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Quality Characterization of Groundwater using Water Quality Index in Gwalior city, Madhya Pradesh, India

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***Abstract*— Groundwater is a characteristic asset for drinking water. Like other normal assets, it ought to be surveyed consistently and individuals ought to be made mindful of the nature of drinking water. The present study is gone for evaluating the water quality index (WQI) for the groundwater of Gwalior city. This has been executed by collection of groundwater samples in winter and summer season consequently December and May months and subjecting the examples to a far reaching physico-chemical investigation. For ascertaining the WQI, the accompanying 13 parameters have been viewed which are: pH, turbidity, electrical conductivity, alkalinity, total hardness, calcium, magnesium, chloride, fluorides, nitrate, sulfate, total dissolved solids, and dissolved oxygen. The result shows that the water quality index of current study fall in poor category and for these examples ranges from 50.86 to 64.28 in winter season and 52.23 to 74.89 in summer season. The high value of WQI has been observed to be primarily due to higher concentration of all out broke up solids, calcium, magnesium, hardness, fluorides, and ions in the groundwater. The investigation have been utilized to propose models for anticipating water quality and uncovers that the groundwater of the region needs some level of treatment before utilization.**

***Index Terms*— Underground water, water quality index, Gwalior water quality, total dissolved solids, fluoride**

I. INTRODUCTION

India is enriched with rich and immense diversified qualities of characteristic assets, water being one of them. Water is nature's most magnificent, inexhaustible and fundamental components for the presence of individuals, creatures and plants [1]. Water is not just vital for the lives of creatures and plants, additionally involves a one of a kind position in industries [2]. Groundwater is an essential source of water supply all through the world. The suitability and the quality of groundwater for human utilization and for watering system are dictated by its physiochemical and bacteriological properties [3]. In a few territories of the world, individuals face genuine water lacks in light of the fact that groundwater are utilized speedier than it's actually recharged [4]. The growth of population and improving living standard puts numerous and various weights on the quality and the amount of water on the entrance to ground. Water quality assessment and its evaluation is established part of water quality administration. Assessment of ground water management is push to acquire data on ground water levels and synthetic quality through agent inspecting [5]. Because of deficient supply of surface waters, the greater parts of population in India are depending on the groundwater assets for drinking, residential, mechanical, and watering system employments. Multitudinous towns and numerous urban communities in India get water supply from groundwater for various uses through municipal supply and extensive number of private boreholes. Around one billion individuals are specifically reliant upon groundwater in Asia alone, and In India, a large portion of the populace is depending on groundwater as the main source of drinking water supply [6]. The groundwater is accepted to be relatively much perfect and free from contamination than surface water. But, effluents discharge from industries, local sewage and waste dump causes the groundwater to get contaminated and formed health issues [7]. As of late, as a result of consistent development in populace, quick industrialization and the going with innovations including waste transfers, the rate of release of the pollutants higher than the rate of their purification. Subsequently, the qualitative analysis of water is most important to evaluate the nature of groundwater of any area that impacts the needs of domestic, industrial, and agricultural activities.

Study area Gwalior is the oldest and major city of central India. It is northern part of Madhya Pradesh state sited at the elevation of 196 meters above the sea level and geographically situated at 26.22 N latitude and 78.18 E longitude coordinates. Gwalior climate is extreme both in summer and winter season. During the summer, the climate of Gwalior is dominated by the scorching heat level is very high from month of April to June. The maximum temperature during this season soars to about 43-47^{o}C. The rains in Gwalior begin in late June or starting of July in monsoon and received 910 mm rain annually. The present study is based on the investigation of underground water quality of Gwalior city. In this study some most dense sites are selected within the city and water samples were collected from these locations. The Eight stations are point out in the city and samples were taken through the deep borewell. The selected locations are marked below in the fig. 1 and details presented in Table 1.

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Figure 1: Map of study area Gwalior city [dots indicate sampling points]

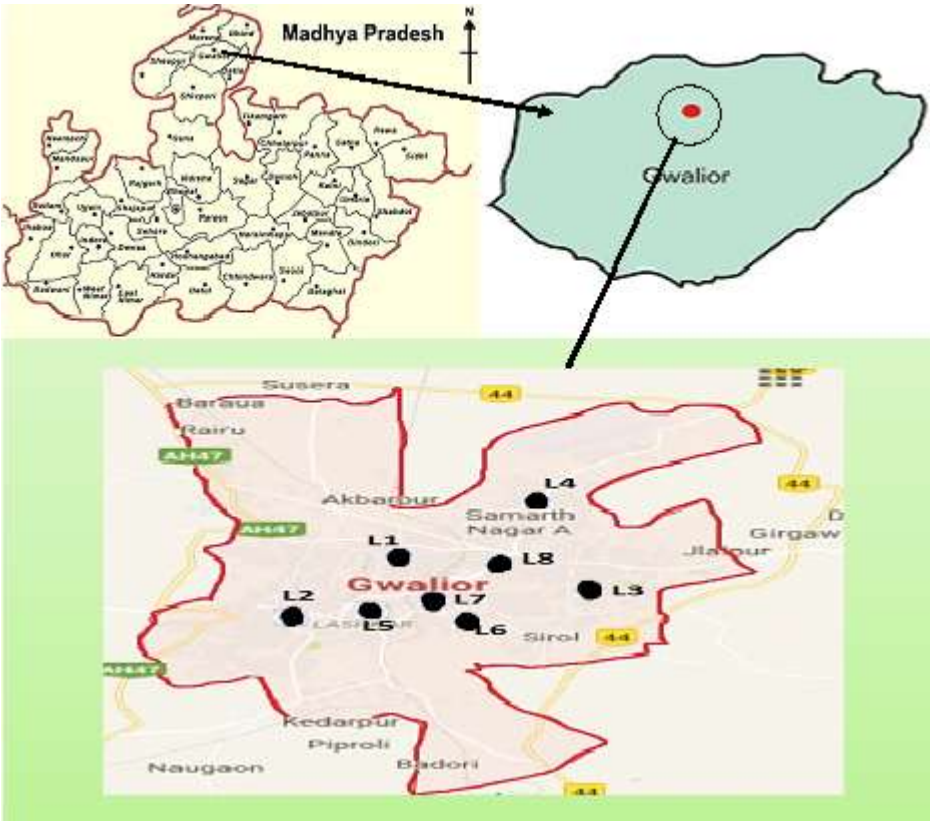

Table 1. Locations of sampling points

Title	Locations	Latitude	Longitude
L1	Hazira (deep, bore well)	26.241421	78.184230
L2	Maharaj bada (deep, bore well)	26.198122	78.147921
L3	Murar (deep,bore well)	26.197323	78.160834
L4	Deen Dayal Nagar (deep, bore well)	26.267369	78.207737
L5	Laskar (deep, bore well)	26.238050	78.187262
L6	Jiwaji University (deep, bore well)	26.200849	78.194916
L7	Padav (deep, bore well)	26.354410	78.096830
L8	MITS (deep, bore well)	26.231715	78.207864

II. MATERIAL AND METHODS

48 Ground water Samples were collected in pre-sterilized plastic bottles from deep bore wells of eight locations, during the period of December (2015) to May (2016). Before collecting samples, water pumped out for 6-10 minutes until water temperature is stabilized then sampling is carried out. Each of the sample is analyzed for various water quality parameters such as pH, electrical conductivity, turbidity, alkalinity, total hardness, calcium, magnesium, chlorides, fluoride, nitrate, sulphate, total dissolved solids, dissolved Oxygen and coliform test (MPN) as per standard procedures recommended by APHA (2012). The experimental values were taken average of the 3 observations of each samples, and compared with standard values recommended by World Health Organization (WHO) and Indian standards for drinking purposes (Table 3). The calculation of Water Quality Index (WQI) has been done by Weighted Arithmetic Index method and obtained result was compared with the drinking water standards as specified by World Health Organization (WHO) and Bureau of Indian Standards (BIS).

Table 2: Methods of Parameters studies: [1]

S. No.	Parameters	Instrument used	Method adopted
1	pH value	Digital pH Meter	pH meter
2	Electrical Conductivity	Digital Conductivity Meter	Conductivity meter

3	Turbidity	NTU meter	Turbidity method
4	Alkalinity	-	Neutralizing by standard HCI
5	Total Hardness	-	EDTA titrimetric method
6	Calcium	-	EDTA titrimetric method
7	Magnesium	-	EDTA titrimetric method
8	Chloride	-	Argentometric Titrimetric
9	Fluoride	UV Spectrophotometer	SPANDS method
10	Sulphate	UV Spectrophotometer	Turbidimetric method
11	Nitrate	UV Spectrophotometer	Colorimetric PDA method
12	Total dissolved solids		Gravimetric method
13	Dissolved oxygen	-	EDTA titrimetric method
14	Coliform test	-	Multiple tube serial dilution

Table 3: Bureau of Indian Standards (BIS) for drinking water (IS 10500: 1991) [1] [8]

S. No.	Parameters	Indian Standards for drinking water (IS 10500: 1991)
1	pH value	8.5
2	Electrical conductivity	300(µmhos)*
3	Turbidity	5(NTU)
4	Alkalinity	120(mg/l)
5	Total hardness	300(mg/l)
6	Calcium	75(mg/l)
7	Magnesium	30(mg/l)
8	Chloride	250(mg/l)
9	Fluoride	1(mg/l)
10	Sulphate	200(mg/l)
11	Nitrate	45(mg/l)
12	Total dissolved solids	500(mg/l)
13	Dissolved oxygen	5(mg/l)
14	Coliform test (MPN)	-

*Considered from Indian council of medical research (ICMR-1975)

III. WATER QUALITY INDEX

Water quality index is one of the most effective tools to monitor the surface as well as ground water pollution and can be used efficiently in the implementation of water quality upgrading programme. The objective of an index is to turn complicated water quality data into simple information that is comprehensible and useable by the public [9]. It is one of the aggregate indices that have been accepted as a rating that reflects the composite influence on the overall quality of numbers of precise water quality characteristics. Water quality index provide information on a rating scale from zero to hundred. Lower value of WQI indicates better quality of water and higher value shows poor water quality. In this study 13 parameters chosen for the reckoning of water quality index of water samples. The WQI has been calculated by using the standard of drinking water quality recommended by the World Health Organization (WHO). The water samples were collected on monthly basis from December 2015 to May 2016.

Calculation of WQI The evaluation of WQI is depending upon the importance of a variety of parameters suitability for the human uses [10]. Weighted arithmetic mean method are following to calculation of water quality index in the current study, were WQI calculated in three steps,

In the first step, quality rating scale (Qn) assigned for the each parameters by the equation;

$$Qn = \frac{100(Vn - Vi)}{(Vs - Vi)}$$

Where,

Qn = quality rating corresponding to nth parameters.

Vn = actual obtained value of water samples in laboratory analysis.

Vs = Recommended value of the water quality parameter by WHO or Indian standard.

Vi = Ideal value = (0 for all, except pH and dissolved Oxygen Vi ≠0, it's taken 7 and 14.6 respectively.)

In the second step, the unit weight (Wn) of various water parameters which is inversely proportional to the recommended standards for the corresponding parameters are assigned.

$$Wn = \frac{k}{Sn}$$

Where,

Wn = unit weight of nth parameters.

Sn = standards permissible value of nth parameters.

k = proportionality constant.

Finally In the tiered step, the water quality index were calculated by

$$WQI = \frac{\Sigma QnWn}{\Sigma Wn}$$

Where, n = no. of parameters assess.

The computed values of water quality index are classified into five categories, "Excellent" to "Unsuitable water for drinking" (Table 4).

Table 4: Water quality Index for groundwater [8] [10]

S. No.	WQI	Description
1.	0-25	Excellent
2.	26-50	Good
3.	51-75	Poor
4.	76-100	Very poor
5.	Above the 100	Unsuitable for drinking

The values of the present investigation of various sampling locations are estimated by using the procedure described previously and WQI is calculated as specified in Table 5.

III. RESULTS AND DISCUSSIONS

The Eight different area locations of Gwalior city are considered to carry out the water samples from December 2015 to May 2016. During that period, 48 underground water samples were collected and examined to recognize the variance in quality characteristics of underground water and formed the WQI. The 13 parameters assigned to establish the WQI in winter and summer periods for each location in the duration of study. The result shows that the water quality index of selected areas falls in the poor category. However, the range of WQI 50.86 to 64.28 in winter season and 52.23 to 74.89 in summer season obtained from the various sampling points. The range of water quality index of the sampling points is higher (>50) than the range of good quality of water. The result of WQI and physico-chemical characteristics of water samples of various point listed below systematically in tables.

Table 5: water quality index of study are in winter and summer season

Locations	WQI	
	Winter season	Summer season
L1	59.05193705	68.68766338
L2	55.70268163	61.46964388
L3	62.96431301	74.84394473
L4	64.28310196	72.03840147
L5	52.09863772	52.23441525
L6	50.86206756	59.36243025
L7	58.00220812	57.77801385
L8	59.48238241	63.39369620

A. pH

The range of pH of groundwater samples from study area varies between7.1-8.0, the Maximum value is found in groundwater sample of locations L4, L5, L8 and the Minimum value of pH found in L1, L2 and L7 location samples. The permissible limits of pH are 6.5 to 8.5 given by Indian Standards. One of the main objectives in controlling pH is to produce water that minimizes corrosion or incrustation. These processes, which can cause considerable damage to the water supply systems, result from complex interactions between pH and other parameters, such as dissolved solids, dissolved gases, hardness, alkalinity, and temperature.

B. Electrical conductivity

The electrical Conductivity (EC) is a measurement of current carrying capability of water samples. EC depends upon the presence of dissolved salts in water, if the amounts of dissolved salts increases conductivity also increase. Dissolved compounds may produce distressing odour, taste and colour. The range of Electrical conductivity of the groundwater samples is varies from 1092µmhos to 2789µmhos. EC is negatively correlated with alkalinity, iron and positively correlated with TDS, pH, Cl, Ca, TH, Mg, and NO3. The higher minerals range tends to produce higher range of dissolved solids present and electrical conductivity range is also higher. It is utilized as indication tool of others water quality problems.

C. Total dissolved solids

The range of Total dissolved solids in the groundwater sample varies from 245mg/l to 830 mg/l, which exceeds the permissible limit of 500 mg/l as per BSI. The Maximum value of total dissolved solids is found in the sample of L1, L4, L7, L8 locations and the Minimum value found in sample of L2 and L5 locations.TDS is negatively associated with alkalinity, fluoride and positively associated with EC, Cl, pH, TH, Mg, Ca and NO_3.

D. Alkalinity

Alkalinity of the groundwater samples is varying from 58mg/l to 110 mg/l, the Maximum value is found in L4, L6 groundwater samples and minimum value in L3 and L5 location water samples. The higher range of alkalinity imparts bitter taste to water and tends to make water hard.

E. Total Hardness

The range of hardness in the groundwater sample in current study varies from 248mg/l to 502 mg/l as $CaCO_3$ and higher concentration found in L7, L8 location samples while lower concentration found in L3, L5 L6 location samples. As per BIS desirable limit of hardness is 300 mg/l as $CaCO_3$ and permissible limit is 600 mg/l as $CaCO_3$. Hardness is negatively associated with alkalinity, iron and positively associated with EC, Cl, pH, Ca, TDS, Mg, SO_4 and NO_3. Hardness occurs in water due to the presence of ions of calcium, magnesium bicarbonate, carbonate, chloride and sulphates and others heavy compounds.

F. Calcium

The main sources of calcium are deposits of limestone, dolomite, gypsum and other calcium bearing rocks. In the present study area, the groundwater samples have calcium range 88.09mg/l to 146.8 mg/l however standards permissible boundary for calcium is 200 mg/l as per Indian standard. Calcium is negatively linked with total alkalinity, iron and positively linked with EC, Cl, Total hardness, pH, Mg, Ca and SO_4. The higher value of calcium precipitate on heating to form harmful scales in boilers, pipes and utensils, but small amount of calcium is beneficial in reducing the deterioration of water pipes.

G. Magnesium

The Magnesium range in study varies from 29.6mg/l to 74.0 mg/l, in the groundwater samples. The higher value is found in groundwater samples L1, L2, L4, L6, L7, L8 locations and Minimum value of magnesium found in L3 and L5 location water samples. Magnesium is negatively interrelated with alkalinity, fluoride and positively interrelated with EC, Cl, Total hardness, pH, Ca, NO_3, SO_4 and TDS. Magnesium occur in all natural water sources and it' mainly lies in rocks. The desirable limit of magnesium is 30 mg/l and permissible limit is 100 mg/l as per BIS 10500 (1991).

H. Chloride

Chloride present in ground water samples are in the range of 80.0mg/l to 250 mg/l which is in range of the permissible limit of 250 mg/l as per Indian standards norms. Maximum chloride concentration is found in groundwater sample collected from L8, L7, L6 locations and Minimum concentration is found in L2, L5 locations.

I. Sulphate

Sulphate concentration in groundwater samples in ranges from 11.0 mg/l to 20.5 mg/l and it is in the permissible limit of 200 mg/l as per Indian standards (BSI). The Maximum sulphate absorption is found in groundwater sample collected from L1 and L6 location while Minimum absorption found in L5 sample. Sulphate is negatively interrelated with iron, alkalinity, fluoride and positively interrelated with EC, pH, total hardness, TDS, Calcium, Magnesium, and Chloride. The higher level of sulphate concerned with health aspects such as diarrhea. The low concentration of sulphate does not affect the human health aspects and test of water.

J. Nitrate

Nitrate observed in the study area varies from 3.5 mg/l to 11.5 mg/l which complies with the permissible limit of 45 mg/l as per Indian standards. Higher value of Nitrate may cause Methemoglobinemia generally known as Blue baby disease in Childs. The major source of nitrate contents in groundwater depends on the type of soil, rock bed present, septic tanks, and civic treatment systems.

K. Fluoride

The concentration of Fluoride in the study area varies from 0.39 mg/l to 0.72 mg/l which is in permissible limit of 1 mg/l recommended by BSI. The deviation of fluoride depends on the various factors like as amount of fluoride in rocks, rainfall, and oxidation-reduction process. The little amount of fluoride presence is harmful for the teeth decaying, and in excessive amount is poisonous to health aspects and causes of dental fluorosis, skeletal damages.

M. Dissolved Oxygen

Dissolved oxygen is a significant factor of aerobic respiration of the aquatic life's metabolism. Presence of DO in water may be due to direct diffusion from air and photosynthetic activity of autotrophs.

Table 6: Physiochemical analysis of Water samples collected in December month 2015

S. No.	Parameters	L1	L2	L3	L4	L5	L6	L7	L8
1	pH value	7.2	7.4	7.6	7.7	8.0	7.4	7.4	7.6
2	Electrical conductivity	2789	2770	1498	1268	1092	1345	1388	2788
3	Turbidity	2	3	4	2	3	2	3	2
4	Alkalinity	98	76	78	110	60	108	98	96
5	Total hardness	430	324	276	320	280	260	500	480
6	Calcium	144.15	120.12	124.10	96.10	88.09	120.10	144.15	132.13
7	Magnesium	63.6	52.4	29.6	70.2	29.8	54.8	60.6	74.0
8	Chloride	140	98	130	166	80	120	150	250
9	Fluoride	0.49	0.45	0.55	0.60	0.40	0.39	0.43	0.48
10	Sulphate	20.5	16.5	14.8	15.5	11.0	20.1	16.5	14.8
11	Nitrate	10.9	10.0	5.0	4.5	4.5	4.2	4.2	8.5
12	Total dissolved solids	720	488	608	784	242	640	826	798
13	Dissolved oxygen	4.2	6.5	6.4	6.3	6.5	4.8	3.8	5.4
14	Coliform test (MPN)	4	3	3	3	3	4	3	4

All of the parameters in mg/l Except pH, MPN and EC (µmhos)

Table 7: Physiochemical analysis of Water samples collected in May month 2016

S. No.	Parameters	L1	L2	L3	L4	L5	L6	L7	L8
1	pH value	7.3	7.4	7.5	7.6	7.9	7.6	7.6	7.7
2	Electrical conductivity	2780	2750	1500	1280	1108	1350	1420	2785
3	Turbidity	3	4	5	2	3	2	2	3
4	Alkalinity	102	76	80	106	58	100	100	98
5	Total hardness	439	338	280	335	285	248	502	479
6	Calcium	146.8	125.1	124.90	99.30	104.10	136.14	137.74	136.14
7	Magnesium	62.4	53.0	32.2	72.0	30.8	53.8	60.0	72.4
8	Chloride	142	92	134	170	82	122	150	240
9	Fluoride	0.59	0.50	0.70	0.72	0.40	0.50	0.45	0.49
10	Sulphate	18.8	16.8	14.8	15.2	11.5	20.0	16.0	14.5
11	Nitrate	10.41	9.0	4.6	4.2	3.8	3.9	4.0	8.8
12	Total dissolved solids	730	490	620	780	250	635	830	790

13	**Dissolved oxygen**	3.8	6.4	6.1	5.8	6.2	4.3	3.7	5.1
14	**Coliform test (MPN)**	4	3	3	3	3	3	3	4

All of the parameters in mg/l Except pH, MPN and EC (µmhos)

Table 8: An example computation of water quality index for sampling location L3 in winter season December month 2015

S. No.	Parameters	Actual Obtained Value (Vn)	Recommended Standard Value (Vs)	Unit Weight (Wi)	Quality Rating (Qi)	Weighted Values (WiQi)
1	**pH**	7.6	8.5	0.000064248	40	0.002569951
2	**Electrical conductivity**	1498	300	0.000001820	499.3333	0.000908977
3	**Turbidity**	4	5	0.000109223	80	0.008737833
4	**Alkalinity**	78	120	0.000004550	65	0.000295812
5	**Total hardness**	276	300	0.000001820	92	0.000167475
6	**Calcium**	124.10	75	0.000007281	165.4666	0.001204850
7	**Magnesium**	29.6	30	0.000018203	98.6666	0.001796110
8	**Chloride**	130	250	0.000002184	52	0.000113592
9	**Fluoride**	0.55	1	0.000546115	55	0.030036301
10	**Sulphate**	14.8	200	0.000002730	7.4	.0000202062
11	**Nitrate**	5.0	45	0.000012136	11.1111	0.000134843
12	**Total dissolved solids**	608	500	0.000001093	121.6	0.000132815
13	**Dissolved oxygen**	6.4	5	0.000109223	85.4166	0.009329457
				Σ Wi= 0.000880629		**ΣWiQi= 0.055448222**
WQI= 62.96431301						

Table 9: An example computation of water quality index for sampling location L3 in summer season May month 2016

S. No.	Parameters	Actual Obtained Value (Vn)	Recommended Standard Value (Vs)	Unit Weight (Wi)	Quality Rating (Qi)	Weighted Values (WiQi)
1	**pH**	7.5	8.5	0.000064248	33.3333	0.002141626
2	**Electrical conductivity**	1500	300	0.000001820	500	0.000910191
3	**Turbidity**	5	5	0.000109223	100	0.010922291
4	**Alkalinity**	80	120	0.000004550	66.6666	0.000303397
5	**Total hardness**	280	300	0.000001820	93.3333	0.000169902
6	**Calcium**	124.93	75	0.000007281	166.5733	0.001212908
7	**Magnesium**	32.2	30	0.000018203	107.3333	0.001953877
8	**Chloride**	134	250	0.000002184	53.6	0.000117087
9	**Fluoride**	0.70	1	0.000546115	70	0.038228019
10	**Sulphate**	14.8	200	0.000002730	7.4	2.02062E-05
11	**Nitrate**	4.6	45	0.000012135	10.2222	0.000124056
12	**Total dissolved solids**	620	500	0.000001092	124	0.000135436
13	**Dissolved oxygen**	6.1	5	0.000109223	88.5416	0.009670779
				Σ Wi= 0.000880629		**ΣWiQi= 0.065909775**
WQI= 74.84394473						

IV. CONCLUSION

The rapid growth of population, industrialization and human development apply numerous and various weights on the quality of water of Gwalior city. This greatly concentrates on the demand of water and the need for the treatment of water. However, the aim of current study was to access the quality characteristics, underground water quality index and prepared a database for future study. The Water quality index of underground water ranges from 50.86-64.28 in winter and 52.23-74.89 in summer season and its fall under the category of poor or bad water quality. The WQI of summer season is higher than the winter season due to the relatively high weight of pollution. The high estimation of WQI has been observed as a result of the most part from the higher estimations of hardness, calcium, magnesium, fluoride, total

dissolved solids and higher concentration of ions in the groundwater. Thus, it is not good to utilizes for drinking purpose and need to provide some degree of improvement to be lower down under acceptable limits. It is concluded that the underground water sources of Gwalior city should be treated earlier than the utilization to avoid health hazardous and also preventing from certain types of activities which are causing the contamination of groundwater, shall be expressed some pre-treatment process like as filtration, disinfection, chlorination etc will be effective to improve the quality crisis.

REFERENCES

[1] G. R. Kalpana, D. P. Nagarajappa, An assessment of groundwater quality index in Vidyanagar, Davanagere city, Karnataka state, India,"*Intl. J. of Emerging Tech. and Adv. Engg*, vol. 4, no. 6, pp. 265-275, June, 2014.

[2] M. Rupal, B. Tanushree, and C. Sukalyan, Quality characterization of groundwater using water quality index in Surat city, Gujarat, India," *International Research Journal of Environment Sciences*, vol. 1, no. 4, pp. 14-23, November, 2012.

[3] S. Richa, and S. Manju, QUALITATIVE AND QUANTITATIVE EVALUATION OF WATER SOURCES OF FEW AREAS IN AND AROUND GWALIOR, MADHYA PRADESH, INDIA," *Journal of Environmental Research and Development*, vol. 8, no. 3, pp. 459, 2014.

[4] S. Kumari, J. Rani, ASSESSMENT OF WATER QUALITY INDEX OF GROUND WATER IN SMALKHAN, HARYANA, *International journal of latest research in science and technology*, vol. 3, no. 6, pp. 169-172, November-December, 2014.

[5] D. Dohare, S. Deshpande, and"A. kotiya, Analysis of groundwater quality parameters: A review," *Research Journal of Engineering Sciences*, vol. 3, no. 5, pp. 26-31, May, 2014.

[6] J. Yisa, T. O. Jimoh, and O. M. Oyibo,"Underground water assessment using water quality index, *Leonardo Journal of Sciences*, vol. 21, pp. 33-42, December, 2012.

[7] H. Shivaprasad, Dr. D. P. Nagarajappa, K. Ravichandra, G. R. Prasanna kumar, kedarraya mallana, Savita Kabakaddi, An Assesment of Groundwater Quality Index in Bommasandra Area, Bengaluru city, Karnataka State, India," *Shivaprasad H et al Int. Journal of Engineering Research and Applications*, vol. 5, no. 4, pp. 90-96, April, 2015.

[8] K. Yogendra, and E. T. Puttaiah, Determination of water quality index and suitability of an urban waterbody in Shimoga Town, Karnataka," In*Proceedings of Taal2007: The 12th World Lake Conference*, pp. 342-346, 2008.

[9] A. Chauhan, and S. Singh, "Evaluation of Ganga water for drinking purpose by water quality index at Rishikesh, Uttarakhand, India," *Rep Opin*, vol. 2, no. 9, pp. 53-61, 2010.

[10] A. Ambica, Groundwater quality characteristics study by using water quality index in Tambaram area, Chennai, Tamil Nadu," *Middle East J Sci Res*, vol. 20, no. 11, pp. 1396-1401, 2014 .