Groundwater quality assessment and its insinuations in some parts of Aheri taluka dist. - Gadchiroli, Maharashtra.

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Abstract
Aheri tehsil of Gadchiroli district in the Indian state of Maharashtra is located on the bank of the Pranhit River, a side stream of the Godavari River. In the present study, total five villages from Aheri taluka were selected to collect groundwater samples. A total number of 25 samples were collected, where five samples represent each village. This study is concerned with physicochemical parameters mainly electrical conductivity, total dissolved solids, temperature, chloride, fluoride, total hardness, pH, nitrate, alkalinity, iron and turbidity to analyse groundwater quality. Out of 25 samples, eight samples of water were detected to be unfit for consumption. Hence, some remedial measures are suggestible. The study revealed the associations among all physicochemical parameters by correlation coefficient analysis.

1. Introduction
Water is the most basic and essential requirement of life. As per human health, potable water plays a vital role in all health-related issues. In developing countries like India, the availability of pure and safe drinking water is still out of reach for people in some places. In rural areas of India, where water treatment is still unavailable and transportation facility does not exist, about 88% of the consumable and safe drinking water is from groundwater source [1]. Quality of water is responsible for causing and healing health-related problems. Generally, people are not that aware of the quality and purity of water they are drinking. Therefore, it is necessary that water quality testing be done accordingly to avoid health problems. Overall, the water for drinking purpose is mainly the groundwater at most of the places [2]. Groundwater is present beneath the surface in numerous small aquifers and different compartments [3]. Hydrosphere’s hydrochemistry, earth’s solid portion and the geochemistry of lithosphere’s affects quality of groundwater and all these factors mainly control the whole quality of water [4]. Groundwater chemical composition changes because of local lithology, the groundwater flow velocity, residence time and interactions between rock and water [5].

The study area lies in the villages of Aheri tehsil of Gadchiroli district in the Indian state of Maharashtra. The selected sites were Welgur (Latitude 19°31′18″N and Longitude 80° 03′ 38″E), Navegaon (Latitude 19°30′05″N and Longitude 80° 04′ 56″E), Develmari (Latitude 19°18′20″N and Longitude 79° 58′ 27″E), Venkatraopetha (Latitude 19°21′33″N and Longitude 79° 59′ 28″E), Allapali (Latitude 19°26′52″N and Longitude 80° 03′ 19″E). In the present study, total number of twenty-five Groundwater samples had been collected and tested analytically for different parameters mainly electrical conductivity, temperature, total dissolved solids, chloride, fluoride, pH, total hardness, nitrate, alkalinity, iron and turbidity.
2. Material and methods

2.1 Collection of samples

From five villages of Aheri Taluka, namely Welgur, Navegaon, Develmari, Venkatraopetha, Allapali, a total number of 25 samples of groundwater had been collected in April 2021 at morning time. The temperature and pH were observed and recorded at the water collection sites and then brought to the laboratory to investigate various parameters.

2.2. Methodology

After collecting samples, temperature and pH were observed and recorded immediately using a digital thermometer and pH meter. The turbidity of the water sample was noted by using a turbidity meter. With the help of a conductometer and TDS meter, electrical conductivity (EC) and total dissolved solids (TDS) were determined, respectively. EDTA titration method was used to calculate the total hardness of the water sample. Quantitative estimation of nitrate was done by the phenol disulphonic acid method [6,7,8]. Standard laboratory methods estimated chloride, fluoride and iron.

3. Result and Discussion

The data of groundwater samples collected from the five different villages of Aheri taluka are summarized in table no.1.1 and 1.2, which includes the parameters such as temperature, pH, electrical conductivity, total dissolved solids, chloride, fluoride, total hardness, nitrate, alkalinity, iron and turbidity.

3.1 Depiction of Groundwater

3.1.1 Temperature. At higher temperatures, groundwater can dissolve more minerals from the rocks in the surrounding. This results in the higher values of some related parameters like EC and TDS. In the present study, all the parameters show a weak correlation with the temperature.

3.1.2 Turbidity. Estimation of the degree of muddiness or clarity of the water reveals the turbidity. It is also used to measure the optical property, which causes the light scattered and also absorbed by water. In the present work, the correlation value between turbidity and fluoride is 0.5209 which is in the moderate range. All the remaining parameters shows a weak correlation with turbidity. There is no
permanent increase or decrease in turbidity levels due to environment brightness changes rather and only temporary changes could take place [9].

3.1.3 pH. The hydrogen ion concentration of the solution is the measure of pH. According to WHO, the pH range for drinking water between 6.5 to 8.5 is permissible. The water below 6.5 pH value is acidic and corrosive to the hand pumps. Water with a pH value of 8.5 is considered alkaline and may have a bitter taste [10]. In this study, 25 water samples were tested for pH and it was to be mentioned that all the values were under the acceptable limit and the range was between 7.2 to 8.4. In the present work, pH was found to be positively weak correlated with TDS, EC and Nitrate.

3.1.4 Electrical Conductivity (EC). EC values increase due to the high amount of salts in groundwater. EC values also depend upon temperature, types, and ions’ concentration in the water [11]. The correlation value of EC with TDS was found to be 0.9258, which was near about the maximum range. This suggests that the amount of dissolved salts in the water samples was quite more. The moderate range of correlation of EC was observed with alkalinity and TH, which also confirmed the more dissolution of salts in the water. As per WHO, the maximum permissible value for EC is 1000 μS/cm [12]. In the present work, all the samples showed higher values of EC except GW8, GW9, GW10, GW15.

3.1.5 Total dissolved solids (TDS). It is considered that the most important parameter of water to count its quality is TDS. It is affected and directly related to the increased alkalinity, hardness, conductivity and turbidity of water. The acceptable range is 500mg/L and it is suggested that the water with TDS value more than 300 mg/L should not be consumed for drinking purposes. The consumption of high TDS value water for drinking may induce gastrointestinal irritation and some unfavorable physiological reaction [13]. In the present work, it was to mention that maximum samples were not in the consumable range and it is due to more amount of dissolved salts, so it is highly recommended that the water should be well treated before consumption. Here it was noted that TDS was correlated in moderate range with Alkalinity and weakly correlated with TH and Cl.

3.1.6 Alkalinity. The high values of alkalinity of groundwater are mainly because of carbonates and bicarbonates. pH can be stabilized by alkalinity. Many substances in the water can be affected by alkalinity, pH and total hardness. The range between 200 to 600 mg/L for alkalinity is acceptable to consume. All the samples except GW11 were found to be safe for consumption. It was found that alkalinity is negatively correlated with pH (r = -0.1471) F (r = -0.2190), Nitrate (r = -0.1958) and Fe (r = -0.5243)

3.1.7 Chloride ions (Cl). Human-made problems are mainly responsible for the increased concentration of chloride content in water. Sewage water generally gets mixed with the water source, which ultimately leads to increase in the chloride concentration of water. Human-made pollution, improper sewage disposal, solid waste, septic tanks linkages, dumping of animal wastes, etc., are the leading causes of this high chloride concentration in groundwater. The chloride concentration permissible limit for drinking water is between 250 and 1000 mg/L [14]. In the present work, chloride concentration was weakly correlated with all the other parameters.

3.1.8 Fluoride ions (F). The fluoride content of water in proper concentration prevents bone damages and dental cavities. As per the Bureau of Indian Standards, the permissible range for fluoride concentration is between 1-1.5 mg/L. The increased level of fluoride may cause teeth yellowing, bone weakness, dental fluorosis and some other diseases. In the present study, it was observed that fluoride is moderately correlated with turbidity. It was also observed that fluoride weakly correlated with the other parameters.

3.1.9 Nitrate. As per WHO, the permissible nitrate content for drinking water is 45 mg/L. This study observed that the water samples GW3, GW4, GW6, GW21, GW24 exceeded the permissible range. These water samples were found to be unfit for consumption. In this work, nitrate was weakly
correlated with the other parameters. The increase in nitrate level in groundwater is mainly due to natural processes, improper sewage disposal, excessive use of fertilizers, and animal and farm wastes.

3.1.10 Total Hardness (TH). Sulphates, chlorides, carbonates, and bicarbonates are mainly responsible for the high degree of hardness of the drinking water. The permissible range of the total hardness is in between 300 – 600 mg/L as per WHO and ICMR. It was observed that out of twenty-five water samples, only one sample (GW17) was found to be unfit for consumption due to 782 mg/L of total hardness. In the present study, total hardness (TH) was negatively correlated with pH, F and Fe; also, it was positively correlated with all other parameters. TH was found in moderate correlation with EC ($r = 0.5148$).

3.1.11 Iron (Fe). Due to the rain falling on the surface of the land, water drips through iron-bearing rock and soil, and iron gets dissolved in the water. The high concentration of Fe needs to the attribution to pyrite's oxidation which is present in rocks exposed because of mining [15, 16]. The and desirable and permissible value of iron in the water sample is 0.3 mg/L. The high concentration of iron present in water causes a bitter like and astringent taste with inky flavor and turbid nature. The soluble iron in water gives a clear appearance when pumped out and on exposure to air causes the precipitation of iron, resulting in rust like color and appear turbid in nature [17]. The dissolved oxygen is removed by some organic matter, which ultimately produces reduced conditions, and this results in increasing the solubility of Fe-bearing minerals [18]. The reddish-brown precipitate that appeared in the water sample and the vicinity of the tap and hand pumps specifies the presence of iron concentration in the high amount [19]. In the present study, all the samples showed the concentration of Fe in the acceptable range except sample numbers GW8 and GW10, with Fe concentration values as 1.28 and 1.16, respectively.

**Table 1: Physicochemical Parameters of Groundwater samples.**

| Sample | Name of Village | Temp. | Tur (NTU) | pH | EC | TDS (mg/l) | Alkalinity (mg/l) |
|--------|----------------|-------|----------|----|----|------------|-------------------|
| GW1    | Welgur         | 27    | 0.9      | 7.62 | 1015 | 564     | 404              |
| GW2    | Welgur         | 24    | 1.02     | 7.8  | 1298 | 722     | 402              |
| GW3    | Welgur         | 22    | 0.38     | 7.72 | 1192 | 662     | 456              |
| GW4    | Welgur         | 23    | 0.45     | 7.78 | 1412 | 784     | 418              |
| GW5    | Welgur         | 21    | 1.11     | 7.75 | 1184 | 658     | 370              |
| GW6    | Navegaon       | 23    | 0.9      | 7.26 | 1124 | 652     | 482              |
| GW7    | Navegaon       | 22    | 0.54     | 8.27 | 1354 | 724     | 328              |
| GW8    | Navegaon       | 22    | 0.76     | 7.22 | 548  | 304     | 136              |
| GW9    | Navegaon       | 23    | 0.7      | 7.36 | 598  | 332     | 166              |
| GW10   | Navegaon       | 25.2  | 0.42     | 8.22 | 656  | 364     | 132              |
| GW11   | Devalmari      | 22    | 0.42     | 7.36 | 1010 | 622     | **632**          |
| GW12   | Devalmari      | 24    | 1.02     | 8.24 | 1326 | 702     | 538              |
| GW13   | Devalmari      | 25    | 0.78     | 8.22 | 1444 | 792     | 488              |
| GW14   | Devalmari      | 22    | 1.32     | 8.12 | 1558 | 826     | 442              |
| GW15   | Devalmari      | 24    | 0.98     | 7.46 | 854  | 402     | 436              |
| GW16   | Venkatraopetha | 24.7  | 0.88     | 7.38 | 1029 | 839     | 360              |
| GW17   | Venkatraopetha | 24    | 0.64     | 7.72 | 1916 | 918     | 402              |
| GW18   | Venkatraopetha | 24    | 0.63     | 7.76 | 1467 | 860     | 362              |
| GW19   | Venkatraopetha | 24    | 0.33     | 7.62 | 1582 | 882     | 412              |
| GW20   | Venkatraopetha | 24.2  | 0.29     | 7.62 | 1527 | 852     | 448              |
| GW21   | Allapalli      | 23    | 1.11     | 8.44 | 1231 | 684     | 296              |
| GW22   | Allapalli      | 24    | 0.42     | 8.2  | 1166 | 648     | 292              |
| GW23   | Allapalli      | 21    | 0.5      | 8.1  | 1181 | 656     | 312              |
| GW24   | Allapalli      | 24    | 0.29     | 8.29 | 1210 | 672     | 274              |
| GW25   | Allapalli      | 22    | 0.57     | 8.3  | 1206 | 670     | 302              |
Table 2: Physicochemical Parameters of Groundwater samples.

| Sample | Name of Village | Temp. | Cl (mg/L) | F (mg/L) | Nitrate (mg/L) | Fe (mg/L) | TH |
|--------|----------------|-------|-----------|----------|----------------|-----------|-----|
| GW1    | Welgur         | 27    | 168       | 0.32     | 41             | 0.01      | 492 |
| GW2    | Welgur         | 24    | 142       | 0.52     | 42             | 0.05      | 350 |
| GW3    | Welgur         | 22    | 196       | 0.02     | 49             | 0.04      | 346 |
| GW4    | Welgur         | 23    | 192       | 0        | 47             | 0.01      | 296 |
| GW5    | Welgur         | 21    | 132       | 0.39     | 38             | 0.02      | 396 |
| GW6    | Navegaon       | 23    | 83        | 0.1      | 48             | 0.22      | 478 |
| GW7    | Navegaon       | 22    | 87        | 0.1      | 42             | 0.24      | 464 |
| GW8    | Navegaon       | 22    | 37        | 0.3      | 39             | 1.28      | 224 |
| GW9    | Navegaon       | 23    | 60        | 0.4      | 21             | 0.02      | 198 |
| GW10   | Navegaon       | 25.2  | 103       | 0.3      | 38             | 1.16      | 214 |
| GW11   | Devalmari      | 24    | 75        | 0.1      | 36             | 0.06      | 298 |
| GW12   | Devalmari      | 25    | 52        | 0.2      | 19             | 0.16      | 228 |
| GW13   | Devalmari      | 22    | 48        | 0.1      | 15             | 0.2       | 288 |
| GW14   | Devalmari      | 24    | 52        | 0.3      | 14             | 0.2       | 274 |
| GW15   | Devalmari      | 24.7  | 96        | 0.1      | 17             | 0.1       | 282 |
| GW16   | Venkatraopetha | 24    | 85        | 0.02     | 19             | 0.07      | 228 |
| GW17   | Venkatraopetha | 24    | 125       | 0.1      | 43             | 0.05      | 782 |
| GW18   | Venkatraopetha | 24    | 141       | 0.03     | 21             | 0.06      | 366 |
| GW19   | Venkatraopetha | 24.2  | 141       | 0.05     | 25             | 0.3       | 408 |
| GW20   | Venkatraopetha | 23    | 131       | 0.01     | 15             | 0.06      | 184 |
| GW21   | Allapalli      | 24    | 64        | 0.02     | 49             | 0.05      | 324 |
| GW22   | Allapalli      | 21    | 68        | 0.02     | 35             | 0.03      | 288 |
| GW23   | Allapalli      | 24    | 90        | 0.02     | 36             | 0.09      | 254 |
| GW24   | Allapalli      | 22    | 78        | 0.02     | 48             | 0.06      | 320 |
| GW25   | Allapalli      | 22    | 92        | 0.02     | 38             | 0.05      | 276 |

3.2 Graphical representation for various parameters are as follows:

Graph 1: Turbidity

Graph 2: pH
Graph 3: Electrical Conductivity

Graph 4: Total Dissolved Solids.

Graph 5: Alkalinity

Graph 6: Chloride
Graph 7: Fluoride

Graph 8: Nitrate

Graph 9: Iron

Graph 10: Total Hardness
3.3 Correlation matrix of various physicochemical parameters

The quality of groundwater is mainly influenced by various physicochemical parameters and their associations can be efficiently sorted out by the correlation analysis [20]. The correlation matrix is shown in table no.3. This mainly involves statistical calculations and provides information about how any variable is influenced by the value of some other variable [21]. If the correlation coefficient ($r$) is less than 0.3, it is considered a weak correlation. If the correlation coefficient value is between 0.5 – 0.7, then it is assumed to be a moderate correlation. If the correlation coefficient value is greater than 0.7, it is considered a strong correlation. Weak values of correlation coefficient indicate the independency of the parameters from each other and the positive values of correlation infer the parameters are influenced by each other [22].

The relation between TDS with EC is found to be ($r=0.9$), which suggests that more salts are dissolved in water, leading to the increase in the electrical conductivity value. The correlation between alkalinity with EC ($r=0.5118$) and TDS ($r=0.5296$) suggests more dissolution of salts in the water sample.

**Table 3**: Correlation matrix of various physicochemical parameters.

|        | Tem. | Tur. | pH       | EC | TDS  | Alkal. | Cl   | F    | Nitrate | Fe | TH   |
|--------|------|------|----------|----|------|--------|------|------|----------|----|------|
| Tem.   | 1    |      |          |    |      |        |      |      |          |    |      |
| Tur.   | -0.02| 1    |          |    |      |        |      |      |          |    |      |
| pH     | -0.01| -0.02| 1        |    |      |        |      |      |          |    |      |
| EC     | 0.02 | -0.04| 0.31     | 1  |      |        |      |      |          |    |      |
| TDS    | 0.06 | -0.05| 0.22     | 0.92| 1    |        |      |      |          |    |      |
| Alkal. | 0.02 | 0.13 | -0.14    | 0.51| 0.52| 1      |      |      |          |    |      |
| Cl     | 0.15 | -0.29| -0.18    | 0.29| 0.29| 0.20   | 1    |      |          |    |      |
| F      | 0.05 | 0.52 | -0.19    | -0.35| -0.43| -0.21 | -0.07| 1    |          |    |      |
| Nitrate| -0.22| -0.20| 0.11     | -0.07| -0.13| -0.1  | 0.32 | -0.04| 1        |    |      |
| Fe     | 0.02 | -0.07| -0.08    | -0.48| -0.51| -0.52 | -0.29| 0.27 | 0.04     | 1  |      |
| TH     | 0.10 | 0.05 | -0.07    | 0.51| 0.37| 0.21  | 0.34 | -0.02| 0.42     | -0.22| 1    |

4. Conclusions and Recommendations

Out of 25 groundwater samples tested, nine samples were found unfit for consumption. The high level of nitrate ions in the five water samples was observed due to the animal wastes, poor drainage system, and some other sources. This could be minimized by selecting proper sites for the hand pumps and septic tanks that should be kept far from the hand pumps and also, the drainage system should be managed appropriately. It was observed that GW8 and GW10 samples were found to be unfit due to excess iron (Fe) concentration. To avoid health-related issues, it is suggested to use a water purification device. The sample number GW11 was found to be highly alkaline. Highly mineralized alkaline drinking water cause drying of the skin, as that could remove normal oils of the skin. It is suggested to use reverse osmosis process to remove alkalinity. Boiled and then filtered water could also be used to minimize the alkalinity. It was observed that the sample GW17 unfit for consumption due to the high value of total hardness. Temporary hardness could be removed by boiling and then filtering the water after cooling. Also, it was suggested not to use the water before proper filtration as it can ultimately affect health.
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