Application of water quality index to assess ground water quality and effects of municipal solid waste dumping yards in southern part of Bengaluru city Karnataka, India

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Abstract: The current research attempts to calculate the water quality index (WQI) for groundwater in the southwest section of Bangalore. This was established by taking groundwater samples from locations near the selected municipal solid waste dumping yards and analyzing them thoroughly. The 12 Physicochemical parameters are used to calculate the WQI. The parameters are pH, total hardness, calcium, magnesium, bicarbonate, and sodium bicarbonate levels have all been considered. The WQI of these samples ranges from 89.21 to 660.56. The results of the analyses have been used to create water quality index. According to the analysis the penetration of leachate from the landfill has contaminated the groundwater in the vicinity.

INTRODUCTION

Ground water:
Aquifer water is naturally brought to the surface by springs or might be discharged into lakes and streams. A well drilled into the aquifer can also be used to extract groundwater. Pollutants can easily sink into groundwater sources in regions where the material above the aquifer is porous. Landfills, septic tanks, leaking underground gas tanks, and overuse of fertilizers and pesticides can all pollute groundwater. If groundwater becomes contaminated, it becomes unsafe to drink.

India is the world's largest user of groundwater. It consumes over 230 cubic kilometers of groundwater per year, which is more than a fourth of the global total.

Groundwater is used for more than 60% of irrigated farmland and 85 percent of drinking water supply. Due to unpredictable and inadequate municipal water supplies, urban people are increasingly relying on groundwater.

Groundwater serves as a crucial buffer against monsoon rain fluctuation. For example, a drought in 1963-66 reduced India's food output by 20%, but a comparable drought in 1987-88 had a little impact on food production, owing to widespread groundwater use at the time.

Bengaluru is the largest city in Karnataka and commonly known as City of Gardens. In recent years the city has grown extensively, and the growth rate is considerably high over past decades. The Bengaluru water supply and sewerage board (BWSSB) which supplies water in the city pumps in 900 million liters of water every day to the city, but the demand is more than 1450 million liters per day.

Type of water supplied	Distribution area covered in %	% of population using water	Amount of Water pumping in MLD
Cauvery water	67	77%	900
Bore well water	33	23%	124

Source: Bengaluru water supply and sewerage board (2016)

Study Area: Bangalore, officially known as Bengaluru, is the capital and the largest city of the Indian state of Karnataka. It has a population of more than 8 million and a metropolitan population of around 11 million; it is in the heart of the Mysore Plateau (a region of the larger Cretaceous Deccan Plateau) at an average elevation of 900 m (2,953 ft). It has a land area of 741 km2 (286 sq mi) and is located at 12°58′44″N 77°35′30″E. Bangalore is a district headquarters located 260km from the state capital of Bangalore, Karnataka, India, at 13°.5’ and 14°50’N and 75°30’ and 76°30’E geographically. The Bangalore district receives an average annual rainfall of 644 mm (25.4 inches). The district enjoys a semi-arid climate with dryness in a major part of the year and a hot summer. In general, the southwest monsoon contributes 58% of total rainfall, and the northeast monsoon contributes 22% of total rainfall. The remaining 20% of rainfall is received as sporadic rains in the summer months. It receives low to moderate rainfall. The groundwater quality is degrading in Bangalore due to increased human habitation and commercial practice. Therefore, the water quality index is one of the most effective, simple and tools for determining the suitability of water quality we have decided to analyze its groundwater so that some remedies for the improvement could be possible.

MATERIALS AND METHODOLOGY

kannahalli CMSWMF is located at Survey No. 85, Kannahalli Village, Yeshwanthpura Hobli, Seegehalli Cross, Magadi Road, Bangalore – 560 091. The site is located towards West of Bangalore city, next to the Seegehalli bus depot. The site has an average elevation of 16 meters. Chikkanagamanagala CMSWMF is constructed on an area of 15.3 acres with design capacity to handle 500 TPD of municipal waste. The yard is located at village Chikkanagamangala, Sarjapur Hobli, Anekal Taluk in the Bangalore Urban district of State of Karnataka at an average elevation of 916m. The Ligadeeranahalli CMSWMF municipal dumping yard is situated in Lingadheeranahalli village Kengeri Hobli, Bangalore South Taluk in the Bangalore Urban district of State of Karnataka. The CMSWMF municipal dumping yard at Subbarayanapalya village is located at an elevation of 775 meters and is sloping from West to East towards the natural nallah adjacent to the site. This CMSWMF is situated at Survey. No. 143, Kumbalgood village, Kengeri Hobli, Bangalore South Taluk, Bengaluru. It has an area of 3.8 hectares and handles about 200 TPD of municipal waste, which is collected from areas within the RR Nagar and Bangalore South Zone. The geographical coordinates of these municipal common treatment facilities are given in the Table 1

Groundwater samples were collected from the surroundings of these four solid waste dumping yards, namely Kannahalli, Lingaderranahalli, Chikkanagamanagala, and Subbarayanapalya, which were selected and located in the southern parts of Bangalore city. Eight ground water samples from each dumping yard were collected during the pre-monsoon (April and May 2017) and post-monsoon (November and December 2017). The collected water samples were transferred into pre-cleaned plastic water bottles for analysis of chemical characteristics. Samples collected in black-coloured bottles of 3 liter capacity at the study sites were properly labeled and recorded. The Gps location of the samples collected is depicted in the table -2.The various physiochemical parameters were analyzed, and the health impacts of chemical parameters are reported (Table 3 to 7). The total alkalinities of the water samples were determined by titrating with N/50 H_2SO4 using phenolphthalein and methyl orange as indicators. The conductivity of the water samples was measured using the conductometric method. The total hardness of the water samples was determined by complex metric titration with EDTA using Erichrome black-T as an indicator. The sulphate and fluoride content of the water samples were estimated by a UV-visible spectrophotometer. The TDS of a water sample was measured using the gravimetric method. Heavy metal concentration of iron, is analyzed by the acid digestion method using an atomic absorption spectrophotometer

Fig-1. Map showing the study area

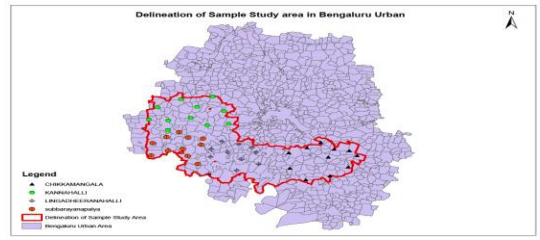

Fig-2: picture showing the study area

CMSWTF	X axis	Y axis
Kannahalli	77.44437	12.96801
Lingadeeranahalli	77.50958	12.87325
Chikkamangala	77.6862	12.86037
subbarayanapalya	77.43094	12.88275

Table -1: The Gps coordinates of the common treatment facilities

Kannahalli			subbarayanapalya			Lingadeeranahalli			Chikkamangala		
Sample	X	Y	sample	X	Y	sample	Y	X	sample	X	Y
KG1	77.45529	12.99889907	SG1	77.46277	12.89384	LG1	12.85372	77.53359	CG1	77.7231	12.87701
KG2	77.38572	12.99798934	SG2	77.46595	12.91087	LG2	12.90355	77.49891	CG2	77.69665	12.88256
KG3	77.47324	12.94743798	SG3	77.42389	12.92905	LG3	12.86057	77.47902	CG3	77.67277	12.90132
KG4	77.51102	12.95154189	SG4	77.4018	12.91555	LG4	12.81389	77.47609	CG4	77.64802	12.88554
KG5	77.50293	12.98657431	SG5	77.3747	12.86449	LG5	12.82328	77.52548	CG5	77.61859	12.82987
KG6	77.42701	13.01991109	SG6	77.37722	12.89822	LG6	12.84176	77.564	CG6	77.64674	12.79724
KG7	77.3705	12.96398174	SG7	77.40451	12.87711	LG7	12.87382	77.55924	CG7	77.68897	12.80791
KG8	77.40433	12.96088526	SG8	77.43863	12.86319	LG8	12.887	77.55248	CG8	77.72075	12.83307

Table -2: Gps coordinates of the location of water samples

RESULT AND DISCUSSION:

Physico chemical characteristic of Groundwater

Physico -chemical characteristics of groundwater samples of pre- monsoon (PRM) and post-monsoon (POM) seasons of two years, i.e., 2017 and 2018, are presented in Tables 4 to 7. BIS (2012) and WHO (2011) standards with calculated percent compliance comparing with BIS standards are presented in Table. 4.2.5. the BIS standards of the parameter analysed is given in the Table-8.

The pH of water samples varies in the range of 6.2 to 8.7 and 6.3 and 9.9 during PRM seasons in POM seasons the values showed in the range of 7.5 to 8.5 and 7.6 to 8.8 of 2017 and 2018 respectively. Most of the samples showed high pH that is greater than 7, which might be due to the presence of carbonate and bicarbonate salts. The samples from near the Subarayanapalya CMSWMF show acidic. Most of the samples lie in the base range in the POM seasons. The reason might be the intrusion of the rainwater into the aquifer. The acceptable limit for the drinking water standard is 6.5 to 8.5. 6.25% and 21.87 %of the samples lie out in the PRM seasons, and 3.1 and 6.25 % and the POM seasons show out of the permissible limit and do not lie in the limit; it is not suitable for drinking. The samples near the Chikanagamangala CMSWTF show highly basic in PRM seasons. All the samples in the post-monsoon show basic, and the reason is due to the infiltration of rainwater into the aquifer.

Electric conductivity is a measure of water's capability to pass electrical flow. The concentration of ions in the water is directly related to this ability. Electric conductivity comes from dissolved salts and inorganic materials such as alkalis, sulfides, and chlorides. The more the ions, the higher the conductivity. All the samples show high and out of the permissible conductivity limit in the PRM season of 2017 and 2018; 83.2 and 81.25 samples and samples are out of the limits in the post-monsoon seasons of 2017 and 2018. In PRM 2017, the EC range is very high in the region of the Kannahalli CMSWTF dumping site. Whereas in the samples of Chikanagamangala and Subarayanapalya CMSWTF region, the values of EC are moderately high. The samples of POM show less EC due to rainwater infiltration.

Total alkalinity values vary from 101 to 692.8 mg/L and 695.2 to 125 mg/L in the PRM seasons 620.9 to 80 and 625.1 to 90 mg/L of 2017 and 2018 respectively. The samples near the Kannahalli and Lingadeeranahalli CMSWTF show very high total alkalinity values in PRM seasons. In the POM season, only the samples near the Kannahalli CMSWTF shows high alkalinity. The desirable limit for total alkalinity is 200 mg/L. The water sample's total alkalinity value is very high compared to the standard. Carbonated and bicarbonates are responsible for causing alkalinity in water bodies. Anthropogenic activity includes alkalinity (bicarbonates and carbonates) from cleaning agents and food residues. In the present study, carbonates fell between 20 to 60 mg/L and 20 to 80 mg/L in PRM seasons and 20 to 60 mg/L and 0 to 130 mg/L in the POM seasons of 2017 and 2018, respectively. Bi carbonates ranged from 165 to 840 mg/L and 178 to 880 mg/L in PRM seasons and 51 to 400 mg/L and 62.2 to 380 mg/L in the POM seasons of 2017 and 2018 respectively.

TDS is generally considered not a primary pollutant. Still, it is rather used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants. The total hardness ranges from 201.6 to 1209.0 mg/L and 211.6 to 1329 mg/L in PRM seasons. 205.0 to 1179 mg/L and 241 to 1247 mg/L in the POM seasons of 2017 and 2018, respectively. 62.5 % and 71.87% of samples were recorded are out of permissible limits in PRM and 46.88 and 50% POM seasons according to BIS standards. BIS's (2012) permissible limit for TDS is 500 mg/L. Most samples near the Subarayanapalya CMSWTF municipal dumping yard show a high concentration of TDS. The average groundwater values of TDS near Kannahalli and Subarayanapalya CMSWTF are very high. The samples in PRM and POM, which are out of permissible limits, show the action of sewage and urban runoff in the study area.

The calcium concentration varies from 28 to 148 mg/L and 32.0 to 158.7 mg/L in PRM seasons and 29.1 to 60.1 mg/L and 32 to 82.6 mg/L in the POM seasons of 2017 and 2018, respectively. The Magnesium concentration varies from 25 to 105 mg/L and 49 to 108 mg/L in PRM seasons, and in POM seasons, the concentration was recorded as 22 to 71 mg/L and 16 to 94 mg/L in 2017 and 2018, respectively. The BIS limit for Calcium is 200 mg/L, and the permissible limit in the absence of an alternate source is 200 mg/L. All the samples collected are within the permissible limit.

The desirable limit for Magnesium is 100 mg/L. 12.5% and 59.62% groundwater samples of PRM seasons of 2017 and 2018 are out of the permissible limit of magnesium. The samples collected near the Chikanagamangala CMSWTF show a high concentration of magnesium.

BIS's permissible limit for fluoride is 1.5 mg/L. If present in low concentration, up to 1 mg/L is generally considered beneficial in water. Such water consumption improves dental health and prevents the formation of dental caries. Excessive fluoride, greater than 1.5 mg/L in drinking water, may cause dental caries to the molting of teeth. The samples near the Kannahalli CMSWTF show high fluoride content in the groundwater. The samples range from 0.1 to 1.8 mg/L and 0.2 to 2.1 mg/L in PRM and 0.1 to 0.9 mg/L and 0.1 to 1.2 mg/L. 9.3 % of the samples contain a higher amount of fluoride and are out of the permissible limit in both the PRM seasons. The high content of fluoride is due to the aquifer's geogenic factors and ion exchange contamination.

Sulphate can be found in almost all-natural water. The origin of most sulfate compounds is the oxidation of sulfite ores, the presence of shales, or industrial wastes. Sulfate is one of the major dissolved components of rain. High concentrations of sulfate in the water we drink can have a laxative effect when combined with calcium and magnesium, the two most common constituents of hardness. The samples contain sulphate concentrations in the range of 0.6 to 68.70 mg/L and 0.8 to 71.7 mg/L in PRM and 0 to 15.3 mg/L and 0 to 15.4 mg/L in POM seasons of 2017 and 2018, respectively. The desirable limit for sulphate is 200 mg/L, and the permissible limit in the absence of an alternate source is 400 mg/L. All the samples in all seasons are within the permissible limit.

Iron: Iron concentration varies from 0 to 1.20 mg/L and 0.0 to 1.3 mg/L in PRM and 0.0 to 0.8 mg/L and 0.0 to 0.9 mg/L POM seasons of 2017 and 2018 respectively. 18.75% and 21.87% of samples of PRM & 6.25 and 12.5% % of Samples of POM are out of the Permissible limit. The concentration of Iron is seen in the samples collected near the Kannahalli CMSWTF.

Water quality Index

Water quality indices aim at giving a single value to the water quality of a source based on one or the system, which translates the list of parameters, and their concentrations present in a sample into a single value. One can then compare different samples for quality based on the index value of each sample (Abbasi & Abbasi 2012).

The following steps are associated with the development of WQI:

a. Parameters selection (pH, EC, TDS, TH , HCO_3, Cl^-, SO_4, PO^4, NO_3, F, Ca^{2+}, Mg^+, Na^+, K^+ and SiO_2
b. Assignments of weight (wi) to all parameters based on its relative importance in the overall quality of water for drinking purposes
c. From the assigned weight, relative weight is calculated from the following equation.

$$Wi = wi \Big/ \sum_{i=1}^{n} wi$$

Where

Wi= relative weight

wi = parameters weight

n= Number of parameters

d. For each parameter quality rating scale (Qi) is assigned by dividing each water sample concertation by its respective standards as mentioned in the guidelines BIS (2012), and the result is multiplied by 100

Qi=(Ci/Si)X100

Where Qi = quality rating

Ci = Each analyzed chemical parameter concentration present in each water sample in Mg/l.

Si = Drinking water standard for each chemical parameter in mg/L as per BIS (2003) guidelines

e. The WQI sub-index (SI) is determined first for each chemical parameter, and then the same is used to determine the WQI by the subsequent equation.

Si= WiXQi (relative weight x quality rating)

WQI =∑SI

f. Computed WQI ranges were used to categorize water quality types (Brown *et al.*, 1972, Chatterji and Raziuddin, 2002) (Table 3 to 7)

In PRM 2017 season, WQI ranges ranged from 316.2 to 5.9 (Table 3) in that 65.62 % of water samples showed excellent water, 12.5 % of samples proved good water, 3.2% of samples as poor water, and only 18.75 % of samples as incompatible for drinking purposes. In the POM season of 2017, WQI ranges from 208.4 to 9.0 (Table 4) in that 56.25% of samples were of excellent water quality, 32% in the category of good water, 3.2 % of samples fell in the poor water category, 6.4% lies in the very poor water category, and 3.2% falls in the category of inappropriate water for drinking purposes.

In PRM 2018 season, WQI ranges were from 346.5 to 7.0 (Table 5) in that 50% of water samples showed excellent water, 25% of samples proved as good water, 3.2% of samples to have poor water, and only 3.2 % of samples as in very poor water category and 18.75% falls in the category incompatible for drinking purposes. In the POM season of 2018, WQI ranges from (Table 6) 246.36 to 9.3 in that 21.87% of samples were in excellent water quality, 64% in the category of good water, 3.2% of samples fall in the poor water category, 6.4% lies in the very poor water category, and 6.4% falls in the category of inappropriate water for drinking purposes.

The samples near the Kannahalli CMSWTF, except for one sample, all the other samples fall in the category of incompatible water in the PRM seasons of the studied years. The samples from the Lingadeeranahalli, Chikanagamangala, and Subarayanapalya CMSWTF fall in the excellent and good water category. In the POM seasons of 2017 and 2018, the samples KG1, KG2, KG3, and KG4 fall in the incompatible and very poor water category. The samples that fall in incompatible water for drinking purposes in PRM seasons are elevated to Goodwater after the monsoon season.

The overall water Type of all the season is depicted in the table 7 and shown in the fig 3 to 6.

Characterstics of Chemical Parameterr of Ground water samples with Water quality Index values in 2017 Pre-monsoon season										
Sample No	pH	EC	TDS	TH	Ca^{2+}	Mg+	Fe	F	SO_4^{2-}	WQI=SI	Water Type
KG1	7.3	1102	804	295.9	40.1	57	0.07	0.2	55.6	24.2859	Excelent water
KG2	7.85	1203	868	469.2	72.2	84	0.22	0.89	45.57	78.3737	Poor water
KG3	7.19	1145	945	464	98.6	85	1.1	0.91	53.1	294.4513	incompatible water
KG4	7.45	1298	828	493.5	122.6	53	0.98	1.59	35.2	279.7668	incompatible water
KG5	7.22	1345	779	445.3	148.4	25	0.71	1.64	55.2	213.4039	incompatible water
KG6	6.89	1411	859	459.8	72.8	44	1.2	0.75	68.7	313.9580	incompatible water
KG7	7.55	1506	942	559.45	56.9	68	1	0.98	38.5	271.5582	incompatible water
KG8	6.98	1831	915	615.6	50.59	89	1.11	1.79	63.8	316.2131	incompatible water
LG1	6.9	669	460.1	396	72.7	101	0	0.25	2.5	8.5651	Excelent water
LG2	7.62	896	420.5	320.3	52.1	105	0.09	0.5	4.4	37.5431	Good water
LG3	7	604	501.5	450.5	111.2	64	0	0.18	3.6	6.4470	Excelent water
LG4	7.34	1050	534	408.6	99.23	84	0.04	0.12	6.3	16.0927	Excelent water
LG5	6.98	890	692.12	561.24	122.54	71	0	0.27	6.5	8.7737	Excelent water
LG6	6.9	777	384.2	582.07	125.8	48	0	0.64	7.2	16.2366	Excelent water
LG7	6.7	689	543	692.8	70.98	44	0.05	0.42	1.3	23.0605	Excelent water
LG8	7.2	962	794	689.23	82.2	57	0.06	0.17	0.56	21.3032	Excelent water
CG1	8.31	778	597	235	87	84	0	0.2	6.3	9.4973	Excelent water
CG2	8.19	662	207	262	94	94	0	0.15	9	8.4079	Excelent water
CG3	7.88	845	327	299	65	101	0	0.19	8.7	8.8896	Excelent water
CG4	8.35	482	291	235	73	86	0.04	0.12	7.9	17.5373	Excelent water
CG5	8.66	608	765	272	35	67	0.09	0.28	4	33.4054	Good water
CG6	8.25	1121	497	190	51	69	0	0.3	0.9	11.1454	Excelent water
CG7	8.37	1224	500	217	29	79	0	0.26	2.8	10.6688	Excelent water
CG8	8.31	784	202	199	116	82	0.06	0.64	5.4	34.0301	Good water
SG1	6.98	1049	690	162	28	70	0	0.28	15	8.4208	Excelent water
SG2	6.29	945	345	119	36	76	0	0.29	15	7.5424	Excelent water
SG3	6.17	1207	697	101	54	82	0	0.42	12	10.5172	Excelent water
SG4	7.21	1325	632	198	72	84	0.06	0.32	7.9	25.0759	Excelent water
SG5	6.18	1024	345	294	124	91	0.08	0.42	11.7	30.7586	Good water
SG6	6.57	1781	741	218	108	105	0	0.14	16.8	5.9997	Excelent water
SG7	7.15	1941	1209	164	38	68	0	0.15	30	6.1008	Excelent water
SG8	6.5	1251	1051	245	87	58	0	0.42	8.2	10.7496	Excelent water

Table 3: Characteristics of chemical parameters of groundwater samples with water quality index in Pre-monsoon seasons 2017

Sample No	pH	EC	TDS	TH	Ca^{2+}	Mg+	Fe	F	SO_4^{2-}	WQI=∑SI	Water Type
KG1	7.3	1102	804	295.9	40.1	57	0.07	0.2	55.6	95.8226	Very Poor water
KG2	7.85	1203	868	469.2	72.2	84	0.22	0.89	45.57	208.4490	incompatible water
KG3	7.19	1145	945	464	98.6	85	1.1	0.91	53.1	86.7719	Poor water
KG4	7.45	1298	828	493.5	122.6	53	0.98	1.59	35.2	106.9383	Very Poor water
KG5	7.22	1345	779	445.3	148.4	25	0.71	1.64	55.2	36.9419	Good water
KG6	6.89	1411	859	459.8	72.8	44	1.2	0.75	68.7	43.0035	Good water
KG7	7.55	1506	942	559.45	56.9	68	1	0.98	38.5	51.4875	Good water
KG8	6.98	1831	915	615.6	50.59	89	1.11	1.79	63.8	35.6380	Good water
LG1	6.9	669	460.1	396	72.7	101	0	0.25	2.5	9.6108	Excelent water
LG2	7.62	896	420.5	320.3	52.1	105	0.09	0.5	4.4	39.7457	Good water
LG3	7	604	501.5	450.5	111.2	64	0	0.18	3.6	14.0672	Excelent water
LG4	7.34	1050	534	408.6	99.23	84	0.04	0.12	6.3	15.6674	Excelent water
LG5	6.98	890	692.12	561.24	122.54	71	0	0.27	6.5	43.7160	Good water
LG6	6.9	777	384.2	582.07	125.8	48	0	0.64	7.2	20.6097	Excelent water
LG7	6.7	689	543	692.8	70.98	44	0.05	0.42	1.3	9.0481	Excelent water
LG8	7.2	962	794	689.23	82.2	57	0.06	0.17	0.56	9.5702	Excelent water
CG1	8.31	778	597	235	87	84	0	0.2	6.3	33.9195	Good water
CG2	8.19	662	207	262	94	94	0	0.15	9	27.6750	Excelent water
CG3	7.88	845	327	299	65	101	0	0.19	8.7	20.0220	Excelent water
CG4	8.35	482	291	235	73	86	0.04	0.12	7.9	42.1229	Good water
CG5	8.66	608	765	272	35	67	0.09	0.28	4	20.1797	Excelent water
CG6	8.25	1121	497	190	51	69	0	0.3	0.9	27.7870	Excelent water
CG7	8.37	1224	500	217	29	79	0	0.26	2.8	11.0704	Excelent water
CG8	8.31	784	202	199	116	82	0.06	0.64	5.4	10.9233	Excelent water
SG1	6.98	1049	690	162	28	70	0	0.28	15	37.1332	Good water
SG2	6.29	945	345	119	36	76	0	0.29	15	28.9067	Excelent water
SG3	6.17	1207	697	101	54	82	0	0.42	12	19.5696	Excelent water
SG4	7.21	1325	632	198	72	84	0.06	0.32	7.9	38.0246	Good water
SG5	6.18	1024	345	294	124	91	0.08	0.42	11.7	18.8280	Excelent water
SG6	6.57	1781	741	218	108	105	0	0.14	16.8	28.7908	Excelent water
SG7	7.15	1941	1209	164	38	68	0	0.15	30	15.3277	Excelent water
SG8	6.5	1251	1051	245	87	58	0	0.42	8.2	10.9319	Excelent water

Table .4: Characteristics of chemical parameters of groundwater samples with water quality index in Post monsoon seasons 2017

Sample No	pH	EC	TDS	TH	Ca^{2+}	Mg+	Fe	F	SO_4^{2-}	WQI=SI	Water Type
KG1	7.3	1102	804	295.9	40.1	57	0.07	0.2	55.6	32.7969	Good water
KG2	7.85	1203	868	469.2	72.2	84	0.22	0.89	45.57	104.1305	Very Poor water
KG3	7.19	1145	945	464	98.6	85	1.1	0.91	53.1	316.6780	incompatible water
KG4	7.45	1298	828	493.5	122.6	53	0.98	1.59	35.2	312.3907	incompatible water
KG5	7.22	1345	779	445.3	148.4	25	0.71	1.64	55.2	243.8946	incompatible water
KG6	6.89	1411	859	459.8	72.8	44	1.2	0.75	68.7	346.5245	incompatible water
KG7	7.55	1506	942	559.45	56.9	68	1	0.98	38.5	285.8455	incompatible water
KG8	6.98	1831	915	615.6	50.59	89	1.11	1.79	63.8	333.6223	incompatible water
LG1	6.9	669	460.1	396	72.7	101	0	0.25	2.5	12.7489	Excelent water
LG2	7.62	896	420.5	320.3	52.1	105	0.09	0.5	4.4	51.8762	Good water
LG3	7	604	501.5	450.5	111.2	64	0	0.18	3.6	8.0871	Excelent water
LG4	7.34	1050	534	408.6	99.23	84	0.04	0.12	6.3	41.1928	Good water
LG5	6.98	890	692.12	561.24	122.54	71	0	0.27	6.5	9.7576	Excelent water
LG6	6.9	777	384.2	582.07	125.8	48	0	0.64	7.2	18.4604	Excelent water
LG7	6.7	689	543	692.8	70.98	44	0.05	0.42	1.3	49.5298	Good water
LG8	7.2	962	794	689.23	82.2	57	0.06	0.17	0.56	47.8027	Good water
CG1	8.31	778	597	235	87	84	0	0.2	6.3	12.5401	Excelent water
CG2	8.19	662	207	262	94	94	0	0.15	9	9.0003	Excelent water
CG3	7.88	845	327	299	65	101	0	0.19	8.7	9.4859	Excelent water
CG4	8.35	482	291	235	73	86	0.04	0.12	7.9	26.8008	Excelent water
CG5	8.66	608	765	272	35	67	0.09	0.28	4	51.6521	Good water
CG6	8.25	1121	497	190	51	69	0	0.3	0.9	14.1258	Excelent water
CG7	8.37	1224	500	217	29	79	0	0.26	2.8	12.4359	Excelent water
CG8	8.31	784	202	199	116	82	0.06	0.64	5.4	65.7486	Poor water
SG1	6.98	1049	690	162	28	70	0	0.28	15	10.0188	Excelent water
SG2	6.29	945	345	119	36	76	0	0.29	15	8.3645	Excelent water
SG3	6.17	1207	697	101	54	82	0	0.42	12	25.9987	Excelent water
SG4	7.21	1325	632	198	72	84	0.06	0.32	7.9	28.3084	Excelent water
SG5	6.18	1024	345	294	124	91	0.08	0.42	11.7	32.1941	Good water
SG6	6.57	1781	741	218	108	105	0	0.14	16.8	7.0093	Excelent water
SG7	7.15	1941	1209	164	38	68	0	0.15	30	7.1287	Excelent water
SG8	6.5	1251	1051	245	87	58	0	0.42	8.2	33.0910	Good water

Table 5: Characteristics of chemical parameters of groundwater samples with water quality index in Pre-monsoon seasons 2018.

Sample No	pH	EC	TDS	TH	Ca^{2+}	Mg+	Fe	F	SO_4^{2-}	WQI=SI	Water Type
KG1	7.3	1102	804	295.9	40.1	57	0.07	0.2	55.6	209.5032	incompatible water
KG2	7.85	1203	868	469.2	72.2	84	0.22	0.89	45.57	246.3612	incompatible water
KG3	7.19	1145	945	464	98.6	85	1.1	0.91	53.1	99.3012	Very Poor water
KG4	7.45	1298	828	493.5	122.6	53	0.98	1.59	35.2	117.0337	Very Poor water
KG5	7.22	1345	779	445.3	148.4	25	0.71	1.64	55.2	45.4789	Good water
KG6	6.89	1411	859	459.8	72.8	44	1.2	0.75	68.7	52.7642	Good water
KG7	7.55	1506	942	559.45	56.9	68	1	0.98	38.5	63.7694	Poor water
KG8	6.98	1831	915	615.6	50.59	89	1.11	1.79	63.8	51.2960	Good water
LG1	6.9	669	460.1	396	72.7	101	0	0.25	2.5	34.9598	Good water
LG2	7.62	896	420.5	320.3	52.1	105	0.09	0.5	4.4	45.9138	Good water
LG3	7	604	501.5	450.5	111.2	64	0	0.18	3.6	51.5995	Good water
LG4	7.34	1050	534	408.6	99.23	84	0.04	0.12	6.3	9.3391	Excelent water
LG5	6.98	890	692.12	561.24	122.54	71	0	0.27	6.5	43.8980	Good water
LG6	6.9	777	384.2	582.07	125.8	48	0	0.64	7.2	39.5657	Good water
LG7	6.7	689	543	692.8	70.98	44	0.05	0.42	1.3	38.4149	Good water
LG8	7.2	962	794	689.23	82.2	57	0.06	0.17	0.56	40.2046	Good water
CG1	8.31	778	597	235	87	84	0	0.2	6.3	48.4737	Good water
CG2	8.19	662	207	262	94	94	0	0.15	9	59.6749	Good water
CG3	7.88	845	327	299	65	101	0	0.19	8.7	27.3879	Excelent water
CG4	8.35	482	291	235	73	86	0.04	0.12	7.9	28.5949	Excelent water
CG5	8.66	608	765	272	35	67	0.09	0.28	4	33.6223	Good water
CG6	8.25	1121	497	190	51	69	0	0.3	0.9	37.1972	Good water
CG7	8.37	1224	500	217	29	79	0	0.26	2.8	33.4559	Good water
CG8	8.31	784	202	199	116	82	0.06	0.64	5.4	20.6172	Excelent water
SG1	6.98	1049	690	162	28	70	0	0.28	15	49.9049	Good water
SG2	6.29	945	345	119	36	76	0	0.29	15	29.2079	Excelent water
SG3	6.17	1207	697	101	54	82	0	0.42	12	30.2163	Good water
SG4	7.21	1325	632	198	72	84	0.06	0.32	7.9	42.4928	Good water
SG5	6.18	1024	345	294	124	91	0.08	0.42	11.7	44.4902	Good water
SG6	6.57	1781	741	218	108	105	0	0.14	16.8	45.1276	Good water
SG7	7.15	1941	1209	164	38	68	0	0.15	30	13.9696	Excelent water
SG8	6.5	1251	1051	245	87	58	0	0.42	8.2	15.6431	Excelent water

Table .6: characteristics of chemical parameters of groundwater samples with water quality index in Post monsoon seasons 2018

Water Type	Number of groundwater samples in 2017-Pre-monsoon season	Number of groundwater samples in 2017-Post-monsoon season	Number of groundwater samples in 2018-Pre-monsoon season	Number of groundwater samples in 2018-Post-monsoon season
Excellent Water	21	18	16	7
Good Water	4	10	8	20
Poor Water	1	1	1	1
Very Poor Water	0	2	1	2
Incompatiable Water for drinking purpose	6	1	6	2
Total	**32**	**32**	**32**	**32**

Table .7: Overall Groundwater Samples water type

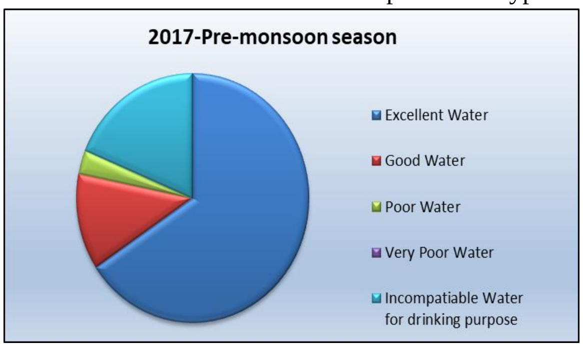

Fig .3: Pie chart showing the water types in PRM 2017

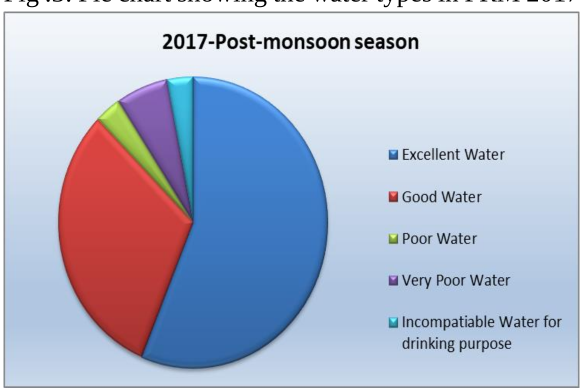

Fig 4. Pie chart showing the water types in POM 2017

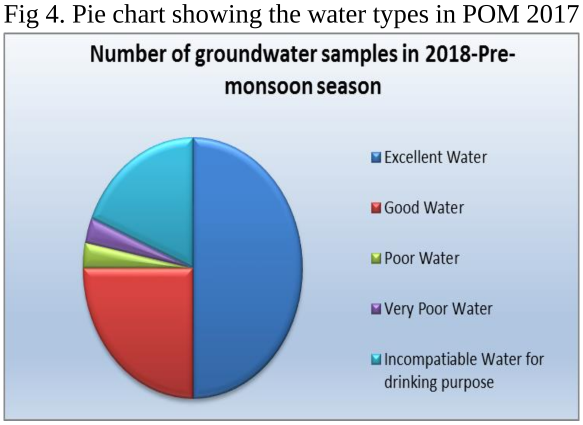

Fig. 5: Pie chart showing the water types in PRM 2018

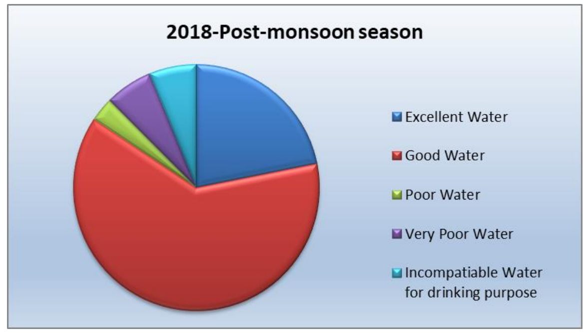

Fig. 6: Pie chart showing the water types in POM 2018

Parameters	BIS standard sn
pH	8.5
EC	300
TDS	500
TH	200
Calcium	75
Magnesium	30
Iron	0.3
Fluoroide	1
Sulphate	200

Table.8: BIS standards of the water quality Description

Categorization of water quality based on WQI level Water Quality Index levels	
0-25	Excellent
26-50	Good water
51-75	Poor water
76-100	Very Poor water
100>	Unsuitable for Drinking

Table-9: classification of water quality

CONCLUSION

During the rainy season, the inflow of good-quality freshwater improves. Magnesium and calcium chloride are inextricably linked, implying that water hardness is a factor. In nature, nothing is permanent. The investigation suggests that the area's groundwater need considerable attention. It also requires treatment before to use for drinking.

The Water Quality Index (WQI), which has been used in several research, is an essential instrument for determining water quality. An attempt was made in this study to improve the tool's outcomes by integrating a temporal component.

The AWQI table demonstrated that water's physicochemical properties were generally within acceptable ranges. There was no problem in the research area. The majority of jurisdiction got an AWQI rating of 'good.'

Apart from a few areas where it was 'poor,' it can be used for drinking. This 'bad' indication was caused by Turbidity is at a greater degree than usual. The use of AWQI and GIS approaches not only aids in the modernization of decision-making and planning, but they also aid in the development of new ideas.

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