAMETERS & BIS PERMISSIBLE LIMITS (STUDY 1)

S.No	Parameter	Maximum	Minimum	Average	BIS limits
1	p^H	8.42	6.55	7.40	6.5to 8 .5
2	Chlorides	1338	60	320.63	1000
3	TDS	2850	200	921.77	2000
4	Total Hardness	1960	70	563.67	600
5	Calcium	386	15	137.83	200
6	Magnesium	249	08	52.63	100
7	Nitrate	157	05	47.6	45
8	Sulphate	216	10	54.17	400
9	Fluoride	2.5	nil	0.87	1.50
10	Iron	1.24	Nil	0.225	1.0

All parameters except p^H in mg/L

TABLE 2: WATER QUALITY PARAMETERS, STANDARDS AND UNIT WEIGHTS

Parameter	Standard (S_n)	weightage (W_n)
pH	8.5	0.026
Total Hardness	300	0.00073
Calcium	75	0.00293
Magnesium	30	0.00733
Chloride	250	0.00088
Nitrate	45	0.00049
Sulphate	200	0.0011
TDS	500	0.00044
Fluoride	1	0.22
Iron	0.3	0.73

TABLE 3: WATER QUALITY INDEX CATEGORIES

Water quality index	Category
0 -25	Excellent (E)
26- 50	Good (G)
51- 75	Poor (P)
76- 100	Very poor (VP)
> 100	Unfit for drinking(UFD) and all other purposes

TABLE 4: COMPARISON OF WATER QUALITY INDICES (PRESENT STUDY) WITH STUDY 1

Sampling station no	WQI (STUDY 1-2006)	WQI (STUDY II-2014)	Percentage increase in WQI	Average percentage increase in WQI
1	62.94	72.43	15.08	**93.83**
2	22.73	37.44	64.72	
3	269.15	340.62	26.55	
4	77.27	152.1	96.84	
5	69.5	74.95	7.84	
6	78.89	84.8	7.49	
7	52.24	134.3	157.08	
8	21.88	33.1	51.28	
9	69.02	126.8	83.71	
10	38.82	112.57	189.98	
11	14.12	32.2	128.05	
12	87.9	162.78	85.19	
13	10.72	42.5	296.46	
14	53.08	118.64	123.51	
15	89.33	108.95	21.96	
16	35	79.7	127.71	
17	11.56	33.7	191.52	
18	38.54	83.29	116.11	
19	36.64	64.5	76.04	
20	18.06	46.31	156.42	
21	10.96	22.23	102.83	
22	188.8	281.43	49.06	
23	104.72	143.5	37.03	
24	35.89	75.4	110.09	
25	17.38	36.4	109.44	
26	11.48	33.38	190.77	
27	22.9	52.22	128.03	
28	274.15	298.14	8.75	
29	288.4	342.44	18.74	
30	114.8	156.78	36.57	

The most alarming thing that is noticed, is that the average percentage increase in water quality index from study 1 to present study is as high as 93.83%, as indicated in table 4. This clearly shows the massive deterioration of water quality in the study span of 8 years, clearly reflecting the unabated and massive increase in the concentration of pollutants from municipal, industrial and agricultural sources. The results imply that the groundwater of all the affected areas are unfit for human consumption and needs elaborate and appropriate treatment for improving its quality. The WQI contours drawn (Fig. 2) gives a very clear picture of the quality of waters in the individual stations of the study areas.

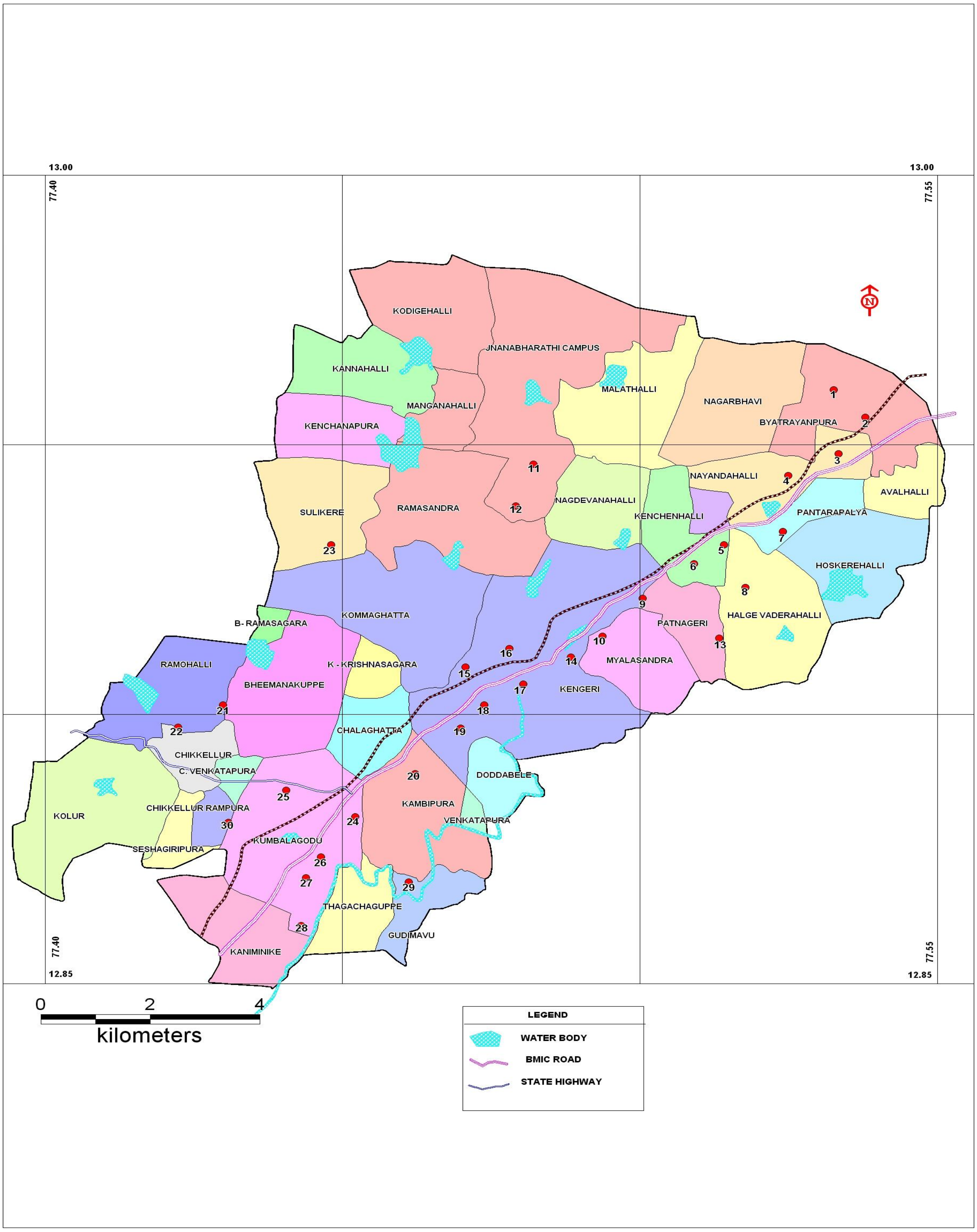

FIG.1 LOCATION MAP OF VRISHABHAVATHI VALLEY BASIN SHOWING THE SAMPLING STATIONS

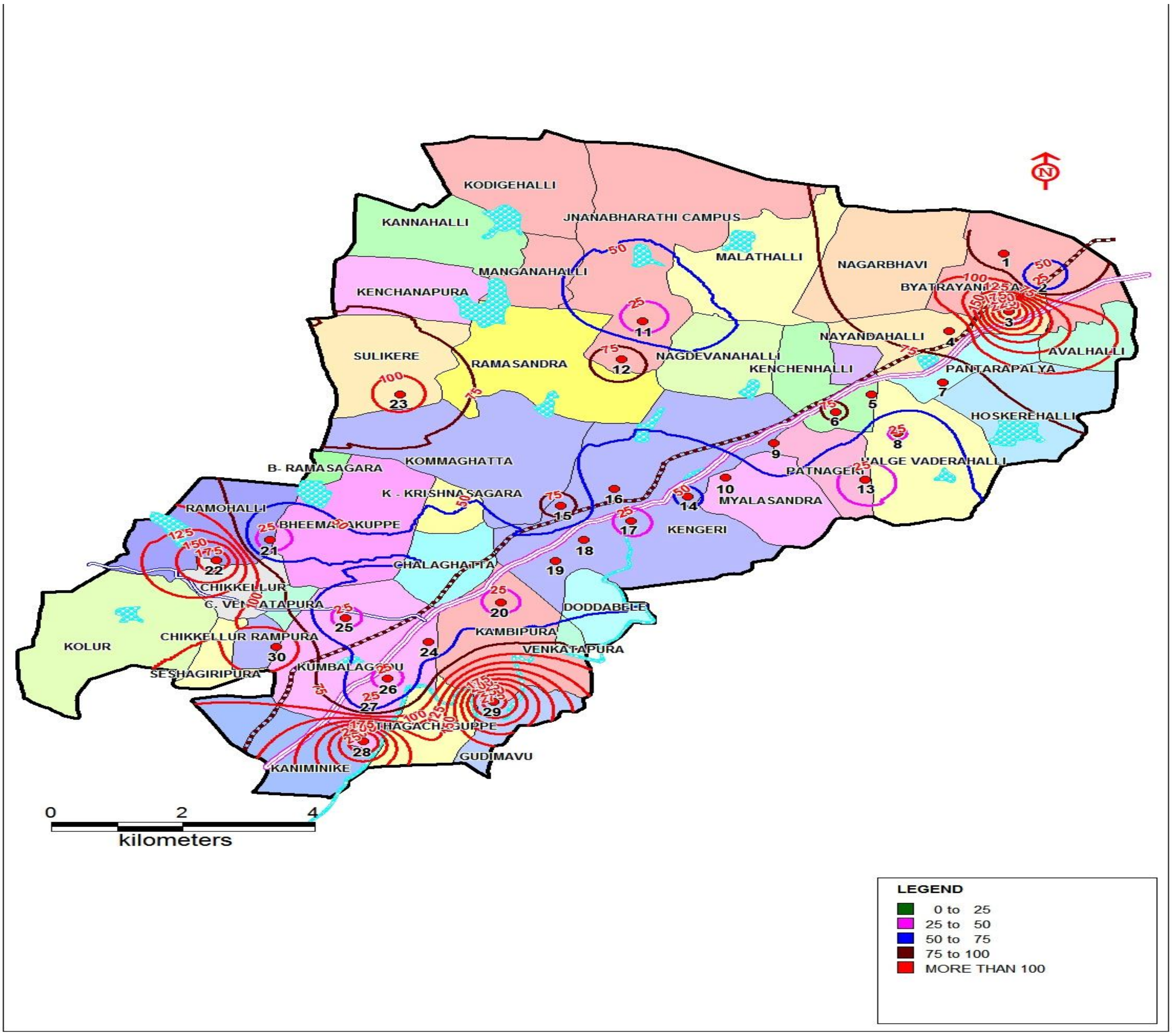

FIG.2 WQI CONTOURS FOR VRISHABHAVATHI VALLEY BASIN

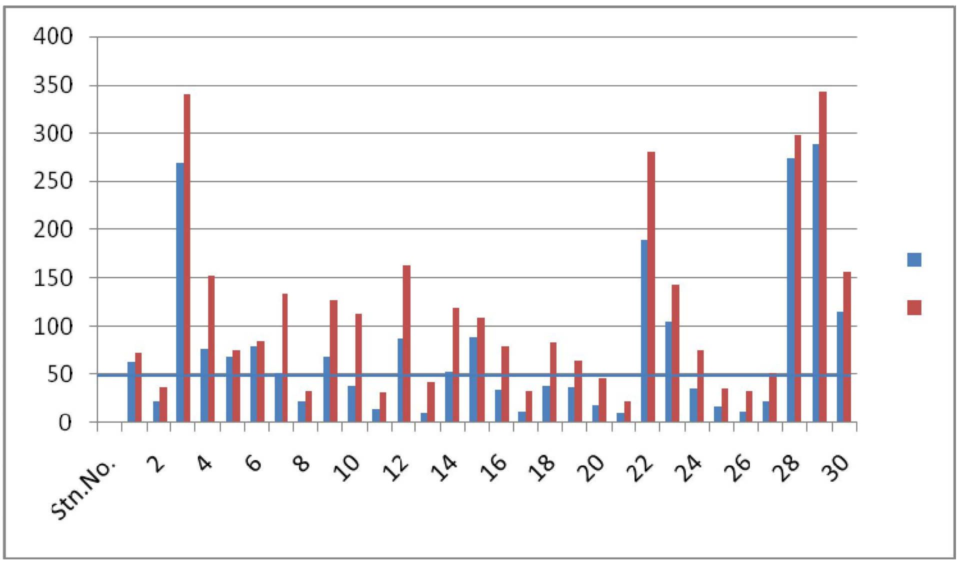

FIG. 3 VARIATION OF WATER QUALITY INDEX

III. CONCLUSIONS

The analysis of groundwater samples based on water quality indices reveal that nearly 67% of the samples are non-potable and it is seen that this number has risen sharply from 50 % non-potability in study 1. This clearly shows that there is a massive deterioration of water quality in the study span of 8 years, clearly reflecting the unabated and huge increase in the concentration of pollutants from municipal, industrial and agricultural sources that have been making their way to the groundwaters of Vrishabhavathi valley basin. The results imply that the groundwater of all the affected areas are completely unfit for human consumption and needs elaborate and appropriate treatment for improving its quality. Strict legislation on industries setting up and operating their effluent treatment plants should be enforced mandatorily. Replacement of damaged pipelines and lining of sewer drains is a must. Augmenting the ground water resources by recharging the ground water aquifer through rain water harvesting and thus reducing the high concentration of chemical parameters is a very important measure. Use of bio fertilizers by farmers instead of chemical fertilizers in agricultural activities is another very important control measure. At the community level, the public should be instructed to use boiled water for drinking, as the study areas have shown considerable hardness, mostly of temporary type. Public awareness programmes should be initiated to create a sense of awareness in them to safeguard against the perils of water-borne diseases.

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