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RESEARCH ARTICLE

ANALYSIS OF GROUNDWATER QUALITY USING WATER QUALITY INDEX: A CASE STUDY OF BOMMANAHALLI MUNICIPAL ZONE, BANGALORE, INDIA

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ABSTRACT

The objectives of this study are to analyze the underground water quality of Bommanahalli zone by water quality index. Eleven physico-chemical parameters such as pH, Electrical Conductivity Calcium, Magnesium, Chloride, Sulphate, Total Hardness, Fluoride, Nitrate, Total Dissolved Solids, Iron and Alkalinity collected from 10 different locations in a pre-monsoon period of 2017. In this study 90% water samples were found poor quality and only 10% water samples falls under moderately good category. The water quality index ranges from 39.03to 453.90. Therefore there is a need of some treatment before usage and also required to protect that area from contamination.

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INTRODUCTION

Increasing population growth, rising living standards and areal extent of the city have increased at an alarming rate in recent years. Water – one of the natural resources has remained a deficit resource in Bangalore since long. Consequently, the growth of groundwater exploitation has been phenomenal, largely through lakes of private bore wells. Discharge of industrial effluents without proper treatment into open pits or through unlined channels to move towards low lying depressions on land, results in the contamination of groundwater. The industrial effluents if not treated and properly controlled, can pollute and cause serious damage to the groundwater resources, which results in poor quality of groundwater. Vulnerability is generally an intrinsic property of a groundwater system that depends on its sensitivity to human impact. The natural hydro-geological factors affect the different pollutants in various ways depends upon their interaction and chemical properties 6. In this study an attempt has made to evaluate the ground water quality of the Bommanahalli municipal zone of Bangalore city.

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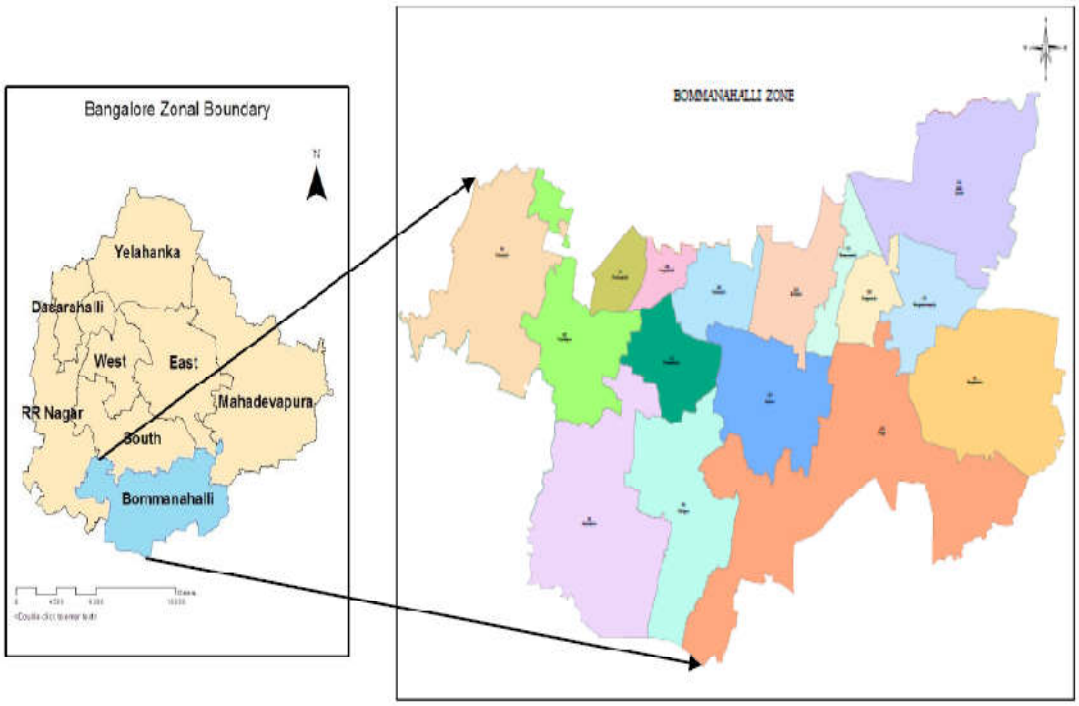
WQI provides a composite influence of different water quality parameters. Water quality index provides information on the quality of any water body. Mathematical equations of WQI transform large number of water quality data into a single number. Most effective tool to transmit information on the quality of water concern to citizens and policy makers is evaluated.

Study area

Bangalore is the capital of Karnataka State and is situated in the central part of peninsular India on the Deccan Plateau, with a world-wide reputation as 'Silicon Valley' of India. It is home to somewhere between 9 to 10 million people. For convenience, Bangalore City, it was divided into 8 zones as Bommanahalli, Dasarahalli, Mahadevapura, Rajarajeswarinagar, Yelahanka, and Central phases of South, East, and West. The study area, Bommanahalli zone, comprises of 106.95 Sq km, lies in the Southern part of Bangalore city. It houses more than 500 industries dominated by chemical, pharmaceutical, metallurgical, plating and allied industries. Map of the study area is as shown in fig-1.Around 10 samples were collected in different areas of that region.



Sampling and Analysis

The groundwater samples from bore wells in the study area from ten locations were collected during pre-monsoon seasons in the year 2017 in two liter PVC containers as per the standard procedure and were analyzed for physico-chemical parameters as per standard methods for examination of water and wastewater (APHA) pH and Electrical Conductivity were determined at the time of sample collection. The results obtained were assessed in accordance with 'Indian Standard Drinking Water Specification IS 10500: 1991 of Bureau of Indian Standards 2003. The Department of Mines and Geology carried out investigations to evaluate the groundwater quality in Bangalore Metropolis. It is reported that 51% of the samples were found to be non-potable due to the presence of excessive concentrations of one or more water quality parameters such as Nitrates, Hardness, Iron, Chloride, Total Dissolved Solids etc. Nitrate was however found to be a major pollutant accounting for 45% of non-potability.

Water quality index determination

Most effective tool to monitor the surface as well as groundwater pollution is the water quality index which can be used efficiently in improving the water quality programmes. Water quality index gives information on a rating scale from zero to hundred. Nine parameters were performed to design the water quality index.

In present study, for the calculation of water quality index eleven parameters (pH, Electrical Conductivity, Total Dissolved Solids, Total Alkalinity Total Hardness, Calcium, Chloride, Sulphate, Fluoride, Nitrate, Iron) quality were chosen. The WQI has been calculated by using the standards of drinking water recommended by the World Health Organization (WHO), Bureau of Indian Standards (BIS) and Indian Council for Medical Research (ICMR). The weighted arithmetic index method has been used for the calculation of WQI of the water body. Further water quality rating or sub index (q_n) was calculated using the following expression.

$$q_{n=}100[V_n-V_{io}]/[Sn-V_{io}]$$

q_n = Quality rating for the n^{th} water quality parameter
V_n= Estimated valve of the n^{th} parameter at a given sampling station.
V_{io} = Ideal Value of n^{th} parameter in pure water. (0 for all other parameters except the parameter pH and Dissolved Oxygen (7.0 and 14.6 mg/l respectively)
Sn= Standard Permissible valve of the n^{th} parameter
Unit weighted was calculated by a value inversely proportional to the recommended standard value Sn of the corresponding parameters.

$$Wn=K / Sn$$

Wn = Unit weight for the n^{th} parameters.
Sn= Standard value of n^{th} parameters.
K= Constant for proportionality.

The overall water quality index was calculated by aggregating the quality rating with the unit weight linearly.

$$WQI=\sum qn\ Wn / \sum Wn$$

Table 1. Water Quality Index (WQI) and status of water quality

S.No.	Range	Type of water
1.	0-25	Excellent
2.	26-50	Good
3.	51-75	Poor
4.	76-100	Very poor
5.	>100	Unsuitable for drinking purpose

Table 2. Drinking Water Standards recommending agencies and unit weight (all the values in mg/l except pH and Electrical Conductivity)

Parameters	Standards	Unit weight
pH	6.5-8.5	0.1428
Electrical Conductivity	300	0.0033
Total Dissolved solids	500	0.0022
Total alkalinity	120	0.0083
Total hardness	300	0.0033
Calcium	75	0.0133
Chloride	250	0.0044
Nitrate	45	0.022
Sulphate	150	0.005
Fluoride	1.0	1.00
Iron	0.3	3.330

RESULTS AND DISCUSSION

Discharge of industrial effluents without proper treatment into open pits or through unlined channels to move towards low lying depressions on land, results in the contamination of groundwater. The industrial effluents if not treated and properly controlled, can pollute and cause serious damage to the groundwater resources, which results in poor quality of groundwater. The effluents also dispersion into the ground water aquifers and making it unsuitable for human utilization.

Physico-Chemical Parameters

Total Dissolved Solids

Estimation of total dissolved solid (TDS) is useful to the suitability of water for drinking, agriculture and industrial purpose.

TDS is the sum of potassium, calcium, sodium, magnesium, carbonates, bicarbonates, chlorides, organic matter, phosphate and other particles. Higher concentration of TDS produces gastro-intestinal irritation in human body. The highest total dissolved solids value is observed to be 678 mg/l at S-1 and lowest value is 200 mg/l at S-6. However, the total dissolved solids values at S-1,S-8,S-9 and S-10 are found to be more than the permissible limits being prescribed in BIS, for drinking water (Figure 1).

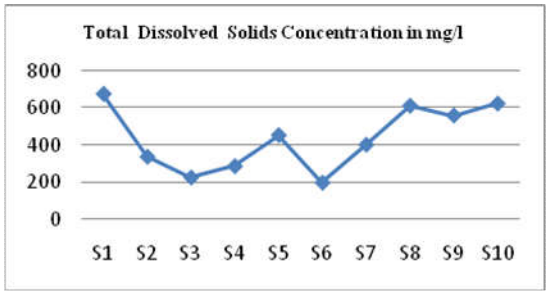


Figure 1. Concentration of TDS of different samples

Sl. No.	Range	Type of water
1.	0-25	Excellent
2.	26-50	Good
3.	51-75	Poor
4.	76-100	Very poor
5.	>100	Unsuitable for drinking purpose

Alkalinity

The highest alkalinity value is observed to be 356. mg/l at S-8 and lowest value is 136 mg/l at S-6. However, the alkalinity in all samples is found to be more than the acceptable limit being prescribed in BIS, for drinking water (Figure 2).

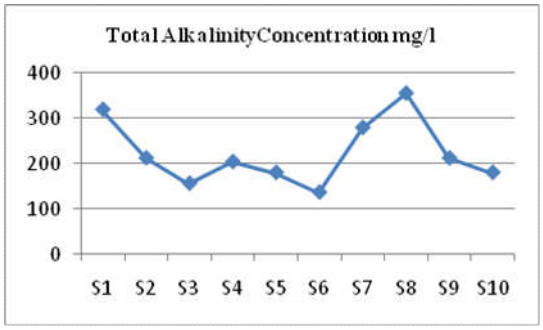


Figure 2. Concentration of alkalinity of different samples

Total Hardness

Hardness due to bicarbonate of calcium or magnesium is temporary hardness and the hardness due to chloride, sulphates and nitrates of calcium and magnesium is permanent hardness. Due to permanent hardness soap consumption will be more. It also produces calcification of arteries. It also affects water supply system by forming scale. Urinary concretions, stomach disorder and diseases of kidney or bladder are produced by hardness without no conclusive proof. The highest total hardness value is observed to be 560 mg/l at S-10 and lowest value is 220 mg/l at S-6. However, the total hardness values at S-1, S-5,S-7,S-8,S-9,S-10 are found to be more than the permissible limits being prescribed in BIS for drinking water (Figure 3).

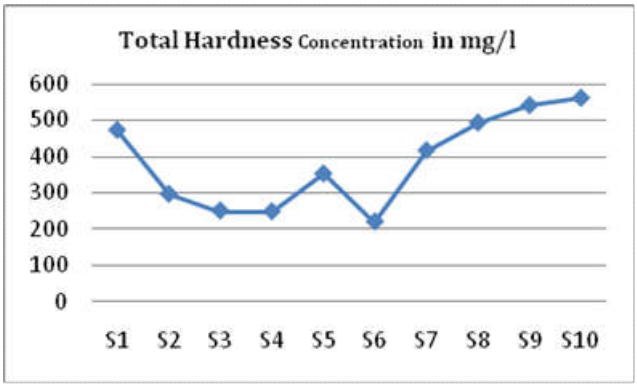


Figure 3. Concentration of Hardness of different samples

Calcium

Calcium serves in our body as vascular contraction, muscle contraction, blood clotting and nerve transmission. Taking lesser amount of calcium is associated increased risk of osteoporosis, hypertension, colorectal cancer and coronary artery diseases obesity and insulin resistance. High content of calcium and magnesium in drinking water should be avoided in the case of kidney stone or bladder stone. The highest calcium value is observed to be 348 mg/l at location S-10 and lowest value is 160 mg/l at S-3. However, the calcium values at all locations are found to be higher than the permissible limits being prescribed in BIS for drinking water (Figure 4).

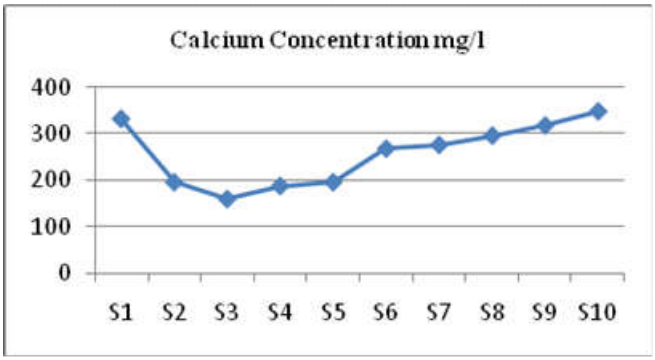


Figure 4. Calcium Concentration of different samples

Chloride Concentration

Chlorides are found in natural water due to leaching of chloride containing rocks and soils discharges of effluents from chemical industries, ice-cream plant effluent, sewage disposal, irrigation drainage.

Higher concentration of chloride is harmful to heart and kidney diseases of the peoples, indigestion, taste, palatability and corrosion are also affected. The highest chloride value is observed to be 439 mg/l at S-3 and lowest value is 110 mg/l at S-10. However, the chloride values at all locations are found to be below the acceptable limits being prescribed in BIS for drinking water (Figure 5).

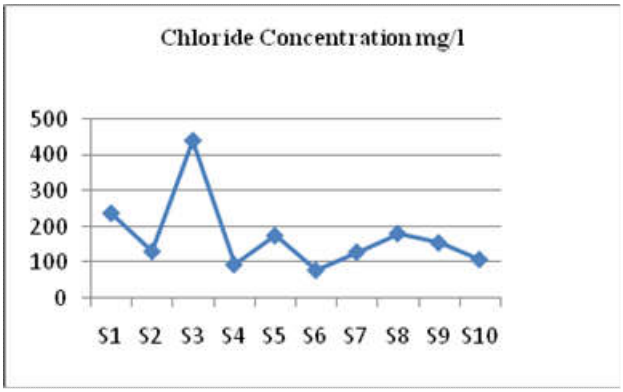


Figure 5. Concentration of Chloride at different samples

Nitrate Concentration

Nitrate is found in groundwater due to leaching of nitrate with the percolating water to the soil. Infant Methaeglobinaemia is produced at very high toxic nitrate concentration. It also affects cardiovascular system and nervous system and also produces gastric cancer. The highest nitrate value is observed to be 198 mg/l at S-4 and lowest value is 38 mg/l at S-8. However, the Nitrate values at all locations are found to be below the acceptable limit being prescribed in BIS for drinking water (Figure 6).

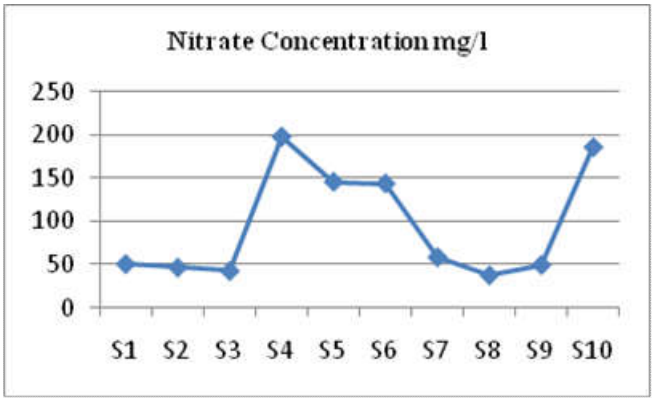


Figure 6. Concentration of Nitrate at different samples

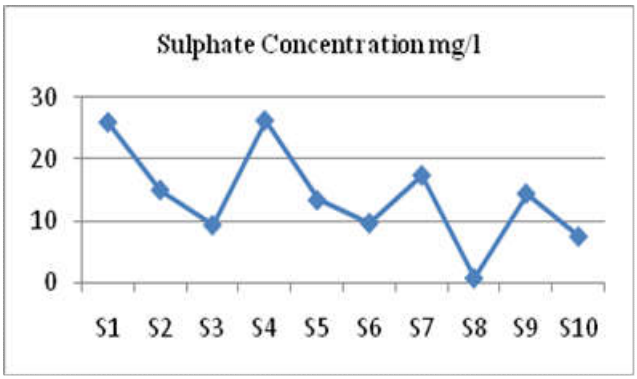


Figure 7. Concentration of Sulphate at different samples

Sulphate Concentration

Contaminated water and waste water has high sulphate concentration. Gastro intestinal irritation is produced due to high concentration of sulphate. The highest sulphate value is observed to be 27 mg/l at S-4 and lowest value is 0.652 mg/l at S-8. However, the sulphate values at all locations are found to be below the allowable limits being prescribed in WHO for drinking water (Figure 7).

Fluoride Concentration

Fluoride is a geochemical contaminant. Fluoride in small dosage influences the dental system. Higher concentration of fluoride causes dental and skeletal fluorosis. The fluoride values at all locations are found to be below the acceptable limits being prescribed in BIS for drinking water (Figure 8).

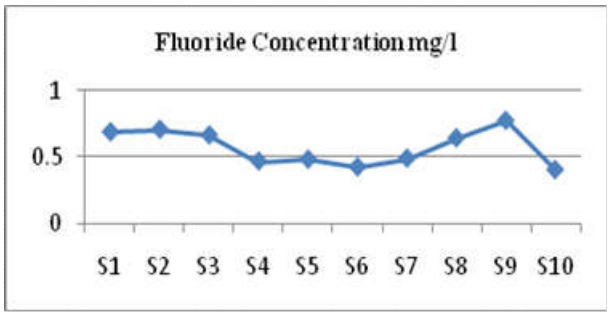


Figure 8. Concentration of Fluoride at different samples

Table 3. Details of Index Rate and type of water for various Samples obtained in the Analysis

Sample	Location	Index rate
S-1	# 12,6th main, Mangammanapalya.	240.84
S-2	5th and 2nd sector opposite lake, HSR layout	366.20
S-3	RB industrial area, Bommanahalli	39.03
S-4	Arkere near reliance fresh	179.84
S-5	Gottigere near SBI bank	453.90
S-6	Konnkunte village (soudhamani)	193.58
S-7	Chunchagatta c g main road circle	345.15
S-8	Jaraganahalli shiva temple	252.50
S-9	Nanjappa layout kashinagara	216.89
S-10	Bikasipura residential area	124.58

Iron Concentration

Human bodies require iron to function properly, but it won't harm your health, iron in your water will destroy property and food. The highest iron value is observed to be 1.35 mg/l at S-7 and lowest value is 0.081 mg/l at S-3.

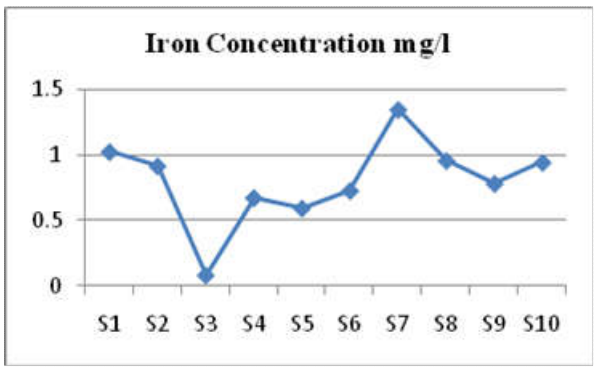


Figure 9. Concentration of Iron at different samples

Water quality index analysis

The physicochemical parameters of Bommanahalli region with their BIS and WHO water quality prescribed values, corresponding weightage factor (Wn), assigned with the help of equations and the values are presented in the Table 2. WQI were calculated from equation 2 and 3. The WQI results are shown in Table 3. Obtained results revealed that the ground water qualities of 10 locations were found good quality ranges from 0–25 and 26–50. And only one place under moderately poor category ranges from 51–75.

Conclusion

In the present study 09 water samples were found poor quality and 01 water sample falls under moderately poor category. The water quality index ranges from 62.43 to 229.99. Therefore there is a need of some treatment before usage and also required to protect that area from contamination. The rain water harvesting structures should be installed to restore the ground water aquifers for improvement of ground water resources in order to maintain the quality and quantity of ground water reservoir and thus diluting the higher concentration of chemical constituents and dissolved salts. Public awareness program should be begun to enhance the knowledge and awareness to save water pollution on human being around their dweller. The study helps us to understand the quality of the water as well as to develop suitable management practices to protect the ground water resources.

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