Review paper

QUALITATIVE AND QUANTITATIVE EVALUATION OF WATER SOURCES OF FEW AREAS IN AND AROUND GWALIOR, MADHYA PRADESH, INDIA

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ABSTRACT

The present study is a review on the water analysis of some areas in Gwalior region conducted by various research groups in recent years. Various water sources of Gwalior region were assessed for its irrigational suitability, fish cultures well as drinking purpose. In this paper, different research studies are summarized on water analysis of different areas in and around Gwalior region, which is helpful to know the quality of water of this area and therefore its usage. Various physico-chemical parameters which were commonly tested by these groups are pH, conductivity, total hardness, TDS, turbidity, DO,several inorganic ions etc. The cumulative evidences obtained after analysing the water samples, supports the fact that the water of this region contains high pathogenic content, TDS, fluoride, chloride and sodium ion concentration mainly and in few samples high BOD and COD is indicative of the pollution status of these water sources. Thus, making it unfit for drinking purpose and requires proper treatement, however in some cases boiling and filtering of water before its usage would be suitable and for defluorination Nalgonda technique at domestic level is suggested.

Key Words : pH, Conductivity, TDS, Turbidity, Nalgonda technique

INTRODUCTION

Historically, Madhya Pradesh State used to have six regions. The sixth region, however, Chhattisgarh, became autonomous in November 2000. Regions forming MP state are Chambal, Malwa, Bundelkhand, Baghelkhand and Mahakaushal regions. Gwalior is the largest city of Chambal region.The water collected from different areas of Gwalior region were tested by various research groups time to time, as we know ground water is the major source of drinking water in both urban and rural areas[1] and unsafe drinking water contributed to numerous health problems in developing countries and more than one billion or more incidents of diarrhoea occurs annually and this needs to be checked.[2] The chemical nature of the ground water is influenced by several factors such as chemical weathering of the country rocks and interaction with the country rocks.[3] The importance of the

hydrochemical analysis underlies the fact that the chemistry of the ground water can directly be rated with the source of water, climate and geology of the region howeverwith the increase in urbanization, industrialization, agriculture activity and various human activities has increased the pollution of surface water and ground water. The quality of water, which means the physical, chemical and biological characteristics of water[4] is vital concern for mankind, since it is directly linked with human welfare, it is a matter of history that fiscal pollution of drinking water caused water borne diseases which wiped out entire population of the societies thus water should be free from various contaminations viz. Organic and inorganic pollutants, heavy metals, pesticides etc. as well as all its parameter like pH, electrical conductivity, calcium, magnesium, total hardness, carbonate, bicarbonate, chloride, total dissolved solid, alkalinity, sodium potassium, nitrate, DO should be within a permissible limit. The entire

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array of life in water is affected due to pollution in water.

AIMS AND OBJECTIVES

Review the water quality of Gwalior region, Madhya Pradesh, India

DISCUSSION

In last few years, a good amount of work has been done to study the water quality with reference to physico-chemical and biological parameter of Gwalior region. In that series of work, Saksena and et. al[5] have reported the physic chemical characteristics of Chambal river water. The water quality parameters namely transpar-ency, colour, turbidity, electrical conducti-vity, total dissolved solids, pH, dissolved oxygen, free carbon dioxide, total alkalinity, total hardness, chloride, nitrate, nitrite, sulphate, phosphate, silicate, biochemical oxygen demand, chemical oxygen demand , ammonia, sodium and potassium reflects on the pristine nature of the river in National Chambal sanctuary. **(Table 1)**

Table 1 : Analysis of physico-chemical parameters of Chambal river

S/N	Parameters	Unit	Station-A (Palighat)			Station-B(Rajghat)			Station-C(Baraighat)		
			Range of variation		Mean and standard deviation	Range of variation		Mean and standard deviation	Range of variation		Mean and standard deviation
			Min.	Max.		Min.	Max.		Min.	Max.	
1.	Water temperature	^{0}C	17.60	31.00	26.47 ± 4.09	17.90	33.00	26.75 ± 4.44	18.10	32.10	26.69 ± 4.33
2.	Transparency	Cm	15.50	100.00	67.66 ± 33.93	12.12	106.20	78.13 ± 34.50	17.00	110.00	82.48 ± 35.38
3.	Flow rate	cm sec^{-1}	12.50	36.00	19.70 ± 7.58	6.00	45.00	19.80 ± 12.09	6.10	46.00	29.68 ± 11.83
4.	Colour		V.T.	Transp.	-	Transp.	V.T.	-	Trancp.	V.T.	-
5.	Depth	M	3.32	9.26	6.27 ± 2.25	3.40	5.88	4.79 ± 0.75	1.47	8.38	2.97 ± 2.40
6.	Turbidity	NTU	1.60	86.30	20.15 ± 24.92	1.35	178.00	29.80 ± 53.38	1.00	107.00	19.70 ± 29.82
7.	Electrical conductivity	µS cm^{-1}	145.60	403.20	283.00 ± 91.98	100.00	666.40	370.60 ± 179.99	168.00	884.00	408.33 ± 248.69
8.	Total dissolved solids	mgl^{-1}	270.00	460.00	325.58 ± 61.13	260.00	450.00	315.58 ± 59.90	260.00	500.00	307.33 ± 64.64
9.	pH	-	7.90	9.33	8.24 ± 0.38	8.10	8.92	8.30 ± 0.23	7.60	8.98	8.36 ± 0.34
10.	Dissolved oxygen	mgl^{-1}	4.86	10.33	7.66 ± 1.64	5.06	11.75	7.88 ± 2.03	5.37	14.59	8.22 ± 2.71
11.	Free carbon dioxide	mgl^{-1}	Nil	3.30	1.63 ± 0.57	Nil	6.60	3.02 ± 1.70	Nil	16.50	2.81 ± 5.46
12.	Total alkalinity	mgl^{-1}	72.50	275.00	145.83±61.13	70.00	270.00	159.30 ± 60.32	75.00	290.00	171.04 ± 62.97
13.	Total hardness	mgl^{-1}	42.00	94.00	74.96 ± 16.95	52.00	134.00	104.31 ± 26.45	62.00	140.00	106.54 ± 26.12
14.	Chloride	mgl^{-1}	15.62	59.64	29.41 ± 15.14	16.33	39.76	28.87 ± 7.29	14.46	80.94	42.16 ± 23.68
15.	Calcium	mgl^{-1}	9.61	31.26	22.50 ± 5.73	17.63	44.08	27.98 ± 7.61	19.23	34.46	24.95 ± 5.07

16.	Nitrates	mgl^{-1}	0.008	0.024	0.014 ± 0.004	0.012	0.025	0.016 ± 0.003	0.010	0.021	0.0155 ± 0.003
17.	Nitrites	mgl^{-1}	0.002	0.022	0.014 ± 0.005	0.006	0.020	0.011 ± 0.003	0.010	0.017	0.012 ± 0.002
18.	Sulphates	mgl^{-1}	8.50	40.40	27.07 ± 8.85	14.00	42.00	31.11 ± 9.34	3.50	45.00	24.60 ± 13.59
19.	Phosphates	mgl^{-1}	0.005	0.030	0.018 ± 0.006	0.006	0.050	0.023 ± 0.012	0.004	0.045	0.018 ± 0.009
20.	Silicates	mgl^{-1}	2.80	13.80	8.03 ± 2.95	4.00	13.50	7.36 ± 2.43	3.80	12.60	7.00 ± 2.88
21.	BOD	mgl^{-1}	0.814	3.24	1.76 ± 0.83	1.01	5.67	2.12 ± 1.37	0.60	3.24	1.87 ± 0.78
22.	COD	mgl^{-1}	24.40	26.80	10.98 ± 6.76	4.00	22.50	11.60 ± 5.79	4.00	17.60	8.33 ± 4.60
23.	Ammonia	mgl^{-1}	Nil	0.56	0.09 ± 0.16	Nil	0.56	0.151 ± 0.14	Nil	0.54	0.15 ± 0.18
24.	Sulphides	mgl^{-1}	Nil	0.14	0.015 ± 0.00	Nil	0.28	0.058 ± 0.040	Nil	0.28	0.035 ± 0.00
25.	Magnesium	mgl^{-1}	2.43	8.28	461.00 ± 1.84	1.70	20.17	8.64 ± 5.79	1.08	14.13	10.92 ± 4.89
26.	Sodium	mgl^{-1}	15.20	52.80	4.56 ± 9.95	26.80	48.80	38.00 ± 6.30	14.30	54.40	39.02 ± 11.55
27.	Potassium	mgl^{-1}	3.10	6.10	4.22 ± 1.03	3.40	6.10	4.89 ± 0.97	2.10	6.30	4.51 ± 1.41

The water analysis indicated that the river water in the sanctuary area is pollution free and can serve as a good habitat for many aquatic animals including endangered species. Thus Chambal river in this stretch can be placed under oligosaprobic(highly oxygenated) area. When various parameters of their study were compared with that of Indian standards, so as to ensure its public water supply, fish culture and irrigation, it was revealed that all such parameters are well within the limits **(Table 2)**.

Table 2 : Comparison of physico-chemical parameters of Chambal river with that of Indian Standards

S/N	Parameters	Present study on Chambal river	IS-2296 : 1974		
			Public water supply	Fish culture	Irrigation
1.	Turbidity (NTU)	1.00-178.00	10(IS: 10500:1991)		
2.	Electrical conductivity (GS cm^{-1})	100.00-884.00		1000.00	
3.	Total dissolved solids (mgl^{-1})	260.00-500.00	500		2100.00
4.	pH	7.6-9.33	6.00-9.00	6.00-9.00	5.50-9.00
5.	Dissolved oxygen (mgl^{-1})	4.86-14.59	>4.00	>3.00	
6.	Free carbon dioxide (mgl^{-1})	0.00-16.50		6.00	
7.	Total alkalinity (mgl^{-1})	70.00-290.00	200-600 (IS-10500:1991)		
8.	Total hardness (mgl^{-1})	42.00-140.00	300-600 (IS-10500:1991)		
9.	Chlorides (mgl^{-1})	15.62-80.94	600.00		600.00
10.	Calcium (mgl^{-1})	9.61-44.08	74-200 (IS-10500:1991)		

11.	Nitrates (mgl⁻¹)	0.008-0.025	50.00		
12.	Nitrites (mgl⁻¹)	0.002-0.022	0.020		
13.	Sulphates (mgl⁻¹)	3.50-45.00	200-400 (IS-10500:1991)		1000.00
14.	BOD (mgl⁻¹)	0.60-5.67	3.00		
15.	Ammonia (mgl⁻¹)	0.00-0.56		1.20	
16.	Sodium (mgl⁻¹)	14.30-54.40	200		

The water characteristics considered for the study, revealed that the river water in the National Chambal Sanctuary is pollution free and can serve as a good habitat for many aquatic animals including endangered species. Naveen K. Singh[6,7] have reported the results of chemical analysis of nearly 5 samples source collected from different areas of Antri as well as 10 samples from different areas of Bhitarwar town from ground water source (Municipal areas). The ground water samples collected from Antri were analysed for different parameters of water like PH, alkalinity, total hardness, calcium ion, magnesium ion, Na^+, K^+, Cl^- NO_3^-, F^-, electrical conductivity and T.D.S.**(Table 3)**.

Table 3 : Physio-chemical parameter of samples from Antri region

S/N	Parameters	S(1)	S(2)	S(3)	S(4)	S(5)
1	pH	8.1	8.0	7.8	7.9	7.8
2	T.A.	260	265	145	155	180
3	T.H.	320	295	135	170	200
4	Mg^{++}	36	24	7.2	42	56
5	Ca^{++}	68	78	42	26.7	14.5
6	Na^+	94.3	188.6	65.8	90.1	63.0
7	K^+	3.1	2.2	20.8	0.2	0.4
8	Cl^-	138.4	294.6	99.4	131.3	88.7
9	NO_3^-	12.41	1.9	6.6	5.3	9.9
10	F^-	0.25	0.27	0.39	0.15	0.49
11	E.C.	1050	1410	609	731	673
12	T.D.S.	672	902.4	389.7	467.8	430.7

On analysing the above data, it is clear that most of the parameters were found to be within permissible range while few parameters like hardness, total dissolved solid and chloride ion concentration was found to deviate in few samples. As suggested from the above data, again the water samples of bhitarwar region were also found to deviate from permissible range in few parameters like hardness, sodium and chloride ion concentration **(Table 4).**

Table 4 : Physico-chemical parameters of samples from Bhitarwar region, Gwalior, India

Parameters	Kashipur(v)	Masoodpur(v)	Karyawati	Dabra Road	Near tehsil	New Bus stand	Karera Road	Main Road	Rampur Shasan(V)	Gohinda (V)
pH	7.8	7.4	7.8	7.6	7.5	8.5	8.4	7.3	7.2	7.4
Electrical conductivity	1758	540	1733	527	540	2193	2059	550	543	530
T.D.S.	1125	346	1109	337	346	1403	1318	352	347	339

Total alkalinity	412	180	374	185	204	541	490	185	195	190
Calcium hardness	310	100	285	65	130	255	340	85	115	125
Total hardness	470	205	425	210	220	500	550	215	210	200
Sodium	186.7	29.9	201.6	30	21.1	218	218.3	25.3	27.6	29.9
Potassium	3.2	0.0	3.1	2.73	4.1	96	4.1	3.9	1.17	0.0
Chloride	315	49.7	312	46.9	35.5	378	340.8	45.7	40.8	47.9
Nitrate	7.2	0.62	7.3	1.24	4.3	5.0	7.5	7.4	1.24	1.86
Sulphate	02	2.4	12	3.36	07	09	9.6	6.2	0.96	0.0

All the value are expressed in mg/L except pH, electrical conductivity Electrical Conductivity is expressed in micromhos/cm at 250°C 1= Kashipur(v),2= Masoodpur(v), 3= Karyawati, 4=Dabra Road, 5= Near tehsil, 6=New Bus stand, 7= Karera Road, 8=Main Road, 9=Rampur Shasan (V), 10= Gohinda (V)

In their further studies, the same group have reported the study of ground water quality of Pichhore town, Dabra, Gwalior, Madhya Pradesh and put forward a report of 6 samples collected from this area[8]. The details of the analysis has been given in the **Table 5.**

Table 5 : Physico-chemical parameter of samples from Dabra region

S/N	Location	pH	T.A.	T.H.	Ca^{++}	Na^{+}	K^{+}	Cl^{-}	SO_4^{2-}	NO_3^{-}	E.C.	T.D.S.
1	A1(H)	8.3	370	420	48	201	3.22	312	16	7.26	1727	1104
2	A2 (H)	8.2	410	471	64	186	3.24	319	0.0	7.51	1752	1121
3	A3(H)	8.6	542	503	82	218	98.8	378	11	5.00	2200	1408
4	A4(H)	8.2	332	342	58	210	3.52	294	09	9.81	1595	1022
5	A5(H)	8.4	312	264	44	195	3.01	252	11	2.80	1370	876
6	A6(H)	8.0	352	208	64	301	126.3	461	04	2.85	2051	1313

All the value are expressed in mg/L except pH and electrical conductivity, Electrical conductivity is expressed in micromhos/cm at 250C, T.A. = total alkalinity, T.H. = total hardness, H=Hand pump A1 = Dabra Road A2=New Bus Stand, A3= Near Hospital A4= Near MaaKalindreeMandir, A5= Police Station , A6= Bazaar

The observations clearly concludes that pH of the water samples collected from Pichhore town, Gwalior was found to be higher though it still exist in reported permissible range i.e 6.5-9, but in few samples it touches the extreme level similarly the concentration of Na^{+} and Cl^{-} ion exceeds in almost all of the samples, making it problematic to some extent. Vineesha and U.C Singh[9] have assessed the groundwater quality of 14 samples collected around Gwalior, Madhya Pradesh during pre-monsoon period (April 2006), for agricultural purposes. Attempt has been made to study the chemical and physical suitability of groundwater for irrigation in Gwalior region of India. The water samples were analysed for major cations i.e., Na+, Ca^{++}, Mg^{++}, K^{+} and anions i.e. Cl^{-}, HCO_3^{-}, CO_3^{--} SO_4^{-}, NO_3^{-}.Total dissolved solids (TDS), electrical conductivity (EC), total hardness and pH were also calculated and the values are reported in the **Table 6**. The important parameters affecting the suitability of groundwater for irrigation purposes were analysed and compared to the standard limits, the constituents of the sample water are within the permissible level and hence the ground water is considered to be suitable for irrigation purpose. However, a few parameters fall at higher side of the limit and thus minimizing its suitability for drinking purposes without treatment. But after filtration, naturally present impurities can be removed in water, which can provide its suitability for drinking and domestic purposes. The SAR (salt absorption ratio) and EC values of the study area were found to be less than 10 and TDS less than 1500 thus could be utilized for irrigation (**Table 7**).

Table 6 : Analytical results compared with the standard specifications of 14 samples collected from various areas of Gwalior, India

S/N	Parameters	Range in the study area	WHO 1984	ISI (1983) Highest desirable	ISI (1983) Maximum permissible	Desirable limits as per IS : 10500, 1991 & 1993
Physical						
1.	Odour	Odourless	Unobject - odour	-	-	Unobjecti-onable
2.	Turbidity(NTU)	-	5	-	-	5
3.	EC(micromhos/cm)	90-1400	1400			
4.	TDS	256-1324	1000	500	1500	500
Chemical						
5.	pH	8.3-8.7	6.5-8.5	7.0-8.5	6.5-9.2	6.5-8.5
6.	Alkalinity	70-253	-	-	-	200
7.	Hardness	110-410	500	-	300	300
8.	calcium	35-155	75	75	200	75
9.	Magnesium	40-190	50	30	100	30
10.	Sodium	28-140	200	-	-	-
11.	Potassium	1.9-9.7	55	-	-	-
12.	Chloride	39-405	250	250	1000	250
13.	Sulphate	3.0-37	400	150	400	200
14.	Bicarbonate	58-340	-	300	600	-
15.	Carbonate	15-54	-	-	-	-
16.	Nitrate	0.9-5.9	50	-	45	45

Table 7 : Results of SAR and EC values of samples collected from various sources

W/N	Location	SAR (epm)	EC (μmhos/cm)
w1	Dullpur	1.805	530
w2	Sikroda	2.337	90
w3	Antri	3.692	2070
w4	Adpura	0.558	467
w5	Sithauli	0.679	400
w6	Jorasi	2.227	670
w7	Baraikapura	2.386	800
w8	Makada	0.744	400
w9	Tighra	-	315
w10	Nayagaon	2.744	1400
w11	Panihar	0.879	530
w12	Ghosipura	2.218	90
w13	Mohanpur	1.078	450
w14	Badagaon	1.617	720

A similar study conducted by V. Singh[10] to assess the ground water quality of nearly 42 water samples collected from different areas of Bhind region, ensures the suitability of ground water for irrigational purpose. As TDS, EC and SAR values were found to be well within the range except in few samples. The limnological studies were conducted to assess the water quality of Tighra(a fresh water reservoir of Gwalior) by observing the different physico-chemical parameter like temperature, pH, biological oxygen demand, hardness, electrical conductance, total dissolved solid, phosphate, nitrate, dissolve oxygen during the one year of study period from January to December 2008 and it was observed that the physico-chemical parameters were within the permissible limit as indicated by WHO, ICMR and ISI, the water of the reservoirs used for fish culture, irrigation, domestic and drinking purpose(**Table 8**).[11] However, a similar study conducted on Sakhya lake, Shivpuri, revealed the high pollution status of it, due to continuous discharge of municipal sewage and run off as reported by Mishra and co-workers[12] S.S Parihar et. al have collected total 16 water samples from different locations in and

Table 8 : Analysis of water samples of Tighra (a fresh water reservoir) of Gwalior region

S/N	Parameters	Summer	Monsoon	Winter	Average
1.	Air Temperature (^{o}C)	41.6	35.8	24.65	34.01
2.	Water Temperature (^{o}C)	26.61	26.29	17.58	23.49
3.	Transparency (cm)	210.65	140	175.50	175.38
4.	pH (mg/l)	7.77	7.57	7.73	7.69
5.	DO (mg/l)	6.44	7.42	7.85	7.23
6.	Total Alkalinity (mg/l)	166.27	126.97	158.65	150.63
7.	Turbidity (NTU)	7.42	9.06	7.35	7.94
8.	Electrical Conductivity(m.mhos)	335.35	598.80	383.10	439.08
9.	Total Hardness (mg/l)	92.50	95.81	129.30	105.87
10.	Chlorides (mg/l)	34.26	30.79	25.47	30.17
11.	Nitrates (mg/l)	0.31	0.25	0.31	0.29
12.	Phosphorus (mg/l)	1.28	0.81	1.25	1.11
13.	TDS (mg/l)	282.05	519.60	367.45	389.70
14.	SS (mg/l)	33.20	37.20	47.06	39.15
15.	BOD (mg/l)	3.51	2.90	2.47	2.96
16.	COD (mg/l)	35.73	35.21	44.38	38.44

around Gwalior city. Electrical conductivity, total dissolved solids, total aerobic microbial count, pH, hardness and DO were observed. [13] The physico-chemical and mic-robeological characteristics of different water samples showed that maximum samples were not suitable for drinking purpose. The samples were collected from different areas as shown in the **Table 9** and **Table 10.**

Table 9 : Sources of water collected from different areas of Gwalior region

Sample No.	Locations	Sources
S1	Rairu	Hand pump
S2	Jaura	Hand pump
S3	Noorabad	Hand pump
S4	Madhavpura	Hand pump
S5	Banmore	Hand pump
S6	Gole Ka Mandir	Hand pump
S7	Thatipur	Municipal supply
S8	C.P. Colony	Municipal supply

S9	K.S. Oli Ltd.	Hand pump
S10	Birla Nagar	Hand pump
S11	Sindhe Ki Chawani	Municipal supply
S12	Railway stations (Moorar)	Hand pump
S13	Barrier chowk (Moorar)	Municipal supply
S14	Maharaj pura	Hand pump
S15	Pintoo park	Hand pump
S16	Gudagudika Naka	Municipal supply

Table 10 : Analysis of physico-chemical and microbiological parameters of different samples

Sample No.	Temp. (^{0}C)	pH	Conductivity (mho/cm)	Total Hardness (mg/lit.)	TDS (ppm)	DO (mg/lit.)	TAMC / 100ml	MPN Index/100 ml	IMViC Test (*E.coli / Enterobacter*)
S1	29	7.8	2889	160	1600	5.9	1450	350	*Enterobacter*
S2	29	8.3	3202	170	1900	6.5	1560	<2	*Enterobacter*
S3	30	8.1	3660	185	2600	5.9	1650	>2400	*Enterobacter*
S4	30	8.5	2913	320	1600	7.1	1240	79	*Enterobacter*
S5	31	8.2	3105	210	1700	5.7	840	920	*E.coli*
S6	30	8.7	3010	180	1600	7.2	1355	<2	Negative
S7	29	7.8	1615	152	800	6.8	450	<2	Negative
S8	31	8.1	2613	332	1300	6.6	510	<2	Negative
S9	28	7.8	3231	316	2000	5.7	480	8	Negative
S10	30	7.6	3594	210	2600	7.4	1445	21	*Enterobacter*
S11	31	7.5	1504	160	600	6.8	380	<2	*E.coli*
S12	30	8.2	1715	277	900	5.9	840	4	*Enterobacter*
S13	28	7.5	1498	318	600	6.4	128	8	*Enterobacter*
S14	28	7.7	1510	298	600	7.1	240	<2	Negative
S15	29	8.6	1601	320	750	7.2	445	<2	Negative
S16	30	8.1	1598	275	600	6.9	370	<2	Negative

The menace of high fluoride concentration in ground water resources has now become one of the major health related geo-environmental issue in many cities of Madhya Pradesh. During recent years, the problem of fluoride has reached an alarming proportion. In one of the study conducted by a group of researchers in special reference to the fluoride concentration in ground water samples collected from various sources of eight villages of Narwar tehsil, Shivpuri, were subjected to evaluation and most of the samples showed high fluoride concentration, and as known high fluoride (>1.5 mg/l) may cause various types of fluorosis manifestations. Fluorosis being an incurable disease, the preventive and control measures are the only solutions. Thus authors strongly suggests the Nalgonda technique for its defluorination at domestic level.[14] However, analysis of Water Quality Index of ground water (GWQI) of Jhabua town Madhya Pradesh, India revealed that the water is safe for drinking and domestic purposes as most of the physico chemical parameters like TDS, hardness, fluoride, chloride, nitrate concentration were found well within the

range.[15] Drinking water samples from 27 different locations of Datia city were collected and studied on most of the physicochemical parameters. The observations indicate higher values of some parameters of the samples. Thus minimizing the suitability of these sources for drinking purposes without treatment.[16] To assess the drinking water quality of Tekanpur area in rainy season 5 samples were collected and studied, results show that over exploitation of ground water which has the largest share of water supplied for human use has deteriorated to such an extent that the crucial parameters such as TDS, hardness etc usually exceed the desirable levels substantially. Their study shows that the lake water as well as ground water of study area is contaminated with total coliform bacterias. The leaching process through surface water during rainy season is also responsible for maximum concentration of TDS in this region.[17] (Table 11)

Table 11 : Average results of physiochemical parameters of samples collected from Tekanpur, Gwalior, India

S/N	Parameters	Requirements as per ISI:10500, 1993	Test method as per ISI	Tekanpur lake lake water; S-1	CSMT borewell water; S-2	Tekanpur bus stand borewell water; S-3	RJIT borewell water; S-4	TCP borewell water; S-5
1.	pH Value	6.5-8.5	3025 (Part-11)	6.97	7.25	7.04	7.17	6.97
2.	Colour	5.0 Max	3025 (Part-4)	>1	>1	>1	>1	>1
3.	Turbidity (NTU)	5.0 Max	3025 (Part-10)	>1	>1	>1	>1	>1
4.	TDS (mg/l)	5.0 Max	3025 (Part-16)	>1	1.3	1.1	1.2	1.1
5.	Nitrate (mg/l)	45	3025 (Part-34)	4.2	10.64	24.18	12.20	16.42
6.	Sulphate	200	3025 (Part-11)	8.40	14.86	42.40	18.84	28.41
7.	Chloride (mg/l)	250	3025 (Part-32)	14.97	72.99	182.56	79.60	177.8
8.	DO (mg/l)	5.0 (As per WHO)	APHA	4.4	2.1	4.80	3.5	3.8
9.	COD(mg/l)	-	APHA	19.5	20.4	19	21.1	19.6
10.	BOD(mg/l)	-	APHA	2.2	2.6	2.4	2.2	2.5
11.	Total hardness (mg/l)	300 Max	3025 (Part-21)	96.0	230	552	362	464
12.	Alkalinity (mg/l)	200Max	3025 (Part-23)	18.20	78.0	142	94	122
13.	Total coliform bacterial (Per 100ml)	10	IS1622-1998	09	02	06	02	03
14.	Chloride (mg/l)	250	3025 (Part-32)	14.97	72.99	182.56	79.60	177.8

The observed value of dissolved oxygen, TDS, BOD, COD, nitrates, chlorides, hardness, alkalinity were found deviated from the permissible limits in few of the samples while sulphates, pH, turbidity were within permissible limits.The water samples showing deviations from water quality standards indicating groundwater contamination because of this, people of that area are prone for the immediate health problems.

CONCLUSION

As a conclusion, we have documented the fact that the Gwalior region as well as some areas around Gwalior region has on an average, poor quality drinking water and most of the analysis revealed that the water sources has high TDS, chloride, fluoride and sodium concentration (as in water samples of Chambal river, Antri, Bhitarwar, Dabra, Tekanpur, proper Gwalior etc). Thus these parameters are need to be lowered down within prescribed limits before usage for drinking purposes. Also, the water samples showed microbial content beyond the potability range, which needs to be disinfected before consumption to avoid water-borne diseases. However water samples of Chambal river, Tigra, Sakhya lake (Shivpuri) etc were found suitable for irrigation and fish culture, a periodical survey is essential to find out the water quality and carryout abatement programmes if required. Therefore, we conclude that thewater sources in this region should be protected by the responsible agencies for water quality by restricting or precluding certain types of activities that are causing serious health hazard by contaminating ground water supplies throughout the region. The water should be pre-treated (filtered and disinfected) before consumption so as to avoid serious health problems which are frequently observed in the people of this region.

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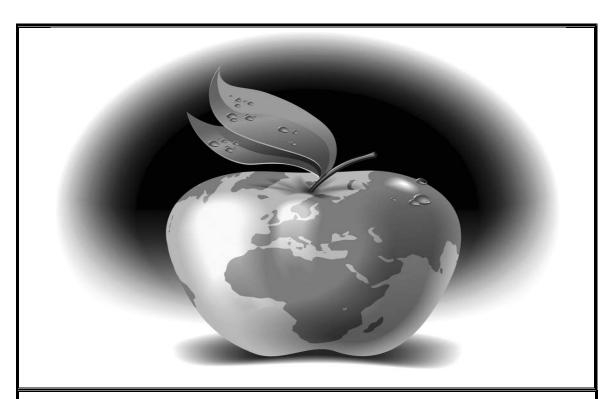
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If all mankind were to disappear, the world would regenerate back to the rich state of equilibrium that existed ten thousand years ago. If insects were to vanish, the environment would collapse into chaos.

Edward O. Wilson