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Water Quality Index of Datia City, (M.P.)

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ABSTRACT: The water quality of different sources of water viz. hand pump, wells, bore wells and taps of urban areas of Datia (M.P.) was studied. The results of Physico-chemical analysis for pH, electrical conductivity, T.S., T.D.S., T.S.S, T. H, T.A. NO_3,Cl, SO_4, Na, and K of 27 water samples collected from 10 wards of municipal area of Datia city are presented. The present study assessed the Water Quality Index (WQI) of Datia city to find out the impact of industrial and human activities. Physicochemical parameters were subjected to calculation of WQI for the winter, summer and rainy seasons. The correlation coefficients were calculated for water qualityassessment.

Key Words: Datia Urban area, Physico-chemical characteristics, Drinking Water Quality Index (WQI), Correlation coefficient.

INTRODUCTION

Ground water is a good source of fresh water. It is the important renewable resource having several inherent advantages over surface water. This potential source of water is economical essential component of our life, but it is getting deteriorated in major cities and urban centers due to pollution caused by population explosion, urbanization and industrialization. Chemical quality of the surface and ground water is of paramount importance in its utilization for municipal and industrial uses as it is a universal solvent which dissolves almost everything that comes in its contact. Since, water is valuable natural resource it is important that its quality be maintained for being used by the people and the industry, and consideration should be given to recycle it to themaximum extent. The mineral impurities in water include principally the Chlorides, Nitrate, Fluoride, and Iron. The water samples in the present study were analyzed for major cations, i.e. total dissolved solids (T.D.S.), electrical conductivity (E.C.), total hardness and pH as ground water is generally used for drinking, domestic and agricultural purposes. The present study attemptsto evaluate the quality of ground water in urban area of District Datia, (M.P.)

Study area: The district is situated in the north part of M.P. and is located between the latitudes $25^0$28'N and $28^0$20' N and longitudes of $78^0$10', E and $78^0$45' E, and Total geographical area 2691 Sq Km. and the major part of the study area is covered with the sand stone rocky quartzite and granite stone types of soil.

MATERIAL AND METHOD

Drinking water samples from 27 different locations of Datia city were collected every season in the year 2009. Sample ware collected in clean two litre plastic bottles. Chemical characteristics were determined by the standard methods (APHA 1989). Water quality index (WQI) and coefficient of variation are the two statistical parameters considered for variability measurement among the parameters. The correlation coefficient (r) was calculated between each pair of parameters using experimental data given in Table 6, 7 and 8.

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Table 1. Chemical parameters and their methods used (APHA-1989).

Parameters	Methods
E.C. (Electrical conductivity) μ mho/cm.	Conductivitybridge.
pH	H^+ion sensitive electrode methods.
Total Solid	Evaporation method.
Total dissolved solids (T.D.S.)	Evaporation to Residue in Crucible
Total Suspended Solid	Calculation Methods
Total Hardness (T.H.)	E.D.T.A. Titrimetric method.
Calcium Hardness	E.D.T.A. Titrimetric Method
Magnesium Hardness	Calculation Method
Chlorides	Argentometric method.
Nitrate	Brucine sulfanilic acidmethod.
Total Alkalinity	Phenolphthalein and Methyl Orange Indicator Method
Sulphate	Turbidimetric Method
Nitrites	N-(1-Napthy)-EthyleneDiamine Dihydro cloride
Potassium	Flame PhotometricMethod
Sodium	Flame PhotometricMethod

Table 2. Physico-chemical characteristics of drinking water in different seasons in Datia City.

Chemical Parameters	Winter Season			Summer Season			Rainy Season		
	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
pH	7.35	8.20	7.727	7.8	8.4	7.879545	7.54	8.22	7.936818
E.C. μmho/cm.	396	2178.40	1024.7	119.0	2942.4	1567.391	406.25	1714.6	935.8809
T.S.	335	2110	850.44	392	2912	1573.182	287	1254	671.7727
T.D.S.	212	1910	671.3	310	2369	1083.136	182	964	461.6364
T.S.S.	90	320	178.33	98	1324	471.3636	105	380	205.2273
Total Alkalinity	110	600	358.88	180	590	410.4545	130	620	384.5455
Calcium Hardness	80	340	188.29	91	410	227.6818	84	326	190.8182
Magnesium Hardness	2.43	72.9	25.81	5.10	68.04	23.27273	2.67	72.9	33.51136
Total Hardness	90	504	291.22	185	490	321	100	521	328.7273
Chlorides	47	243	169.89	45.5	423.9	199.135	45.5	256.4	167.7136
Sulphate	.0023	16.4	10.464	0.023	18.3	12.65252	3.5	18.7	10.65909
Sodium (PPM)	24	258.6	102.97	9.6	481.2	126.3455	30.2	254.6	99.89091
Potassium (PPM)	23.8	98.8	44.46	6.3	74.2	47.53182	14.5	102.5	41.6
Nitrate	0.9	9.2	5.088	0.8	5.8	2.85	1.2	8.5	3.231818

Note : All values are in mg. l^{-1}except pH , E.C. (μmho/cm.) and Na, K (PPM).

Water Quality Index (WQI): The concept of indices to represent gradation in water quality was first proposed [8] It indicates the quality by an index number, which represents the overall quality of water for any intended use. It is defined as a rating reflecting the composite influence of different water quality parameters on the overall quality of water [5, 7, 10]. The WQI has been calculated from the point of view of the suitability of water for humanconsumption.

(a) WQI Calculation : For calculation of WQI, selection of parameters has great importance. Since

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selection of too many parameters might make the results obscure and the water quality index, and the importance of various parameters depends on the intended use of water, eight physicochemical parameters, namely pH, TS, TDS, TSS, EC, total alkalinity, magnesium, calcium, total hardness, chloride, sulphate, were used to calculate the WQI. The calculation of WQI was made using a weighted arithmetic index method given below [3] in the followingsteps.

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Calculation of sub index of quality rating (q_n) : Let there be n water quality parameters where the quality rating or sub index (q_n) corresponding to the nth parameter is a number reflecting the relative value of this parameter in the polluted water with respect to its standard permissible value. The value of *qn* is calculated using the following expression.

$$q_n = 100[(Vn - Vio) / (Sn - Vio)] \quad \ldots(1)$$

Where, q_n= quality rating for the n^{th}water quality parameter, *Vn* = estimated value of the n^{th}parameter at a given sampling station, *Sn* = standard permissible value of n^{th}parameter, *Vio* = ideal value of n^{th}parameter in purewater.

Calculation of unit weight (*Wn*) : Calculation of unit weight (*Wn*) for various water quality parameters are inversely proportional to the recommended standards for the correspondingparameters.

$$Wn = K/Sn \quad \ldots(2)$$

Where *Wn* = unit weight for n^{th}parameter, *Sn* = standard value for n^{th}parameters, K = proportionality constant.

Calculation of WQI: WQI is calculated from the following equation -

$$WIQ = \sum_{n=1}^{n} \frac{qn\,Wn}{\sum_{n=1}^{n} Wn} \quad \ldots(3)$$

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Table 3. Calculation of WQI in Winter Season of Ward No. 01.

Parameter	Observed value	Standards	Recommended agency	Unit Wight (w_n)	Quality rating (q_n)	$w_n q_n$
pH	7.71	6.5-8.5	BIS	0.219	47.33333	10.365
EC	807.6	1000	BIS	0.0018545	80.76	0.1497
T.S.	581.75	1500	BIS	0.0012363	38.78333	0.0479
T.D.S	461.5	500	BIS	0.0037089	92.3	0.3423
T.S.S.	120.3	500	BIS	0.0037089	24.06	0.0892
T.A	417.5	200	BIS	0.0092723	208.75	1.9355
Cl^-	183.8	250	BIS	0.0074178	73.52	0.5453
SO_4^{2-}	11.2	200	BIS	0.0092723	5.6	0.0519
Ca_2^+	190.2	75	BIS	0.024726	253.6	6.2705
Mg_2^+	45.07	30	BIS	0.061815	150.2333	9.2866
T.H.	383.2	300	BIS	0.0061815	127.7333	0.7895
No_3	4.6	45	BIS	0.04121	10.22222	0.4212
WIQ = 77.7989			**W_n** = 0.389403		**$W_n q_n$** = 30.295	

Table 4. Water Quality Index (WQI) of Datia City.

Ward No.	WQI in Winter season	WQI in Summer season	WQI in Rainy season
01	77.7989	94.144	79.875
02	59.346	69.8067	60.593
03	64.929	76.474	64.6452
04	67.8279	62.802	69.229
05	63.3102	64.502	64.757
06	72.988	78.68	73.169
07	72.627	61.326	74.179
08	73.415	76.554	77.125
09	48.346	64.236	50.101
10	60.150	77.410	58.509

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Table 5. Status of water quality based on WQI in different Seasons in Datia City.

Water Quality Index	Status	Ward No. Winter Season	Ward No. Summer Season	Ward No. Rainy Season
0-25	**Excellent**	Nil	Nil	Nil
26-50	**Good**	09,	Nil	09
51-75	**Poor**	02,03,04,05,06,07,08,10	02,04,05,07,09	02,03,04,05,06,07,10
76-100	**Very Poor**	01,	01,03,06,08,10	01,08
< 100	**Unsuitable for drinking**	Nil	Nil	Nil

Table 6. Correlations (r) between some Physico- chemical Parameters in WinterSeason.

Parameter	pH	EC	T.S.	T.D.S	T.S.S.	T.A	Cl	SO_4	Ca	Mg	T.H.	Na	K	NO_3
pH	1													
EC	-0.797	1												
T.S.	-0.790	**0.984**	1											
T.D.S	-0.781	**0.974**	**0.989**	1										
T.S.S.	-0.663	***0.727***	**0.731**	**0.642**	1									
T.A	0.031	0.150	0.166	0.154	-0.052	1								
Cl	-0.379	0.327	**0.523**	0.274	0.464	0.224	1							
SO_4	0.100	0.113	0.092	0.084	0.309	**0.560**	0.291	1						
Ca	-0.007	0.048	-0.182	-0.021	-0.011	0.301	-0.441	0.326	1					
Mg	-0.339	0.225	0.167	0.169	0.092	**0.704**	0.201	0.282	0.241	1				
T.H.	-0.236	0.161	-0.006	0.091	0.014	**0.595**	-0.233	0.278	**0.747**	**0.808**	1			
Na	-0.783	**0.823**	**0.845**	**0.836**	**0.640**	0.113	0.051	0.045	0.202	0.252	0.298	1		
K	-0.451	0.466	0.399	0.483	-0.032	-0.009	-0.209	-0.434	0.336	0.009	0.234	**0.595**	1	
NO_3	0.050	-0.448	-0.544	-0.386	0.009	-0.205	-0.035	0.204	0.104	-0.192	-0.072	-0.199	-0.417	1

Table 7. Correlations (r) between some Physico-chemical Parameters in SummerSeason.

Parameter	pH	EC	T.S.	T.D.S	T.S.S.	T.A	Cl	SO_4	Ca	Mg	T.H.	Na	K	NO_3
pH	1													
EC	-0.693	1												
T.S.	-0.667	**0.955**	1											
T.D.S	-0.634	**0.923**	**0.815**	1										
T.S.S.	-0.277	0.266	**0.505**	-0.071	1									
T.A	-0.371	0.183	0.162	-0.070	0.347	1								
Cl	0.019	0.280	0.066	0.441	-0.639	0.012	1							
SO_4	0.015	0.243	0.168	0.216	-0.162	0.146	0.238	1						

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Ca	0.247	-0.126	-0.116	-0.177	-0.068	0.224	-0.003	0.413	1					
Mg	0.265	0.025	-0.114	0.154	-0.461	-0.238	0.383	**0.521**	0.036	1				
T.H.	0.323	0.006	-0.114	0.083	-0.420	-0.049	0.357	**0.655**	**0.551**	**0.850**	1			
Na	-0.360	0.267	0.143	0.262	-0.154	0.265	0.186	-0.016	0.442	-0.074	0.191	1		
K	-0.035	0.239	0.234	0.209	0.017	-0.243	0.133	0.142	0.357	0.004	0.186	**0.639**	1	
NO_3	0.151	0.199	0.099	0.365	-0.404	-0.417	0.382	0.266	0.268	**0.785**	**0.799**	0.246	0.339	1

Table 8. Correlations (r) between some Physico- chemical Parameters in Rainy Season.

Parameter	**pH**	**EC**	**T.S.**	**T.D.S**	**T.S.S.**	**T.A**	**Cl**	**SO_4**	**Ca**	**Mg**	**T.H.**	**Na**	**K**	**NO_3**
pH	1													
EC	-0.454	1												
T.S.	-0.396	**0.991**	1											
T.D.S	-0.365	**0.975**	**0.986**	1										
T.S.S.	-0.458	**0.798**	**0.788**	**0.682**	1									
T.A	0.461	0.060	0.167	0.167	0.110	1								
Cl	-0.247	0.080	0.077	0.030	0.243	0.053	1							
SO_4	0.255	-0.025	0.026	-0.084	0.411	0.481	0.206	1						
Ca	-0.352	0.366	0.366	0.373	0.285	0.121	-0.631	-0.027	1					
Mg	-0.179	0.402	0.453	0.464	0.334	**0.716**	0.068	0.213	**0.503**	1				
T.H.	-0.148	0.216	0.227	0.292	0.012	0.206	-0.627	-0.140	**0.780**	**0.558**	1			
Na	-0.400	**0.933**	**0.922**	**0.913**	**0.773**	0.037	0.108	-0.058	0.261	0.318	0.250	1		
K	-0.277	0.271	0.251	0.348	-0.079	-0.396	-0.256	-0.581	0.210	-0.219	0.350	0.433	1	
NO_3	-0.130	-0.499	-0.487	-0.487	-0.379	-0.211	0.425	0.213	-0.369	-0.247	-0.347	-0.549	-0.102	1

RESULTS AND DISCUSSION

The pH values of all the sample was in the range of 7.35 to 8.4, which indicates the desirable limits. Electrical Conductivity of water samples varied from 396 to 2178.40, 119.0 to 2942.4 and 406.25 to 1714.6 µ mho/cm. in winter, summer and rainy seasons respectively**,** but samples 18, 5 and 19 had relatively higher conductivity in winter, summer and rainy seasons, which may be due to contamination of conducting material in water samples. Total dissolved solids varied from 182 to 2369 mg l^{-1}. These values were the lowest in the winter season, 620 mg l^{-1}in rainy season, but sample 16 (ward no.06) had relatively higher total alkalinity in rainy season (maximum permissible limit BIS 600 mgl^{-1}).

Total hardness levels varied from 90 to 521 mg l^{-1}. The BIS desirable limit for total hardness is 300 mg $l^{-1}$and permissible limit 600 mg l^{-1}but only 13, 09 and 13 samples showed the values below the permissible limit in winter, summer and rainy seasons. The leaching of calcium and magnesium rich minerals from rocks and other deposits like limestone, gypsum and clay minerals possibly contributed to total hardness. Sewage and domestic wastes may also be contributing to total hardness in ground water. Calcium determination is usually required for potability of water. Its values varied from 80 to 410 mg l^{-1}(BIS desirable value

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75 mg $l^{-1}$and permissible limit of 200 mg l^{-1}). Magnesium is an essential element for human being. Its desirable limit is 30 mg l^{-1}(BIS 1992). However, at higher levels, magnesium salts have a laxative effect. In the present study, magnesium values varied from 2.43 to 72.9 mgl^{-1}.

Chloride is one of the important parameters to adjudge water quality. High chloride content causes cardiovascular problem, gives a bitter taste to water, corrodes steel and affects the solidity and strength of concrete. The study showed chloride values ranging from 45.5 to 423.9 mg l^{-1}. The value was within the permissible limit of 250 mg $l^{-1}$for 26, 23 and 23 samples in winter, summer and rainy seasons (BIS 1992).

Sodium is commonly present in water and its concentration in unpolluted water is less than that of calcium or magnesium. The concentration of sodium (9.6 to 481.2 mg l^{-1}) was below the BIS permissible limit (200 mg l^{-1}). Potassium is a naturally occurring element. Its concentration (6.3 to 102.5 mg l^{-1}) is however, usually quite lower than that of sodium, calcium and magnesium (BIS permissible limit 12 mg l^{-1}). Thus, the excess amount of potassium present in the water sample may lead to nervous and digestive disorders[11].

High amount of sulphate imparts bitter taste to the sample 9 and 10 in summer and rainy seasons. Also, this may cause laxative effect in children in hot weather climates [6]. Nitrate in food may cause methemoglobinemia in babies [10], cancer of the colon, rectum or other gastrointestinal cancer [4, 13], Alzeimer's disease, vascular dementia of Biswanger type or multiple small infarct type [12]. All samples have nitrate concentration below permissible limit BIS (45 mg l^{-1}).

Statistical Analysis

Correlation Coefficient Analysis: Sources of measured parameters in groundwater were examined through the analysis of linear correlation [10]. The correlation metric for all samples are given in Table 5. We considered the correlation as good if r>0.6 and marginal of 0.47< r <0.6 Table 06, 07, & 08. The high positively correlated values were found between TS and EC (0.984, 0.955 and 0.991), TDS and EC (0.974, 0.923 and 0.975), TDS and TS (0.989, 0.815 and 0.986),TSSandTS(0.731,0.505and0.788),TH and Mg(0.808,0.558and0.850),THandCa(0.747,0.551 and 0.780) winter, summer and rainy seasons, TSS and EC(0.727and0.798)NaandEC(0.823and0.933),, Na and TS (0.845 and 0.922), TSS and TDS (0.642 and 0.682), Na and TDS (0.836 and 0.913), Naand TSS (0.640 and 0.773) winter and rainy seasons, K and Na (0.595 and 0.639) winter and summer, .$Cl^-$and TS (0.523) , $SO_4$and TA (0.560) , Mg andTA (0.704) ,
TH and TA (0.595) winter season, Mg and SO_4(0.521), TH and SO_4(0.655), $NO_3$and Mg (0.785)
summer season, Mg and Ca (0.503), $NO_3$and TH (0.799) rainy season.

Water Quality Index (WQI) : Water Quality Index (WQI) out of 10 wards, showed that only 01 ward in winter and 01 ward in rainy season rated good, 08 wards in winter , 05 wards in summer and 07 wards in rainy season rated poor and 01 ward in winter, 05 wards in summer and 02 wards in rainy seasons rated very poor. The physico-chemical properties of the groundwater highly varied in locations. The area rated poor and very poor for drinking water quality requires treatment before use for publicconsumption.

CONCLUSION

The above observations in the present study indicate higher values of some parameters of the samples. They minimize the suitability of these sources for drinking purposes without treatment. But, after the filtration and disinfection, naturally present impurities can be removed, which may enhance its suitability for drinking and domestic purposes. People depend on this water are often prone to health hazards due to polluted drinking water, therefore, some effective measures are urgently required to enhance the drinking water quality by delineating an effective water quality management plan for Datia City(M.P.).

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