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A Study on Effect of the Treated Effluent on Groundwater in and Around STP, Shivanagara, Davanagere

Kalpana B.[1]; Dr. D. P. Nagarajappa[2]; Bhagyashree H N[3]; Dr. P Shiva Keshava Kumar[4]
P. G. Student[1]; Professor[2,4]; Research Scholar[3];
Department of Studies in Civil Engineering,
University B D T College of Engineering, Davangere,
Visvesvaraya Technological University, Belagavi, Karnataka, India

Abstract:- The adverse activities implemented at the municipal sewage treatment plant and the anthropogenic activities of human beings are adversely affecting top layer soil and groundwater quality. This paper discusses about the effect of treated effluent on groundwater quality around STP, Shivanagara, Davangere. The analyzed samples were collected at 17 different locations and carried out to analysis of the physico-chemical properties later the obtained results were discussed by comparing it with the permissible limit of water standards published by the Bureau of Indian Standards and provides the reason for effect of effluent percolation into groundwater. However, the WQI analysis has revealed that about the 99% of the samples are classified as good and 1% of the water was poor and indicates that treatment processes implemented at the STP is insufficient in an order to avoid the contamination of the groundwater and advises that the sewage treatment plant facility must enhance the treatment of effluent before discharging it to the open field, canal, storage tanks.

Keywords:- *Sewage Treatment Plant, Groundwater, Anthropogenic Activities, Effluent, Physico-Chemical Properties.*

I. INTRODUCTION

Water is an auspicious gift from nature to all living things and is necessary for both modern industrial processes and human usage.[2] The mineral concentration of the region will determine the groundwater quality since it affects the aquifer composition, the infiltration process, and the rock-water interaction system.[3]

➢ *Overview*

Effluent discharge is one of the most significant and difficult environmental issues in emerging nations. Due to the rapid population growth and activities, industrialization, municipal wastewater, and effluent releases, numerous viruses and other pathogens have contaminated both surface water and groundwater in recent years [1]. These pathogens are accompanied by harmful organic and inorganic pollutants. Such effluent water contains a variety of compounds, including nitrates, different salts, and possible pesticide residues, all of which are often expected in farmed and irrigated farming [6].

When water sources, such as groundwater, become contaminated by pollutants (like chemicals, heavy metals, or pathogens), it can severely affect the quality of drinking water and the overall ecosystem. Monitoring and analyzing the grade of water—often through methods like chemical analysis, physical testing, and microbiological assessments becomes an important concern in saturated zone water studies.[5]

In the areas of Doddabudihal, Chikkabudihal, and B Kalpanahalli, groundwater serves as a vital source of water for local communities. However, the quality of this groundwater is reported to be close to permissible limits. This study shows a detailed analysis of the groundwater's physico-chemical characteristics. The study indicates that the discharge of treated effluent for irrigation purposes may have an adverse effect on the groundwater quality and could pose a significant risk to nearby areas that rely on these water sources for drinking and domestic use, especially those in proximity to sewage treatment plants (STPs) and receiving water bodies.

II. MATERIALS AND METHODOLOGY

The present study focuses on the sewage treatment plant (STP) located at Shivanagara, Davanagere, and the surrounding residential areas of Doddabudihal, Chikkabudihal, and B Kalpanahalli. The STP, with a treatment capacity of 20 MLD, is designed to handle the wastewater generated from the town. It is situated at a latitude of 14.4637° N and longitude of 75.9213° E. The treated effluent from the STP is discharged into open fields around the plant and is utilized for irrigation, as well as various industrial activities such as cleaning and melting.

The study used an analytical approach to assess groundwater quality around the STP. A total of 17 groundwater samples were obtained from bore wells ranging in depth from 250 to 350 feet. The samples were collected in pre-cleaned 2-liter water bottles that had been rinsed with tap water to prevent contamination. The samples were subsequently taken to the lab for analysis.

Water quality parameters were assessed using conventional techniques, and the results were compared to the Bureau of Indian Standards (BIS) recommendations for water quality, with an emphasis on suitability for irrigation and potable use.

Table 1: The Study Areas Located Near STP.

Sl no	Area	Distance from the STP in kilometer's	Latitude	Longitude
1	Chikkabudihal	2	14.43	75.90
2	Doddabudihal	1.8	14.50	75.94
3	B Kalpanahalli	1.5	14.46	75.92

Source: Davanagere City Sewage and Sanitation Scheme Google Earth Maps

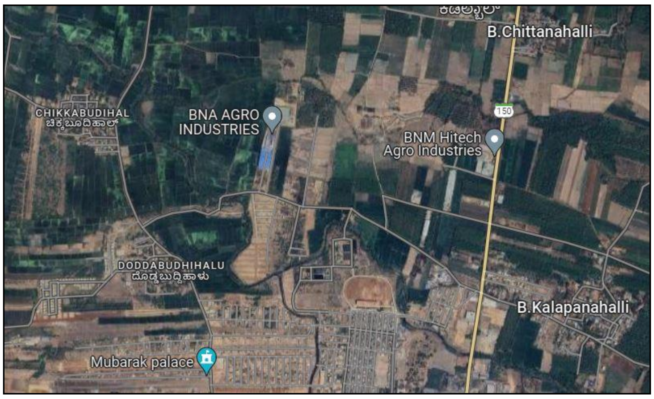

Fig 1: Study area used for the Collection of Samples

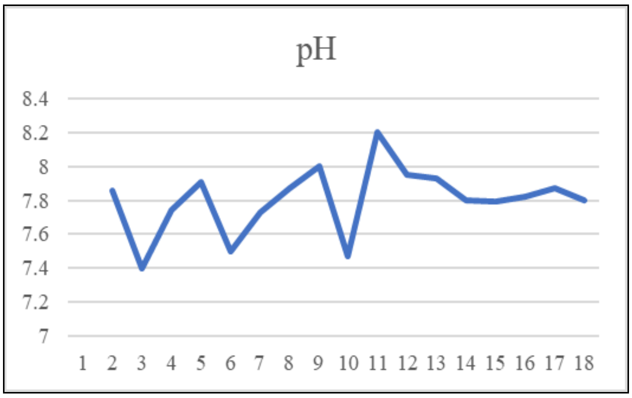

Fig 2: Variation of pH in Collected Water Samples

III. RESULTS AND DISCUSSION

➢ *Physicochemical Characteristics of Water Samples:*

This study evaluated several physicochemical parameters of groundwater samples collected from various locations. Key parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), hardness, and chlorine concentration are summarized in Table 1. These values were compared with the permissible limits set by the Bureau of Indian Standards (BIS, 2012). The results reveal significant variations in groundwater quality across the different sampling sites.

The treated sewage water sample collected at the discharge point showed elevated levels of both organic and inorganic contaminants, indicating that the sewage treatment process was insufficient. This incomplete treatment may pose risks to the local ecosystem, potentially impacting both soil and water quality.

- **pH:** The pH values of collected samples ranged from 7.4 to 8.0, with a minimum detected at Location 2 (pH = 7.4) and a maximum at Location 8 (pH = 8.0). These values indicate a slightly alkaline nature of the water, which is typical for groundwater in contact with geological formations rich in carbonate minerals. However, a pH values are above the permissible limits near the sewage treatment plant (STP) suggests potential contamination from treatment processes. Elevated pH can lead to the precipitation of calcium and magnesium ions, thereby reducing nutrient availability and altering metal solubility, thus impacting aquatic ecosystems and plant nutrient balance.

- **Alkalinity:** Alkalinity of the samples varied from 144 mg/L at Location 8 to 504 mg/L at Location 17. These values are within the acceptable limits prescribed by Indian standards (200–600 mg/L). However, high alkalinity levels in some locations could lead to corrosion of irrigation equipment and the need for water treatment to bring alkalinity to acceptable levels. Elevated alkalinity may result from the dissolution of carbonate and phosphate minerals in groundwater, influenced by geological formations. Variation of alkalinity may result from the dissolution of carbonate and phosphate minerals in groundwater, influenced by geological formations.

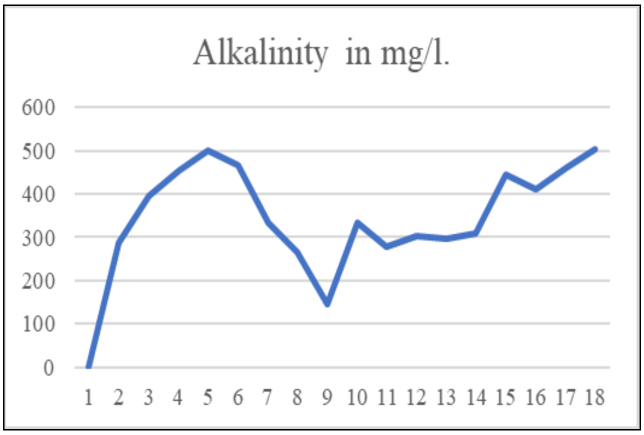

Fig 3: Alkalinity of the Water Samples

- **Electrical Conductivity:** The EC values ranged from 374 µS/cm (Location 5) to 1800 µS/cm (Location 14) reflects the salt content in the water. High EC values, especially at Location 14, indicates that the dissolved mineral content, likely due to industrial discharge and

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agricultural runoff. The lower values indicate purer water with minimal dissolved salts, while higher values indicate more mineral-laden water due to industrial and agricultural activities. EC can negatively affect both drinking water quality and crop productivity by salinizing soil, reducing the availability of essential nutrients.

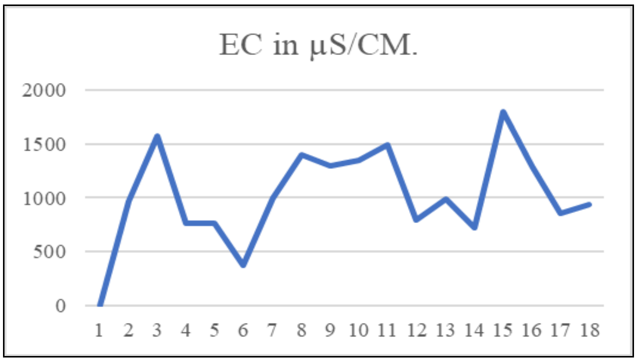

Fig 4: EC in the Collected Water Samples

- **Turbidity:** Turbidity provides information of water clarity, Turbidity values ranged from 0.35 NTU at Location 4 to 12.4 NTU at Location 2. The higher turbidity indicating poor quality due to suspended particles, due to industrial runoff, indicate suspended solids in the water that can affect light penetration, aquatic life. The lowest turbidity (0.35 NTU) indicates clear water, which can be improved further by disinfection, suitable for drinking and irrigation after simple treatment.

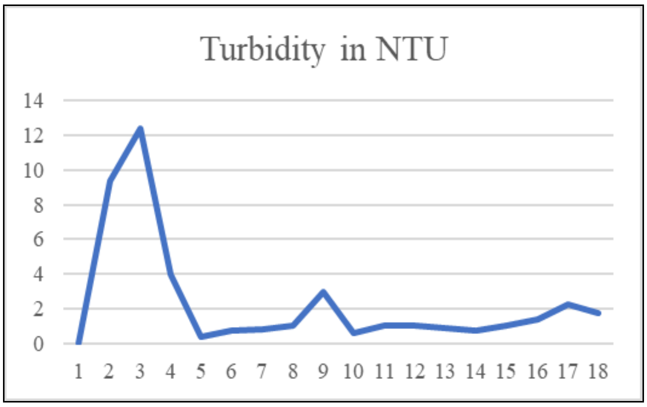

Fig 5: Turbidity: in the Collected Water Samples

- **Total Dissolved Solids (TDS):** Total Dissolved Solids (TDS) analysis shows values as the highest recorded as 1440 mg/L. Lower TDS values, like 80 mg/L at location 12, indicate low mineral content, which is likely due to rainwater recharge. High TDS at Location 14 suggests possible contamination from industrial and agricultural activities. However, can lead to soil salinity issues, affecting nutrient availability for crops.

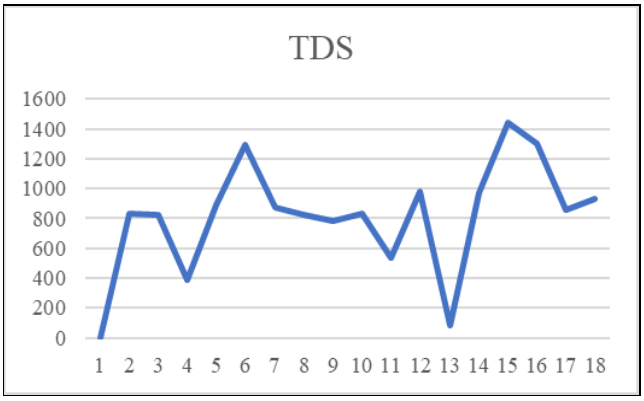

Fig 6: TDS in the Collected Water Samples

- **Hardness:** Hardness is determined by the concentration of calcium and magnesium in the water. The hardness is influenced by the time take for the interaction of the water and its surrounding minerals. Total hardness varies significantly, from 230 to 668 mg/L as CaCO3. Hard water, particularly at 668 mg/L (sample 14), can cause corrosion in pipes and equipment, High hardness levels can affect irrigation systems and increase the need for water treatment. while softer water (230 mg/L) may cause less scaling.

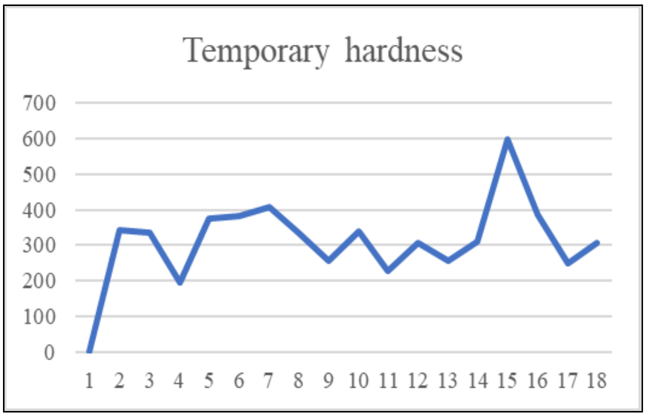

Fig 7: Hardness of the Water Samples

- **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.

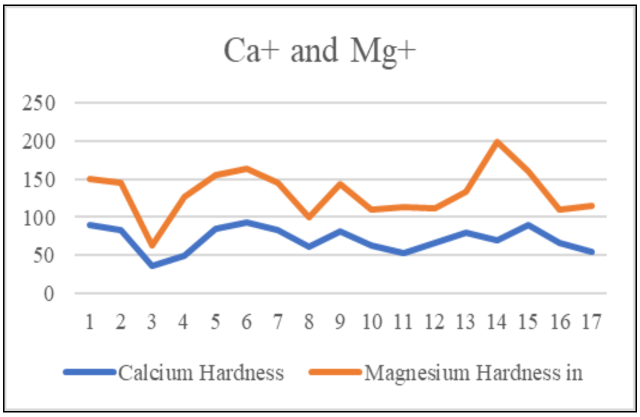

Fig 8: Ca+, Mg+ Hardness of the Samples

- **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 content it could be due to discharge of the effluent from sources such as industrial discharges, agricultural runoff containing fertilizers represents that the water sources are being filled with the higher concentration of the chlorides and interaction with the surface water having the high salinity levels.

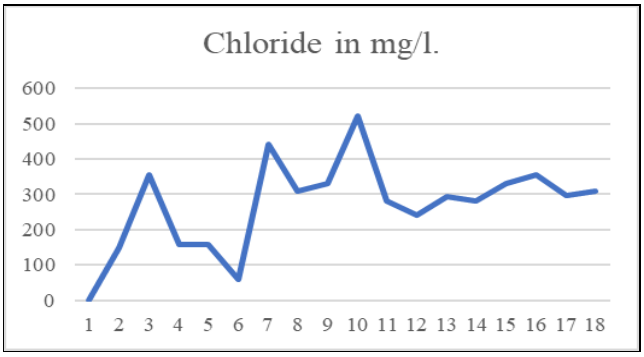

Fig 9: Chloride Concentration of the Collected of the Samples

➢ *Water Quality Index (WQI) Analysis.*

WQI is an essential tool for assigning quality of water and it involves in integrating all the parameters while comparing it with the standard values recommended by the BIS standards to safe guide the human health. The WQI helps in employing the unique weightage to the water to represent its purity in a single number by considering the combined influence of each water quality attribute or parameter. It helps in indicating the quality of water by a unit less value readily communicated to the common localities and the other authorized organizations.

WQI for the collected samples is determined by using the WAWQI method which is used for the measurement of quality of the water parameters (pH, TA, EC, TDS, Cl-, Hardness, Ca+, Mg+) and it is determined by the formula:

$$WAWQI = \sum WiQi / \sum wi \qquad \text{Eq-(1)}$$

Were, Wi is a factor which measures the importance of a parameter in the calculation of the WQI index (relative weight), i represents the No. of parameters taken into consideration, qi is determined by applying formula.

$$Qi = 100 * vi - vo / si - vo \qquad \text{Eq-(2)}$$

Were, vi- represents the value experimentally determined, V0 represents the ideal value of that parameter; Si represents the standard, legally accepted, value for the water category in which the water sample was included. qi is calculated by applying formula.

$$wi = k * si \qquad \text{Eq-(3)}$$

K is a constant which is evaluated by using the standard values.

$$k = 1 (\sum 1/si) \qquad \text{Eq-(4).}$$

Substituting values of equation 2,3,4 and in equation 1 to determine the value of the WQI of the sample by comparing it with water quality range standard provided by the WAWQI and determining the quality of the sample from the table below.

According to analysis the data, the WQI values observed are ranging from 25.93 to 54.23. But one samples are rated as Good, with the exception of one that is rated as Poor. Generally, the WQI scale being used determines whether the water quality is Good or Poor. The higher WQI values at the location were primarily caused by the excess amount of the EC, TDS, TH, CL- and other substances. A pie chart (Fig. 10) depicting the percentage of each category is produced from the distribution of water samples based on the various classes of the WQI values.

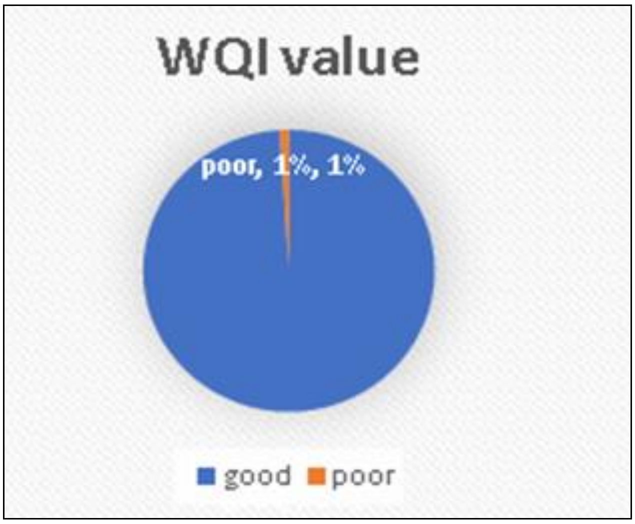

Fig 10: Graphical Representation of WQI Value of the Collected Samples

➢ *Correlation Analysis of the Collated Samples.*

Correlation analysis is carried out for the determination of the relationship between the parameters used for the water quality analysis and interpolation between the parameters. There is frequently a positive correlation between irrigation water use and crop yields. Analysing this correlation aids in optimising water use for maximum productivity in agriculture. Correlating groundwater recharge rates with surface water levels can provides knowledge about how groundwater and surface water systems interact. Steps involved in the correlation Analysis by using the 2 variables.

- Step 1: calculate the mean of the X parameter and square it.
- Step 2: calculate the mean of the Y parameter and square it.
- Step 3: calculate the product of the XY parameter and square it.
- Step 4: Then the substitute obtained values into the Pearson Correlation Formula. Solve it to find the correlation coefficient.

$$r = n\sum(XY) - (\sum X)(\sum Y)/\surd[n\sum(x\ 2) - (\sum(X)2] * [n\sum(Y2) - \sum(Y)2]$$

Where, n is the No. of data points, ∑X=sum X, ∑X is the sum of pH values, ∑Y=sum Y, ∑Y is the sum of parameters. In this case, r is theoretically capped at ±1. The above result suggests an error in calculations, potentially due to arithmetic or rounding. Typically, results are within ±1.

- r = 1: Strong positive correlation.
- r =-1: Strong negative correlation.
- r = 0: No linear correlation.

For a full correlation matrix, we should repeat the above procedure for the all the pair of variables.

Table 2: Correlation Matrix of all the Parameters

	pH	TA	EC	TDS	TR	Cl^-	TH	Ca+	Mg+
pH	1								
TA	0.35	1							
EC	-0.42	0.54	1						
TDS	-0.38	0.5	.92	1					
TR	0.12	-0.07	.21	.18	1				
Cl^-	0.21	0.41	.63	.57	-.03	1			
TH	-0.15	0.34	.54	.49	.09	0.48	1		
Ca+	-0.18	0.28	.58	.54	0.1	0.51	0.82	1	
Mg+	-0.20	0.18	.46	.42	.07	0.39	0.71	0.62	1

Correlation analysis revealed several important relationships between water parameters. There was a strong positive correlation between TDS and EC (0.92), suggesting that dissolved solids contribute significantly to the electrical conductivity of the water. A moderate correlation between chloride and EC (0.63) indicates that chloride levels are linked to the mineral content in the water, possibly from industrial and agricultural sources.

➢ *The Correlation Analysis Between Different Parameters Shows that:*

- pH and Alkalinity: A positive correlation (0.35) suggests that higher alkalinity buffers pH changes, maintaining a stable pH.
- EC and TDS: A strong positive correlation (0.92) shows that higher conductivity indicates more dissolved solids in the water.
- Chloride and EC: A positive correlation (0.63) suggests that higher chloride content increases electrical conductivity due to the presence of salts.

The correlation analysis can guide water management strategies, such as reducing industrial runoff and monitoring agricultural practices to prevent excess salt accumulation.

IV. CONCLUSION

The study highlights the main aspects that regarding the variation of the physiochemical parameters and the practice of irrigation with highly alkaline water due to the penetration of the can water and effluent released from STP to groundwater can lead to the retardation of crop growth and yield and increase the economic problems to farmers.

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 that the WWTP realizing the effluent should be treated well before it is discharged into the canal or storage tank.

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