Water quality index assessment for drinking and irrigation purpose for Wardha district

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Abstract. It is always said that groundwater is safe for consumption i.e. free from microorganisms. But in many places, the groundwater is subjected to contamination due to human and industrial activities. The unsafe disposal of domestic and industrial wastes is found to be the main source for contamination of groundwater with micro-organisms, nitrates, etc. Therefore, it is inevitable to assess the quality of groundwater in terms of the Water Quality Index (WQI) before it is supplied to the end-user. Water Quality Index (WQI) is an index that converts complex data about water quality into the simplest form. This manuscript discusses the level of contamination of groundwater in the villages situated in the vicinity of Wardha River in Wardha District. Groundwater samples were collected during ninety days starting from 1st May 2021 to 30th July 2021. Analysis was carried out for the assessment of 12 parameters and their WQI. The results reveal that 40% of the 12 parameters assessed are higher values whereas, 60% of the 12 parameters assessed are reported safe values as per Indian Standards for Drinking Water. On the other hand, WQI for all the groundwater samples (barring very few) has shown bad quality.

Keywords: Ground Water Quality, Water Quality Index, physio-chemical

1. Introduction

Water is the only source for the survival of all living beings. All human activities (Domestic, Agricultural, and Industrial) requires water. The water quality appears to be of utmost importance for domestic, especially from a potability viewpoint. The usefulness of water is determined by its physicochemical, metallic and bacteriological analysis.[1][2].

Water, being the priceless natural resource, is available for the end-user as surface and groundwater. A large amount of groundwater is extracted for domestic as well as industrial use. Due to human activities and industrial effluent, the quality of groundwater getting contaminated day by day. On the other hand, access to clean drinking water in the world is a matter of grave concern. An interesting fact about water is that 97% of water is available in oceans 2% is available in glaciers and
the remaining 1% it is available for human purposes out of which only 0.2% is in form of freshwater, which is called pure water. Similarly, A large number of irrigation activities are usually dependent on groundwater more than 60% of the total area under irrigation depends upon groundwater sources. Ever since the rise of the industrial era, groundwater has gotten polluted besides human activities. It is indispensable to carry out the investigations of water quality to figure out this issue and hence, the concept of water quality index is chosen to mark the suitability of the source for its uses.

2. Study Area
Wardha district is part of Maharashtra state in western India having a population of 1,300,774 (Census 2011). Hinganghat, Seloo, Arvi, and Wardha are the major cities in the district. The district had a population of 1,300,774 as of 2011. The Wardha District lies between 20°44’ north latitudes and 78°36’ east longitudes covering an area of 6310 sq. km. The present study deals with the analysis of water for one hundred and six villages of Wardha District.

3. Background
Wardha is a district place that boasts habitable as well as industrial units. Industries such as sponge iron, khadi, dairy, sugar, fertilizers, polyester, etc. are responsible for the effluents, which find their way to the groundwater source. The increase in population and the industrial activities in Wardha have led to water contamination of groundwater in the last decade (presence of faecal coliforms and nitrates) [3][4][5][6].

Determination of Water Quality Index is a numeric expression used to transfer a large quantity of water characterization data into a single number, representing the level of water quality [7][8][9]. For WQI, a total of nine different parameters viz. temperature, pH, dissolved oxygen, turbidity, faecal coliforms, biochemical oxygen demand, total phosphate, nitrates, and total solids are taken into consideration [1][10][11][12][13].

The 100 point Water Quality Index has been divided into the following ranges.

| Range    | Quality     |
|----------|-------------|
| 90 – 100 | Excellent   |
| 70-90    | Good        |
| 50-70    | Medium      |
| 25-50    | Bad         |
| 0-25     | Very Bad    |

4. Material and Methodology
The villages situated in the vicinity of Wardha River in Wardha District were selected as the source for groundwater sample collection. Besides sampling bottles, testing kits, chemicals and other accessories were used to assess the groundwater quality parameters.

Groundwater samples from the designated villages for 90 days were collected in sampling bottles. The parameters like Temperature, pH, and dissolved oxygen, were noted at the place of sample collection using the respective testing kit following the process duly mentioned in the manual IS10500 - 2012. The samples were brought to the laboratory for testing their suitability for intended end-use. Other required parameters were tested in the laboratory following the standard equipment and methods for the examination of water and wastewater [14]. The results are tabulated in Tables 2 to 5.
5. Result and Discussion
The analysis result for 12 parameters for all the 106 samples of Wardha District are given in Tables 2 to 5. And the calculated WQI for all the 106 water samples is shown in figures 1 to 3. All the result values were cross-checked [16] and compared with Indian Standard for Drinking Water [15].

5.1 Temperature
The temperature of nearly all the samples was lying very close to 24°C.

5.2 pH
The pH value ranges between 7.0 and 8.4. The lowest pH is for water sample number 78, i.e., 7.0; whereas, a higher pH value is shown by samples 51 and 101; while other water samples showed good pH values.

5.3 Turbidity
All the water samples show turbidity less than 5 NTU, which is well within the prescribed limits.

5.4 Electrical Conductivity
Maximum electrical conductivity (EC) is recorded for sample number 51 (5440 µmhos/cm) and the minimum for sample number 97 (449 µmhos/cm). The EC for 16 samples is above the prescribed limit of 2000 µmhos/cm.

5.5 Total Solids
Total Solids (TS) ranged between 292 mg/L to 3536 mg/L. TS value of 292 mg/L is for sample number 97, whereas sample number 51 showed the highest value of 3536 mg/L. Whereas all the water samples are well within the limits.

5.6 Dissolved Oxygen
The dissolved oxygen (DO) level for the water sample varied between 0 to 1.5 mg/L.

5.7 Alkalinity
The alkalinity values ranged between 120 - 740 mg/L. Nearly 90% of the water samples show alkalinity above 200 mg/L and 10% of the water samples are very close to the permissible limit of 600 mg/L. The highest value of 740 mg/L is for water sample number 80.

5.8 Nitrate
The nitrate ions concentration lies in the range of 1 to 371 mg/L. 36 Water samples out of 106 show values above 100 mg/L while 50% of the water samples show values greater than the desirable limit of 45 mg/L.

5.9 Total Phosphorus
The total phosphorus values for all the 106 water samples varied between 0.001 to 0.396 mg/L. The highest value is shown by sample no 77.

5.10 Faecal Coliforms
According to the Indian Standards for Drinking Water, there should not be any coliforms in the 100mL sample. The Most Probable Number (MPN count) for nearly all the water samples is undesirable. It ranges from 0 to 15 MPN/100 mL.

5.11 Water Quality Index
From the figures, it is seen that 41 groundwater samples out of 106 show the WQI less than 50, which is considered as bad water quality. On the other hand, only 10 groundwater samples show the WQI greater than 60. None of the samples shows good water quality i.e. above 70. While 20 samples falling in the ‘Medium’ quality range of WQI are very close to the lower limit of the Medium range, i.e. 50.
Table 2: Groundwater analysis data for samples 1 – 30

| S N | Village                  | Temp | PH | Turbidity NTU | DO mg/l | EC | TS mg/l | Alkalinity mg/l | TH mg/l | Nitrate mg/l | T.Phosp. mg/l | BOD mg/l | Fecal Coliforms | WQI |
|-----|--------------------------|------|----|---------------|---------|----|---------|----------------|---------|--------------|---------------|----------|----------------|-----|
| 1   | BHUGAON                  | 24.2 | 7.9| 0.6           | 0.8     | 2138| 1390    | 280            | 600     | 102          | 0.019         | < 2      | 3.6            | 53.55 |
| 2   | DHOTRA RAILWAY           | 24.0 | 8.0| 0.80          | 0.7     | 2323| 1510    | 400            | 520     | 151          | 0.127         | < 2      | 7.3            | 47.86 |
| 3   | WADADHA                  | 24.1 | 7.6| 0.2           | 1.2     | 1449| 942     | 360            | 480     | 92           | 0.11          | < 2      | 3.6            | 50.29 |
| 4   | SELSURA                  | 24.2 | 8.3| 3.2           | 0.0     | 3878| 2521    | 520            | 104     | 362          | 0.312         | < 2      | 15             | 42.84 |
| 5   | SIRASGAON DHAHADE        | 24.1 | 7.8| 0.2           | 1.2     | 1214| 789     | 520            | 400     | 51           | 0.037         | < 2      | 3              | 53.84 |
| 6   | DHANOLI (MEGHE)          | 26.0 | 8.1| 1.3           | 0.5     | 2554| 1660    | 400            | 680     | 204          | 0.208         | < 2      | 7.3            | 46.31 |
| 7   | MOZARI                   | 24.3 | 7.1| 1.9           | 1.3     | 1114| 724     | 280            | 320     | 42           | 0.028         | < 2      | 3              | 53.87 |
| 8   | SEKAPUR                  | 24.2 | 8.0| 1.6           | 1.0     | 1800| 1170    | 440            | 600     | 182          | 0.2           | < 2      | 7.2            | 46.68 |
| 9   | KAPSI                    | 24.1 | 7.9| 0.8           | 1.3     | 889.2| 578     | 320            | 320     | 44           | 0.041         | < 2      | 3              | 47.14 |
| 10  | KATRI                    | 24.2 | 7.6| 1.2           | 1.2     | 815.4| 530     | 160            | 120     | 2            | 0.001         | < 2      | 0              | 62.71 |
| 11  | KANHOLI                  | 24.5 | 7.9| 0.4           | 0.9     | 1172| 762     | 320            | 400     | 122          | 0.146         | < 2      | 3.6            | 49.14 |
| 12  | DAWLAPUR                 | 24.2 | 7.9| 0.8           | 0.6     | 2418| 1572    | 400            | 240     | 50           | 0.076         | < 2      | 3              | 51.74 |
| 13  | POTI                     | 24.2 | 7.9| 2.2           | 0.9     | 1754| 1140    | 480            | 560     | 122          | 0.122         | < 2      | 3.6            | 49.14 |
| 14  | BHAYYAPUR                | 24.7 | 7.6| 0.4           | 1.4     | 910.8| 592     | 360            | 280     | 42           | 0.04          | < 2      | 3              | 54.01 |
| 15  | KHANGAO N1               | 24.3 | 7.6| 0.8           | 1.5     | 640  | 416     | 320            | 240     | 38           | 0.021         | < 2      | 3              | 54.35 |
| 16  | KHANGAO N2               | 24.4 | 7.6| 0.6           | 0.8     | 1357| 882     | 320            | 280     | 66           | 0.104         | < 2      | 3.6            | 50.25 |
| 17  | SATI                     | 24.2 | 7.2| 0.1           | 0.9     | 1062| 690     | 240            | 280     | 32           | 0.068         | < 2      | 3              | 52.87 |
| 18  | WARUD                    | 24.2 | 7.4| 0.6           | 1.0     | 892.3| 580     | 280            | 240     | 42           | 0.071         | < 2      | 3              | 52.69 |
| SN | Village               | Temp | PH  | Turbidity | DO  | EC  | TS  | Alkalinity | TH  | Nitrate | T.Phot. | BOD  | Fecal Coliforms | WQI  |
|----|----------------------|------|-----|-----------|-----|-----|-----|------------|-----|---------|---------|------|-----------------|------|
| 31 | SIRASGAON            | 24.6 | 7.7 | 0.8       | 1.0 | 1988| 1292| 480        | 400 | 104     | 0.082   | <2   | <2              | 3.6  |
| 32 | FUKTA                | 24.8 | 7.5 | 1.0       | 1.1 | 1309| 851 | 200        | 240 | 44      | 0.051   | <2   | <2              | 3    |
| 33 | FUKTA                | 24.7 | 7.9 | 0.7       | 0.8 | 2465| 1602| 480        | 840 | 51      | 0.056   | <2   | <2              | 3    |
| 34 | NAGAPUR              | 24.5 | 7.9 | 0.3       | 0.9 | 1665| 1082| 360        | 480 | 54      | 0.071   | <2   | <2              | 3.6  |
| 35 | KARANJI (BHOGE)      | 24.6 | 7.4 | 0.5       | 0.8 | 2111| 1372| 320        | 760 | 244     | 0.311   | <2   | <2              | 15   |
| 36 | SHIRPUR              | 24.6 | 7.8 | 0.2       | 1.0 | 1754| 1140| 400        | 520 | 58      | 0.074   | <2   | <2              | 3.6  |
| 37 | SONDLAPUR            | 24.7 | 7.9 | 0.1       | 1.0 | 929.2| 604 | 200        | 360 | 41      | 0.038   | <2   | <2              | 3    |
| 38 | WADGAON              | 24.7 | 7.4 | 0.6       | 1.5 | 723 | 340 | 240        | 220 | 12      | 0.001   | <2   | <2              | 0    |

Table 3: Groundwater analysis data for samples 31 – 60
|   | GADEGAON   |   |   |   |   |   |   |   |   |   |
|---|------------|---|---|---|---|---|---|---|---|---|
| 39|            | 24.5| 7.6| 1.6| 1.1| 1034| 672| 360| 440| 42| 0.031| < 2 | 3 | 53.94 |
| 40| DIGRAS     | 24.6| 8.0| 0.8| 0.9| 1006| 654| 280| 240| 39| 0.026| < 2 | 3 | 53.51 |
| 41| ZADGAON    | 24.6| 7.9| 1.2| 0.9| 1357| 882| 280| 480| 104| 0.217| < 2 | 7.3 | 46.74 |
| 42| DHANORA    | 24.6| 7.6| 2.0| 1.1| 1205| 783| 520| 440| 102| 0.181| < 2 | 11 | 46.79 |
| 43| RAGHUNATHPUR | 24.5| 7.8| 3.1| 0.7| 1742| 1132| 440| 560| 182| 0.304| < 2 | 14 | 44.55 |
| 44| BHAGWA     | 24.7| 7.2| 0.2| 1.3| 1014| 659| 240| 280| 14| 0.001| < 2 | 0 | 58.57 |
| 45| CHANKI     | 24.8| 7.3| 1.2| 1.2| 1012| 658| 280| 360| 2| 0.001| < 2 | 0 | 62.79 |
| 46| NALWADI    | 24.8| 7.4| 0.6| 1.1| 1108| 720| 240| 360| 68| 0.101| < 2 | 3.6 | 50.45 |
| 47| TALEGAON   | 24.6| 7.4| 0.9| 1.2| 956.9| 622| 320| 360| 20| 0.011| < 2 | 0 | 57.86 |
| 48| JAGULGAON  | 24.6| 7.8| 1.7| 1.0| 1615| 1050| 400| 368| 182| 0.207| < 2 | 14 | 45.81 |
| 49| MANDAWA    | 24.7| 7.9| 1.5| 1.0| 1372| 892| 400| 240| 2| 0.001| < 2 | 0 | 62.15 |
| 50| KUTKI      | 24.6| 8.3| 2.2| 0.9| 2203| 1432| 740| 984| 256| 0.346| < 2 | 15 | 43.17 |
| 51| KHARANGANA | 24.8| 8.4| 1.7| 0.0| 5440| 3536| 200| 840| 342| 0.339| < 2 | 15 | 42.67 |
| 52| SONEGAON(Station) | 24.8| 7.6| 0.5| 1.3| 473.8| 308| 200| 120| 1| 0.001| < 2 | 0 | 64.97 |
| 53| SONDI      | 24.8| 7.4| 0.2| 1.5| 452.3| 294| 200| 120| 1| 0.001| < 2 | 0 | 65.17 |
| 54| GAIMUKH    | 24.7| 7.9| 0.2| 1.5| 621.5| 404| 280| 240| 32| 0.046| < 2 | 3 | 53.41 |
| 55| JUNGAD     | 24.6| 7.9| 2.7| 1.4| 963.1| 626| 280| 320| 78| 0.118| < 2 | 3.6 | 49.17 |
| 56| GHIORAD    | 24.7| 7.8| 0.2| 1.2| 1511| 982| 440| 416| 152| 0.214| < 2 | 11 | 46.51 |
| 57| SURGAON    | 24.7| 7.8| 1.7| 1.2| 1572| 1022| 480| 496| 104| 0.119| < 2 | 9.1 | 47.89 |
| 58| SURGAON    | 24.7| 7.6| 2.4| 1.4| 863.1| 561| 280| 240| 16| 0.001| < 2 | 0 | 57.48 |
| 59| NABABPUR   | 26.0| 7.9| 0.2| 1.2| 1445| 939| 240| 404| 1| 0.001| < 2 | 0 | 64.56 |
| 60| REHAKI(KALA) | 24.9| 7.8| 0.6| 1.2| 1360| 884| 160| 280| 1| 0.001| < 2 | 0 | 64.66 |

Table 4: Groundwater analysis data for samples 61 – 90
| Village | Temp | PH | Turbidity | S | N |
|---------|------|----|-----------|---|---|
| PALASGAON N (BAI) | 26.8 | 7.6 | 0.2 | 2 | 11 |
| ASHTA A | 24.9 | 7.9 | 2.1 | 1 | 11 |
| PANNAR | 25.0 | 8.2 | 4.2 | 0 | 2 |
| ITALIA | 25.0 | 7.6 | 2.2 | 0 | 2 |
| JANGAPUR | 25.2 | 7.9 | 2.1 | 1 | 11 |
| MAHABAL | 25.3 | 7.8 | 2.1 | 12 | 11 |
| SALAI (PEVATH) | 26.0 | 7.6 | 1.2 | 1.5 | 1.5 |
| GOHDA (KALA) | 25.4 | 7.5 | 1.4 | 1.5 | 1.5 |
| AKOTTI | 25.4 | 7.9 | 0.8 | 1.4 | 1.4 |
| AMGAON | 25.3 | 7.6 | 2.1 | 1.2 | 1.2 |
| MADNI | 26.0 | 7.8 | 0.2 | 1.3 | 1.3 |
| MAHAR | 25.4 | 7.1 | 0.2 | 1.5 | 1.5 |
| KANGAON | 25.5 | 7.8 | 1.0 | 1.2 | 1.2 |
| MAHAR | 25.3 | 7.4 | 0.2 | 1.3 | 1.3 |
| NANGAO N | 25.0 | 7.8 | 0.5 | 1.5 | 1.5 |
| MADNI | 25.4 | 7.9 | 1.7 | 1.3 | 1.3 |
| MUDHAPO | 25.7 | 8.3 | 4.0 | 0.0 | 2 |
| TIGAO | 25.8 | 7.0 | 0.2 | 1.5 | 1.5 |
| BARBADI | 26.0 | 7.9 | 0.1 | 0.8 | 1.0 |
| SN | Village           | Temp | PH | Turbidity | DO  | EC  | TS  | Alkalinity | TH  | Nitrate | T. Phosp. | BOD  | Fecal Coliforms | WQI |
|----|------------------|------|----|-----------|-----|-----|-----|------------|-----|----------|----------|------|-----------------|-----|
| 80 | WADGAON KH.      | 25.6 | 7.4| 0.5       | 1.4 | 1025 | 666 | 120        | 352 | 17      | 0.008    | <2   | 0               | 58.18|
| 81 | SALAI (KALA)     | 25.7 | 7.8| 1.2       | 1.5 | 686.2| 446 | 360        | 216 | 12     | 0.001    | <2   | 0              | 58.32|
| 82 | TAKALI (KITE)    | 26.0 | 7.6| 0.1       | 1.0 | 1169 | 1769 | 2         | 480 | 432     | 0.143    | <2   | 7.2            | 48.5 |
| 83 | KOLPAI           | 25.6 | 7.4| 2.8       | 1.0 | 1354 | 880 | 360        | 428 | 131    | 0.167    | <2   | 9.1            | 47.25|
| 84 | KOLGAON          | 25.5 | 7.4| 1.9       | 0.9 | 1335 | 868 | 380        | 352 | 44     | 0.082    | <2   | 3              | 51.73|
| 85 | JUNONA           | 25.4 | 7.4| 0.2       | 0.8 | 1726 | 1122| 360        | 352 | 222    | 0.281    | <2   | 14             | 45.73|
| 86 | WADGAON (KALA)   | 25.6 | 7.9| 0.2       | 1.4 | 843.1| 548 | 480        | 276 | 9      | 0.001    | <2   | 0              | 59.13|
| 87 | WAIKAD           | 25.7 | 7.9| 0.9       | 1.0 | 716.9| 466 | 280        | 248 | 32     | 0.073    | <2   | 3              | 52.47|
| 88 | PIPALGAON        | 25.6 | 7.9| 2.3       | 0.8 | 2169 | 1410| 560        | 400 | 162    | 0.196    | <2   | 7.3            | 46.76|
| 89 | DIGRAJ           | 25.4 | 7.9| 2.2       | 0.9 | 1954 | 1270| 520        | 400 | 62     | 0.054    | <2   | 3.6            | 52.27|
| 90 | PARSODI          | 25.7 | 7.9| 4.8       | 0.7 | 2129 | 1384| 400        | 320 | 102    | 0.181    | <2   | 9.1            | 46.05|

Table 5: Groundwater analysis data for samples 91 – 106
|   | Location   | Lat.  | Lon.  | Temp.  | Hum.  | Wind. | Salinity | pH | DO | Secchi Depth |
|---|------------|-------|-------|--------|-------|-------|----------|----|----|--------------|
| 97| MHASALA    | 25.8  | 7.5   | 2.8    | 1.8   | 449.2 | 292      | 240| 160| 3            |
| 98| SAKHARA    | 26.0  | 7.2   | 1.3    | 1.3   | 698.5 | 454      | 280| 240| 34           |
| 99| SAWALI SAKHARA | 25.6 | 7.9   | 4.0    | 1.4   | 646.2 | 420      | 320| 400| 21           |
| 100| BORKHED I  | 25.6  | 7.9   | 1.5    | 1.2   | 1148  | 746      | 360| 360| 105          |
| 101| BOTHALI    | 26.0  | 8.4   | 3.1    | 1.1   | 1218  | 792      | 320| 400| 161          |
| 102| ANTARGA ON | 25.8  | 7.9   | 1.4    | 1.5   | 858.5 | 558      | 280| 280| 44           |
| 103| HIWARA     | 25.7  | 7.8   | 0.9    | 1.4   | 984.6 | 640      | 360| 320| 50           |
| 104| KAMTHI     | 25.8  | 7.8   | 1.4    | 1.2   | 1646  | 1070     | 440| 640| 188          |
| 105| ALAMDOH    | 25.6  | 7.6   | 0.2    | 0.9   | 2462  | 1600     | 520| 320| 182          |
| 106| EKURLI     | 25.6  | 7.6   | 3.0    | 1.1   | 1634  | 1062     | 440| 440| 174          |
6. Conclusion
The analyzed data for all one hundred and six places of collection in Wardha district show that a few parameters including nitrate, alkalinity and bacterial count are above the permissible limits. From the analysis, it is clear that the groundwater is contaminated and is not fit for drinking without treatment. The WQI calculated is below 50 for 41 water samples showing the deteriorated quality of water. While 20 samples falling in the ‘Medium’ quality range of WQI are very close to the lower limit of the range, i.e. 50.

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