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Groundwater Quality Assessment of Vadlipada Village of Kushalgarh Block in Banswara District (Rajasthan) India and it's Suitability for Potable Purposes

Purva Vohra[1], Ashok Kumar Kakodia[2], Shiv Lal[3] and Kumud Tanwar[4]*

1. Govind Guru Tribal University, Banswara, Rajasthan, **INDIA**
2. Department of Chemistry, Government College, Rajgarh, Alwar, Rajasthan, **INDIA**
3. Rajasthan Technical University, Kota, Rajasthan, **INDIA**
4. Kanoria P.G Mahilla Mahavidyalaya, Jaipur, Rajasthan, **INDIA**

Email: sl@rtu.ac.in, tanwar.kumud@gmail.com

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ABSTRACT

The Vadlipada village faces acute water shortage in summer due to the drying of open wells, rivers and is depended mainly on the groundwater for their daily requirements. The groundwater pollution sources in this area are open defecation, domestic effluents, discharge of sewage, septic tanks, soak pits, dumping of solid waste and use of pesticides and fertilizers in agriculture. Hence, regular monitoring and assessment of the quality of the groundwater resources of this region is quite necessary. Following physicochemical parameters were analyzed in the present investigation to determine the quality of groundwater samples collected during assessment year from April 2022 to March 2023 from the selected hand pump of the village: temperature, pH, turbidity, total dissolved solid, total alkalinity, total hardness, chloride, fluoride and nitrate. The present study is carried out the groundwater quality assessment of village Vadlipada of Kushalgarh block in Banswara district, Rajasthan, India.

Graphical Abstract:

Assessment of Fluoride in groundwater of Vadlipada village.

Keywords: Groundwater, Quality assessment, Fluoride, Physicochemical Parameters.

INTRODUCTION

Groundwater is the most commonly utilized natural resource which fulfills the demand of public water supplies worldwide as it is more convenient, cheaper, easily available and less vulnerable to contamination than surface water. It is necessary to save and recover the available water sources from pollution and the water treatment processes may help in the improvement of the groundwater quality to make it suitable and appropriate for its utilization specifically [1]. India is the largest country of the world in terms of population. Fast growing population demands high quantity of resources including clean drinking water. Due to the scarcity and unavailability of clean surface water in most part of the year, groundwater is mainly used for drinking, household and agricultural purposes in many rural areas of India. Contamination of groundwater also depends on the geology of the region. The changes in excellence of groundwater reply to difference in physical, chemical and biological environments throughout which it passes [2]. In 14 states of India, *viz.* Andhra Pradesh, Bihar, Gujarat, Maharashtra, Rajasthan, Haryana, Kerala, Orrisa, Madhya Pradesh, Punjab, Karnataka, Uttar Pradesh, West Bengal and Tamil Nadu, the concentration of fluoride found beyond the permissible limit of 1.5 mg L^{-1}. According to some other studies, 65% towns in India are suffered from fluoride issues [3]. Defluoridation of such fluoride containing water is most correct way to overcome this issue [4]. Not only fluoride, but other physicochemical parameters in higher concentration can be hazardous to human health and arises many health-related problem. To root out this problem, time to time inspection of quality status of groundwater is mandatory especially in villages because people of villages are mainly dependent on groundwater for their daily needs [5].There is no research work done in Kushalgarh block regarding the groundwater quality assessment and its suitability for human consumption. Hence, the present work will help to determine the quality status of groundwater in rural areas of Kushalgarh block.

MATERIALS AND METHODS

Study Area: Rajasthan is awarded with pride, the largest state of India, but it has very limited and minimum water resources due to its anomalous geographical conditions. The major source of recharge to groundwater in the state is rainfall, but it is much lower as compared to the other parts of the country. Because of the arid conditions of Rajasthan, a considerable amount of total rainfall is consumed for making the soil moisture and also lost due to evaporation. Thus, groundwater plays a significant role in rural areas of Rajasthan as important drinking water source. Banswara district is situated in the southernmost part of Rajasthan. Kushalgarh is situated at the southern part of Banswara district. The only means of irrigation in this block is groundwater. In rural areas of the block the groundwater is the primary natural resource for drinking and irrigation purposes. The present study was carried out in the Vadlipada village of Kushalgarh block.

Figure 1. Sample Station Photo and Location map of Study village Vadlipada.

Sample Collection: The groundwater samples from identified hand pumps, which are functionally active and extensively used by the local population living there, for drinking and other household purposes, were collected during April-2022 to March-2023 on monthly basis. The collected samples were then analyzed for the following physicochemical parameters: temperature, pH, turbidity, total alkalinity, total hardness, total dissolved solids (TDS), chloride, fluoride andnitrate. The collected groundwater samples were compared with standard values laid by Bureau of Indian Standard (BIS) IS 10500:2012 [6]. The water quality index (WQI) and Aggressive Index (AI) was calculated from data obtained.

RESULTS AND DISCUSSION

Groundwater samples of Vadlipada village collected from April 2022 to March 2023 and analyzed for different physicochemical parameters. The observed data of selected parameters shown in the table 1.

Table 1. Groundwater testing data of Vadlipada village

Month / Parameter	Limit as BIS Standard IS 10500:2012	Apr 2022	May 2022	Jun 2022	Jul 2022	Aug 2022	Sep 2022	Oct 2022	Nov 2022	Dec 2022	Jan 2023	Feb 2023	Mar 2023
Temp.	(°C)	27.6	27.5	28.6	27.3	28.5	29.5	27.8	27.8	27.0	26.0	26.0	27.0
Turbidity	1.0-5.0 NTU	0	0	0	0	0	0	0	0	0	0	0	0
pH	6.5-8.5	7.4	8.2	9.1	7.8	8.6	7.7	9.2	8.3	8.8	7.8	7.6	8.1
Total Alkalinity	200-600 mg L^{-1}	390	410	400	340	230	280	220	150	260	200	190	150
Total Hardness	200-600 mg L^{-1}	260	120	100	150	100	270	80	40	40	40	40	120
TDS	500-2000 mg L^{-1}	875	648	643	430	370	754	258	213	289	290	291	307
Chloride	250-1000 mg L^{-1}	90	70	70	40	40	50	30	20	30	30	30	40
Fluoride	1.0-1.5 mg L^{-1}	2.8	5.9	5.3	3.9	2.6	2.0	5.2	4.1	8.5	7.1	6.7	6.7
Nitrate	45-45 mg L^{-1}	10	2	3	5	5	10	2	2	2	5	5	15

The acceptable limit of turbidity is 1 NTU and the permissible limit is 5 NTU as per IS:10500-2012. The values of turbidity were found zero in all the months from April 2022 to March 2023. This shows that all the samples of groundwater collected from sample station were clear and no turbidity was found. There were no suspended particles present in the collected samples of groundwater which causes the turbidity in water.

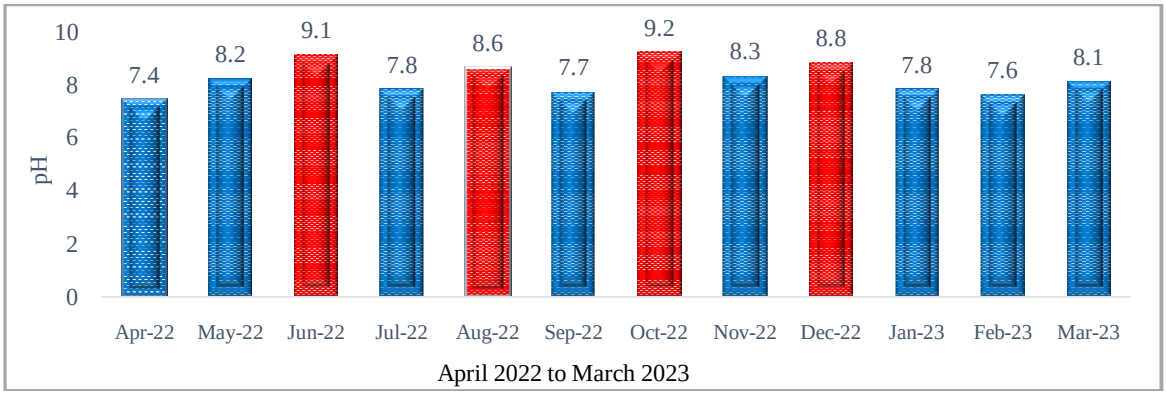

Figure 2. Assessment of pH in ground water of Vadlipada village.

pH: Figure shows the variation of pH values during April 2022 to March 2023 in graphical pattern. In the June 2022, August 2022, October 2022 and December 2022 the pH value for ground water sample of the village crosses permissible limit i.e., 8.5 as per IS 10500: 2012 and rest other months in entire assessment period the pH value for ground water sample of the village were within the IS10500:2012 permissible limit.

Alkalinity: The maximum total alkalinity 410 mg $L^{-1}$was observed in the month of May 2022 and the minimum total alkalinity was 150 mg L^{-1}observed in the month of November-2022 and March 2023. The total alkalinity values for ground water of the village were within the IS10500:2012permissible limit in entire assessment period.

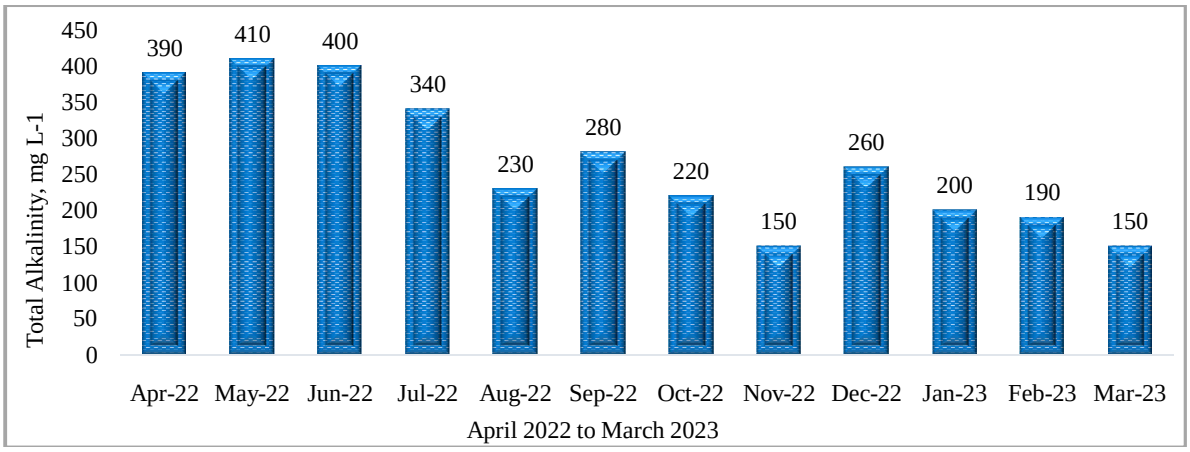

Figure 3. Assessment of Total Alkalinity in groundwater of Vadlipada village.

Total Hardness: The maximum value of total hardness 270 mg $L^{-1}$was observed in the month of September 2022 and the minimum value of total hardness 40 mg $L^{-1}$was observed in the month of November-2022 to February 2023. The total hardness values for groundwater sample of the village were within the IS10500:2012 permissible limit in entire assessment period of April 2022 to March 2023.

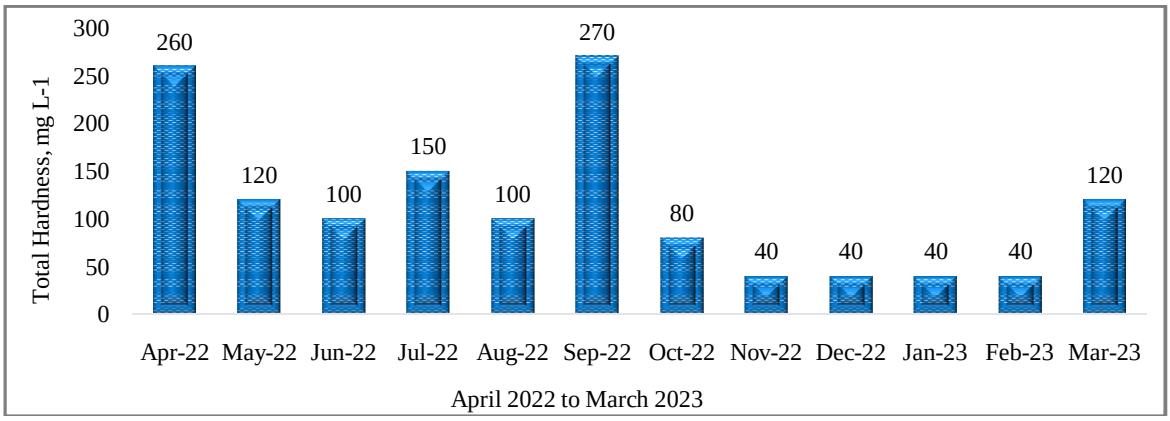

Figure 4. Assessment of Total Hardness in groundwater of Vadlipada village.

TDS: The maximum value of TDS was 875 mg L^{-1}which was observed in the month of April 2022 and the minimum value was 213 mg L^{-1}which was observed in the month of November-2022. The TDS values for ground water of the village are within the IS 10500:2012 permissible limit in entire assessment period of April 2022 to March 2023.

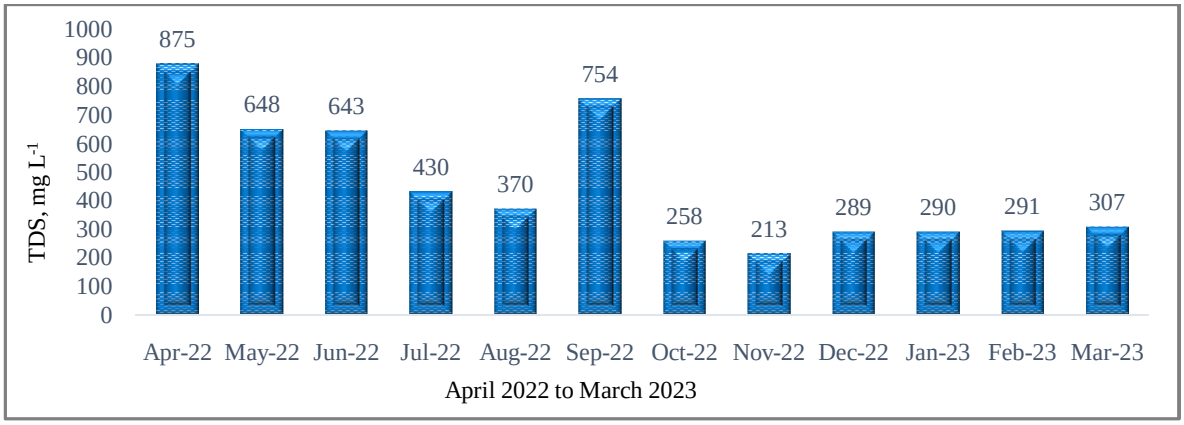

Figure 5. Assessment of Total Dissolve Solid in groundwater of Vadlipada village.

Chloride: The maximum chloride concentration was 90 mg L^{-1}observed in the month of April 2022 and the minimum chloride concentration was 20 mg L^{-1}observed in the month of November-2022. The chloride concentration values for groundwater of thevillage were within the IS 10500:2012 permissible limit in entire assessment period of April 2022 to March 2023.

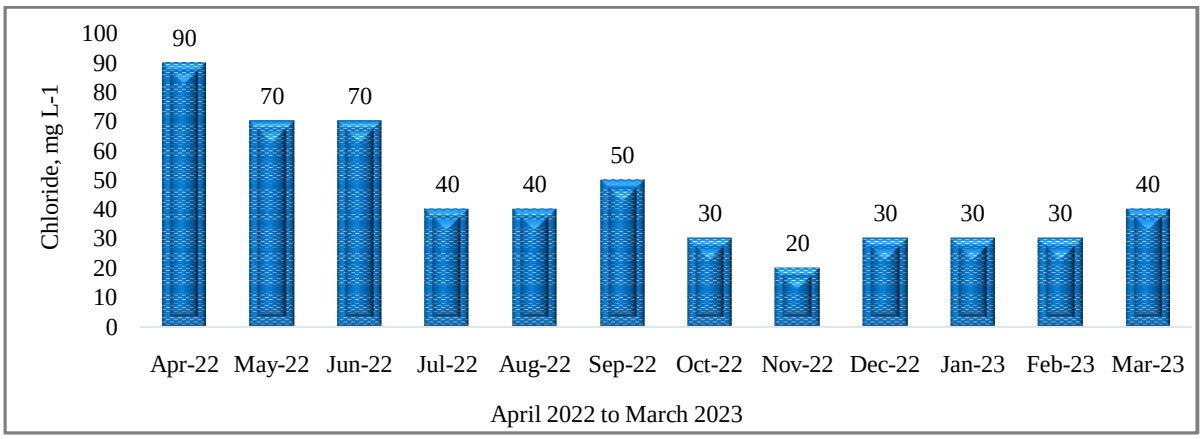

Figure 6. Assessment of Chloride in groundwater of Vadlipada village.

Fluoride: The maximum fluoride concentration was 8.5 mg L^{-1}observed in the month of January 2023 and the minimum fluoride concentration was 2 mg L^{-1}observed in the month of September 2022. The fluoride concentration values for groundwater sample of the village were beyond IS10500:2012 permissible limit in entire assessment period of April 2022 to March 2023.

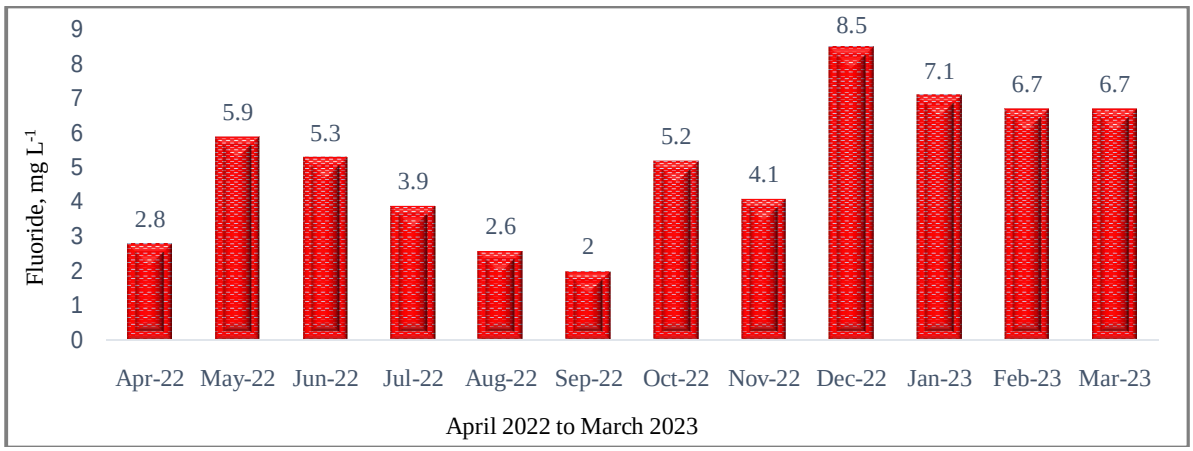

Figure 7. Assessment of Fluoride in groundwater of Vadlipada village.

Nitrate: The maximum nitrate concentration was 15 mg L^{-1}observed in the month of March 2023 and the minimum nitrate concentration was 2 mg L^{-1}observed in the month of May 2022 and October to December 2022. The nitrate concentration values for ground water sample of the village were as per IS10500:2012 acceptable limit of 45 mg L^{-1}in entire assessment year.

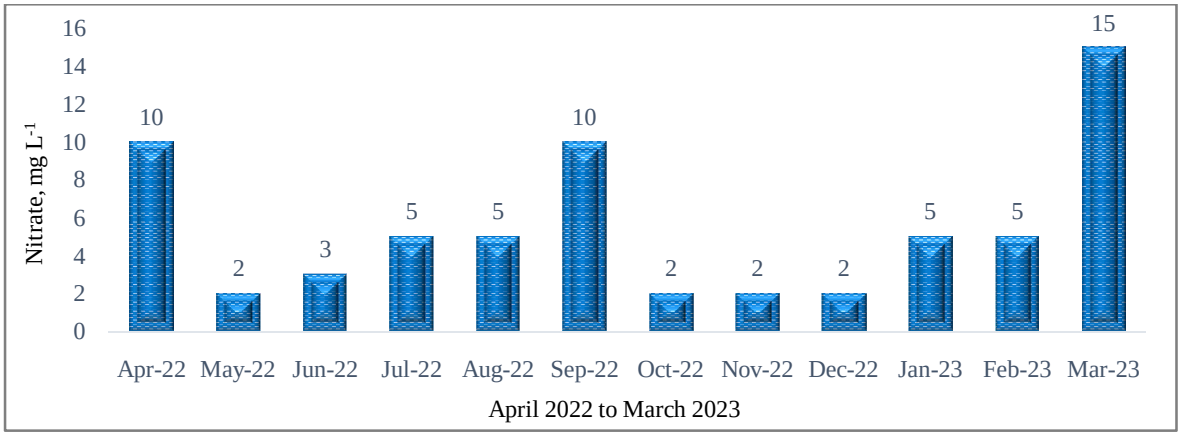

Figure 8. Assessment of Nitrate in groundwater of Vadlipada village.

Water Quality Index (WQI): WQI is the most effective and well-known technique to describe all physicochemical parameters as a single component to express groundwater quality and its suitability for human consumption. WQI of samples of the study village was calculated by weighted index method [7] and the water quality classification is given in the table 2 [8].

Table 2. Water quality classification based on WQI value

WQI Value	Water Qulaity	Grading
<50	Excellent	A
50-100	Good Water	B
100-200	Poor Water	C
200-300	Very Poor Water	D
>300	Water Unsafe for drinking	E

The calculated values of WQI and water quality grading of groundwater sample of Vadlipada village during April 2022 to March 2023 are given in table 3.

Table 3. Water Quality Index of Vadlipada village

Month	WQI	Water Quality	Grading
Apr-22	97.94	Good Water	B
May-22	124.39	Poor Water	C
Jun-22	117.56	Poor Water	C
Jul-22	91.94	Good Water	B
Aug-22	69.36	Good Water	B
Sep-22	79.58	Good Water	B
Oct-22	96.58	Good Water	B
Nov-22	76.11	Good Water	B
Dec-22	137.36	Poor Water	C
Jan-23	117.27	Poor Water	C
Feb-23	111.71	Poor Water	C
Mar-23	117.15	Poor Water	C

For the assessment period of April 2022 to March 2023 the measurement of assurance of quality of groundwater as WQI shown in above table which revealed that in the months of Apr 2022 and July 2022 to Nov 2022 the groundwater quality was good but on the other side remaining other month of assessment year the groundwater quality was poor.

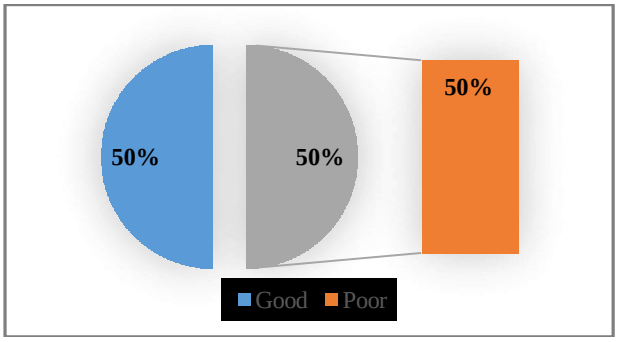

Figure 9. Groundwater quality of Vadlipada village.

The above table and figure show that groundwater quality class of Vadlipada village is overall 50% good and 50% poor. The consumption of poor quality of water possesses sickness and to root out this problem the more suitable way is to use Reverse Osmosis filtration process [**9**].

Aggressive Index (AI): Water storage and water supply affect by corrosivity and scaling property of water. The value of AI determines the corrosive nature of water. If the value of AI is more than 12, the water is non aggressive means non corrosive nature of water [**10**]. The Aggressive index is related to corrosive tendency of water and to be calculated from the pH of water, the total alkalinity and total hardness of water by the given formula [**11**] and AI of Vadlipada village shown in the table 5.

$$AI = pH + \log(A*H)$$

Where A is Total Alkalinity and H is Total Hardness of water.

Table 4. Aggressive index value and class of ground water

AI Value	Class of Water
AI>12	Non-Aggressive/Non-Corrosive
10<AI<12	Moderately Aggressive
AI<10	Very Aggressive / Corrosive

Table 5. A.I. of groundwater of Vadlipada

Month	Village Vadlipada
22-Apr	12.40604
22-May	12.89197
22-Jun	13.70206
22-Jul	12.50757
22-Aug	12.96173
22-Sep	12.57852
22-Oct	13.44551
22-Nov	12.07815
22-Dec	12.81703
23-Jan	11.70309
23-Feb	11.48081
23-Mar	12.35527
Mean Value	**12.57731**

CONCLUSION

In the present study, results of WQI showed that the groundwater quality of the month April 2022, July 2022, August 2022, September 2022, October 2022 and November 2022 was good which is safe for drinking and other household purposes but during the month May 2022, June 2022 and December 2022 to March 2023 the groundwater quality was poor and not suitable for human consumption and

other household uses and need to be treated before use. It is clear from the table 1 that in the whole assessment year i.e., from April 2022 to March 2023 the amount of fluoride found was far above the permissible limit as per IS 10500:2012 range from 2 to 8.5 mg L^{-1}. Higher amount of fluoride was observed in the month of December 2022 which was 8.5 mg $L^{-1}$and least amount of fluoride was observed in September 2022 which was 2.0 mg L^{-1}. Excessive amount of fluoride in drinking water created many health problems among the resident of the village and their domestic animals. Dental and skeletal fluorosis are common health issues found in the Vadlipada village. Intensive use of phosphate fertilizers could be the reason behind the excess of fluoride concentration in groundwater of the village. In the present work, it is clear shown that in each of the month, the fluoride concentration was higher than 1.5 mg L^{-1} in the collected sample of groundwater. The fluoride contamination in groundwater is the major problem in the village.AI of groundwater samples of Vadlipada village were found more than 12 during April 2022 to March 2023. Thus, the water of the village found non-corrosive in nature during the year. The village Vadlipada is tribal area where the majority of people are uneducated and below poverty line. Hence the techniques used for treatment should be cheap, effective, easily understood and operative by people.

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