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Groundwater Quality assessment: A Study on Effect of Treated Effluent in and around Shivanagara STP, Davanagere Taluk

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Abstract

This study examines the impact of treated effluent on groundwater quality near the Shivanagara STP in Davangere, highlighting the role of inadequate municipal sewage treatment practices and human activities in degrading topsoil and groundwater. Water samples from 17 locations were analyzed for physico-chemical properties and compared to the permissible limits set by the Bureau of Indian Standards. The findings indicate that percolation of treated effluent is contaminating the groundwater. According to the Water Quality Index (WQI) analysis, 99% of the samples are classified as good, while 1% are deemed poor. These results suggest that the STP's treatment processes are insufficient and improvements are necessary to prevent further groundwater contamination. To protect groundwater quality, wastewater treatment plants must enhance treatment before discharging effluent into canals or storage tanks.

Keywords: Groundwater Quality Sewage, STP, Treater Effluent, WQI.

1. Introduction

1.1. Overview

Groundwater is essential requirements of the human being and living organisms to lead their luxurious and comfortable lives and also for agricultural development, so we consider the Ground water is constituents of an ecosystem. Its quality should be assessed regularly, and the condition of sources of water should be maintained accordingly (7), as earth's planet consists of 97% of the salt water and the 3% of freshwater. Out of 3%, only 0.02% of it is available to human use in the form of ground water, which is the used by human for their consumption, agricultural, modern industrial activities (2). due to over population and their requirement the groundwater resources are under the stress, and its sustainability is assessed by comparing its quality with the water standards established by the national and international bodies. The main factors affecting the original water quality are soil type and liquid pollutants present on soil layer and excellence of water will be due to the water bearing rock system and the proper utilization of the land by the people, which may lead to the potential provider of contamination. (4)

1.2 Effect Caused by Release of Effluent from STP to Groundwater.

A sewage treatment plants (STP) effluent discharge can negatively affect neighboring sites by lowering soil fertility and polluting the soil, which impacts crop development. Rivers, lakes, and other surface water bodies may also get contaminated, endangering aquatic life and rendering the water unfit for human use []. Exposure to diseases and hazardous substances poses health concerns to local residents, and disruption of ecosystems can result in a loss of biodiversity. Unpleasant smells and visual pollution can also diminish property prices and negatively impact occupants' quality of life. Long-term environmental damage can have an influence on both the ecosystem and human activity, making it challenging to rehabilitate impacted places.

1.3 Objectives.

1. To Analyze the Groundwater Quality Parameters at Different Distance from the STP.
2. To Compare the Water Quality with the Standards needed for Agriculture Application and Drinking Purposes.
3. To Obtain the Ground Water Quality by Using WQI (Water Quality Index).

2. Materials and Methodology

2.1 Study Area : Davanagere is a semi-arid region considered as Manchester of the Karnataka situated in a Deccan plateau and the hub industrial area in Karnataka located at the latitude of 14'28"N and 75'59"E at an average altitude of 602.5m from the MSL, and falls under Zone II which is the lowest earthquake risk zone in India. The STP at Shivanagara, Davanagere, is well designed to handle the waste that comes from the town with a capacity of 20MLD. At a latitude of 14.4637’ N, longitude of 75.9213’, it has potential influence on the groundwater quality in the surrounding areas.

The samples were collected using the 2 liters of plastic bottles from the borewell point after rinsing the bottles with the same water at 17 different locations from the STP near the Doddabudihal and Chikkabudihal, B Kalpanahalli villages situated in the Davanagere.

Table 2.1 – The study areas located near STP.

Sl no	Name of the area	Distance from the STP in kilometers	Latitude	Longitude	Number of the houses
1	Chikkabudihal.	2	14.43	75.90	197
2	Doddabudihal.	1.8	14.50	75.94	179
3	B Kalpanahalli.	1.5	14.46	75.92	234

Source: Davanagere City sewage and sanitation scheme and Google earth maps

2.2 Methodology

After the collection of the sample, the bottles were sealed tightly and marked with thesample number and the sample location and later carried to the laboratory to prevent variation in the water quality due to external environmental conditions. The IS-10500-2012 is employed in the examination of the. pH, Total Alkalinity, Electrical Conductivity, Turbidity, Total Dissolved Solids, Total Hardness,and Ca^{+} Hardness, Mg^{+} hardness, Chloride, Nickel, Lead, Chromium, Cadmium. The analyzed for parameters were examined. The results were compared with BIS standards to assess their suitability for drinking and irrigation purposes.

3. RESULTS & DISCUSSIONS

3.1 Physicochemical Parameters Analyzed Results.

The quality and concentration of parameter present in the water is most effective for the reuse of the contaminated resources and to use it for drinking and irrigation, therefore to meet the objective of the project the collected samples were tested their parametric concentration are discussed to determine the quality of water and to obtain the variation in the water parameters. Table 3.1: Table of obtained results of various parameters by laboratory analysis.

3.1.1 pH: The pH of treated effluent samples, varying from 7.4 to 8.2. The highest pH value (8.0) was recorded close to the sewage treatment plant (STP), while the lowest pH value (7.4) was found at location 2 shown in fig 3.1. This indicates the treatment process which probably involved the addition of lime or other alkaline substances contributed to the higher pH values. Because of the increased solubility of trace elements.

3.1.2 Alkalinity: The alkalinity of collected water is determined by titrating it with an acid & measured value shows that the minimum values at the location 8 with a value of 144mg/l shows slightly acidic condition and maximum is at the location number 17 an alkalinity value 504 mg/l with an alkaline condition the which can be based on geological formation. As per the Indian Standards, the alkalinity value recommended for acceptable and permissiblelimits is 200 to 600 mg/l all the 17 location samples graphical representation fig 3.2 are in below the desirable limits so they can be used the water for the various purposes.

3.1.3 EC: Electrical conductivity (EC) is an indicator of salt content and dissolved ions in groundwater. Among the 17 collected samples, EC values ranged from 293 µS/cm to 1800 µS/cm, with BIS standards recommending a maximum of 400 µS/cm Elevated EC levels, as seen at location 14 (1800 µS/cm), This can lead to groundwater salinization, reducing its suitability for drinking and irrigation. Conversely, very low EC value as 374 µS/cm at location 15 suggests that over-treatment, which may remove essential minerals, limiting the water's nutrient content for plants.

3.1.4 Total Hardness: Form the analysis and graphical representation fig 3.6 shown that sample no 3 shows an less total hardness value as 230 mg/l as CaCO3 and indicates that lower hardness water can help toscale formation in pipes and the irrigational equipment's and the interaction of the GW with the geological formations may contain the lesser minerals and less to lower hardness similarly, the sample location 14 has an higher hardness as 668 mg/l as CaCO3 it represents that the amount of the Ca+ and Mg^{+} are high the results significance of contact with geological layerthat are rich in these elements.

3.1.5 Calcium and Magnesium Hardness: The calcium and the magnesium ions are the important nutrients for the living organisms in an environment and occurs naturally in the form of Ca+ & Mg. The area which is near to the STP have an interaction with the geographical layer having a lower Ca+ & Mg+ minerals as gypsum and lime stone. Magnesium levels in sample 15 exceed safe levels, likely due to the use of magnesium-based fertilizers. This can inhibit crop growth over time and Overuse of magnesium-containing fertilizers can elevate groundwater magnesium levels.

3.1.6 Chloride: The sample no 5 shows lesser chlorine content indicates that GW channels could come in contact with the areas having higher concentrations of chloride or may interact with geological formations layer that is rich in chloride faster. Similarly, the sample no 9 shows the higher chlorine it could be due to discharge of the effluent from sources such as industrial discharges, agricultural runoff containing fertilizers with the higher concentration of the chlorides.

3.2 Detection of heavy metals in the collected samples: Heavy metals can leach from soil into groundwater when effluents containing them are applied to fields during irrigation or from industrial activities. These metals can accumulate in soil over time, eventually seeping into the water table, which leads to contamination. Certain metals like chromium can stimulate microbial activity at low levels, as stated from analysis, but excessive levels of any heavy metal will reduce microbial diversity and activity, thus harming soil fertility.

The presence of chromium in groundwater is shown in fig 3.9, especially the which is in toxic hexavalent form (Cr VI), can pose serious health risks, including cancer and organ damage, as it easily migrates through soil into aquifers. Even at low levels, Cr contamination can spread, threatening water supplies, while trivalent chromium (Cr III) is less harmful but may still disrupt soil and plant systems if concentrations rise.

Table 3.1: Table of obtained results of various parameters by laboratory analysis.

Slno.	pH	Alkalinity In Mg/L.	EC In µs/CM.	Chloride in Mg/L.	Temporary Hardness in Mg/L.	Calcium Hardness in Mg/L.	Magnesium Hardness in Mg/L.
1.	7.86	287	970	148	343	90	60.2
2.	7.4	396	1580	355.8	336	83	61.7
3.	7.74	454	758	157.95	194	36	26.3
4.	7.91	499	759	158	374	49	78
5.	7.5	467	374	59.98	382	85	71.2
6.	7.73	334	997	441.91	406	94	69
7.	7.87	266	1400	309.9	336	83	61.7
8.	8	144	1300	329.9	256	61	39.6
9.	7.47	334	1350	521.8	340	82	61.6
10.	8.2	278	1490	281.91	228	63.8	45.8
11.	7.95	304	789	241.36	305	53	60.4
12.	7.93	298	985	292.48	256	67	45.3
13.	7.8	309	719	281.9	310	79	55.4
14.	7.79	444	1800	329.9	598	70.5	128
15.	7.82	412	1300	356	387	89.5	71.4
16.	7.87	460	856	297.5	248	66.2	43.6
17.	7.80	504	934	308.5	307	55	60.4

Table 3.2 - Table of results obtained for of various heavy metals for water quality.

Sample no	Location number	Cadmium	Chromium	Lead	Nickel
1	1	00	0.046	00	00
2	4	00	0.043	00	00
3	6	00	0.034	00	00
4	9	00	0.030	00	00
5	11	00	0.026	00	00

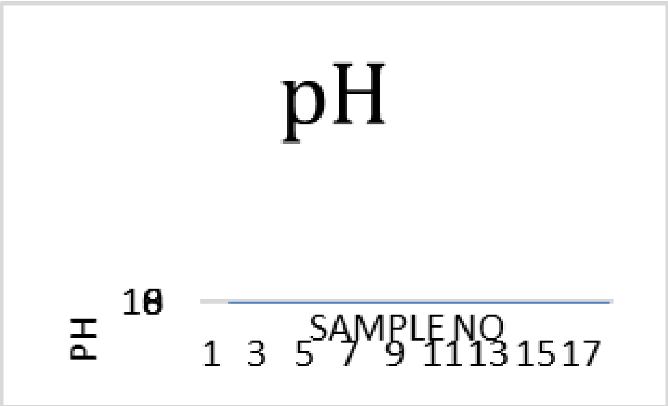

Figure 3.1: pH of the water samples.

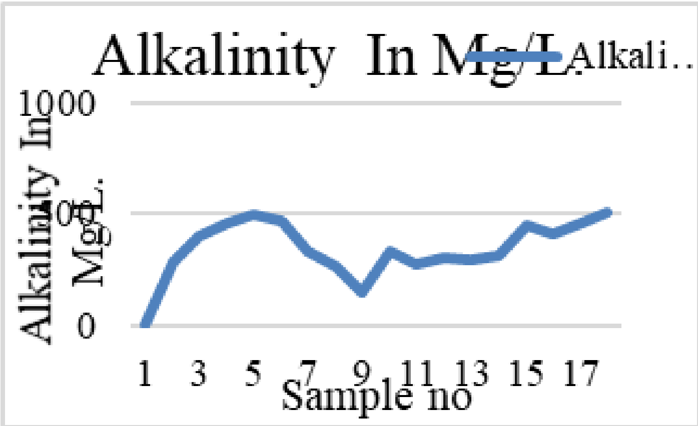

Figure 3.2: Alkalinity of the water samples.

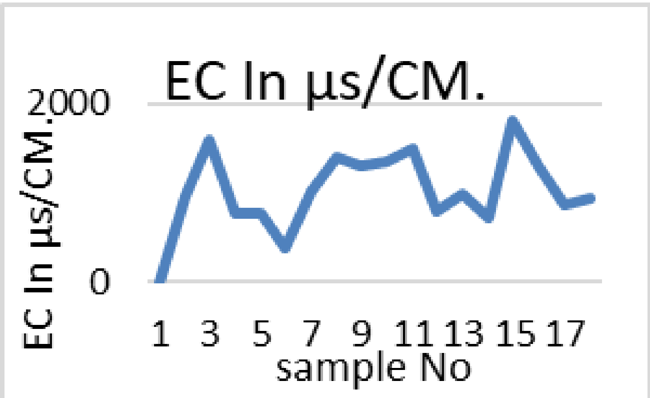

Figure 3.3: EC In µs/CM. of the water samples.

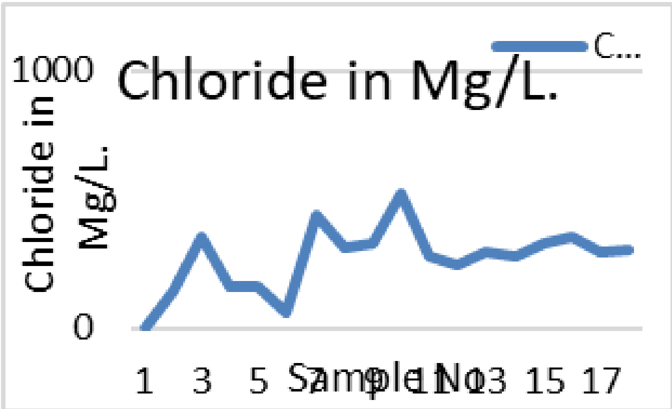

Fig: 3.6: Chloride of the collected samples

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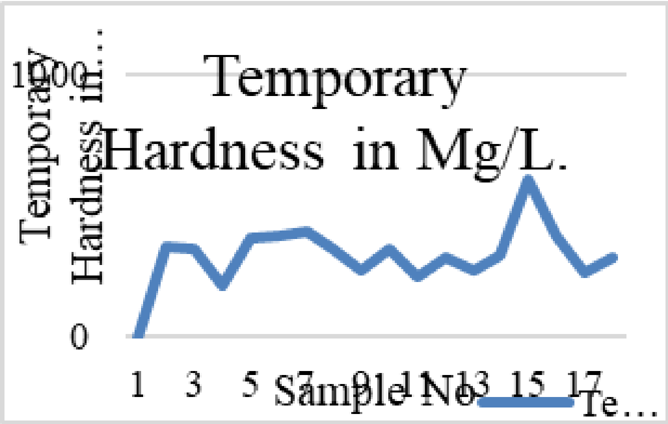


Figure 3.7: Temporary Hardness of the water samples

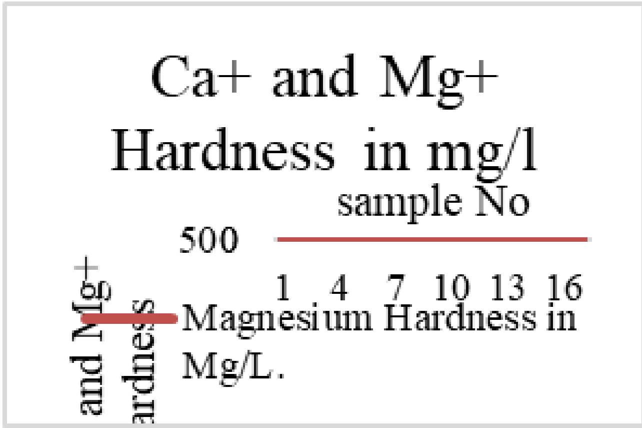


Figure 3.8: Ca^{+} and Mg^{+} of the water sample

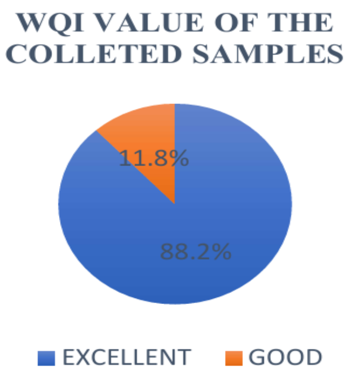
3.3 CALCULATION OF WATER QUALITY INDEX (WQI):

The WAWQI method has been chosen for this study because of its advantages over alternative approaches. In particular, this method involves in providing a several water quality parameters into a mathematical equation that rates the health of a water body using the WQI and describes if surface and ground water sources are suitable for human consumption. Which follows the five steps.

1. The water quality index analysis is determined by the formula:

$$\mathbf{WQI=\sum WiQi/ \sum wi} \quad (1)$$

2. Calculate the value of K by doing the summation of the relative values provided by BIS.
3. Determine the value of Wi by multiplying the K values and the relative values Si. (Wi=k*Si) (2)
4. With the help of the observed values (Vi), calculate the value of the Qi=100*Vi-Vo/Si-Vo. (3)
5. Finally, by substituting values Wi, Qi in the equation 1 determine of value of WQI.



The pie chart based on the Water Quality Index (WQI) results, showing that 88.2% of the samples fall under the "Excellent" category, while 11.8% are classified as "Good." As "Excellent" water quality indicates minimal contamination, meaning the groundwater is suitable for drinking and other uses without significant treatment. It implies that factors like dissolved oxygen, nutrients, pH levels, and the absence of harmful contaminants are within acceptable limits. Groundwater with excellent quality will support healthy ecosystems, agricultural uses, and human consumption.

Conclusion

The study highlights the main aspects that regarding the variation of the physiochemical parameters and the practice of irrigation with highly alkaline water dueto the penetration of the can water and effluent released from STP to groundwater canlead to the retardation of crop growth and yield and increase the economic problems tofarmers. The WQI the samples have the groundwater of the area is caused 99% of the samples to be classified as poor, a sizable percentage of 1% of samples were classified as extremely poor. Stressing the need of quick and effective management and planning to deal with pollution problems and suitable for irrigation the study found that EC and TDS, Turbidity chloride values of the collected samples were near to permissible limit so thatthe WWTP realizing the effluent should be treated well before it is discharged into thecanal or storage tank.

Authors bibliography:

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