



Research Article

ANALYSIS OF PHYSICO- CHEMICAL PARAMETERS AND CORRELATION COEFFICIENT OF GROUND WATER SAMPLES IN RESIDENTIAL AREA OF EAST ZONE OF CENTRAL INDIA

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ABSTRACT

In the present study twenty sampling location were selected from study area. These factors influence the water resources quantitatively and qualitatively the parameters live temperature, pH, turbidity, total hardness, TDS, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrate, sulphate and phosphate for water analysis. The mean values of each parameter together with its standard deviation (SD) and coefficient of variation (CV) were calculated. The present study deals with the various relationship derived statistically by calculation 'r' and 't' among the physic-chemical parameters. BOD, COD and phosphate are exceeded the permissible limit by WHO in most of the ground water samples.

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INTRODUCTION

The central India plateau is environmentally very important to understand the rich Indian biodiversity and diffuse chemical pollution. Madhya Pradesh literally means 'central province' and is located in the geographic heart of India, between latitude 21.2°N-26.87°N and longitude 74°02'-82°49'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 ground water source levels change by the regular withdrawal and hence the quality of ground water reported seasonal as well as annual change in the ground water quality (Garg 1990, Kaur 1992, Rajmohan 1997, Singh 2000). Ground water which now accounts for 80% of rural and 60% of urban water supply in India is depleting at an alarming rate in several states (Gayatri 2001, Dwivedi 2013). Domestic wastewater has always been a low cost option for farmers to go in for irrigated agriculture in water scarce regions of the world. Apart from its resource value as water, the high nutrient content of domestic wastewater helps the farmers to fertilize their crops without spending substantial amount on additional fertilizers. Both temporal and spatial water scarcity, along with rising demand for water from competing sectors

(growing population, urbanization and industrialization) have also forced the farmers to go for wastewater irrigation. However, safe utilization of wastewater for irrigation requires proper treatment and several precautionary measures in use, as it may cause environmental and human health hazards⁷⁻¹¹ (Butt 2005, Minhas 2004, Bradford 2003, Tripathi 2013, Tripathi 2014). It is estimated that 60-70% of water pollution is attributable to the discharge of sewage and other wastes from municipalities while remaining from industries. There are several states in India where more than 90% populations are dependent on ground water for drinking and other purpose (Brindha, 2012). In India, there are over 20 million private wells in addition to the government tube wells (Ramchandraiah, 2004). The wells are generally considered as the worst types of ground water sources in term of physico-chemical contamination due to the surrounding drainage and waste water disposal system (Tripathi, 2015). Over burden of the population pressure, unplanned urbanization, unrestricted exploration and dumping of the polluted water at appropriate place enhance the infiltration of harmful compounds to the ground water (CGWB, 2009). The extensive use of fertilizers, agrochemicals, fuel and other chemicals, along with growing industrial and urban activities have put in severe strain on the river ecosystem. Generally, increasing population and subsequently, Industrial and urban activities are main cause of unabated pollution of water sources in the world. About 40% population of the world

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resides in the urban areas which occupy only about 0.30% of the world's geographical area (Pandey 2009, Das 2013). The aim of present work is to assess the quality of drinking water of the residential area of east zone of central India by analyzing various inorganic non-metallic constituent are present in water.

MATERIALS AND METHODS

The Ground water samples were collected seasonally from twenty sampling location in residential area of East 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

$$r = \frac{\sum xy}{\sqrt{\sum x^2 \sum y^2}} \times 100$$

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 B. 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 ₁ = Rewa Near Bus Stand,
2	R ₂ = Satna Near District Hospital,
3	R ₃ = Sidhi Near Sanjay Gandhi P.G. College,
4	R ₄ = Singrauli Near Railway station,
5	R ₅ = Shahdol Near New Bus Stand,
6	R ₆ = Umaria Near Govt. R.V.P.S. College,
7	R ₇ = Katni Near Swetamber Temple,
8	R ₈ = Panna Near Bus Stand,
9	R ₉ = Chhatarpur Near Higher Secondary,
10	R ₁₀ = Jabalpur Near S.B.I. Chhorha,
11	R ₁₁ = Near R.D. P.G College Mandala,
12	R ₁₂ = Dindori Near Main Post Office,
13	R ₁₃ = Near Govt P.G. College Siwani,
14	R ₁₄ = Chhindwara Near State Bank of India,
15	R ₁₅ = Narsinghpur Near Railway Station,
16	R ₁₆ = Near District Hospital Hosangabad,
17	R ₁₇ = Betul Near Excellence School,
18	R ₁₈ = Damoh Near Bus Stand,
19	R ₁₉ = Sagar Near Railway Station,
20	R ₂₀ = Bhopal Near Hamidia Hospital.

RESULTS AND DISCUSSION

Characteristics of ground water samples collected from residential area of East zone central India. Ground water samples were collected from twenty different locations in Residential area of East zone central India, the details of the locations are given in Table-B. The ground water samples were collected during the three seasons (monsoon, winter and summer) to know the seasonal variation in characteristics. The physico-chemical characteristics of the ground water samples of residential area of east zone central India during the three seasons are presented in Table-1 to 3. The water temperature averaged 29.29 which were lower than the average value of ground water Mandala near R.D.P.G. College (25.3) and higher than those of Chhindwara near state bank of India (33.0) of location R₄ in residential area of East zone central India during monsoon season. PH of all water samples analyzed was within the permissible limit of 6.5 to 8.5 given by BIS and (WHO, 1984) standards. The PH values greater than 8.5 are consider being too alkaline for human consumption. In this study the PH value of water ranges from 6.5 to 8.4 with a mean value of 7.35. The PH values slightly alkaline nature. total hardness In the present samples varied from 195 to 463 mg/l with the mean value from 293.10 mg/L. the maximum total hardens was fired (463 mg/l) at sampling station R₂ (Satna Near district hospital). The TDS values ranges from 245.0 to 534 mg/l with a mean 339.00. All the samples of total hardness were below the standard limit set by WHO as 600 mg/l. Dissolved oxygen was found ranged between 1.8 to 5.8 mg/l with an average 3.72 value of DO at sampling stations R₁₂ (4.5). Biological oxygen Demand varied from 2.5 to 10.2 and average value of BOD found 4.84 mg/l. BOD of al the samples were below the permissible limit except two samples R₂ (7.8) and R₄ (10.2) mg/l. Chemical oxygen Demand was found ranged from 5.89 mg/l. The maximum COD was recorded at samples R₂₀ (8.5 mg/l). Chemical oxygen Demand of all the water samples during monsoon season were below the limit set by who as 10 mg/l. Nitrate ion concentration varies from 0.5 to 7.7 mg/l. with an average value of 5.1 mg/l. Nitrate were found and all the sampling station during monsoon season in Residential area of East zone central India were below the permissible limit prescribed by WHO. The salphate values in the study area varied from 0.05 to 200 mg/l. The mean value of salphate was found 20.33 mg/l are shown in Table-1. The maximum concentration of salphate 200 mg/L was found at sampling station R₆ (Umaria, near govt. R.V.P.S college). Phosphate varied from ND to 3.0 mg/l. Values of phosphate sampling station R₂ Satna (2.0), R₄ Singraoli (0.5) R₁₀ Jabalpur (3.0) and R₁₃ Siwani (1.0) mg/l are higher than the permissible limit set by WHO.

The standard deviation value of temperature (1.97), PH (0.64) turbidity (1.26) DO (1.06), BOD (1.81), COD (1.58), Nitrates (2.43), phosphate (0.78) of each parameters between very little deviation, but in the case of total hardness (92.76), TDS (64.77) and salphate (43.14) S.D. value gave greater deviation together all the each parameters as shown in Table-1. The coefficient variation values of temperature (6.92), pH (8.70), turbidity (63.95), hardness (31.64), TDS (19.07), DO (28.49), BOD (37.39), COD (26.82), Nitrate (62.14), and showed wide fluctuations with each other with respect to relation of these parameter between stations. The correlation coefficient (r and t) among various water quality parameters are given in Table- 1a.

Table 1. Physico-chemical characteristics of ground water in Residential area of East Zone Central India During Monsoon Season (of Year 2013 to 2014)

Parameters	Sampling Location																				Mean	S.D	C.V
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20			
Temperature	30.7	28.5	26.0	30.4	31.3	28.2	27.5	30.1	31.0	28.4	25.3	30.2	29.6	33.0	27.3	28.2	31.4	28.1	31.5	29.0	29.29	1.97	6.92
pH	6.8	7.5	6.6	8.0	6.7	8.2	8.4	7.1	7.4	7.6	6.9	6.5	6.7	8.2	6.9	8.0	8.3	6.7	7.5	7.0	7.35	0.64	8.70
Turbidity	2.3	2.0	1.2	0.7	0.4	3.0	1.7	5.4	2.4	3.1	4.0	1.5	2.5	1.3	0.0	1.7	0.5	1.9	1.8	2.0	1.97	1.26	63.95
Hardness	228	463	320	270	195	217	571	359	226	314	268	368	290	235	240	210	258	315	300	215	293.10	92.76	31.64
TDS	340	312	406	285	245	332	534	347	321	330	390	336	292	421	326	382	250	290	324	329	339.60	64.77	19.07
DO	5.1	3.82	1.8	4.0	4.5	2.9	3.5	3.0	5.8	2.9	1.8	4.5	3.4	5.6	4.2	3.1	4.0	3.2	3.8	3.4	3.72	1.06	28.49
BOD	4.5	7.8	4.5	10.2	4.7	4.9	6.0	4.2	5.3	3.6	3.5	2.5	3.0	4.5	4.2	6.4	3.9	6.0	4.3	2.7	4.84	1.81	37.39
COD	4.5	6.0	4.9	5.1	6.1	8.0	6.2	8.1	7.5	5.0	6.7	6.5	6.1	4.3	3.0	5.3	4.5	8.0	3.5	8.5	5.89	1.58	26.82
Nitrate	4.3	6.7	0.5	0.6	0.8	4.0	1.5	0.7	0.6	5.9	5.0	3.0	3.5	3.2	7.7	6.8	5.9	5.6	6.7	5.1	3.91	2.43	62.14
Sulphate	5.2	9.1	0.05	8.0	5.0	200	27.3	12.4	5.7	8.9	0.0	15.2	26.5	7.8	12.3	7.9	8.2	7.9	7.0	32.2	20.33	43.14	212.19
Phosphate	0.20	2.0	0.007	0.5	0.03	0.2	ND	0.031	0.19	3.0	0.011	0.002	1.0	0.029	0.008	0.06	0.0	0.02	0.09	0.1	0.39	0.78	200

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

Residential Area- R1= Rewa Near Bus Stand, R2= Satna Near District Hospital, R3= Sidhi Near Sanjay Gandhi P.G. College, R4= Singrauli Near Railway station, R5= Shahdol Near New Bus Stand, R6= Umaria Near Govt. R.V.P.S. College, R7= Katni Near Swetamber Temple, R8= Panna Near Bus Stand, R9= Chhatarpur Near Higher Secondary, R10= Jabalpur Near S.B.I. Chhorha, R11= Near R.D. P.G College Mandala, R12= Dindori Near Main Post Office, R13= Near Govt P.G. College Siwani, R14= Chhindwara Near State Bank of India, R15= Narsinghpur Near Railway Station, R16= Near District Hospital Hosangabad, R17= Betul Near Excellence School, R18= Damoh Near Bus Stand, R19= Sagar Near Railway Station, R20= Bhopal Near Hamidia Hospital.

**Table -1a Correlation coefficient (r) among various water quality parameters
(Physico-chemical characteristics of ground water in Residential area of East Zone Central India During Monsoon Season)**

Parameters	Temperature	pH	Turbidity	Hardness	TDS	DO	BOD	COD	Nitrate	Sulphate	Phosphate
Temperature	1										
pH	0.216	1									
Turbidity	0.938		1								
Hardness	-0.205	-0.095		1							
TDS	0.911	-1.142			1						
DO	-0.271	0.1353	0.151			1					
BOD	-1.197	0.579	0.659				1				
COD	-0.371	0.286	0.185	0.504				1			
Nitrate	-1.694	1.270	0.802	2.479*	-0.192				1		
Sulphate	0.788	0.125	-0.383	-0.203	-0.834	0.087				1	
Phosphate	5.447**	0.538	-1.518	-0.881	-0.834	0.199	-0.012				1
Temperature	0.003	0.427	-0.235	0.199	0.199	0.087	1				
pH	0.056	2.005	-1.026	0.863	-0.076	0.143		1			
Turbidity	-0.174	-0.161	0.555	0.078	-0.032	-0.032	-0.077		1		
Hardness	1.015	0.693	2.830*	0.146	-0.507	-0.507	-0.147			1	
TDS	-0.183	0.074	-0.108	-0.113	-0.168	-0.168	-0.155	-0.323			1
DO	0.792	2.144*	-0.463	0.668	-0.726	0.726	0.666	-1.451			
BOD	-0.124	0.316	0.193	-0.128	0.0083	0.008	-0.038	0.371	0.012		
COD	-0.525	0.948	0.834	-0.549	0.014	0.014	0.103	1.698	0.053		
Nitrate	-0.121	0.136	0.193	0.455	-0.129	-0.129	0.127	-0.085	0.241	-0.041	
Sulphate	-0.521	0.584	0.836	2.168*	0.991	-0.554	0.546	-0.399	1.054	-0.184	
Phosphate											1

1% Level of significance =** (2.878)

5% Level of significance =* (2.101)

Table 2. Physico-chemical characteristics of ground water in Residential area of East Zone Central India During Winter Season (of Year 2013 to 2014)

Parameters	Sampling Location																				Mean	S.D	C.V
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20			
Temperature	22.1	23.2	18.2	23.4	26.2	22.5	20.4	24.2	28.9	24.7	18.5	25.4	26.5	28.5	22.2	22.1	24.7	23.4	25.2	24.0	23.715	2.801	11.81
pH	6.5	7.2	6.5	7.6	6.4	8.0	8.5	6.7	7.1	7.4	7.3	6.8	6.1	8.1	7.5	7.8	8.2	6.5	7.4	6.9	7.225	0.675	9.34
Turbidity	2.4	2.0	1.0	0.5	0.2	2.6	1.5	5.2	2.1	2.8	3.5	1.2	2.7	1.8	0.0	1.3	0.3	1.7	2.0	1.5	1.815	1.227	67.60
Hardness	225	462	322	266	193	219	561	358	228	316	265	368	238	310	230	200	252	312	305	210	292.000	92.461	31.66
TDS	342	310	413	280	249	328	529	341	316	337	380	329	290	408	315	361	240	282	322	315	334.350	64.134	19.18
DO	4.35	3.86	1.5	4.0	4.2	3.7	3.2	2.9	5.4	3.2	1.6	4.1	3.8	5.3	4.6	2.8	3.5	2.5	3.2	2.9	3.531	1.031	29.19
BOD	3.6	7.6	3.7	9.6	2.3	4.0	5.2	3.7	6.3	2.3	3.0	2.5	2.8	4.3	4.0	5.2	2.7	5.1	3.6	2.4	4.195	1.895	45.17
COD	4.7	5.1	3.8	3.9	5.3	6.2	5.7	7.4	7.2	5.7	6.4	5.1	6.0	3.9	2.7	4.3	3.6	7.6	3.1	7.2	5.245	1.483	28.27
Nitrate	3.0	4.2	0.1	0.26	0.74	3.4	1.0	0.5	0.3	5.7	4.3	2.7	3.2	2.4	7.2	6.7	5.4	4.9	5.6	4.2	3.290	2.258	68.63
Sulphate	4.7	8.2	0.0	7.8	4.8	123	24.5	8.0	4.1	8.3	0.0	12.7	24.2	5.1	11.5	7.2	6.8	8.6	6.9	28.9	15.265	26.509	173.65
Phosphate	0.19	1.7	0.005	0.45	0.021	0.13	ND	0.025	0.18	2.7	0.014	0.001	1.2	0.016	0.007	0.05	0.0	0.03	0.07	0.018	0.358	0.711	198.60

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

Residential Area- R1= Rewa Near Bus Stand, R2= Satna Near District Hospital, R3= Sidhi Near Sanjay Gandhi P.G. College, R4= Singrauli Near Railway station, R5= Shahdol Near New Bus Stand, R6= Umaria Near Govt. R.V.P.S. College, R7= Katni Near Swetamber Temple, R8= Panna Near Bus Stand, R9= Chhatarpur Near Higher Secondary, R10= Jabalpur Near S.B.I. Chhorha, R11= Near R.D. P.G College Mandala, R12= Dindori Near Main Post Office, R13= Near Govt P.G. College Siwani, R14= Chhindwara Near State Bank of India, R15= Narsinghpur Near Railway Station, R16= Near District Hospital Hosangabad, R17= Betul Near Excellence School, R18= Damoh Near Bus Stand, R19= Sagar Near Railway Station, R20= Bhopal Near Hamidia Hospital.

Table 2a. Correlation coefficient (r) among various water quality parameters (Physico-chemical characteristics of ground water in Residential area of East Zone Central India during Winter Season)

Parameters	Temperature																							
		pH	Turbidity	Hardness	TDS	DO	BOD	COD	Nitrate	Sulphate	Phosphate													
Temperature	1																							
pH	-0.081	1																						
Turbidity	-0.377	-0.016	1																					
Hardness	-0.071	-0.197	-1.076	1																				
TDS	-0.216	0.258	0.164	0.164	1																			
DO	-1.218	1.133	0.707	0.707	0.595	1																		
BOD	-0.435	0.377	0.209	0.209	3.141**	-0.229	1																	
COD	-5.161**	1.730	0.907	0.907	0.139	-0.243	-0.147	-0.229	1															
Nitrate	0.739	0.139	-0.243	-0.147	-0.744	-1.325	0.217	1																
Sulphate	4.662**	0.595	-1.439	-0.744	0.150	0.943	0.217	0.943																
Phosphate	-0.032	0.258	-0.147	0.150	0.054	-0.010	-0.089	-0.089	1															
	-0.141	1.132	-0.746	1.106	0.054	-0.010	-0.089	-0.010	-0.186															
	0.104	-0.342	0.591	0.591	0.0229	-0.998	-0.382	1																
	0.445	-2.595*	0.806	0.229	-0.042	-0.998	-0.382	-0.382																
	-0.097-	0.227	-0.123	-0.223	-0.226	-0.128	-0.254	-0.263	1															
	0.462	0.989	-0.604	-1.273	-1.299	-0.633	-1.543	-1.626	-1.626															
	-0.065	0.264	0.131	-0.118	0.014	0.050	-0.063	0.224	0.224															
	-0.070	1.164	0.563	-0.576	0.060	0.215	-0.286	0.978	0.144															
	0.119	-0.044	0.220	0.370	-0.076	0.035	0.077	0.088	0.185															
	0.510	-0.196	08.52	1.689	-0.350	0.999	0.330	0.375	0.802															

1% Level of significance =**

5% Level of significance =*

Table 3. Physico -chemical characteristics of ground water in Residential area of East Zone Central India during Summer Season

Parameters	Sampling Location																				Mean	S.D	C.V
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20			
Temperature	35.3	36.0	31.6	32.5	28.1	27.5	30.0	29.5	28.4	33.5	31.0	29.0	27.2	36.7	28.3	27.0	34.2	32.4	28.2	30.0	30.820	3.058	9.92
pH	6.2	7.5	6.6	7.4	7.2	6.9	8.7	7.5	7.2	8.0	7.8	6.3	7.6	8.4	7.3	8.1	8.5	6.8	7.2	6.7	7.395	0.707	9.56
Turbidity	2.4	2.0	1.5	1.0	0.2	1.6	2.5	3.7	3.2	3.0	4.8	1.0	3.5	1.2	0.3	2.0	0.0	2.8	2.5	3.5	2.135	1.293	60.56
Hardness	232	480	326	248	187	210	569	370	235	306	278	370	262	252	238	221	262	310	312	219	294.350	94.485	32.09
TDS	354	314	419	290	264	324	538	335	328	332	396	332	295	415	322	366	246	288	315	325	339.900	64.613	19.0
DO	4.6	3.0	1.0	4.8	3.4	2.7	3.9	3.2	5.2	3.5	2.0	3.8	4.0	5.8	5.1	3.4	4.5	4.8	4.2	2.6	3.775	1.172	31.04
BOD	2.7	6.9	8.5	12.4	2.3	4.7	5.6	3.2	7.2	4.3	10.5	4.2	3.5	6.3	5.3	7.4	4.3	8.2	4.7	5.8	5.900	2.597	44.01
COD	6.9	6.0	7.8	15.0	10.0	4.8	11.2	23.0	7.5	8.2	8.5	7.4	15.4	9.6	4.8	11.4	9.3	7.8	5.2	9.8	9.480	4.309	45.45
Nitrate	5.2	4.5	0.3	0.8	0.92	3.0	2.6	1.2	0.7	4.8	6.3	2.9	4.2	5.0	8.5	9.4	8.6	5.8	7.1	6.4	4.411	2.817	63.86
Sulphate	6.7	12.4	0.03	9.2	5.1	187	30.7	9.7	6.3	8.6	0.02	16.3	19.7	7.4	13.1	8.7	7.0	6.9	8.7	32.7	19.813	40.246	203.12
Phosphate	0.17	1.9	0.008	0.49	0.028	0.17	0.002	0.032	0.019	2.8	0.015	0.00	1.6	0.027	0.009	0.07	0.0	0.06	0.08	0.024	0.375	0.778	207.46

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

Residential Area- R1= Rewa Near Bus Stand, R2= Satna Near District Hospital, R3= Sidhi Near Sanjay Gandhi P.G. College, R4= Singrauli Near Railway station, R5= Shahdol Near New Bus Stand, R6= Umaria Near Govt. R.V.P.S. College, R7= Katni Near Swetamber Temple, R8= Panna Near Bus Stand, R9= Chhatarpur Near Higher Secondary, R10= Jabalpur Near S.B.I. Chhorha, R11= Near R.D. P.G College Mandala, R12= Dindori Near Main Post Office, R13= Near Govt P.G. College Siwani, R14= Chhindwara Near State Bank of India, R15= Narsinghpur Near Railway Station, R16= Near District Hospital Hosangabad, R17= Betul Near Excellence School, R18= Damoh Near Bus Stand, R19= Sagar Near Railway Station, R20= Bhopal Near Hamidia Hospital.

**Table 3a. Correlation coefficient (r) among various water quality parameters
(Physico -chemical characteristics of ground water in Residential area of East Zone Central India during Summer Season.)**

Parameters	Temperature	pH	Turbidity	Hardness	TDS	DO	BOD	COD	Nitrate	Sulphate	Phosphate
Temperature	1										
pH	0.153	1									
Turbidity	0.657		1								
Hardness	-0.113	-0.015		1							
TDS	-0.545	-0.066	0.160		1						
DO	0.206	0.264	0.687	0.534		1					
BOD	2.468*	1.161	0.256	2.684*	-0.198		1				
COD	0.071	0.294	0.124	0.027	-1.087	-0.103		1			
Nitrate	0.305	1.307	0.114	0.777	-0.090	-0.495			1		
Sulphate	0.191	0.208	0.445	0.006	-0.025	-0.219				1	
Phosphate	0.827	0.902	0.026	-0.090	-0.111	-0.219					1
	0.173	0.092	-0.021	-0.139	-0.060	-0.060					
	0.746	0.392	-0.092	-1.068	0.699	0.790					
	-0.121	0.276	-0.131	-0.006	-0.202	-0.155					
	-0.591	1.220	-0.303	-0.649	-0.029	-1.113					
	0.062	0.262	0.201	0.199	-0.178	-0.101					
	0.267	1.156	0.871	0.862	-0.942	0.483					
	-0.296	-0.143	0.871	0.862	-0.942	0.483					
	-1.974	0.719	-0.303	-0.649	-0.029	-1.113					
	0.268	0.185	0.201	0.199	-0.178	-0.078					
	1.183	0.801	0.871	0.862	-0.942	0.483					

1% Level of significance ==**

5% Level of significance ==*

Table 4. Average Physico -chemical characteristics of ground water in Residential area of East Zone Central India

Parameters	Sampling Location																			
	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20
Temperature	29.37	29.23	25.27	28.77	28.53	26.07	25.97	27.93	29.43	28.87	24.93	28.20	27.77	32.73	25.93	25.77	30.10	27.97	28.30	27.67
SD (±)	6.70	6.43	6.73	4.76	2.58	3.11	4.98	3.25	1.38	4.42	6.26	2.50	1.63	4.11	3.27	3.23	4.88	4.50	3.15	3.21
pH	6.50	7.40	6.57	7.67	6.77	7.70	8.53	7.10	7.23	7.67	7.33	6.53	6.80	8.23	7.23	7.97	8.33	6.67	7.37	6.87
SD(±)	0.30	0.17	0.06	0.31	0.40	0.70	0.15	0.40	0.15	0.31	0.45	0.25	0.75	0.15	0.31	0.15	0.15	0.15	0.15	0.15
Turbidity	2.37	2.00	1.23	0.73	0.27	2.40	1.90	4.77	2.57	2.97	4.10	1.23	2.90	1.43	0.10	1.67	0.27	2.13	2.10	2.33
SD(±)	0.06	0.00	0.25	0.25	0.12	0.72	0.53	0.93	0.57	0.15	0.66	0.25	0.53	0.32	0.17	0.35	0.25	0.59	0.36	1.04
Hardness	228.33	468.33	322.67	261.33	191.67	215.33	567.00	362.33	229.67	312.00	270.33	368.67	263.33	265.67	236.00	210.33	257.33	312.33	305.67	214.67
SD(±)	3.51	10.12	3.06	11.72	4.16	4.73	5.29	6.66	4.73	5.29	6.81	1.15	26.03	39.32	5.29	10.50	5.03	2.52	6.03	4.51
TDS	345.33	312.00	412.67	285.00	252.67	328.00	533.67	341.00	321.67	333.00	388.67	332.33	292.33	414.67	321.00	369.67	245.33	286.67	320.33	323.00
SD(±)	7.57	2.00	6.51	5.00	10.02	4.00	4.51	6.00	6.03	3.61	8.08	3.51	2.52	6.51	5.57	10.97	5.03	4.16	4.73	7.21
DO	4.68	3.56	1.43	4.27	4.03	3.10	3.53	3.03	5.47	3.20	1.80	4.13	3.73	5.57	4.63	3.10	4.00	3.50	3.73	2.97
SD(±)	0.38	0.49	0.40	0.46	0.57	0.53	0.35	0.15	0.31	0.30	0.20	0.35	0.31	0.25	0.45	0.30	0.50	1.18	0.50	0.40
BOD	3.60	7.43	5.57	10.73	3.10	4.53	5.60	3.70	6.27	3.40	5.67	3.07	3.10	5.03	4.50	6.33	3.63	6.43	4.20	3.63
SD(±)	0.90	0.47	2.57	1.47	1.39	0.47	0.40	0.50	0.95	1.01	4.19	0.98	0.36	1.10	0.70	1.10	0.83	1.59	0.56	1.88
COD	5.37	5.70	5.50	8.00	7.13	6.33	7.70	12.83	7.40	6.30	7.20	6.33	9.17	5.93	3.50	7.00	5.80	7.80	3.93	8.50
SD(±)	1.33	0.52	2.07	6.09	2.51	1.60	3.04	8.81	0.17	1.68	1.14	1.16	5.40	3.18	1.14	3.84	3.06	0.20	1.12	1.30
Nitrates	4.17	5.13	0.30	0.55	0.82	3.47	1.70	0.80	0.53	5.47	5.20	2.87	3.63	3.53	7.80	7.63	6.63	5.43	6.47	5.23
SD(±)	1.11	1.37	0.20	0.27	0.09	0.50	0.82	0.36	0.21	0.59	1.01	0.15	0.51	1.33	0.66	1.53	1.72	0.47	0.78	1.11
Sulfates	5.53	9.90	0.03	8.33	4.97	170.00	27.50	10.03	5.37	8.60	0.01	14.73	23.47	6.77	12.30	7.93	7.33	7.80	7.53	5.53
SD(±)	1.04	2.21	0.03	0.76	0.15	41.22	3.10	2.22	1.14	0.30	0.01	1.84	3.46	1.46	0.80	0.75	0.76	0.85	1.01	1.04
Phosphates	0.187	1.867	0.007	0.480	0.026	0.167	0.002	0.029	0.130	2.833	0.013	0.001	1.267	0.024	0.008	0.060	0.000	0.037	0.080	0.047
SD(±)	0.015	0.153	0.002	0.026	0.005	0.035	0.001	0.004	0.096	0.153	0.002	0.001	0.306	0.007	0.001	0.010	0.000	0.021	0.010	0.046

The temperature of ground water in residential area of East zone central India during monsoon showed positive relationship with pH, DO and BOD and negative relationship with turbidity, hardness TDS, COD, Nitrate, sulphate and phosphate. PH showed positive relationship with, temperature, pH, hardness, TDS, DO, BOD, nitrate, sulphate and phosphate and negative relationship with turbidity and COD. Turbidity showed negative relationship with temperature, pH, DO, BOD, and nitrate and positive relationship with turbidity, total hardness, TDS, COD, sulphate and phosphate. Total hardness showed positive relationship with pH, Turbidity, hardness, TDS, BOD, COD, and phosphate and negative relationship temperature, DO, nitrate and sulphate. TDS showed significant positive relationship with pH, turbidity, total hardness, TDS. and sulphate and negative relationship with temperature, DO, BOD COD, nitrate and phosphate. Dissolved oxygen showed (DO) positive relationship with temperature, pH, DO, BOD, and sulphate and negative relationship with turbidity, total hardness, TDS, COD, nitrate and phosphate. Biochemical oxygen Demand (BOD) showed positive relationship with temperature, pH, total hardness, DO, BOD, and phosphate and negative relationship turbidity and TDS. Chemical oxygen demand (COD) showed positive relationship with turbidity, total hardness and sulphate and negative relationship with temperature, pH, TDS, DO, BOD, nitrate and phosphate.

Nitrate showed significant positive relationship with pH, nitrates, sulphates and phosphate and negative relationship with temperature, total hardness, BOD and phosphate. Sulphate showed positive relationship with pH, turbidity, TDS, DO, COD, and Nitrate and negative relationship with temperature, hardness and BOD. Phosphate showed significant positive relationship with pH, turbidity, total hardness, BOD nitrates and phosphate. The various relationship derived statistically by calculation r and t' among the physico- Chemical characteristics. The r value was negative twenty nine times and positive thirty seven times showed 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 east Zone central India and stabilized the correlation by using ANOVA statistical software. The table values of 5% significant level were 2.10 and at 1% significant level were 2.878. In the case of nitrate and pH, COD and turbidity, TDS and total hardness and Phosphate and Total Hardness we established a correlation ship which were positive and value were 2.144, 2.830, 2.479 and 2.168 respectively, which was greater than 5% significant level. Dissolved oxygen and temperature were found positive value of correlation significant 1% significant level i.e. 5.447.

It showed that nitrates, pH, COD, turbidity, TDS, total hardness, phosphate, Dissolved oxygen and temperature play major role in the physico-chemical characteristics of ground water in residential area of east zone central India during monsoon season. In the present study the temperature was found ranged between 18.2^oC to 28. 9^oC. The maximum temperature was recorded at sampling stations (R₉) Chhatarpur, near higher secondary school. PH concentration was observed ranged between 6.4 to 8.5. pH concentration was found at all the samples were below the permissible limit excellence one locations R₇ (8.5 gm/l). The total hardness varied between 173 mg/l to 561 mg/l. values of total hardness in all the sampling location were below the limit prescribed by WHO. The TDS from 240 to 529 mg/l, which was found, varied in (R₁₇) Batul near excellences school and highest R₇ (katni near Swetanber temple). The dissolved oxygen between 1.5 to 5.4 mg/l. the maximum DO was observed at sampling stations R₇ (katni near Swetanber temple). The Biochemical Oxygen Demand (BOD) and chemical oxygen Demand (COD) were also found within the limits prescribed by WHO, during the winter season. The concentration of nitrate ions varied from 0.1 to 7.2 mg/l. All the samples nitrate concentration, are below the permissible limit set by WHO. The concentration of sulphate ions was found to be between 0.0 to 123 mg/l, with in the permissible limit. The concentration of phosphate in ground water varied from 0.0 to 123 mg/l. Value of phosphate at sampling at station R₂ (1.7mg/l), R₄ (0.45), R₁₀ (2.7), R₁₃ (1.2) mg/l are higher than the permissible limits set by WHO. In the case of temperature, pH, turbidity, hardness, TDS, DO, BOD, COD, Nitrate, sulphate and phosphate the mean value were to recorded as 23.71, 7.22, 1.81, 292.0, 334.3, 3.53, 4.19, 5.24, 3.29, 15.26 and 0.35 mg/l respectively. The standard deviation value of temperature (2.80), pH (0.67), turbidity (1.22) DO (1.03), BOD (1.89), COD (1.48), nitrate (2.25), sulphate (26.50), and phosphate (0.711) of each parameters between very little deviations but in the case of total hardness (92.46) and TDS (64.13) S.D value have greater deviation together all the each parameters The coefficient variation values of temperature (11.81,) pH (9.34), total hardness (31.66), TDS (19.18), DO (29.19) BOD (45.17) and COD (28.27) showed wide fluctuations with each other with respect to relation of these parameters between station. The CV values of turbidity (67.60), nitrate (68.63), sulphate (73.65) and phosphate (198.60) showed the turbidity, nitrate, sulphate and phosphates Indicated their significant variation from one station to another.

The correlation coefficient (r and t) among various water quality parameters are given in **Table 2a**. The temperature of ground water during winter seasons showed positive relationship with temperature, DO, COD and phosphate and negative relationship with pH, turbidity, total hardness, TDS, BOD, nitrate and sulphate. The pH of the ground water showed positive relationship between pH, total hardness, TDS, DO, BOD, nitrate and sulphate and negative relationship with temperature, turbidity, COD, and phosphate. Turbidity showed significant positive relationship with turbidity, total hardness, TDS, COD sulphate and phosphate and negative relationship with temperature, pH, DO, BOD and nitrate. Total hardness in present investigation showed positive relationship with pH, turbidity total hardness, BOD, COD, and phosphate and negative relationship with temperature, DO, nitrate and sulphate. TDS showed significant positive relationship with pH, turbidity, total hardness, TDS, BOD and sulphate and negative relationship with temperature, DO, COD, nitrate and phosphates.

Dissolved oxygen (DO) in present investigation showed positive relationship with temperature, pH, DO, BOD, sulphate and phosphate and negative relationship with turbidity total hardness, TDS, COD and nitrate. Biochemical oxygen demand (BOD) showed positive relationship between pH, total hardness, TDS, DO, BOD, and phosphate and negative relationship with temperature, turbidity, COD, nitrate and sulphate. Chemical oxygen demand (COD) in present investigation showed positive relationship with temperature, turbidity, total hardness, COD, sulphate and phosphate and negative relationship with pH, TDS, DO, BOD, and nitrate. Nitrate showed positive relationship between pH, nitrate, sulphate and phosphate and negative relationship with temperature, turbidity, total hardness, TDS, DO, BOD, and COD. Sulphate of the ground water winter showed significant positive relationship with pH, turbidity, TDS, DO, COD, nitrate and sulphate and negative relationship with temperature total hardness, BOD, and phosphate. Phosphate showed significant negative relationship with pH, TDS, and sulphate and positive relationship with temperature, turbidity, Total hardness, DO, BOD, COD. The present study deals with the various relationship derived statistically by calculation of 'r' and 't' among the physico-chemical characteristics. The r value was twenty seven times negatives and thirty Eight times positive this showed that positive relationship in the present study. During the winter seasons correlated between different parameter with each other, statistically this shows great variation positive to negative values for 1% significant value (2.878) and 5% significant value (2.101). In case of DO and temperature and TDS and total hardness we established correlations which were positive and value were 4.662 and 3.141 respectively, which was more than 1% significant level. TDS and temperature were found negative value of correlation ship at 1% significant level i.e. - 5.161. COD and pH were found negative value of correlation ship at 5% significant level i.e. -2.595. It showed that DO, temperature, TDS, total hardness, COD, and pH play major role in the physico- chemical characteristics of ground water in residential area of East zone of central India during winter seasons.

The temperature was found ranged between 27.^oC to 36.7^oC. The maximum temperature was recorded at sampling station R₁₄ Chindwara, near state bank of India). The pH of the sample water was observed that the value varies between 6.2 to 8.7 all the samples were found range between limits prescribed by WHO. Turbidity of the water sample is in between 0.2 to 4.8 mg/l. Total hardness of the ground water samples were varied from 187 to 569 mg/l. TDS in the studied area varied between the 246 to 538 mg/l. DO values in the present finding varied from 1.0 to 5.8 mg/l. Maximum DO was recorded at sampling station R₁₄ (Chindwara, near state bank of India). In present Investigation BOD varied in the range of 2.3 to 12.4 mg/l. Value of BOD was found at sampling station R₂ (6.9), R₃ (8.5) R₄ (12.4), R₉ (7.2), R₁₁ (10.5), R₁₄ (6.3), R₁₆ (7.4), R₁₈ (8.2) mg/l are higher than the permissible limit set by WHO. Chemical oxygen demand has found ranged between 4.8 to 23.0 mg/l. COD value at sampling station R₄ (15.0) R₅ (10.0) R₇ (11.2) R₈ (23.0), R₁₃ (15.4), R₁₆ (11.4) mg/l are more than the standard limit set by WHO 10 mg/l. Nitrate concentrations are varying from 0.3 to 9.4 mg/l. All the samples of nitrate concentration were below the permissible limit prescribed by WHO as 45 mg/l. Sulphate concentration are varying from 0.02 to 187 mg/l. all the samples from the study area are within the permissible limit. Phosphate concentration are varying from 0.002 to 2.8 mg/l. Values of

phosphate at samples R₂ (1.9), R₄ (0.49) R₁₀ (2.8), R₁₃ (1.6) mg/l are higher than the permissible limit set by WHO as 0.3 mg/l. In the case of temperature, pH, turbidity, total hardness, TDS, DO, BOD, COD, nitrate, sulphate and phosphate, the mean value were recorded as 30.82°C, 7.39, 2.13, 294.3, 339.9, 3.77, 5.90, 9.48, 4.41, 19.81 and 0.37 mg/l respectively. The standard deviation values of temperature (3.05), pH (0.70), turbidity (1.29), DO (1.17), BOD (2.59), COD (4.30), nitrate, (2.81) and phosphate (0.77) of each parameters between very little deviation, but in the case of total hardness (94.48) and TDS (64.61) S.D value have more deviation together all the each parameter. The CV values of temperature (9.92), pH (9.56), total hardness (32.09), TDS (19.0), DO (31.04), BOD (44.01), and COD (45.45) showed wide fluctuations with each other with respect to relation of these parameters between stations. The CV values of turbidity (60.56), nitrate (63.86), sulphate (203.12) and phosphate (207.46) showed the turbidity their significant variation from one station to another. The correlation coefficient (r and t) among various water quality parameters are given in Table-3a. The temperature of ground water during summer showed positive relationship with temperature, pH, total hardness, TDS, DO, BOD, nitrate and phosphate and negative relationship with turbidity, COD and sulphate. pH of the ground water in residential area of east zone central India during summer showed significant positive relationship between temperature, pH, total hardness, TDS, DO, BOD, COD, nitrate and phosphate.

Turbidity showed significant positive relationship with turbidity, total hardness, TDS, BOD, COD, and phosphate and negative relationship with temperature, pH, DO, nitrate and sulphate. Total hardness in present investigation showed positive relationship with temperature, pH, turbidity, total hardness, TDS, BOD, COD, and phosphate and negative relationship with DO, nitrate and sulphate. TDS showed positive relationship with temperature, pH, turbidity, total hardness, TDS, BOD, and COD and negative relationship with DO, nitrate, sulphate and phosphate. Dissolved oxygen (DO) showed positive relationship with temperature, pH, DO and nitrate and negative relationship with turbidity, total hardness, TDS, BOD, COD, sulphate and phosphate. Biochemical oxygen demand (BOD) showed negative relationship with DO, COD, nitrate, sulphate and phosphate and positive relationship with temperature, pH, turbidity, total hardness, TDS and BOD. Chemical oxygen demand (COD) showed positive relationship between pH, turbidity, total hardness, TDS, COD and phosphate and negative relationship with temperature, DO, BOD, nitrate and sulphate. Nitrate showed significant positive relationship with temperature, pH, DO and nitrate and negative relationship with turbidity, total hardness, TDS, BOD, COD, sulphate and phosphate. Sulphate in present investigation showed positive relationship with sulphate and negative relationship with temperature, pH, turbidity, total hardness, TDS, DO, BOD, COD, nitrate and phosphate. Phosphate showed significant positive relationship between temperature, pH, turbidity, total hardness, COD, and phosphate and negative relationship with TDS, DO, BOD, nitrate and sulphate. The present study deals with the various relationship derived statistically by calculation 'r' and 't' among the physico-chemical characteristics, the r value was negative thirty eight times and positive twenty eight times and positive thirty eight times this showed that positive relationship in the present study during summer season, correlated different parameter each other

statistically which shows great variation negative to positive value for 1% significant value (2.878) and 5% significant value (2.101). In the case of total hardness and temperature, TDS and total hardness we established a correlation ship which were positive and value were 2.468 and 2.684 respectively, which was more than 5% significant level. For nitrate and COD we have found positive value of correlation ship at 5% significant level ie-2.254. It showed that total hardness, temperature, TDS, nitrate and COD play major role in the physico-chemical characteristics of ground water in residential area of east zone central India during summer season. The average physico-chemical characteristics in residential area of east zone central India are shown in Table - 4. The variation of temperature in this study area was observed to be 25.27°C minimum to 32.73°C maximum. The average pH was ranging from 6.50 to 8.53. The average range of turbidity was found to be 0.10 to 4.77 NTU and total hardness was ranged between 191.67 to 567.0 mg/l. The average TDS of the study area was found to be 245.33 to 533.67 mg/l. The range of DO was recorded to be 1.43 to 5.57 mg/l. biochemical oxygen Demand and chemical oxygen Demand were in the range of 3.07 to 10.73, 3.50 to 12.83 mg/l respectively. In the case of nitrate, sulphates and phosphates, the values were ranged between 0.30, 0.01 and 0.001 to 6.47, 170.0 and 2.83 mg/l respectively. The maximum sulphate and phosphate concentration were found during monsoon season, but the maximum nitrate values was observed during the summer season. The ground water samples from all the locations in the residential area of east zone central India are found to be within the prescribed limits as physico-chemical characteristics are concerned except phosphate R₂ (1.86), R₄ (0.480), R₁₀ (2.833) and R₁₃ (1.267) mg/l was found beyond the WHO prescribed limit.

Conclusion

The change in physico-chemical studies had been carried out in recent years at different locations of Residential area of East Zone of Central India. The values of different physico-chemical parameters i.e. temperature 18.2°C-36.7°C, pH 6.2-8.7, turbidity 0.01-5.4 NTU, total hardness 187-569 mg/l, TDS 240-538 mg/l, DO 1.0-8.5 mg/l, BOD 2.3-12.4 mg/l, COD 3.0-23.0 mg/l, nitrate 0.1-7.9 mg/l, sulphate 0.01-187 mg/l and phosphate ND-3.0 mg/l in the ground water of Residential area of East Zone of central India. The temperature values range from 18.2°C to 36.7°C. Maximum temperature was recorded at samples R₁₄ (Chhindwara Near state bank of India). pH, turbidity, TDS, nitrate and sulphate are well within the permissible limit set by WHO. Total hardness values of all the samples were below the permissible limit except sampling location R₇. BOD, COD and phosphate are exceeded the permissible limit by WHO in most of the ground water samples. From obtained result it is suggested to monitor the ground water quality and assess periodically to prevent the further contamination.

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REFERENCES

Bradford, A., Brook R. and Hunshal C. S. 2003, "Wastewater Irrigation in Hubli-Dharwad, India: Implications for Health

- and Livelihoods”, *Environment and Urbanization*, 15 (2): 157-70.
- Brindha, K., Rajesh, R., Murugan, R. and Elango, L. 2012. Nitrate Pollution in Ground water in Some Rural Areas of Nalgonda District, Andhra Pradesh, India, *Journal of Environ. Science & Engg.*, 54 (1): 64-74.
- Butt, Masood Sadiq, Kamran Sharif, Babar Ehsan Bajwa and Abdul Aziz, 2005. “Hazardous effects of sewage water on the environment: Focus on heavy metals and chemical composition of soil and vegetables”, *Management of Environmental Quality: An International Journal*, 16(4): 338-346.
- Central Ground water Board (CGWB), 2009. Ground Water Quality in Shallow Aquifers of India, Faridabad, *Ministry of Water Resources, Govt. of India*.
- Das Dhvajendra Nath, Baruwa A.K., Das, M.L. and Sharma Pradeep, 2013. A Study on the Impact of Industrial and Urban Development in Bongaigaon Town, Assam Based on Water Quality Index of the Tunia River, *IJIP*, 33 (11): 911-919
- Dwivedi, A. P., Tripathi, I.P. and Kumar, M. Suresh, 2013. Assessment of soil and ground water quality in Rewa district of Vindhyan Plateau (India), *J Environ. Sciences & Engg*, 55: 51-64.
- Garg, D.K. Pant A. B., Agrawal Manju and Goyal B, R. N. 1990. Seasonal variation in ground water quality in Roorkee City, *Indian J. Env. Prot.*, 10 (9): 673- 676.
- Gayatri Prakash and Jai Prakash, 2001, water post present and future, *Science reporter* 10-14.
- Kaur A. Pallah, Sahota B.S., G. P.S. and Sahota H.S. 1992. Seasonal and spatial variation of chemical parameters in drinking water from shallow aquifer, *Indian J. Env. Prot.*, 12 (6): 409-415.
- Minhas, P. S. and Samra J. S. 2004. “Wastewater Use in Peri-Urban Agriculture: Impacts and Opportunities”, Central Soil Salinity Research Institute, Karnal, India
- NEERI manual on water and waste water analysis, Nagpur 1988
- Pandey Sandeep Kumar and Tiwari S., 2009. Physico-chemical Analysis of Ground Water of Selected area of Ghazipur City A Case Study, *Nature and Science*, 7 (1).
- Rajmohan, N. Elango, L. and elampooranam, T. 1997. Seasonal and spatial Variation in magnesium and chloride concentration in ground water of Nagar Quad –E-Milleth District in Tamilnadu, *Indian J. Env. Prot.* 17 (6): 448-453.
- Ramchandraiah C. 2004, Right to Drinking Water in India *Center for Economic and Social Studies*, 56.
- Singh R. P., Chauhan, B. S., Devendra Swaroop and yadav, Y.S. 2000. Seasonal variation in ground water of Agra City, *Indian J. Env. Prot.* 42 (2): 59-69.
- Standard method for the examination of water and waste water, APHA AWWA and WEF, 18th ed. 1992
- Tripathi I. P., Dwivedi Arvind Prasad and Kumar M. Suresh, 2014. Assessment of Ground water Quality in Umaria District, Vindhya Pradesh, India, *Journal of applicable Chemistry*, 3(2): 798-811.
- Tripathi Indra Prasad and Dwivedi Arvind Prasad, 2015. Multivariate analysis of soil and ground water quality ins Sidhi District of Vindhya Plateau, *Journal of Applicable Chemistry*, 4(1): 178-203.
- Tripathi Indra Prasad, Kumar M. Suresh and Dwivedi Arvind Prasad, 2013. Characterization of diffuse chemical pollution in Satna district of Vindhya Region, India, *International Research Journal of Environment Sciences*, 2 (11): 46-60.
- WHO, 1984. guidelines for drinking water quality, Vol 2, Geneva 1984.
- WHO, 1997. Guide Lines for Drinking Water Quality Recommendation, *World Health Organization Geneva*, 1
