Assessing the quality of Groundwater in Gondpipri Region, Chandrapur District, Maharashtra, India using Water Quality Index (WQI)

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Abstract: Safe and potable drinking water is a common necessity for all; hence the quality of water must be assessed regularly. Particularly in rural areas assessment of water quality is often neglected. In rural areas, groundwater is the main source of drinking water, and activities like Bathing, Washing, and Agricultural runoff in the near vicinity of groundwater sources can cause water pollution through the percolation of chemicals into groundwater. There is a need to assess the water quality of rural areas intermittently so that preventive measures can be taken to minimize pollution. In the present study, the quality of groundwater in Gondpipri tehsil of Chandrapur district, Maharashtra is assessed using Weighted Arithmetic Water Quality Index (WAWQI). 27 different groundwater sources were identified from six different villages and all these samples were analyzed for parameters like pH, Total Alkalinity, Total Hardness, TDS, Dissolved Oxygen, Turbidity, and Chloride ion concentration from February to July. After obtaining values of these parameters for all samples, WAWQI was calculated for each water source and compared with reference standards for each parameter according to IS, WHO, and CPCB. The whole study indicated that 22.22% of water sources were found to be of Excellent quality and 44.44% of sources were found to be of Good quality. Principle factors responsible for low water quality were Total Hardness, Alkalinity, and Turbidity, but as these factors can be either removed or minimized by using appropriate methods the quality of groundwater in this region can be corrected. This study emphasizes the fact that more such studies are needed for assessing the water quality of different regions.

Keywords – WAWQI, Carboys, Groundwater Resources, Gondpipri, Analysis, Percolation

I. Introduction

Surface of earth is predominantly covered by water but out of the total water on earth a small fraction of about 2.5% is freshwater (**Gleik,1993**). Out of total freshwater more than 99% is ground water. Water is said to be polluted when it is unfit for human consumption and other uses(**Annan. K.,2005**). Potable drinking water becoming scarce globally because of multiple reasons like pollution from different sources , rise in population, large scale industrialization, malpractices in agriculture (**Kummu, M., Guillaume, et al.2016**).

Even though there are various sources of drinking water like Lake, Pond, Streams, River , Groundwater in rural area, the most commonly used source for drinking water in rural areas of Maharashtra is groundwater which is obtained through borewells and open wells. According to **CPCB,2007,** groundwater interacts with different materials in geological strata as a result of which it has higher percentage of dissolved contents as compared to surface water. Particularly in rural parts pollution of groundwater occurs due to improper sewage systems , landfills and agricultural run off (**N. Subba Rao et al.,2022**). New age agricultural practices like irrigation systems , excessive use of pesticides and fertilizers causes percolation of salts and chemicals in to groundwater on the other hand soil erosion caused to anthropogenic activities is not allowing ground water to recharge (**Gates et al.,2011**).Consumption of contaminated and polluted water can cause various diseases in humans that may be pathogenic as well as metabolic like Fluorosis, Kidney stone, etc.(**Li P et al., 2021**)hence proper assessment of groundwater quality is highly important but such assessment is often not done in rural areas as these areas do not have any major industries , additionally the health infrastructure and health awareness in rural areas is weak (**B. Muniswamy et al.,2021, Patle et al 2014**) which makes this problem even more severe in rural areas. For addressing this problem, it is important to give emphasis on proper assessment of water resources in rural areas to check its suitability for drinking and other purposes.

Different parameters can be used for analysis of water like pH, Total Hardness(TH), Total Alkalinity(TA), Total Hardness(TH), Total Dissolved Solids(TDS), Heavy metals , ions etc.(**K. Saravanakumar and R. Ranjith Kumar, 2011, Gabhane et al 2016**). Analysis of all or some of these parameters can give a good indication about quality of water , but while studying multiple sources it is more convenient to use water quality index rather than measuring value of every parameter for every sample as use of water quality index gives a wholesome idea about quality of water. In water quality index a specific mathematical formula is used in which water quality parameters are used as inputs. There are lot of water quality indices that are used globally , most prominent amongst them are , Weighted Arithmetic Water Quality Index(WAWQI), National Sanitation Foundation Water Quality Index (NSFWQI), Ground Water Quality Index (GWQI).

Out of these different indices , for studying and assessing groundwater quality of samples from Gondpipri taluka of Chandrapur district in Maharashtra WAWQI index was selected. This water quality index works on a principle of comparing parameters used for analysis of water quality with standard values , as this water quality index gives idea about quality of water without elucidating each parameter it helps in rapid decision making about management of groundwater quality.

Gondpipri is a tribal dominated taluka which is about 60km away from district headquarter of Chandrapur, Maharashtra and around 1100 km away from state capital Mumbai. There is total 97 villages in Gondpipri tehsil , in present study 6 out of these 97 villages were selected on the basis of their common topography and adjoining nature as per the guidelines of National Sample Survey Organization(NSSO). Mainly Limestone, Pebbles and gravels are found in this area. The present study was conducted from the month of February to July and average depth of water during this period was about 40 to 50m beneath ground level.

Table 1: Sociodemographic data of selected villages

S.N.	Name of Village	Population	Literacy (%)	Sex Ratio
1	Bhangaram Talodhi	3446	51	1015
2	Vitthalwada	2511	65	976
3	Tarsa	1207	60.4	1039
4	Darur	1088	58	922
5	Hiwara	1001	67.33	986
6	Ghadoli	878	64.24	964

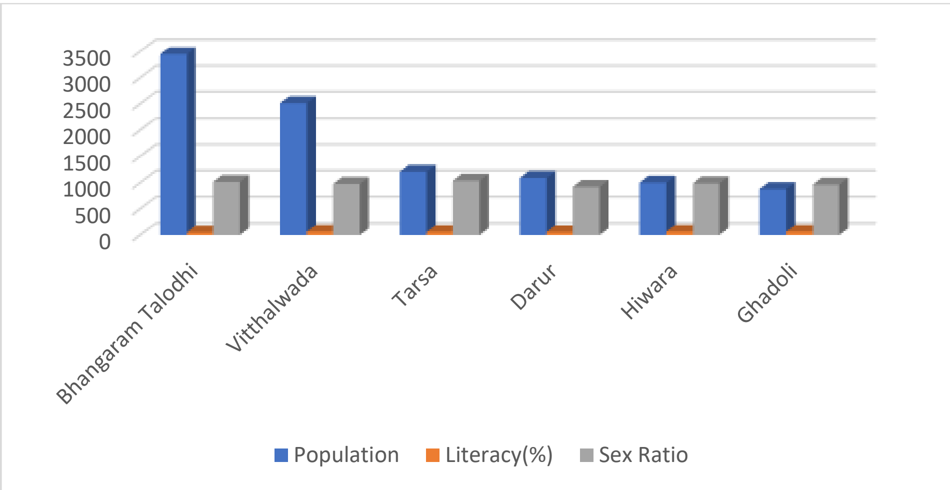

Fig.1. Sociodemographic Data of selected villages

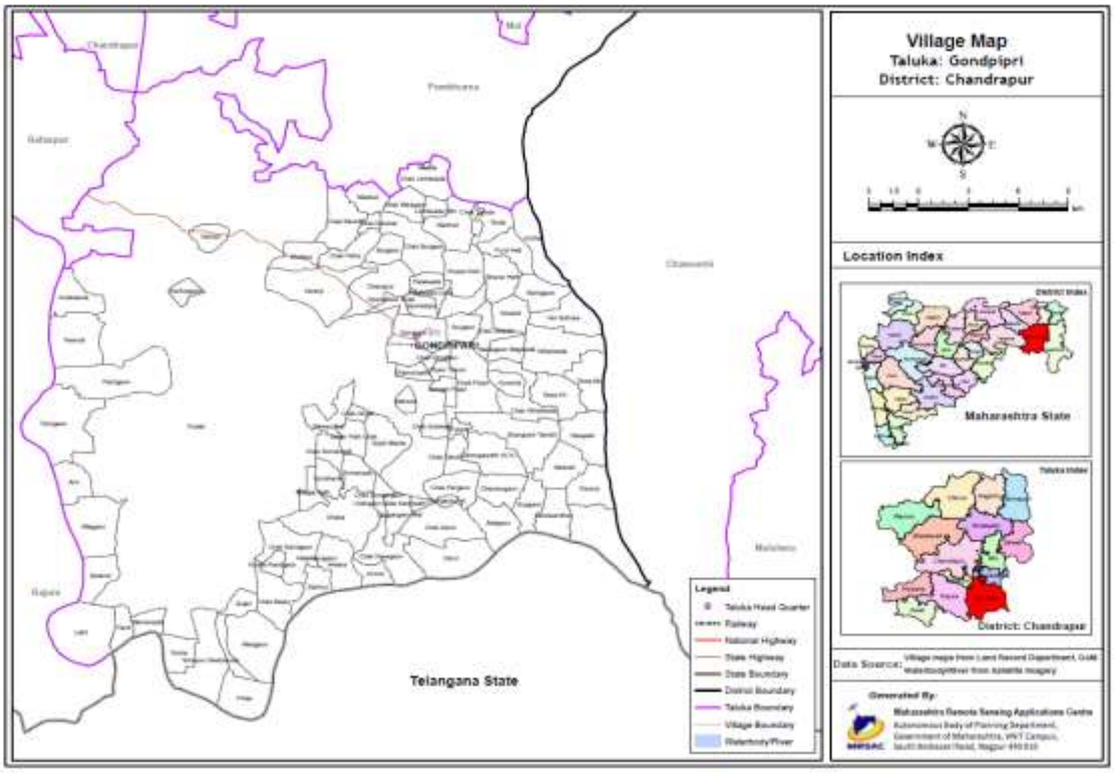

Fig.2. Map showing Gondpipri tehsil with selected villages for Sampling

II. Materials and methods

II. i Area of Study and sampling

Villages that were selected for study included Bhangaram Talodhi, Vitthalwada, Tarsa, Darur, Hiwara, and Ghadoli, all these villages are quite adjacent to each other and have a different number of groundwater resources. There are six groundwater resources each in Bhangaram Talodhi and Vitthalwada, Four groundwater resources in Tarsa, Darur, and Hiwara while there are three groundwater resources in Ghadoli. Each of these resources was provided with a unique code and used for sampling. Six Groundwater resources from Bhangaram Talodhi were coded as B1, B2, B3, B4, B5, and B6 while groundwater resources from Vitthalwada were denoted as V1, V2, V3, V4, V5, V6. Four groundwater resources from Tarsa, Darur, and Hiwara were coded as T1, T2, T3, T4; D1, D2, D3, D4 and H1, H2, H3 H4 respectively and three resources from Ghadoli village were coded as G1, G2 and G3. Out of these, G1 resource from Ghadoli, B2 and B3 resources from Bhangaram Talodhi, G3 resource from Tarsa are open wells while all others are borewells. Data of Amount of Groundwater resources out of Total water resources from each village is shown in **Table 2 and Fig. 2**while **Table 1 and Fig 1**shows sociodemographic data of selected villages.

Table 2: Number of Groundwater resources in selected villages out of total resources

S.N.	Name of Village	Total number of water resources	Number of groundwater resources	Number of suface water resources	Percentage(%)of Groundwater Source
1	Bhangaram Talodhi	8	6	2	75
2	Vitthalwada	7	6	1	85.71
3	Tarsa	6	4	2	75
4	Darur	6	4	2	75
5	Hiwara	6	4	2	75
6	Ghadoli	3	3	0	100

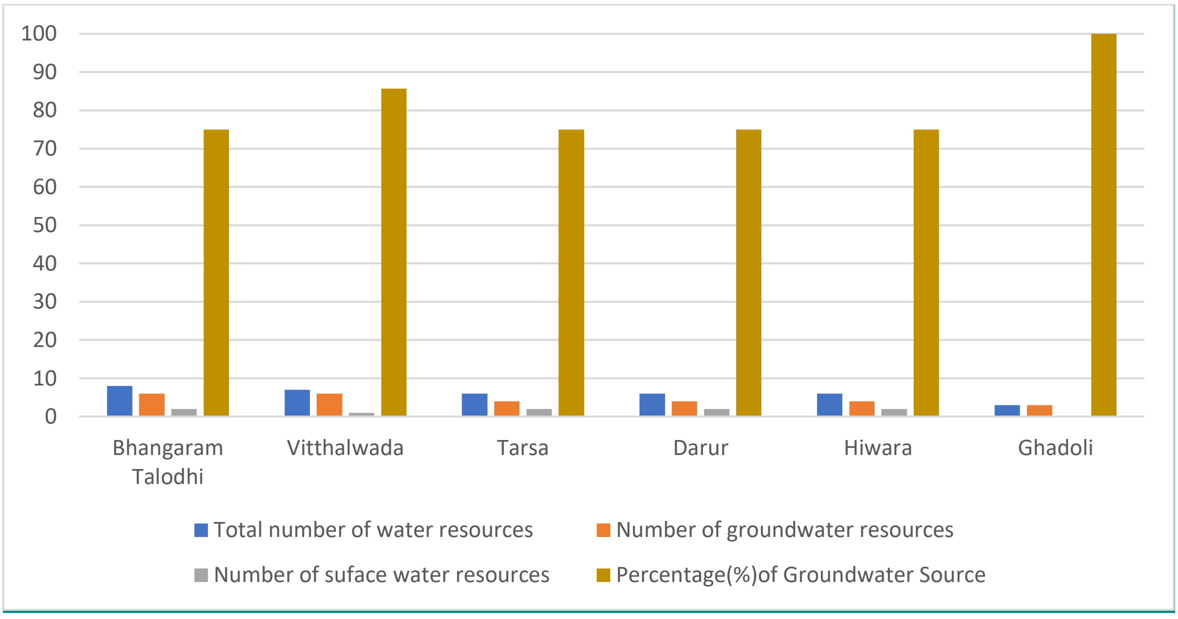

Fig.3. Number of Groundwater sources out of total water resources in each village

II. ii. *water quality index*

Water quality index used for assessing the water quality of six selected villages was WAWQI. The standard values for each parameter that were used for analysis was taken according to IS 2296 (**CPCB, 1982) and (WHO , 2006)**standards that are shown in **Table 3.** Here for Total Alkalinity (TA) as WHO and CPCB standards are not available hence BIS 10500, (**BIS, 2012**) standard is used while for Dissolved oxygen as only CPCB standard is available only CPCB standard is considered.

Table 3: Parameter standards for water quality index calculation

S.N.	Parameter	CPCB	WHO
1	pH	6.5-8.5	6.5-8.5
2	Turbidity (NTU)	5	1
3	TDS (mg/Lit)	500	600
4	Total Hardness(mg/L)	300	200

5	Total Alkalinity (mg/L)	200	200
6	Dissolved Oxygen(mg/L)	6	0
7	Chloride (mg/L)	250	250

The WAWQI index for assessment of groundwater quality uses different parameters as inputs in specific mathematical equations where initially a unit weight is calculated for each parameter , this calculated unit weight is inversely proportional to summation of standards used for each parameter(**Table 3**). The calculations involved in WAWQI is as follows…

At first , unit weightage of i^{th} parameter is calculated as ….

$$Wi = K/Si$$

Where, Wi is a unit weight of each parameter while Si is standard value of each parameter that is to be used according to decided standards.
K is a constant of proportionality and is calculated as ..

$$K = 1/\sum \frac{1}{Si}$$

Qi is the quality rating index of i^{th} parameter ; it is calculated for all the parameters used for analysis as

$$Qi = \left(\frac{Qa - Q_i}{Sstd - Q_i}\right)$$

Where, Qa is actual measured value of parameter
Qi is ideal value of parameter in pure water
After obtaining values of Wi and Qi , one can easily calculated WAWQI value as ..

$$WAWQI = \frac{\sum_{i=1}^{n} W_i Q_i}{\Sigma w_i}$$

Here, Qi = 0 for all the parameters apart from Dissolved oxygen and pH, complete rating scale for WAWQI is given in **Table 4.**

Table 4: Standard status categories for WAWQI

S.N.	WAWQI Value	Water Quality
1	Up to 25	Excellent
2	26-50	Good
3	51-75	Poor
4	76-100	Very Poor
5	More than 100	Unsuitable for Drinking

Table 5: Data of parameters analysed for groundwater samples from Gondpipri during February to July

S.N.	**Parameter**	**Bhangaram Talodhi**	**Vitthalwada**	**Tarsa**	**Darur**	**Hiwara**	**Ghadoli**
February							
1	Turbidity (NTU)	0.2-1.2	0.3-0.45	0.11-0.35	0.11-0.17	0.45-2.9	0.10-0.70
2	pH	7.8-8.8	7.95-8.95	7.60-8.10	7.55-7.78	7.7-8.1	7.9-8.2
3	Total Alkalinity(mg/L)	78-138	235-275	225-370	160-240	220-380	410-570
4	Dissolved Oxygen(mg/L)	8.1-13	6-10.1	7.8-10	4-8.1	7.7-8.1	7.9-8.2
5	TDS (mg/L)	425-690	345-690	380-650	255-520	415-1220	710-820
6	Total Hardness(mg/L)	30-410	340-420	210-370	180-240	220-400	410-520
7	Chloride (Cl-)(mg/L)	70-130	70-140	50-110	30-70	110-380	150-420
March							
1	Turbidity (NTU)	0.32 - 1.42	0.03-0.47	0.11-0.35	0.11-0.19	0.50-2.94	0.11-0.72
2	pH	7.7-8.9	7.9-8.2	7.8-8.2	7.6-7.8	7.6-8.1	7.9-8.3
3	Total Alkalinity(mg/L)	82-140	340-490	220-270	195-310	290-450	420-540
4	Dissolved Oxygen(mg/L)	6.1-14	7.5-10	8.1-10	5.2-7	6.3-8	7.2-9

5	TDS (mg/L)	430-650	340-550	390-550	270-520	440-1120	780-1420
6	Total Hardness(mg/L)	20-420	320-380	220-380	160-250	220-400	380-580
7	Chloride (Cl-)(mg/L)	80-140	70-170	40-90	18-60	110-450	138-448
April							
1	Turbidity (NTU)	0.31-1.22	0.03-0.05	0.12-0.38	0.13-0.17	0.52-3.12	0.15-0.69
2	pH	7.5-8.72	7.85-8.72	7.55-8.01	7.51-7.71	7.2-8.01	7.81-8.11
3	Total Alkalinity(mg/L)	78-138	240-274	205-268	168-305	270-440	425-570
4	Dissolved Oxygen(mg/L)	5.5-14.5	6.5-8.5	8.2-9	5-7.2	6.2-7	6 - 7.1
5	TDS (mg/L)	435-685	335-560	380-650	240-540	420-1200	780-1350
6	Total Hardness(mg/L)	18-350	335-490	220-380	165-245	225-405	395-580
7	Chloride (Cl-)(mg/L)	72-142	82-141	38-102	18-58	105-170	138-420
May							
1	Turbidity (NTU)	0.32-1.41	0.31-0.41	0.13-0.33	0.12-0.16	0.45-3.1	0.12-0.64
2	pH	7.8-8.77	7.92-8.14	7.59-8.13	7.4-8.4	7.8-8.1	7.9-8.2
3	Total Alkalinity(mg/L)	78-128	238-270	205-265	165-305	270-420	444-565
4	Dissolved Oxygen(mg/L)	6.1-12	7.3-10	8.5-10.5	6.5-8.4	5.3-7.1	7.3-9.2
5	TDS (mg/L)	420-670	320-550	390-595	270-536	440-1370	760-1420
6	Total Hardness(mg/L)	18-390	320-498	210-370	168-240	225-405	398-565
7	Chloride (Cl-)(mg/L)	70-168	75-138	35-98	18-55	95-155	144-490
June							
1	Turbidity (NTU)	0.31-8.21	0.028-0.45	0.102-0.35	0.10-0.19	0.45-2.82	0.12-0.68
2	pH	7.8-8.9	7.9-8.1	7.4-8.3	7.4-7.7	7.3-8.1	8.7-8.3
3	Total Alkalinity(mg/L)	78-138	235-265	205-265	165-295	275-445	415-555
4	Dissolved Oxygen(mg/L)	6.1-11	8.2-13	7.1-9	7.3-9	5.4-9.5	8.5-9.5
5	TDS (mg/L)	430-680	340-560	350-590	265-525	430-1420	780-1440
6	Total Hardness(mg/L)	20-460	340-490	220-370	160-240	222-402	270-401
7	Chloride (Cl-)(mg/L)	82-168	81-140	38-102	15-60	95-400	135-420
July							
1	Turbidity (NTU)	0.38-1.32	0.025-0.425	0.13-0.34	0.11-0.18	0.46-3.14	0.10-0.71
2	pH	7.74-8.74	7.84-8.13	7.55-8.01	7.51-7.74	7.3-8.01	7.75-8.1
3	Total Alkalinity(mg/L)	70-130	230-250	348-393	252-420	438-1290	413-564
4	Dissolved Oxygen(mg/L)	7.1-11	8.2-11	6.2-10.1	6.2-701	5.2-8	6.3-8.5
5	TDS (mg/L)	430-680	335-660	355-690	255-520	435-1330	780-1500

6	Total Hardness(mg/L)	25-450	330-480	221-382	165-240	215-410	401-280
7	Chloride (Cl-)(mg/L)	15-148	82-142	41-98	17-72	105-455	132-427

II. iii Sample collection and analysis

Groundwater samples were collected from designated sites from February to July and these samples were analyzed using water quality parameters like Turbidity, pH, Alkalinity, Hardness, TDS, Dissolved Oxygen (DO) and Chloride ions concentration. Water samples were collected form groundwater sources of each village specially in designed glass bottles i.e., Carboys . Each collected sample wash stored at 4^0C till analysis.

Dissolved oxygen (DO) was measured using wrinklers titration method for which water samples were collected in 300 ml BOD bottles and amount of dissolved oxygen present in sample at the time of collection was fixed using Manganese sulphate and Potassium iodide, Dissolved oxygen in each sample was calculated in mg/Lit. pH , Turbidity , TDS were measured using pH meter, Turbidity meter and TDS meter respectively while Total hardness, Alkalinity and Chloride ion concentration was measured using Titration methods , all parameters were analyzed according to BIS protocols ,Except turbidity which was measured in NTU, all other parameters were measured in mg/Lit. For ensuring accuracy, every parameter was analyzed thrice and mean value was considered.

Table 6: Data of WAWQI values (Source wise)

Name of Village	Source	WAWQI Value
Bhangaram Talodhi	B1	90.5
	B2	113.16
	B3	39.69
	B4	33.51
	B5	97.37
	B6	74.56
Vitthalwada	V1	28.21
	V2	24.2
	V3	43.33
	V4	18.45
	V5	13.21
	V6	14.52
Tarsa	T1	21.2
	T2	42.56
	T3	52.91
	T4	29.93
Darur	D1	27.61
	D2	28
	D3	27.13
	D4	26.17
Hiwara	H1	97.95
	H2	20.14
	H3	112.51
	H4	42.62
Ghadoli	G1	34.42
	G2	71.21
	G3	50.33

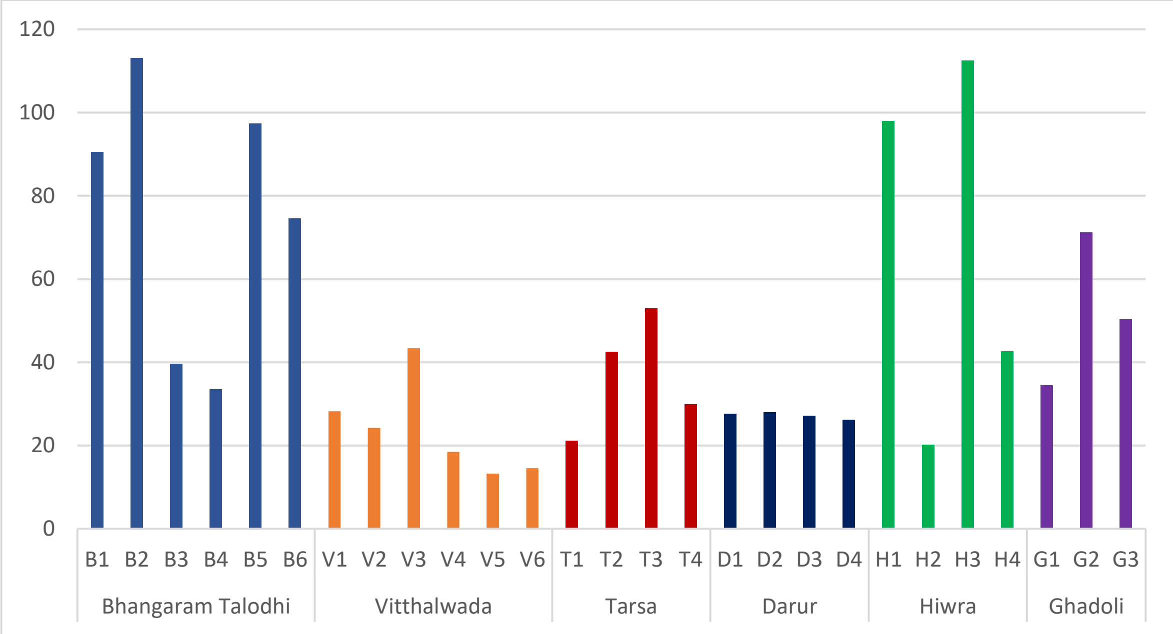

Fig.4. Source wise WAWQI values

III. Results and Discussion

Data regarding different measured parameters from all sources during month of February to July is mentioned in **Table 5**. while analyzing data it was seen that pH levels of two groundwater sources B3 and V2 were slightly above the prescribed limit of 8.5 , these both sources were located to percolation site of agricultural field.

Turbidity values for all the sources were well within the prescribed limits except that of B3 and H4 that ranged between 1.42 to 3.14 NTU. All the analyzed groundwater sources showed exceeding alkalinities than prescribed limit of 200mg/lit, except those from Bhangaram Talodhi i.e., B1 to B6(70-140mg/lit) and one source from Darur i.e. D2 (160-195mg/lit), particularly a source from Ghadoli village G2 showed highest alkalinity ranging between 410-570mg/Lit. while all other parameters should have their values below prescribed limits in a water sample, Dissolved oxygen(DO)is one such factor whose value should be higher than standard value , out of all samples analyzed except D2 source from Darur village that showed DO values in the range of 4-5.4mg/Lit, all other sources had DO values either at par with or higher than prescribed value of 6mg/Lit. TDS values of B5 (420-435mg/lit), V3(235 – 340mg/Lit), T2(220-348mg/Lit), D1(255-270mg/Lit) and H2(415-440mg/Lit) were within the prescribed limits while all other sources showed exceeding TDS. All other sources Except B3 (18-30mg/Lit) and D2(160-180mg/Lit), showed increased levels of total hardness ranging from 210-580mg/Lit. The except for G3 source, where it was found to be higher i.e., ranging between 420-490mg/Lit. interestingly this source is an open well. WAWQI value of each source was calculated on the basis of measured parameters , source wise WAWQI values are mentioned in **Table 6 and Fig 4.**while The data showing source wise comparison of ground water quality in Gondpipri is shown in **Table7(Fig 5).** This table shows that around 22.22% of the Groundwater sources were found to be excellent, 44.44% sources were found to be Good, 14.81% sources were found to be of poor quality, 11.11% sources have very poor-quality water while there are 7.4% sources whose water is completely unsuitable for drinking.

From above analysis it is seen that Total hardness, Alkalinity and Total dissolved solids are the principal factors that are responsible for lower quality of water, out of 27 sources analyzed, 20 of them had higher than normal levels of alkalinity, 22 sources had more than normal TDS and 25 resources had more than normal levels of hardness, all these three factors are may be due to leeching of mineral ions from parent rocks present underneath and can be removed by treatment methods. As this region under study is relatively free from industrialization , the extent of pollution in groundwater is substantially low.

Table7: Source wise Groundwater Quality as per WAWQI index

S.N.	Sources	Water Quality	Percentage out of Total
1	V2, V4, V5, V6, T1, H2	Excellent	22.22%
2	B3, B4, V1, V3, T2, T4, D1D2, D3, D4, H4, G1	Good	44.44%
3	B6, T3, G2, G3	Poor	14.81%
4	B1, B5, H1	Very Poor	11.11%
5	B2, H3	Unsuitable for Drinking	7.40%

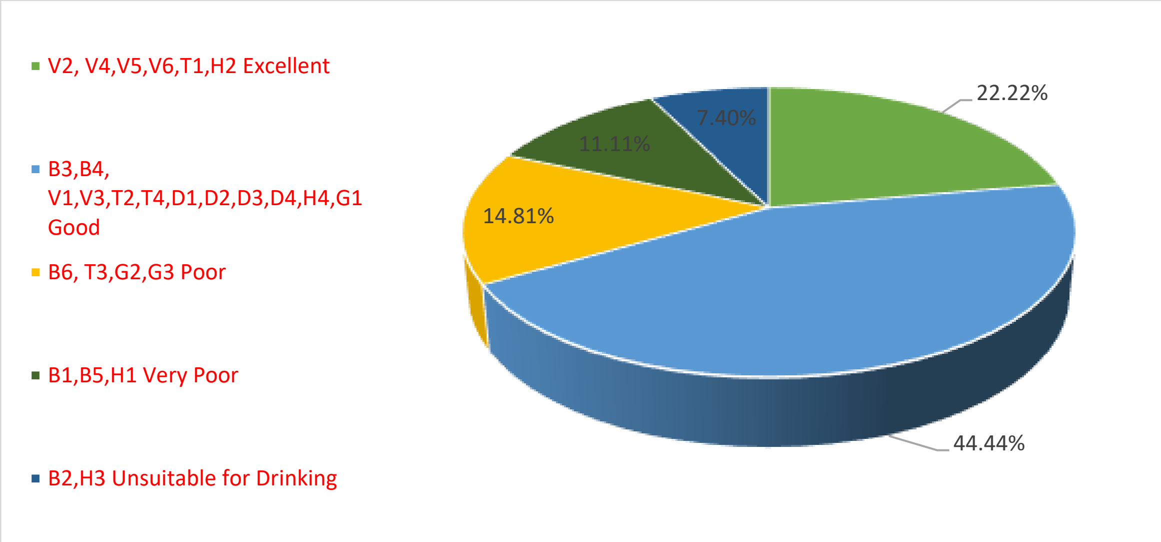

Fig.5. Percentage of groundwater sources with different qualities of water

IV. **Conclusion**

In the present study, the WAWQI index has been used for assessing the groundwater quality of Gondpipri, District Chandrapur of Maharashtra. Here, a total of 27 different groundwater sources from Six different villages were examined for 7 different parameters like pH, Turbidity, Total Alkalinity, TDS, Chloride concentration, Total Hardness, and Dissolved oxygen. All these parameters were examined from February to July every month. From the analysis, it was found that these parameters did not change much during the period of study but values of Total Hardness, Total alkalinity, and TDS were higher in most of the samples.

Study shows that there are about 22.22% sources where water quality is excellent while about 44.44% resources are there where water is found to be good for consumption according to WAWQI. As lowering of quality in water from other sources is mainly due to factors like TDS, TA, and TH and as these parameters can be corrected by conventional water treatment methods easily, (**B K Bindhuet al., 2021**) this study is indicative of the fact that groundwater in Gondpipri is mostly suitable for drinking purpose. The principal reason behind this good quality groundwater is the lack of heavy industrialization and absence of large-scale municipal pollution. This study highlights the fact that, if the percolation of industrial, agricultural, and municipal pollutants is prevented then the pristine nature of the groundwater can very well be maintained.

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