

Status of Ground Water Quality in Residential Area of West Zone of Central India

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Abstract— The Ground water samples were collected seasonally from twenty sampling locations in residential area of West Zone of Central India of year 2013. Physical parameters like temperature, pH, TDS, and DO were determined on the site with the help of multi parameter analyzer kit. The turbidity, total hardness, BOD, COD, nitrate, sulphate and phosphates were determined by titration methods. The values of the above listed parameters were found to be ranged between 170C to 350C, pH 6.2 to 8.5, turbidity 0.1 to 4.1, total hardness 240 to 960 mg/l, TDS 121to 39.0 mg/l, DO 1.9 – 6.2 mg/l, BOD 2.0 to 23.0 mg/l, COD 2.8 to 65.2 mg/l, nitrate 0.03 to 2.35 mg/l, sulphate 0.03 to 194 mg/l, phosphate 0.003 to 0.251 mg/l. all the parameters are compared with WHO Standards. Temperature, TDS, nitrate, sulphate and phosphate were found below the permissible limit prescribed by WHO. The results obtained showed that the ground water quality is poor and suitable for the drinking purposes at same sampling station. Access amount of organic and inorganic pollutants are observed in the ground water samples of residential area of west zone of central India and cause severe problem to the human health.

Keywords— Ground water, physico-chemical parameters, residential area, west zone, central India.

I. INTRODUCTION

Ground water is becoming an important source of water supply in many regions in India and abroad, since there has been a considerable increase in the demand for fresh water due to population growth. The rapid growth of urban areas has adversely affected the ground water quality due to over exploitation of resources and improper waste disposal practices.[1] In India due to rapid growth of population, industrialization and increased the agricultural activity, the ground water resources are adversely affected in recent post. The unused fertilizers, pesticides, effluents discharged from industries and sewage water are the main contaminants in the ground water. The evaluation of hydro chemical faces and the ground water quality as well as pollution potential and their effects on human being have been carried out by various researchers [3-12].

There are several states in India where more than 90% populations are dependent on ground water for drinking and other purposes [14]. Biochemical oxygen Demand (BOD) and chemical oxygen Demand (COD), indirect indicators of organic matters, are representative parameters for sewer water quality. The ground water is believed to comparatively cleaner and free from pollution than surface water. But nowadays the ground water potential and its quality level in major cities and urban centers is getting in major cities and urban centers is

getting deteriorated due to the population explosion, urbanization, industrialization and the failure of monsoon and improper management of rain water [15]. Contamination of drinking water may occur by percolation of toxics through the soil to ground water [16]. Study of chemical budget of major ions in ground water and the level of contamination by natural as well as anthropogenic sources [17]. It was reported in a summary of a study in Australia that mortality from all categories of ischacamic heart disease and acute myocardial infection was increased in a community with high level of soluble solid, calcium, magnesium, sulphate ,chloride, fluoride, total hardness. Madhya Pradesh literally means 'central province' and is located in the geographic heart of India, between latitude 21.20N-26.870N and longitude 74002'-82049'E. Madhya Pradesh is the second largest state in the country by area. It borders the state of Uttar Pradesh to the north-east, Chhattisgarh to the southeast, Maharashtra to the south, Gujarat to the west, and Rajasthan to the North West. The present report discusses the results of chemical analysis of ground water samples from twenty District i.e Gawaliar, Shivpuri, Ashok Nagar, Datiya, Muraina, Bhind, Guna, Tikamgarh, Vidisha, Raisen, Sihora, Rajgarh, Sajapur, Dewash,Ujjain, Ratlam, Indore, Khandawa, Burhanpur and Harda with reference to its suitability for multiple uses like bathing , washing and drinking. The present study is aimed to evaluate the ground water, surface water quality of central India covering various physical & inorganic nonmetallic constituent ie. Temperature, pH, Turbidity, Total Dissolve Solids, Hardness, Dissolved Oxygen (DO) Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrate, Sulphate and Phosphate for water quality parameters determination.

II. MATERIAL METHODS

In the present study we are intended to find out the diffuse chemical pollution in East Zone of Central India on the basis of Residential area. We have designed twenty sampling stations district for this study in west zones i.e. Gawaliar, Shivpuri, Ashok Nagar, Datiya, Muraina, Bhind, Guna, Tikamgarh, Vidisha, Raisen, Sihora, Rajgarh, Sajapur, Dewash,Ujjain, Ratlam, Indore, Khandawa, Burhanpur and Harda.

The Ground water samples were collected seasonally from twenty sampling locations in residential area of West Zone of Central India of year 2013. The water samples were collected in polythene double Stoppard bottles, which were cleaned

previously with acid and deionized water (NEERI, 1998). Chemical used in the study were AR/GR grade and obtained from M/S Qualigens - Fisher Scientific, Mumbai. Physical parameters like temperature, pH, TDS, and DO were determined on the site with the help of multi parameter analyzer kit. The turbidity, total hardness, BOD, COD, nitrate, sulphate and phosphates were determined by titration methods. Following the procedure are prescribed in the standard methods (APHA AWWA and WEF, 1992). The location of sampling stations is shown in table A. The coefficient of variation (CV) was determined using the formula.

$$CV = \frac{SD}{Average} \times 100$$

Where CV = coefficient of variation, SD = Standard Deviation

The correlation coefficient 'r' was calculated using the equation

$$r = \frac{\sum xy - \sum x \cdot \sum y}{\sqrt{(\sum x^2 - \frac{(\sum x)^2}{n})(\sum y^2 - \frac{(\sum y)^2}{n})}} \times 100$$

Where x and y represents two different parameters.

The t- test (t) was calculated by using the following formula

$$t = \frac{r}{\sqrt{1 - r^2}} \sqrt{n - 2}$$

at degree of freedom = n - 2

TABLE A. Location of sampling station with code for ground and surface water in east zone central India.

S. No	Sampling Location of Residential Area
1	R ₂₁ = Near Gajaraja Medical College Gawaliar
2	R ₂₂ = Near Tatyatope Park Shivpuri
3	R ₂₃ = Ashok Nagar Near Bus stand
4	R ₂₄ = Datia Near Pitamabra Temple
5	R ₂₅ = Muraina Near Railway Station
6	R ₂₆ = Bhind ,Near Head Post Office
7	R ₂₇ = Near Delhi Public School Guna
8	R ₂₈ = Civil Line Tikamgarh
9	R ₂₉ = Near S.A. Institute of Technology Vidisha
10	R ₃₀ = Raisen ,Near Higher Secondary School
11	R ₃₁ = Sihore, Near Railway Colony
12	R ₃₂ = Near Anjalilal Temple ,Rajgarh Biora
13	R ₃₃ =Near Ghati Shajapur Housing Board Colony.
14	R ₃₄ =Near Tilak Nagar Dewas
15	R ₃₅ =Near Dussehra Maidan, Ujjain
16	R ₃₆ = Near Sai Baba Mandir Ratlam
17	R ₃₇ =Near Maheswari Higher Secondary School, Indore.
18	R ₃₈ =Near Malviya Colony,lal chowki Khandwa.
19	R ₃₉ =Near Bus Stand Burhanpur District
20	R ₄₀ =Near Harda Polytechnique College.

III. RESULT AND DISCUSSION

In the study area, ground water samples recorded temperature in the range of 25.0°C to 36.0°C. The maximum temperature was found of 33.0°C at sampling station R₃₆ (Near Sai Baba Mandir Ratlam) and minimum temperature was found 25.0°C at sampling station R₂₈ (Civil line Tikamgarh). The PH values of water ranged from 6.2 to 8.3 which are within the permissible limit 6.5-8.5 given by standards, also complies with standard of 7.0 to 8.0 given WHO. The turbidity of the given samples varied from 0.2 to 3.6 NTU with a mean value 1.97 NTU. The total hardness of the water

samples under test varied from 252 to 960 mg/l with a mean value of 555.0 mg/l as show in (table 1). Nine samples exceeded the permissible limit of 600 mg/l as per BIS standard. The total dissolved solid of the ground water in residential area of west zone central India during monsoon seasons ranges from 130.0 to 325.6 mg/l as in the permissible limit 500 mg/l as per WHO standard. maximum concentration found in ground water samples collected from Near Delhi public school Guna (R₂₇) which is 325.6 mg/l. water samples of R₃₈ (Near Malviya Colony, LaL Chowki Khandwa). Dissolved oxygen varied from 2.3 to 6.2 mg/l with a mean value of 4.20 mg/l and most of the samples shows values of dissolve oxygen within the permissible limit. BOD values varied between 4.6 to 18.8 mg/l. values of BOD at sampling station R₂₁ (13.6), R₂₂ (7.5), R₂₃ (6.6), R₂₄ (6.9), R₂₅ (7.7), R₂₆ (8.3), R₂₇ (12.3), R₂₈ (7.8) R₃₀ (9.3) R₃₁ (18.8), R₃₅ (7.8) and R₃₇ (8.2) mg/l are higher than the permissible limit prescribed by WHO as 6.0 mg/l. Chemical oxygen demand varies from 3.9 to 50.0 mg/l with and mean value of 19.54 mg/l. The maximum values of COD in water samples collected from R₂₅ (Murina Near Railway station) which is 50.0 mg/l. Minimum concentration is 3.9 mg/l found in ground water samples of R₃₄ (Near Tilak Nagar Dewas). Thirteen samples higher than the permissible limit of 10.0 mg/l and per WHO standard. In the case of nitrate sulphate and phosphate. the mean values were recorded 0.36, 38.20 and 0.03 mg/l respectively, the nitrates, sulphates and phosphate values observed in the present study were well within the limit of (45 mg/l for nitrates, 250 mg/l for sulphate and 0.3 mg/l for phosphate) prescribed by WHO for drinking water as shown in table 1. The standard deviation value of temperature (2.15), PH (0.55), turbidity (1.10), DO (1.22) BOD (3.43), COD (13.6), nitrate (0.40) and phosphate (0.049) of each parameters between very little deviation, but in the case of total hardness (199.92), TDS (57.87) and sulphate (38.31) SD values have greater deviation together all the each parameters. The coefficient variation of temperature (7.53), PH (7.27), total hardness (36.0), TDS (26.42), DO (29.20), BOD (43.05) showed wide fluctuations with each other with respect to relation of these parameters between station the CV values of turbidity (58.61), COD (69.65), nitrate (110.84), sulphate (100.29) and phosphate (148.48) showed the turbidity COD, nitrate, sulphate and phosphate their significant variation from one station to another.

The correlation coefficient (r) among various water quality parameters are given in table 1a. The temperature of ground water showed significant positive relationship with PH, turbidity, TDS, DO and nitrate and negative relationship with total hardnes, BOD, COD, sulphate and phosphate. The PH of the ground water showed positive relationship with temperature, PH, turbidity, total hardness, TDS, DO, BOD, COD, nitrate and phosphate and negative relationship with sulphate. Turbidity showed significant positive relationship between temperature, pH, turbidity, total hardness, TDS, DO, BOD, COD, nitrate, sulphate and phosphate and negative relationship with not showed in given eleven parameters. Total hardness showed positive relationship with PH, turbidity, TH,

TDS, DO, BOD, COD, nitrate, sulphate and phosphate and Negative relationship with temperature.

TDS showed significant positive relationship with temperature, pH, turbidity, TH, TDS, BOD, COD, nitrate, sulphate and phosphate and negative relationship with DO. Dissolved oxygen (DO) showed positive relationship with temperature, PH, turbidity, total hardness, DO, BOD, nitrate, and phosphate and negative relationship with TDS, COD and sulphate. Biochemical oxygen demand (BOD) showed significant negative relationship with temperature and positive relationship with, PH, turbidity, TH, TDS, DO, BOD, COD, nitrate, sulphate and phosphate. Chemical oxygen demand (COD) showed significant positive relationship with pH, turbidity, TH, TDS, BOD, COD, nitrate, sulphate and phosphate and negative relationship with temperature and DO. Nitrate showed positive relationship with temperature, pH, turbidity, TH, TDS, DO, BOD, COD, nitrate and phosphate and negative relationship with sulphate. Sulphate showed negative relationship between temperatures, pH, DO and nitrate and positive relationship with turbidity, total hardness, TDS, BOD, COD, sulphate and phosphate. Phosphate showed significant positive relationship with pH, turbidity, total hardness, TDS, DO, BOD, COD, nitrate sulphate and phosphate and negative relationship with temperature.

The present study deals with the various relationship derived statically by calculation r and t among the physico-chemical characteristics. The r value was negative Ten times and positive fifty five times, this showed that positive relationship in the present ground water studied. During monsoon season, we have investigated the different physico-chemical characteristics of ground water in residential area of west zone of central India and stabilized the correlation by using ANOVA statistical software. The table value of 5% significant level (2.101) and at 1% level was (2.878). In the case of turbidity and pH, COD and turbidity, TDS and total hardness, COD and total hardness, sulphate and TDS we established a correlation ship which were positive and values were 2.606, 2.641, 2.322, 2.547 and 2.775 respectively, which was greater than 5% significant level. For total hardness and turbidity, phosphate and nitrate we have found positive value of correlation ship at 1% significant level i.e., 3.748 and 6.125. It showed that turbidity, pH, COD, TDS, total hardness, sulphate, phosphate and nitrate play major role in the physico-chemical characteristics of ground water in residential area of west zone central India during monsoon season.

The temperature was found mean 22.75°C, maximum temperature 25.7°C, was found at sampling station R₃₉ (Near Maheswari Higher Secondary School, Indore) and minimum was found 17.0°C at sampling station R₃₃ (Near Ghati Shajapur Housing Board Colony). The PH concentration in the ground water of west zone central India during winter seasons ranges from lower to higher level 6.5 to 8.4 with an mean value 7.65, WHO (1984) prescribed the desirable limit of PH range between 7 and 8.5 mg/l. The turbidity of water was found to be 0.1 to 3.9 NTU, the mean value was obtained 1.90 NTU. Turbidity of all the samples was below the permissible limit set by WHO as 5.0 NTU. Hardness of ground water is found in the range of 240 to 865 mg/l with mean of 523.0

mg/l. Values of total hardness at sampling station R₂₁ (720.0), R₃₁ (643.0), R₂₇ (640.0) R₂₈ (722), R₂₉ (865.0), R₃₁ (755.0) and R₃₂ (665) mg/l are observed more than the permissible limit set by WHO as 600 mg/l. TDS of ground water sours of residential area of west zone central India was found ranged from 121.0 to 311.0 mg/l with mean of 223.8 mg/l which is within the range of permissible limit according to WHO standards. Dissolved oxygen values varied between 2.0 to 5.8 mg/l. The Maximum DO was 5.8 mg/l was found at sampling station R₂₈ mg/l (Bhind, Near head Post Office) and minimum 2.0 mg/l was recorded at sampling station R₂₇ (Near Delhi Public School Guna). The Biochemical oxygen demand of water a was found to be 3.7 to 15.7 mg/l with an mean value 8.5 mg/l. Twelve samples exceeded the permissible limit set by WHO as 6.0 mg/l. chemical oxygen demand was ranged between 3.0 to 53.6 mg/l the maximum value was recorded during the winter seasons in samples R₂₅ collected from Muraina Near Railway station, while the minimum value 3.0 mg/l was found at sampling station R₃₄ (Near Tilak Nagar Dewas) as show in the table 2. Seventy percent samples had chemical oxygen demand was found higher than the permissible limit prescribed by WHO standard as 10.0 mg/l mean value of nitrate, sulphate and phosphate are observed to be 0.47, 41.3 and 0.037 mg/l respectively. The nitrates, sulphate and phosphate values found in the present study were well within the limit prescribed by WHO. The S.D value of temperature (2.60), PH (0.55), turbidity (1.18), DO (1.17), BOD (5.1), COD (14.5), nitrate (0.44) and phosphate (0.05) of each parameters between very little deviations, but in the case of total hardness (176.6), TDS (52.2) and sulphate (38.4) S.D. value have more deviation together all the each parameters. The coefficient variation values of temperature (11.43), PH (7.25), total hardness (33.76), TDS (23.33), DO (28.64), showed wide fluctuation with each other with respect to relation of these parameters between stations, but in the case of turbidity (62.20), BOD (60.01), COD (73.99), nitrate (93.31), sulphate (93.07) and phosphate (135.1) are C.V. values found greater than 50% which shows their significant variation between station to station.

The correlation coefficient (r) among various water quality parameters are given in table 2a. The temperature showed significant positive relationship with pH, TH, TDS, DO, BOD, nitrate and phosphate and negative relationship with turbidity, COD and sulphate, pH showed positive relationship with temperature, pH, turbidity, total hardness, DO, COD and nitrate and negative relationship with TDS, BOD, sulphate and phosphate.

Turbidity showed significant negative relationship with temperature, nitrate and phosphate and positive relationship with pH, turbidity, total hardness, TDS, DO, BOD, COD and sulphate. Total hardness of the ground water showed significant positive relationship with temperature, pH, turbidity, total hardness, TDS, DO, BOD, COD, nitrate sulphate and phosphate and negative relationship with found in given Eleven parameters. TDS shows positive relationship with temperature, turbidity, total hardness, TDS, DO, BOD, COD, nitrate, sulphate and phosphate and negative relationship with pH.

Dissolved oxygen (DO) showed negative relationship with COD and sulphate and positive relationship with temperature, pH, turbidity, total hardness, TDS, DO, BOD, nitrate and phosphate. Biochemical oxygen demand (BOD) in present investigation showed significant positive relationship with temperature, turbidity, total hardness TDS, DO, BOD, COD, nitrate, sulphate and phosphate and negative relationship with pH. Chemical oxygen Demand (COD) in present investigation showed positive relationship with PH, turbidity, total hardness, TDS, BOD, COD, nitrate, sulphate and phosphate. Nitrate showed significant positive relationship with temperature, pH, total hardness, TDS, DO, BOD, COD, nitrate and phosphate and negative relationship with turbidity and sulphate. Sulphate in ground water samples during monsoon showed positive relationship with turbidity, total hardness, TDS, BOD, COD, sulphate and phosphate and negative relationship with temperature, PH, DO and nitrate. Phosphate showed significant positive relationship with temperature, total hardness, TDS, DO, BOD, COD, nitrate, sulphate and phosphate and negative relationship with pH and turbidity.

In the present study deals with the various relationship derived statically by calculation r and t among the physico-chemical characteristics of the ground water quality in residential area of west zone of central India. The r value was negative twelve times and positive twenty six times, this showed that positive relationship in the present ground water studied. During winter seasons, correlated different parameters each other statistically which shows great variation negative to positive for 5% significant value (2.101) and 1% significant value (2.878). In the case of total hardness and turbidity, TDS and total hardness, sulphate and BOD and phosphate and nitrate we established a correlation ship which were positive and value were 3.501, 2.949, 3.232 and 5.425 respectively which was greater than 1% significant level. For TDS and turbidity and phosphate and BOD we have found positive relationship at 5% significant level i.e. 2.224 and 2.247. It showed that total hardness, turbidity, TDS, sulphate, BOD, phosphate, nitrate play major role in the physico-chemical characteristics of ground water in residential area of west zone of central India during winter season.

The temperature was found range between 27.0°C to 35.0°C with a mean value 30.4.°C. The maximum temperature (35.0°C) was recorded at sampling station R₃₂ (Near Anjani Lal Temple, Rajgarh Biora) and minimum 27.8°C was recorded at sampling station R₂₇ (Near Delhi Public School Guna). The PH ranged from 6.8 to 8.5, with mean value of 7.8 pH concentrations of all the samples were found within the permissible limit except one samples R₂₉. The turbidity of water was found to be 0.2 to 4.1 NTU, with mean value 2.25 NTU. Turbidity of all the samples residential area of west zone central India were found below the permissible limit set by WHO as 5.0 NTU. Total hardness values obtained from 276.0 mg/l 940.0 mg/l, with mean value 568.3 mg/l. The maximum hardness 940.0 mg/l was found at sampling station R₂₉ (Near S.A. Institute of Technology Vidisha). Fifty Percent samples of total hardness were found more than the permissible limit according to WHO as 600 mg/l. Total dissolved Solid Varied from 156 mg/l to 39.0 mg/l, with a

mean value 958.9 mg/l. total dissolved solid varied from 156mg/l to 39.0 mg/l, with a mean value 258.9 mg/l. All ground water samples shows TDS within permissible limit (600 mg/l, WHO). The mean value of dissolved oxygen in the ground water of residential area of west zone central India during summer season was 3.95 mg/l respectively. Dissolved oxygen was ranged between 1.9 to 6.2 mg/l. The maximum value was recorded during summer seasons in samples R₂₆ (Bhind, Near Higher Secondary School). Biochemical oxygen demand of water was found to be 4.0 to 23.0 mg/l values of BOD at sampling station R₂₁ (16.2), R₂₂ (11.4), R₂₃ (19.6), R₂₄ (20.5), R₂₅ (8.4), R₂₇ (23.0), R₂₉ (7.4), R₃₀ (9.8), R₃₁ (19.7), and R₃₈ (7.6) mg/l are more than the permissible limit prescribed by WHO as show in the table 3. Chemical oxygen demand was found ranged between 2.8 to 65.2 mg/l Maximum COD 65.2 mg/l was found at sampling station R₂₄ (Datia Near pitamabara temple). A Seventy Percent sample of COD was found more than the permissible limit prescribed by WHO. Maximum concentration of nitrate, sulphate and phosphate are observed to be 2.35, 194 and 0.25 mg/l, while minimum values were recorded as 0.07, 11.0 and 0.11 mg/l respectively, the nitrate, sulphate and phosphate values observed in residential area of west zone central India during summer seasons were well within the limit (45.0 mg/l, for nitrates, 250.0 mg/l for sulphate and 0.3 mg/l for phosphate) prescribed by WHO. S.D. value of temperature (2.25), PH (0.47), turbidity (1.23), DO (1.17), BOD (6.50), COD (17.1), nitrates (0.48) and phosphate (0.05) of each parameters between very little deviation, but in the case of total hardness (194.3), TDS (58.1) and sulphate (39.4) standard deviation value have greater deviation together all the each parameters. The C.V. values of turbidity (54.8), BOD (68.4), COD (80.2), nitrates (81.63), sulphate (87.1) and phosphate (126.8) shows greater than 50% which shows significant variation between station to stations. The C.V. values of temperature (7.39), PH (6.03), hardness (34.19), TDS (22.45), DO (29.58) shows wide fluctuations with each other with respect to relation of these parameters between stations.

The correlation coefficient (r) among various water quality parameters are given in table 3a. The temperature of ground water in study area during summer showed positive relationship with PH, TDS, DO and negative relationship with turbidity total hardness, BOD, COD, nitrate, sulphate and phosphate. PH of the ground water showed significant positive relationship with temperature, pH, turbidity, total hardness, DO, COD, and nitrate and negative relationship with TDS, BOD, sulphate and phosphate.

Turbidity showed significant positive relationship with PH, turbidity, total hardness, TDS, DO, BOD, COD, nitrate, sulphate and phosphate and negative relationship with temperature. Total hardness showed significant positive relationship with pH, turbidity, TH, TDS, DO, BOD, COD, nitrate, sulphate and phosphate and negative relationship with temperature.

TABLE 1. Physico -chemical characteristics of ground water in residential area of west zone central India during monsoon season

Parameters	Sampling Location																				Mean	S.D	C.V
	R ₂₁	R ₂₂	R ₂₃	R ₂₄	R ₂₅	R ₂₆	R ₂₇	R ₂₈	R ₂₉	R ₃₀	R ₃₁	R ₃₂	R ₃₃	R ₃₄	R ₃₅	R ₃₆	R ₃₇	R ₃₈	R ₃₉	R ₄₀			
Temperature	28.2	25.4	29.3	28.1	26.5	29.5	26.3	25.0	30.4	27.1	26.8	31.5	29.0	30.5	28.0	33.0	31.5	27.0	28.9	30.0	28.600	2.155	7.53
pH	7.8	7.2	8.2	7.5	8.0	7.8	6.8	7.5	8.3	7.7	7.8	8.0	7.6	8.2	7.8	7.9	8.3	6.8	6.2	7.2	7.630	0.555	7.27
Turbidity	2.0	3.0	1.5	1.0	3.4	2.6	2.3	1.0	3.5	2.1	2.8	3.6	1.5	ND	0.5	2.0	3.2	0.4	1.0	0.2	1.979	1.160	58.61
Hardness	770	684	570	396	570	620	720	706	960	800	720	690	308	504	330	404	436	284	380	252	555.200	199.924	36.0
TDS	263.0	246.0	259.0	158.0	171.7	196.0	325.6	295.0	255.4	176.2	188.0	215.3	196.0	256.0	146.0	270.0	290.0	130.0	218.0	125.0	219.010	57.879	26.42
DO	6.0	4.8	3.9	3.1	4.7	5.2	2.4	3.7	4.0	3.6	6.2	3.2	3.0	6.1	4.5	6.2	2.3	3.4	4.0	3.8	4.205	1.228	29.20
BOD	13.6	7.5	6.6	6.9	7.7	8.3	12.3	7.8	5.5	9.3	18.8	5.6	7.6	5.6	7.8	5.6	8.2	4.9	5.3	4.6	7.975	3.434	43.05
COD	36.6	16.6	8.0	21.3	50	5.3	25.3	16.0	43.3	30.0	8.0	36.0	19.2	3.9	22.3	15.7	14.9	6.7	5.2	6.5	19.540	13.610	69.65
Nitrate	1.91	0.03	0.27	0.06	0.36	0.07	0.00	0.59	0.17	0.24	0.36	0.59	0.38	0.33	0.56	0.43	0.52	0.14	0.28	0.09	0.369	0.409	110.84
Sulphate	034	011	031	021	029	041	180	026	038	024	049	036	010	032	045	024	093	016	021	003	38.200	38.313	100.29
Phosphate	0.231	0.016	0.030	0.028	0.008	0.006	0.058	0.016	0.048	0.016	0.030	0.034	0.015	0.022	0.029	0.010	0.009	0.036	0.017	0.003	0.033	0.049	148.48

All the Values except Temperature, pH and Turbidity expressed in mg/l.

Residential Area- R₂₁= Near Gajaraja Medical College Gawaliar, R₂₂= Near Tatyatope Park Shivpuri, R₂₃= Ashok Nagar Near Busstand, R₂₄= Datia Near Pitamabra Temple, R₂₅= Muraina Near Railway Station, R₂₆= Bhind ,Near Head Post Office, R₂₇= Near Delhi Public School Guna, R₂₈= Civil Line Tikamgarh, R₂₉= Near S.A. Institute of TechnologyVidisha, R₃₀= Raisen,Near Higher Secondary School, R₃₁= Sihore, Near Railway Colony, R₃₂= Near Anjalilal Temple ,Rajgarh Biora, R₃₃=Near Ghati Shajapur Housing Board Colony, R₃₄=Near Tilak Nagar Dewas, R₃₅=Near Dussehra Maidan, Ujjain, R₃₆= Near Sai Baba Mandir Ratlam, R₃₇=Near Maheswari Higher Secondary School, Indore, R₃₈=Near Malviya Colony,lal chowki Khandwa, R₃₉=Near Bus Stand Burhanpur District, R₄₀=Near Harda Polytechnique College.

TABLE 1a. Correlation coefficient (r) among various water quality parameters (Physico -chemical characteristics of ground water in residential area of west zone central India during monsoon season)

Parameters	Temperature	pH	Turbidity	Hardness	TDS	DO	BOD	COD	Nitrate	Sulphate	Phosphate
Temperature	1										
pH	0.431 2026	1									
Turbidity	0.165 0.709	0.523 2.606*	1								
Hardness	-0.239 -1.047	0.314 1.404	0.662 3.748**	1							
TDS	0.099 0.422	0.177 0.763	0.413 1.923	0.480 2.322*	1						
DO	0.088 0.375	0.254 1.114	0.119 0.510	0.156 0.673	-0.010 -0.043	1					
BOD	-0.408 -1.895	0.062 0.266	0.264 1.165	0.436 2.060	0.171 0.737	0.283 1.253	1				
COD	-0.093 -0.397	0.326 1.466	0.537 2.641*	0.514 2.547*	0.075 0.322	-0.115 0.493	0.091 0.391	1			
Nitrate	0.078 0.335	0.259 1.139	0.045 0.192	0.190 0.822	0.224 0.927	0.334 1.503	0.340 1.538	0.327 1.472	1		
Sulphate	-0.078 -0.332	-0.050 -0.215	0.290 1.286	0.266 1.173	0.547 2.775*	-0.329 -1.480	0.417 1.949	0.121 0.518	-0.069 -0.294	1	
Phosphate	-0.090 -0.384	0.0406 0.172	0.034 0.147	0.353 1.663	0.242 1.658	0.254 1.114	0.429 2.015	0.354 1.609	0.822 6.125**	0.131 0.564	1

1% Level of significance =**, 5% Level of significance =*

TABLE 2. Physico-chemical characteristics of ground water in residential area of west zone central India during winter season

Parameters	Sampling Location																				Mean	S.D	C.V
	R ₂₁	R ₂₂	R ₂₃	R ₂₄	R ₂₅	R ₂₆	R ₂₇	R ₂₈	R ₂₉	R ₃₀	R ₃₁	R ₃₂	R ₃₃	R ₃₄	R ₃₅	R ₃₆	R ₃₇	R ₃₈	R ₃₉	R ₄₀			
Temperature	25.5	23	24.3	25.2	20.5	22.5	21	19	22.4	24	23.5	25.3	17	26	21	23	24.2	18	25.7	24	22.755	2.603	11.43
pH	7.4	7	8.4	7.8	8.1	7.6	6.5	7.7	8	7.9	8	8.2	7.4	8.3	8	7.6	8	6.9	6.5	7.8	7.655	0.555	7.25
Turbidity	1.2	2.7	1.8	0.5	2	2.4	3	1.5	4	1.5	2.5	3.9	3	ND	0.9	1.4	2.6	0.5	0.7	0.1	1.905	1.185	62.20
Hardness	720	549	459	416	530	643	640	722	865	560	755	665	332	544	240	452	479	299	330	265	523.250	176.675	33.76
TDS	286	262	278	174	159	208	254	311	263.4	212	194	235	220	242	164	248	278	138	229	121	223.820	52.231	23.33
DO	4.6	4.2	4.8	3.3	5.4	5.8	2	4.2	3.9	3.2	6	3.6	3.3	5.6	4	5.3	2.7	2.8	4.9	2.5	4.105	1.176	28.64
BOD	15.7	9	14.8	6.3	9.2	7.6	21.2	4.6	6.1	10.2	19	5.2	3.9	5.2	8.1	3.7	6.2	5.9	3.8	5.6	8.565	5.140	60.01
COD	37	18.3	11.5	18.4	53.6	5	27.5	12.8	46.8	36.5	9.4	32.4	15	3	20	12.6	11.3	9.6	4.3	8.2	19.660	14.548	73.99
Nitrate	2.11	0.09	0.39	0.13	0.61	0.15	0.04	0.81	0.32	0.41	0.54	0.75	0.52	0.38	0.61	0.5	0.63	0.19	0.32	0.07	0.479	0.447	93.31
Sulphate	39	15	37	25	34	37	185	30	35	27	53	41	13	34	43	29	96	20	26	7	41.300	38.441	93.07
Phosphate	0.242	0.025	0.037	0.03	0.013	0.011	0.064	0.02	0.052	0.021	0.034	0.036	0.013	0.019	0.034	0.015	0.011	0.04	0.02	0.008	0.037	0.050	135.13

All the Values except Temperature, pH and Turbidity expressed in mg/l.

Residential Area- R₂₁= Near Gajaraja Medical College Gawaliar, R₂₂= Near Tatyatope Park Shivpuri, R₂₃= Ashok Nagar Near Busstand, R₂₄= Datia Near Pitamabra Temple, R₂₅= Muraina Near Railway Station, R₂₆= Bhind ,Near Head Post Office, R₂₇= Near Delhi Public School Guna, R₂₈= Civil Line Tikamgarh, R₂₉= Near S.A. Institute of TechnologyVidisha, R₃₀= Raisen,Near Higher Secondary School, R₃₁= Sihore, Near Railway Colony, R₃₂= Near Anjalilal Temple .Rajgarh Biora, R₃₃=Near Ghati Shajapur Housing Board Colony, R₃₄=Near Tilak Nagar Dewas, R₃₅=Near Dussehra Maidan, Ujjain, R₃₆= Near Sai Baba Mandir Ratlam, R₃₇=Near Maheswari Higher Secondary School, Indore, R₃₈=Near Malviya Colony,lal chowki Khandwa, R₃₉=Near Bus Stand Burhanpur District, R₄₀=Near Harda Polytechnique College.

TABLE 2a. Correlation coefficient (r) among various water quality parameters (Physico-chemical characteristics of ground water in residential area of west zone central India during winter season)

Parameters	Temperature	pH	Turbidity	Hardness	TDS	DO	BOD	COD	Nitrate	Sulphate	Phosphate
Temperature	1										
pH	0.261 1.144	1									
Turbidity	-0.088 -0.372	0.166 0.722	1								
Hardness	0.161 0.691	0.178 0.769	0.637 3.501**	1							
TDS	0.176 0.758	-0.012 -0.051	0.464 2.224*	0.571 2.949**	1						
DO	0.241 1.053	0.293 1.300	0.037 0.157	0.288 1.274	0.135 0.575	1					
BOD	0.096 0.411	-0.102 -0.433	0.164 0.706	0.387 1.781	0.138 0.589	0.028 0.117	1				
COD	-0.065 -0.274	0.166 0.711	0.379 1.738	0.428 2.007	0.047 0.198	-0.122 -0.519	0.221 0.959	1			
Nitrate	0.147 0.629	0.166 0.712	-0.012 -0.494	0.314 1.403	0.388 1.783	0.216 0.936	0.174 0.750	0.332 1.490	1		
Sulphate	-0.018 -0.074	-0.266 -1.168	0.352 1.594	0.269 1.183	0.281 1.240	-0.333 -1.500	0.606 3.232**	0.119 0.507	-0.064 -0.270	1	
Phosphate	0.213 0.926	-0.166 -0.713	-0.048 -0.203	0.348 0.937	0.309 0.951	0.009 0.040	0.468 2.247*	0.358 1.624	0.788 5.425**	0.143 0.613	1

TABLE 3. Physico-chemical characteristics of ground water in residential area of west zone central India during summer season

Parameters	Sampling Location																				Mean	S.D	C.V
	R ₂₁	R ₂₂	R ₂₃	R ₂₄	R ₂₅	R ₂₆	R ₂₇	R ₂₈	R ₂₉	R ₃₀	R ₃₁	R ₃₂	R ₃₃	R ₃₄	R ₃₅	R ₃₆	R ₃₇	R ₃₈	R ₃₉	R ₄₀			
Temperature	27	28	30	31.5	29.2	30.5	27	31	29	30.2	29	35	29.5	31.2	31.3	35	32.1	29	33.7	30	30.460	2.253	7.39
pH	7.6	7.2	8	8.1	7.9	8	6.9	7.8	8.5	7.9	8.1	8.4	7.8	8.4	8.2	7.8	8.1	7.3	6.8	7.6	7.820	0.472	6.03
Turbidity	2.4	3.2	2	0.3	3.8	3	2.9	1.8	4	1.8	3	4.1	2.8	0.2	1.3	1.8	3.8	0.9	1.5	0.5	2.255	1.237	54.85
Hardness	720	698	472	432	545	655	733	750	940	830	780	695	347	519	320	449	511	334	360	276	568.300	194.355	34.19
TDS	291	270	292	188	187	243	390	332	282	248	220	280	241	272	158	305	296	156	292	236	258.950	58.139	22.45
DO	4.8	3.6	3	2.6	5.7	6.2	1.9	4.2	3.6	3.4	5.5	4.1	3.7	5.1	3.5	4.7	2.9	2.5	5	3.1	3.955	1.170	29.58
BOD	16.2	11.4	19.6	20.5	8.4	6	23	4.7	7.4	9.8	19.7	4.8	4.5	4.6	4	3.2	6	7.6	4.4	4.8	9.530	6.504	68.24
COD	37.4	21.3	15	65.2	46	4.6	29.1	13.7	49	32.2	10.8	27	11.6	2.8	17.4	9.2	7.9	14.7	4.8	6.9	21.330	17.111	80.22
Nitrate	2.35	0.15	0.61	0.28	0.84	0.22	0.07	0.96	0.4	0.74	0.6	0.86	0.68	0.53	0.67	0.6	0.68	0.25	0.37	0.11	0.599	0.489	81.63
Sulphate	43	20	41	29	32	43	194	38	39	30	57	46	16	36	41	34	99	24	31	11	45.200	39.402	87.17
Phosphate	0.251	0.037	0.042	0.032	0.018	0.016	0.07	0.024	0.056	0.027	0.039	0.037	0.011	0.016	0.039	0.02	0.013	0.044	0.023	0.013	0.041	0.052	126.8

Residential Area- R₂₁= Near Gajaraja Medical College Gawaliar, R₂₂= Near Tatyatope Park Shivpuri, R₂₃= Ashok Nagar Near Busstand, R₂₄= Datia Near Pitambra Temple, R₂₅= Muraina Near Railway Station, R₂₆= Bhind ,Near Head Post Office, R₂₇= Near Delhi Public School Guna, R₂₈= Civil Line Tikamgarh, R₂₉= Near S.A. Institute of TechnologyVidisha, R₃₀= Raisen,Near Higher Secondary School, R₃₁= Sihore, Near Railway Colony, R₃₂= Near Anjalilal Temple ,Rajgarh Biora, R₃₃=Near Ghati Shajapur Housing Board Colony, R₃₄=Near Tilak Nagar Dewas, R₃₅=Near Dussehra Maidan, Ujjain, R₃₆= Near Sai Baba Mandir Ratlam, R₃₇=Near Maheswari Higher Secondary School, Indore, R₃₈=Near Malviya Colony,lal chowki Khandwa, R₃₉=Near Bus Stand Burhanpur District, R₄₀=Near Harda Polytechnique College.

TABLE 3a. Correlation coefficient (r) among various water quality parameters (Physico-chemical characteristics of ground water in residential area of west zone central India during summer season)

Parameters	Temperature	pH	Turbidity	Hardness	TDS	DO	BOD	COD	Nitrate	Sulphate	Phosphate
Temperature	1										
pH	0.271 1.194	1									
Turbidity	-0.119 -0.509	0.147 0.629	1								
Hardness	-0.312 -1.390	0.208 0.901	0.565 2.902**	1							
TDS	0.020 0.086	-0.266 -1.168	0.278 1.226	0.432 2.032	1						
DO	0.189 0.814	0.211 0.913	0.193 0.836	0.172 0.742	-0.093 -0.394	1					
BOD	-0.545 -2.757*	-0.181 -0.778	0.034 0.142	0.303 1.347	0.152 0.651	-0.304 -1.355	1				
COD	-0.265 -1.164	0.179 0.773	0.165 0.709	0.349 1.577	-0.162 0.697	-0.238 -1.040	0.454 2.159*	1			
Nitrate	-0.100 -0.424	0.181 0.781	0.161 0.692	0.233 1.018	0.097 -0.412	0.304 1.355	0.038 0.161	0.184 0.794	1		
Sulphate	-0.233 -1.014	-0.246 -1.078	0.310 1.192	0.294 1.304	0.575 2.977**	-0.336 -1.515	0.468 2.244*	0.039 0.165	-0.115 -0.490	1	
Phosphate	-0.463 -2.214*	-0.155 -0.663	0.084 0.356	0.300 1.332	0.186 0.802	0.020 0.086	0.405 1.881	0.328 1.473	0.754 4.875**	0.146 0.627	1

1% Level of significance =**, 5% Level of significance =*

TABLE 4. Average Physico-chemical characteristics of ground water in residential area of west zone central India

Parameters	Sampling Location																			
	R ₂₁	R ₂₂	R ₂₃	R ₂₄	R ₂₅	R ₂₆	R ₂₇	R ₂₈	R ₂₉	R ₃₀	R ₃₁	R ₃₂	R ₃₃	R ₃₄	R ₃₅	R ₃₆	R ₃₇	R ₃₈	R ₃₉	R ₄₀
Temperature	26.90	25.47	27.87	28.27	25.40	27.50	24.77	25.00	27.27	27.10	26.43	30.60	25.17	29.23	26.77	30.33	29.27	24.67	29.43	28.00
SD (+)	1.35	2.50	3.11	3.15	4.45	4.36	3.28	6.00	4.27	3.10	2.77	4.91	7.08	2.82	5.26	6.43	4.40	5.86	4.03	3.46
pH	7.60	7.13	8.20	7.80	8.00	7.80	6.73	7.67	8.27	7.83	7.97	8.20	7.60	8.30	8.00	7.77	8.13	7.00	6.50	7.53
SD(+)	0.20	0.12	0.20	0.30	0.10	0.20	0.21	0.15	0.25	0.12	0.15	0.20	0.20	0.10	0.20	0.15	0.15	0.26	0.30	0.31
Turbidity	1.87	2.97	1.77	0.60	3.07	2.67	2.73	1.43	3.83	1.80	2.77	3.87	2.43	0.20	0.90	1.73	3.20	0.60	1.07	0.27
SD(±)	0.61	0.25	0.25	0.36	0.95	0.31	0.38	0.40	0.29	0.30	0.25	0.25	0.81	0.00	0.40	0.31	0.60	0.26	0.40	0.21
Hardness	736.67	643.67	500.33	414.67	548.33	639.33	697.67	726.00	921.67	730.00	751.67	683.33	329.00	522.33	296.67	435.00	475.33	305.67	356.67	264.33
SD(±)	28.87	82.28	60.68	18.04	20.21	17.79	50.36	22.27	50.08	147.99	30.14	16.07	19.67	20.21	49.33	26.89	37.63	25.66	25.17	12.01
TDS	280.00	259.33	276.33	173.33	172.57	215.67	323.20	312.67	266.93	212.07	200.67	243.43	219.00	256.67	156.00	274.33	288.00	141.33	246.33	160.67
SD(+)	14.93	12.22	16.56	15.01	14.02	24.42	68.03	18.56	13.65	35.90	17.01	33.16	22.52	15.01	9.17	28.75	9.17	13.32	39.93	65.27
DO	5.13	4.20	3.90	3.00	5.27	5.73	2.10	4.03	3.83	3.40	5.90	3.63	3.33	5.60	4.00	5.40	2.63	2.90	4.63	3.13
SD(+)	0.76	0.60	0.90	0.36	0.51	0.50	0.26	0.29	0.21	0.20	0.36	0.45	0.35	0.50	0.50	0.75	0.31	0.46	0.55	0.65
BOD	15.17	9.30	13.67	11.23	8.43	7.30	18.83	5.70	6.33	9.77	19.17	5.20	5.33	5.13	6.63	4.17	6.80	6.13	4.50	5.00
SD(±)	1.38	1.97	6.57	8.03	0.75	1.18	5.73	1.82	0.97	0.45	0.47	0.40	1.99	0.50	2.29	1.27	1.22	1.37	0.75	0.53
COD	37.00	18.73	11.50	34.97	49.87	4.97	27.30	14.17	46.37	32.90	9.40	31.80	15.27	3.23	19.90	12.50	11.37	10.33	4.77	7.20
SD(+)	0.40	2.38	3.50	26.22	3.80	0.35	1.91	1.65	2.87	3.31	1.40	4.53	3.81	0.59	2.45	3.25	3.50	4.05	0.45	0.89
Nitrates	2.12	0.09	0.42	0.16	0.60	0.15	0.04	0.79	0.30	0.46	0.50	0.73	0.53	0.41	0.61	0.51	0.61	0.19	0.32	0.09
SD(+)	0.22	0.06	0.17	0.11	0.24	0.08	0.04	0.19	0.12	0.25	0.12	0.14	0.15	0.10	0.06	0.09	0.08	0.06	0.05	0.02
Sulfates	38.67	15.33	36.33	25.00	31.67	40.33	186.33	31.33	37.33	27.00	53.00	41.00	13.00	34.00	43.00	29.00	96.00	20.00	26.00	7.00
SD(+)	4.51	4.51	5.03	4.00	2.52	3.06	7.09	6.11	2.08	3.00	4.00	5.00	3.00	2.00	2.00	5.00	3.00	4.00	5.00	4.00
Phosphates	0.241	0.026	0.036	0.030	0.013	0.011	0.064	0.020	0.052	0.021	0.034	0.036	0.013	0.019	0.034	0.015	0.011	0.040	0.020	0.008
SD(±)	0.010	0.011	0.006	0.002	0.005	0.005	0.006	0.004	0.004	0.006	0.005	0.002	0.002	0.003	0.005	0.005	0.002	0.004	0.003	0.005

Dissolved oxygen (DO) showed positive relationship with temperature, pH, turbidity, total hardness, DO, nitrate and phosphate and negative relationship with TDS, BOD, COD, and sulphate. Biochemical oxygen demand (BOD) showed significant positive relationship with turbidity, total hardness, TDS, BOD, COD, nitrate, sulphate and phosphate and negative relationship with temperature, pH, and DO. Chemical oxygen demand (COD) showed positive relationship with pH, turbidity, total hardness, BOD, COD, nitrate sulphate and phosphate and negative relationship with temperature, TDS, and DO.

Nitrate showed significant positive relationship between pH, turbidity, total hardness, DO, BOD, COD, nitrate and phosphate and negative relationship with temperature, TDS, and sulphate.

Sulphate of the ground water showed significant negative relationship between temperature, pH, DO, and nitrate and positive relationship between turbidity total hardness, TDS, BOD, COD, sulphate and phosphate.

Phosphate in the present investigation showed positive relationship with turbidity, TH, TDS, DO, BOD, COD, nitrate, sulphate and phosphate and negative relationship with temperature and pH.

The present study deals with the various relationship derived statically by calculation r and t among the physico-chemical characteristics. The r value was negative eighteen times and positive forty eight times, this showed that positive relationship with the present ground water studied. During summer seasons, we have investigated the different physico-chemical characteristic of ground water in residential area of west zone of central India and stabilized the correlation by using ANOVA statistical software. Table value of 5% significant level was 2.101 and at 1% significant level were 2.878. In the case of COD and BOD and sulphate and BOD we established a correlation ship which were positive and value were 2.159 and 2.244 respectively which was greater than 5% significant level. BOD and temperatures, phosphate and temperature shows negative relationship i.e. - 2.757 and - 2.214 respectively with each other at 5% significant level, while total hardness and turbidity, sulphate and TDS and phosphate and nitrate shows positive relationship i.e. 2.902, 2.977 and 4.875 respectively with each other at 1% significant level. It showed that COD, BOD, sulphate, temperature, phosphate, total hardness, turbidity and TDS play major role in the physico-chemical characteristics of ground water in residential area of west zone central India during summer season.

The average physico- Chemical Characteristics in Residential area of west zone central India are shown in table 4. The variation of temperature in study area was observed to be 24.67°C minimum to 30.60°C maximum. PH was ranging from 5.9 to 7.7. The turbidity was found range from 0.20 to 3.87 NTU and total hardness was ranged between 264.3 to 921.67 mg/l. TDS was found ranged between 141.3 to 3.23.2 mg/l. DO, BOD and COD were in the range of 2.10- 5.90, 4.17- 19.17 and 3.23- 49.87 mg/l respectively. In the case of nitrate, sulphate and phosphate, the values were ranged between 0.09 7.0 and 0.008 to 2.12. 186.3 and 0.24 mg/l respectively as given in table 4.

IV. CONCLUSION

Ground water quality in residential area of west zone of central India has been analyzed. The values of the above listed parameters were found to be ranged between 17°C to 35°C, pH 6.2 to 8.5, turbidity 0.1 to 4.1, total hardness 240 to 960 mg/l, TDS 121to 39.0 mg/l, DO 1.9 – 6.2 mg/l, BOD 2.0 to 23.0 mg/l, COD 2.8 to 65.2 mg/l, nitrate 0.03 to 2.35 mg/l, sulphate 0.03 to 194 mg/l, phosphate 0.003 to 0.251 mg/l. The temperature was found ranged between 17°C to 35°C, the maximum temperature was found during summer season in Residential area of west zone of central India, at sampling station R32 (Near Anjanil temple, Rajgarh Biora).pH of all the sample during all the seasons were found below the permissible limit except R₂₅ (8.5). Observed value of total hardness was found at sampling station R₂₁, R₂₂, R₂₆, R₂₇, R₂₈, R₂₉, R₃₀, R₃₁, and R₃₂ are higher than the permissible limit prescribed by WHO, during all the seasons. Dissolved oxygen was observed at 25% samples are higher than the limit. BOD and COD were found at sampling station R₂₁, R₂₂, R₂₄, R₂₅, R₂₇, R₃₅, R₃₆, and R₃₇ are higher than the permissible limit, during all the seasons. Temperature, TDS, nitrate, sulphate and phosphate were found below the permissible limit prescribed by WHO. The results obtained showed that the ground water quality is poor and suitable for the drinking purposes at same sampling station. Access amount of organic and inorganic pollutants are observed in the ground water samples of residential area of west zone of central India and cause severe problem to the human health. For efficient management of the water resources, monitoring of the ground water resources is essential in such areas where sustainable mechanism for maintaining proper health conditions the population.

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