



Assessment of Ground Water Samples Collected from Industrial Area in East Zone of Central India

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ABSTRACT

A Study was carried out in Industrial area of East Zone central India to evaluate the current status of physico-chemical contaminants and their sources in ground water. Ground water samples collected from Industrial area in 20 different locations were analysed. The parameters likes Temperature, nitrate and sulphate were found below the permissible limit, during all the seasons (monsoon, winter and summer) and pH, Turbidity, Total hardness, TDS, DO, BOD, COD, and Phosphate in the ground water showed wide fluctuations. The results were compared with standard value of World Health Organization (WHO). The high access of contamination may be the outcome of high human and industrial activities in their locality.

Keywords: Ground water, Physico-chemical parameters, correlation coefficient, T-test, Industrial area, East Zone of Central India.

INTRODUCTION

The central India plateau is environmentally very important to understand the rich Indian bio-diversity and diffuse chemical pollution. It is well known that India is a densely populated country, very large fractions of this population live in rural communities, and very large parts of the total area are under agriculture and cattle population. The Central India covers the seven states of our country, it has long industrial development and also has deep cultural heritage. Geographically this region extends between 20^o to 24^o North and 74^o to 84^o East longitudes. According to diffuse unsystematic residential, natural, industrial and geological structure of this area the proposed research project is intended to analyzing and mapping of diffuse chemical pollution in Central India.

Concern over agricultural diffuse pollution sources in integrated water quality management has been growing recently. Such sources are likely to be even more critical in developing countries, including India, where agriculture and rural habitats are still dominant, unlike the G7 or other affluent industrialized nations. Pollution due to agricultural return waters, either as wash-off or as seepage, appears to be rare. However, surface wash-off of pollutants from agricultural sources becomes the dominant factor during flood flows, and seepage/drainage from agricultural fields/soils continues to pollute streams for a month or

two after the monsoons are over. Application of chemical fertilizers and pesticides (or any other agricultural chemicals) in India is still low compared to developed countries, and while eutrophication due to high levels of washed-off nutrients is observed in rural ponds and other stagnant bodies of water receiving agricultural drainage, and excessive pesticide residuals are often reported for vegetables, fodder, milk, etc., monitoring of streams and rivers does not show any significant pollution due to nutrients or pesticides from agricultural diffuse pollution during fair weather months. The major problem of agricultural diffuse pollution appears to be the heavy silt loads, along with large quantities of dissolved salts, nutrients, organics and even heavy metals and bacterial contaminants washed off during floods. With the introduction of intensive agriculture and adoption of modern farming techniques involving the application of much irrigation water and agricultural chemicals, the problems caused by diffuse agricultural pollution are bound to grow [1].

Rapid industrial development in the last few decades has added huge loads of pollutants to our rivers (CPCB, 2004) [2]. Out of these pollutants, heavy metals are of major concern because of their persistent and bio-accumulative nature. These heavy metals may be of geological origin entering into the river system by weathering and erosion anthropogenic due to mining, industrial processing, agricultural run-off and sewage disposal [3]. In the aquatic system a rapid removal of these heavy metals from the water to sediments may occur by settling particles while some of these pollutants can be mobilized by getting accumulated into the biota from the sediments sink)[4].

In developing countries such as India, urbanization and industrialization are not as far advanced as in developed nations and most of the population still lives in traditional rural communities and practice agriculture and animal husbandry for their livelihood. Sewer systems of point's outfalls are rare, only small amounts of sludge waters flow through surface drains, except during rainy periods when most of the accumulated pollutants are flushed to receiving waters. Effluents from urban centres and from major industries are also flushed out in the environment. Thus the problem of diffuse pollution is of greater importance and concern for any integrated air and water quality management program in a developing country such as India. In India due to rapid growth of population, industrialization and increased the agricultural activity, the ground water resources are adversely affected in recent past. 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 [5-18]

The present study is aimed to evaluate the ground water in industrial area of East Zone of central India covering various inorganic non-metallic constituent covered are Temperature, pH, Turbidity, Total dissolve solids, Hardness, Dissolved Oxygen (DO) Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrate, Sulphate, Phosphate and heavy metals like Iron (Fe), Copper (Cu), Chromium (Cr), Lead (Pb), Nickel (Ni), Cadmium (Cd).

MATERIALS AND METHODS

We assume Madhya Pradesh as a central India (study area) which is divided in to two zones (a) East Zone of Central India (b) west Zones of Central India. In the present study we are intended to find out the diffuse chemical pollution in East Zone of Central India on the basis of industrial area. We have designed twenty sampling stations district for this study in east zones i.e Rewa, Satna, Sidhi, Singrauli, Shahdol, Umaria, Katni, Panna, Chhatarpur, Jabalpur, Mandala, Dindori, Siwani, Chhindwara, Narsinghpur, Hosangabad, Betul, Damoh, Sagar, Bhopal.

Twenty sampling locations consisting of bore wells and hand pumps were selected in the study area. Sampling was done during summer, rainy and winter seasons (of year 2013 to 2014). The month of April-May, July-August and December-January, were selected as representative month of summer, rainy and winter seasons

respectively. Sampling was done in accordance with grab sampling methods in polyethylene bottles of one liter capacity. To avoid leaching of metals and interaction with the surface wall of the container, bottles were first cleaned with detergent and then with 1:1 HNO₃ for 24 h. Finally bottles were cleaned and rinsed with the distilled water. During sampling bottles were rinsed two to three times with the sample to be examined before finally filling with it. Samples were collected by immersing the rinsed bottles in river water [19, 20]. During sampling from hand pumps and bore wells, the water pumped to waste for about five minutes and sample was collected directly. All the samples were refrigerated at 4⁰C in the laboratory [19- 21] and procedures were followed as per the standard methods [22] and different physicochemical parameters like, temperature, pH, turbidity, TDS hardness dissolved oxygen, BOD, COD, nitrate, sulphate and phosphate were analyzed. The digested samples were analyzed for heavy metals using Atomic Absorption Spectrophotometer. The location of sampling stations are shown in **table-1**

Table-1: Sampling location of Industrial Area of East Zone of Central India

S.No	Sampling location of Industrial Area of East Zone of Central India
1	I ₁ = Near J.P. Cement Plant Rewa,
2	I ₂ = Near Birla Cement Plant Satna,
3	I ₃ = Near Madariya Industrial area Sidhi,
4	I ₄ = Near N.T.P.C. Singurauli,
5	I ₅ = Near Ramnagar Coal Mince area Shahdol,
6	I ₆ = Near beersinghpur Coal Mince area Umaria,
7	I ₇ = Near Ardinance Factory Katni,
8	I ₈ = Near Majhgama Mince area Panna,
9	I ₉ = Near Mince area Chhatarpur,
10	I ₁₀ = Near Khamaria Industrial area Jabalpur,
11	I ₁₁ = Maneri Industrial area Mandala,
12	I ₁₂ = Mining area Dindori,
13	I ₁₃ Near Kelori Tehsil Mince area Siwani,
14	I ₁₄ = Near Amabana Coal Mince area Chhindwada,
15	I ₁₅ = Near Oil Mills Gadarwara Narsinghpur,
16	I ₁₆ = Near Itarsi Industrial area hosangabad,
17	I ₁₇ = Near Oil Plant Betul,
18	I ₁₈ = Near Gandhi Ashram Industrial area Damoh,
19	I ₁₉ = Near Belai Industrial area Sagar,
20	I ₂₀ = Near Manddeep Industrial area Bhopal.

RESULTS AND DISCUSSION

Present research work done on ground water of Industrial area of East Zone of central India, the results indicate that pH, turbidity, TDS, TH, dissolved oxygen (DO) biochemical oxygen demand (BOD), COD, chlorides, sulphates, phosphates, nitrates, heavy metals (like copper, chromium, lead, Nickel, Iron, Cadmium) respectively. The physico-chemical characteristics of the ground water samples of Industrial area of East Zone central India during three seasons are shown in **table- 2, 3 and 4**. The average physico-chemical characteristics of the ground water samples of Industrial area of East Zone Central India are present in **table- 5**. The correlation coefficient (r) among various water quality parameters of the ground

water samples of Industrial area of East Zone Central India during the three seasons are represented in **table-2a, 3a, 4a**.

The temperature between 21.8⁰C to 33.2⁰C was found satisfactory and mean temperature (23.71) was found during monsoon season in industrial area of east zone central India. pH of the samples varied from 6.7 (Near ram Nagar coal mince area Shahdol) 8.5, (Near Birla cement plant Satna), with mean value (7.69) was found with in ranged of WHO standard, during the seasons. All the sample were found within the range of WHO [23] except one sample I₂ (8.5) is similar to the standard limit. The values to turbidity varied from 0.3 to 7.0 NTU with a mean value 1.22 NTU are shown in **table-2**. The total hardness of the samples varied from 186 to 638 mg L⁻¹, the mean value 322.0 mg L⁻¹. The maximum hardness 638 mg L⁻¹ was found at samples I₇ (Near ordinance factory katni), the TDS of all the water samples were below the limit prescribed by WHO as 500 as mg L⁻¹. DO varied between 1.0 to 4.5 mg L⁻¹. The maximum DO was recorded at sampling station I₁₇ (Near ail plant Betul). BOD in the ground water of Industrial area of east zone central India varied from 1.8 to 13.6 mg L⁻¹, which was lowest in I₅ (Near Ram Nagar coal mince area shahdol) and highest in I₂₀ (Near Manndeeep Industrial area Bhopal). Values of BOD was found at samples I₁ (9.2), I₂ (11.5), I₃ (8.7), I₅ (6.7), I₇ (9.2) I₁₀ (8.3), I₁₁ (7.2), I₁₄ (8.5), I₁₆ (7.8) and I₂₀ (13.6) mg L⁻¹ are more than the permissible limit set by WHO as 6.0 mg L⁻¹. Chemical oxygen Demand varied in the range of 4.6 to 28.0 mg L⁻¹. Concentration of COD was found at sampling stations I₁ (22.3), I₂ (28.0) I₃ (10.5) I₅ (12.5), I₆ (16.8), I₇ (26.7) I₁₀ (19.0), I₁₁ (15.6), I₁₄ (14.8), I₁₆ (10.2) and I₂₀ (12.7) are higher than the permissible limit prescribed by WHO. Nitrate concentrations are varying from 0.22 to 12.9 mg L⁻¹. Sulphate of all the ground water from study area during the monsoon season are below the permissible limit set by WHO as 45.0 mg L⁻¹.

Sulphate content ranges from 0.21 to 128 mg L⁻¹, which indicates that the sulphate content is well within the norm. The phosphate concentration varied from 0.047 to 0.478 mg L⁻¹. Values of phosphate was observed at sampling stations I₂ (1.0), I₇ (1.2), I₁₀ (0.38), I₁₂ (0.52), I₁₅ (1.7), I₁₈ (0.37) and I₂₀ (0.65) mg L⁻¹ are more than the perusable limit prescribed by WHO. The S.D value of temperature (2.75), pH (0.67), turbidity (1.88), DO (1.01), BOD (3.28), COD (7.09), nitrate (3.69) of sulphate (33.13) and phosphate (0.46) of very little deviation but in the case of total hardness (117.43) and TDS (81.01) S.D. value have greater deviation together all the each parameters. The coefficient variation values of temperature (9.90), pH (8.75), total hardness (36.48), TDS (24.37), DO (33.31), BOD (52.27) COD (57.07), showed wide fluctuations with each other with respect to each relation of these parameters between relation of these parameters between stations. The CV values of turbidity (110.60), nitrate (79.54), sulphate (119.70), and phosphate (129.5) showed the turbidity, nitrate, sulphate and phosphate indicated their significant variation from one station to another.

The correlation coefficient (r and t) among various water quality parameters are shown in **table-2a**. The temperature of ground water during monsoon showed positive relationship with temperature PH, DO, BOD, nitrate and sulphate and negative relationship with turbidity, total hardness TDS, COD, and phosphate. The pH of the ground water showed significant, positive relationship with temperature are pH, turbidity, total hardness, TDS, BOD, COD nitrate, sulphate and phosphate and negative relationship with DO.

Table: 2 Physico -chemical characteristics of Ground water in Industrial area of East Zone Central India during Monsoon Season

Parameters	Sampling Location											
	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12
Temperature	30.2	27.3	30.2	29.0	31.2	26.5	27.0	33.1	26.8	27.0	24.0	21.8
pH	8.0	8.5	7.8	7.4	7.8	8.0	9.5	7.8	6.7	8.2	7.4	7.1
Turbidity	2.0	4.0	0.5	1.0	0.3	5.0	0.8	0.6	1.2	7.0	0.7	ND
Hardness	260	485	305	384	232	262	638	349	235	453	206	250

TDS	316	330	412	298	265	350	493	302	323	329	207	335
DO	1.9	1.0	2.9	3.7	4.2	3.2	2.5	4.5	4.2	2.1	2.16	3.8
BOD	9.2	11.5	8.7	3.0	1.8	6.7	9.2	3.6	2.9	8.3	7.2	4.0
COD	22.3	28.0	10.5	6.7	12.5	16.8	26.7	7.5	6.2	19.0	15.6	9.8
Nitrate	7.74	4.26	6.15	3.6	6.75	1.25	3.27	ND	0.63	7.8	0.85	ND
Sulphate	44.0	23.0	11.0	6.0	18.5	12	45.6	16.9	0.58	27	0.67	0.43
Phosphate	0.03	1.0	0.12	0.08	0.05	0.13	1.2	0.06	0.12	0.38	0.03	0.01

Continue Table :2

Parameters	Sampling Location										
	I13	I14	I15	I16	I17	I18	I19	I20	Mean	S.D	C.V
Temperature	30.5	29.2	25.0	29.7	29.2	24.5	26.0	28.5	27.83	2.758	9.90
pH	7.5	7.9	6.8	7.9	6.9	7.6	8.3	6.8	7.69	0.674	8.75
Turbidity	0.8	1.4	ND	0.5	0.3	0.7	3.6	0.3	1.70	1.887	110.60
Hardness	186	337	189	298	325	490	315	241	322.0	117.435	36.46
TDS	220	416	219	324	332	524	317	335	332.3	81.014	24.37
DO	3.9	2.6	3.8	2.3	4.5	2.9	3.3	1.6	3.053	1.017	33.31
BOD	2.5	8.5	2.7	7.8	4.3	4.9	5.2	13.6	6.280	3.283	52.27
COD	4.7	14.8	5.2	10.2	4.6	6.7	8.2	12.7	12.43	7.097	57.07
Nitrate	0.22	1.43	ND	7.62	3.46	2.12	8.9	12.9	4.644	3.694	79.54
Sulphate	0.21	69.0	14.2	32.5	6.0	12.0	86	128	27.68	33.134	119.70
Phosphate	0.52	0.02	1.7	0.23	ND	0.37	0.12	0.65	0.359	0.465	129.52

All the Values except Temperature, pH and Turbidity expressed in mg l.⁻¹

Industrial Area- I1= Near J.P. Cement Plant Rewa, I2= Near Birla Cement Plant Satna, I3= Near Madariya Industrial area Sidhi, I4= Near N.T.P.C. Singurauli, I5= Near Ramnagar Coal Mince area Shahdol, I6= Near beersinghpur Coal Mince area Umaria, I7= Near Ardinance Factory Katni, I8= Near Majhgama Mince area Panna, I9= Near Mince area Chhatarpur, I10= Near Khamaria Industrial area Jabalpur, I11= Maneri Industrial area Mandala, I12= Mining area Dindori, I13 Near Keleri Tehsil Mince area Siwani, I14= Near Amabana Coal Mince area Chhindwada, I15= Near Oil Mills Gadarpura Narsinghpur, I16= Near Itarsi Industrial area hosangabad, I17= Near Oil Plant Betul, I18= Near Gandhi Ashram Industrial area Damoh, I19= Near Belai Industrial area Sagar, I20= Near Manddeep Industrial area Bhopal.

Table: 2a Correlation coefficient (r) among various water quality parameters (Physico-chemical characteristics of Ground water in Industrial area of East Zone Central India During Monsoon Season)

Parameters	Temperature	pH	Turbidity	Hardness	TDS	DO	BOD	COD	Nitrate	Sulphate	Phosphate
Temperature	1										
pH	0.133 0.572	1									
Turbidity	-0.342 - 2.282*	0.377 1.728	1								
Hardness	-0.047 -0.212	0.705 4.224**	0.227 0.991	1							
TDS	-0.104 0.500	0.432 2.036	-0.025 0.110	0.723 4.441**	1						
DO	0.154 0.662	-0.419 - 4.439**	-0.335 -2.481*	-0.331 -2.420	-0.230 -1.331	1					
BOD	0.003 0.013	0.371 1.699	0.227 0.991	0.332 1.494	0.353 1.600	-0.899 -4.268**	1				
COD	-0.052	0.723	0.440	0.508	0.262	-0.747	0.701	1			

	-0.237	4.443**	2.080	2.507*	1.153	-4.506**	4.180**				
Nitrate	0.269	0.043	0.095	-0.029	-0.029	-0.386	0.483	0.131		1	
	1.186	0.185	0.407	-0.129	-0.126	-3.441**	2.342*	0.561			
Sulphate	0.117	0.172	0.041	0.087	0.209	-0.471	0.621	0.239	0.705		1
	0.502	0.743	0.174	0.372	0.908	-8.359**	3.364**	1.048	4.218**		
Phosphate	-0.205	0.120	0.090	0.269	0.009	-0.206	0.163	0.206	0.066	0.102	
	-1.138	0.513	0.384	1.233	0.042	-1.144	0.703	0.915	0.281	0.482	1

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

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

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

The present study deals with the various relationships derived statistically by calculation 'r' and 't' among the physico-chemical characteristics, the value was negative sixteen times and positive fifty times this showed that positive relationship in the present ground water studied.

During monsoon season correlated between different parameter with each other, statistically this shows great variation negative to positive values for 1% significant value 2.878 and 5% significant value 2.101. In case of total hardness and PH, COD and PH, TDS and total hardness, COD, and BOD, sulphate and BOD and sulphate and nitrate. We established a correlation which was positive and values were 4.224, 4.443, 4.441, 4.180, 3.364 and 4.218 respectively, which was more than 1% significant level. For DO and pH, BOD and DO, COD and DO, nitrate and DO and sulphate and DO showed negative relationship i e - 4.439, -4.268, -4.506, 3.441, and -8.359 respectively with each other at 1% significant level, COD and total hardness and nitrate and BOD showed positive value of a correlation ship at 5% significant level i.e. 2.507 and 2.342 respectively, we established a correlation other at 5% significant level. For turbidity and temperature and DO and turbidity showed negative i e- 2.282 and -2.481, which shows greater variation at 5% significant level. It showed that total hardness, pH COD, TDS, BOD, sulphate, nitrate, DO turbidity and temperature play major role in the physico-chemical characteristics of ground water in residential area of east zone central India during monsoon season.

The temperature was observed ranged from 14.5 to 25.0°C. The maximum temperature (25°C) was found during winter seasons at sampling station I₅ (Ramnager coal mince area, Shahdol) and minimum temperature was recorded (14.5°C) at sampling station I₁₂ (mining area Dindori). pH was ranging from 6.5 to 9.2 with a mean value 7.57. WHO (1984) prescribed the desirable limit of pH range between 7 and 8.5. The turbidity of ground water was found to be 0.1 to 6.8 NTU and the mean value was 1.56 NTU as shown in **table-3**. The highest value of 6.8 NTU was found at sampling station I₁₀ (Near Khamaria Industrial area

Jabalpur), while the minimum value 0.1 NTU was found at location I₅ (Ramnagar coal mince area Shahdol) as given in **table-3**. The total hardness was found ranged between 178.0 to 632.0 mg L⁻¹. The maximum hardness (632 mg L⁻¹) was found at sampling station I₇ (Near Ordinance factory katni). The TDS was low in all the water samples except in I₁₈ (528 mg L⁻¹) samples. The dissolved oxygen was found ranged between 1.0 to 5.0 mg L⁻¹. The minimum DO was recorded at samples I₂ (1.0 mg L⁻¹) Near Berla cement plant Satna. The biochemical oxygen demand was observed ranged from 2.0 to 13.2 mg L⁻¹. The maximum BOD (13.2 mg L⁻¹) was found at samples (I₂₀) near Manddeep industrial area Bhopal. 50% samples of BOD are higher than the limit set by WHO. Chemical oxygen Demand (COD) was found ranged between 5.0 to 32.4 mg L⁻¹. In sixty percent samples of COD concentration was found more than the standard limit set by WHO as 10.0 mg L⁻¹.

The nitrate concentration was found to be between 0.05 to 10.5 mg L⁻¹, within the permissible limit prescribed by WHO. The concentration of sulphate ion was found to be between from 0.53 to 136.0 mg L⁻¹. All the samples of sulphate concentration were below the permissible limit prescribed by WHO standard. Phosphate concentration was found ranged from 0.05 to 1.9 mg L⁻¹. Values of phosphate was observed at sampling station I₂ (1.2), I₇ (1.5), I₉ (0.43), I₁₁ (0.46), I₁₄ (0.57), I₁₆ (1.9) and I₂₀ (0.69) mg L⁻¹ are more than the standard limit set by WHO as shown in **table-3**. The standard deviation value of temperature (2.83), pH (0.65), turbidity (1.88), DO (1.08), BOD (3.16), COD (7.76), nitrate (3.29), sulphate (34.3) and phosphate (0.53) of each parameters, but in the case of total hardness (118.31) and TDS (83.08) S.D. value have greater deviation together all the each parameters. The coefficient variation values of temperature (13.71), pH (8.63), total hardness (37.86), TDS (25.24), DO (34.12), BOD (49.31), and COD (59.21) showed wide fluctuations with each other with respect to relation of these parameters between stations. The CV values of turbidity (120.0), nitrate (82.67) sulphate (111.4) and (124.0) showed the turbidity, nitrate sulphate and phosphate indicated 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 winter showed positive relationship with temperature, pH, DO, BOD, nitrate and sulphate and negative relationship with turbidity, total hardness, TDS, COD and phosphate. PH showed significant positive relationship with temperature, pH, turbidity total hardness, TDS, BOD, COD nitrate, sulphate and phosphate and negative relationship with DO.

Turbidity showed negative relationship between temperature, TDS, DO, and phosphate and positive relationship with pH, turbidity, total hardness BOD, COD, nitrate and sulphate. Total hardness showed significant positive relationship with pH, turbidity, total hardness TDS, BOD, COD, nitrate sulphate and phosphate and negative relationship between temperatures and DO. TDS in present investigation showed positive relationship with pH, total hardness TDS, BOD, COD, sulphate and phosphate and negative relationship between temperatures, turbidity, DO and nitrate. Dissolved oxygen (DO) showed negative relationship between pH, turbidity, total hardness, TDS, BOD, COD nitrate sulphate and phosphate and positive relationship with temperature and DO. Bio-chemical oxygen demand (BOD) showed significant positive relationship with temperature, pH turbidity total hardness TDS, BOD, COD, nitrate, sulphate and phosphate and negative relationship with DO. Chemical oxygen demand (COD) showed negative relationship between temperature and DO and positive relationship with pH, turbidity, total hardness, TDS, BOD, COD, nitrate, sulphate and phosphate.

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

The present study deals with the various relationship with derived statistically by calculation 'r' and 't' among the physico-chemical characteristics. The r value was positive forty nine times and negative seventeen times, this showed that positive relationship in the present ground water studied. During winter season, correlated different parameter each other statically which shows great variation negative to positive for 5% Significant value (2.101) and 1% significant value (2.878). In the case of COD and hardness, phosphate and COD i.e. 2.649, 2.778, 2.342 and 2.312 we established a correlation other at 5% significant level. hardness and pH, COD and pH, TDS and hardness, COD and BOD, sulphate and BOD and phosphate and BOD, sulphate and nitrate, we established a correlation which were positive and values were 3.465, 4.174, 4.712, 4.191, 3.215, 2.977 and 3.911 respectively, which was more than 1% significant level. DO and turbidity, BOD and DO, nitrate and DO sulphate and DO and phosphate and DO, shows negative relationship i.e. 2.930, 4.320, -5.288, -3.939, -4.369, -11.870 respectively with each other at 1% significant level. It showed that COD, hardness, phosphate, nitrate, BOD, pH, TDS, sulphate, nitrate turbidity, DO play major role in the physico-chemical characteristics of ground water in Industrial area of east zone central India during winter season.

Table-: 3 Physico -chemical characteristics of Ground water in Industrial area of East Zone Central India During Winter Season

Parameters	Sampling Location											
	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12
Temperature	23.5	20.0	22.3	19.5	25.0	19.4	18.2	23.2	16.4	22.0	18.2	14.5
pH	7.9	8.6	7.6	7.2	7.8	7.9	9.2	7.6	6.8	8.0	7.2	7.1
Turbidity	2.5	3.8	0.3	0.8	0.1	4.8	0.6	0.3	1.0	6.8	0.4	ND
Hardness	256	480	298	372	212	259	632	342	215	438	198	238
TDS	319	334	406	297	269	348	498	298	310	321	205	315
DO	2.0	1.0	2.6	3.9	4.6	3.0	3.2	5.0	4.3	2.7	2.24	3.7
BOD	8.9	12.0	8.5	4.0	2.0	6.5	9.0	3.8	3.0	8.5	7.6	4.2
COD	22.0	32.4	9.6	6.9	13.0	16.5	28.0	7.6	6.9	21.0	17.9	10.0
Nitrate	7.52	3.98	5.12	3.2	5.22	0.98	2.87	ND	0.58	8.0	0.89	0.05
Sulphate	47.0	26.0	9.0	8.0	24.0	19.2	51.2	23.6	0.62	32.5	0.72	0.64
Phosphate	0.05	1.2	0.10	0.09	0.16	0.19	1.5	0.08	0.14	0.43	0.46	0.18

Continue Table :3

Parameters	Sampling Location										
	I13	I14	I15	I16	I17	I18	I19	I20	Mean	S.D	C.V
Temperature	23.7	24.3	20.4	22.5	23.0	18.0	18.5	20.6	20.660	2.834	13.71
pH	7.4	7.8	6.9	7.8	6.8	7.2	8.2	6.5	7.575	0.654	8.63
Turbidity	0.5	1.2	ND	0.3	0.2	0.6	3.5	0.5	1.567	1.881	120.03
Hardness	178	324	186	290	315	486	295	235	312.450	118.11	37.86
TDS	209	419	221	316	338	528	305	327	329.150	83.08	25.24
DO	4.2	2.9	4.0	2.5	4.7	2.3	2.9	1.8	3.177	1.084	34.12
BOD	2.8	9.0	3.1	8.0	4.5	4.8	5.0	13.2	6.420	3.166	49.31
COD	5.4	14.5	5.0	8.0	6.2	7.4	9.6	14.5	13.120	7.769	59.21

Nitrate	0.39	1.34	ND	7.56	3.26	1.93	8.3	10.5	3.983	3.293	82.67
Sulphate	0.53	76.8	17.5	38.0	7.6	15.2	82	136	30.806	34.327	111.4 2
Phosphate	0.02	0.57	0.06	1.9	0.19	ND	0.15	0.69	0.429	0.532	124.0

All the Values except Temperature, pH and Turbidity expressed in mg l⁻¹

Industrial Area- I1= Near J.P. Cement Plant Rewa, I2= Near Birla Cement Plant Satna, I3= Near Madariya Industrial area Sidhi, I4= Near N.T.P.C. Singurauli, I5= Near Ramnagar Coal Mince area Shahdol, I6= Near beersinghpur Coal Mince area Umaria, I7= Near Ardinance Factory Katni, I8= Near Majhgama Mince area Panna, I9= Near Mince area Chhatarpur, I10= Near Khamaria Industrial area Jabalpur, I11= Maneri Industrial area Mandala, I12= Mining area Dindori, I13 Near Kelori Tehsil Mince area Siwani, I14= Near Amabana Coal Mince area Chhindwada, I15= Near Oil Mills Gadarwara Narsinghpur, I16= Near Itarsi Industrial area hosangabad, I17= Near Oil Plant Betul, I18= Near Gandhi Ashram Industrial area Damoh, I19= Near Belai Industrial area Sagar, I20= Near Manddeep Industrial area Bhopal

Table : 3a Correlation coefficient (r) among various water quality parameters (Physico -chemical characteristics of Ground water in Industrial area of East Zone Central India During Winter Season)

Parameters	Temperature	pH	Turbidity	Hardness	TDS	DO	BOD	COD	Nitrate	Sulphate	Phosphate
Temperature	1										
pH	0.109 0.469	1									
Turbidity	-0.126 -0.622	0.402 0.177	1								
Hardness	-0.142 -0.715	0.632 3.465**	0.208 0.904	1							
TDS	-0.150 -0.766	0.352 1.597	-0.025 -0.111	0.743 4.712**	1						
DO	0.139 0.599	-0.298 -1.994	-0.362 -2.930**	-0.281 -1.809	-0.289 -1.896	1					
BOD	0.058 0.254	0.318 1.424	0.270 1.189	0.357 1.625	0.328 1.476	-0.840 -4.320**	1				
COD	-0.038 -0.170	0.701 4.174**	0.481 2.328*	0.529 2.649*	0.250 1.098	-0.626 -5.288**	0.702 4.191**	1			
Nitrate	0.351 1.592	0.113 0.486	0.230 1.006	0.050 0.213	-0.034 -0.150	-0.404 -3.939**	0.483 2.342*	0.167 0.720	1		
Sulphate	0.167 0.720	0.128 0.549	0.097 0.414	0.103 0.442	0.217 0.946	-0.417 -4.369**	0.608 3.251**	0.258 1.134	0.677 3.911**	1	
Phosphate	-0.048 -0.216	0.485 2.355	-0.045 -0.202	0.547 2.778*	0.422 1.978	-0.484 -11.870**	0.574 2.977**	0.478 2.312*	0.224 0.978	0.301 1.343	1

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

In the present Investigation the temperature ranged between 26.5⁰C to 36.2⁰C, the highest temperature (36.2⁰C) was recorded in (I₂) near Birla cement plant Satna while the lowest value (26.5⁰C) was observed in I₁₂ (Near kelori tehsil mince area Siwani). The pH of all the water samples varied from 6.9 to 8.5, the highest pH was observed 8.5 at sampling location (I₇) near ordinance factory katni and the minimum value 6.9 (I₁₅) Near oil mills Gadarwara Narsinghpur Industrial area. The turbidity of water was found to be 0.2 to 8.7 NTU and the mean value was 2.31 NTU. All the samples of turbidity was found below the limit except two samples I₆ (7.2) and I₁₀ (8.7) NTU. The mean value of hardness in the ground water of Industrial area during summer season was 322.2 mg L⁻¹ which was ranged between 192 to 645 mg L⁻¹. The maximum hardness was recorded in the sample I₇ collected from near ordinance factory katni. Total dissolved solid was found ranged between 218 to 542.0 mg L⁻¹. All the samples were below the limit of standard value except one location I₁₈ (542 mg L⁻¹) as shown in **table-4**. The mean value of DO in the ground water of Industrial area in east zone central India, during summer seasons was 3.3 mg/l which was ranged between

1.4 to 6.2 mg L⁻¹. The lowest DO was found at samples I₂ (1.4 mg L⁻¹) as shown in **table-4**. In the present study BOD varied in the range of 3.0 to 17.1 mg L⁻¹. 80% samples of BOD were found more than the permissible limit prescribed by WHO. Chemical oxygen Demand (COD) was found to be 6.8 to 35.6 mg L⁻¹. Eighty percent samples of COD concentration are observed more than the permissible limit during summer season in industrial area of east zone central India. Nitrate and sulphate were in the range of 0.11 to 12.8 mg L⁻¹, 0.77 to 1.62 mg L⁻¹ respectively. All the samples of nitrate and sulphate were below the permissible limit set by WHO. Range of phosphate was found to be 0.009 to 2.38 mg L⁻¹. Value of phosphate at sampling stations I₂ (1.5), I₆ (1.0), I₁₀ (1.27), I₁₅ (2.38), I₁₆ (1.95) and I₂₀ (0.78) mg L⁻¹ are more than the standard limit prescribed by WHO.

The standard deviation value of temperature (2.43), pH (0.50), turbidity (2.41), DO (1.32), BOD (3.68), COD (7.90), nitrate (3.71), sulphate (41.74) and phosphate (0.71) of each parameters between very little deviation together all the each parameters. The coefficient variation values of temperature (7.99), pH (8.35), total hardness (34.36), TDS (24.40), DO (40.21), BOD (44.71), COD (50.22) showed wide fluctuations with each other with respect to relation of these parameters between station. The CV values of turbidity (104.4), nitrate (91.05), showed the turbidity, nitrate, sulphate and phosphate indicated their significant variation from one station to another.

The correlation coefficient (r and t) among various water quality parameters are given in **table- 4a**. The temperature of ground water in Industrial area of east zone central India during summer showed positive relationship with temperature, pH, turbidity, total hardness, TDS, BOD COD, nitrate sulphate and phosphate and negative relationship with DO. PH showed significant positive relationship with temperature, pH, turbidity total hardness, TDS, BOD, COD, nitrate sulphate and phosphate and negative relationship with DO.

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

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

Table-4: Physico-chemical characteristics of Ground water in Industrial area of East Zone Central India During Summer Season.

Parameters	Sampling Location											
	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12
Temperature	31.0	36.2	30.0	31.0	31.5	27.0	32.4	31.0	28.5	30.0	27.0	26.5
pH	8.2	8.4	7.9	7.5	8.0	7.9	8.5	8.0	6.9	8.3	7.6	7.5
Turbidity	3.1	5.6	0.4	2.0	0.7	7.2	1.6	1.0	2.3	8.7	0.6	0.2
Hardness	245	396	312	393	254	302	645	329	246	463	213	268
TDS	323	327	416	309	262	359	475	293	339	315	224	342
DO	1.7	1.4	2.6	4.2	4.0	3.5	2.8	5.7	6.2	2.7	2.3	3.6
BOD	13.4	17.1	8.6	6.0	7.2	6.5	10.5	4.9	7.4	9.5	8.9	4.0
COD	25.2	35.6	14.2	7.8	19.3	21.0	27.8	10.4	8.4	23.5	21.8	12.3
Nitrate	8.14	3.72	5.86	4.2	5.6	0.87	3.57	ND	0.49	7.0	0.82	0.15
Sulphate	59.0	30.0	15.3	6.3	28.6	20.0	48.3	22.0	0.79	38.0	1.37	0.77
Phosphate	0.13	1.5	0.19	0.14	0.08	0.23	1.0	0.09	0.13	1.27	0.28	0.009

Continue Table :4

Parameters	Sampling Location										
	I13	I14	I15	I16	I17	I18	I19	I20	Mean	S.D	C.V
Temperature	32.1	34.0	29.0	30.5	33.0	28.0	31.0	30.0	30.485	2.438	7.99
pH	8.0	7.8	6.9	8.1	6.9	7.8	8.5	7.3	7.800	0.507	6.5
Turbidity	0.7	1.6	ND	1.0	1.2	1.0	4.3	0.8	2.316	2.419	104.44
Hardness	192	322	194	280	342	482	318	248	322.200	110.725	34.36
TDS	218	432	228	312	340	542	298	341	334.750	81.710	24.40
DO	4.2	3.0	3.5	2.8	5.2	2.1	3.0	1.5	3.300	1.327	40.21
BOD	6.3	8.2	3.0	8.5	7.9	6.3	4.8	16.0	8.250	3.689	44.71
COD	7.8	16.2	6.8	12.4	8.0	11.6	10.5	14.2	15.740	7.906	50.22
Nitrate	0.45	1.14	0.11	9.3	2.97	1.87	8.5	12.8	4.082	3.717	91.05
Sulphate	0.64	88.1	23.0	40.0	9.3	10.0	110	162	35.674	41.742	117.0
Phosphate	0.05	0.04	2.38	1.95	0.01	ND	0.27	0.78	0.554	0.715	129.06

All the Values except Temperature, pH and Turbidity expressed in mg L⁻¹

Industrial Area- I1= Near J.P. Cement Plant Rewa, I2= Near Birla Cement Plant Satna, I3= Near Madariya Industrial area Sidhi, I4= Near N.T.P.C. Singurauli, I5= Near Ramnagar Coal Mince area Shahdol, I6= Near beersinghpur Coal Mince area Umaria, I7= Near Ardinance Factory Katni, I8= Near Majhgama Mince area Panna, I9= Near Mince area Chhatarpur, I10= Near Khamaria Industrial area Jabalpur, I11= Maneri Industrial area Mandala, I12= Mining area Dindori, I13 Near Keleri Tehsil Mince area Siwani, I14= Near Amabana Coal Mince area Chhindwada, I15= Near Oil Mills Gadarpur, I16= Near Itarsi Industrial area hosangabad, I17= Near Oil Plant Betul, I18= Near Gandhi

Ashram Industrial area Damoh, I19= Near Belai Industrial area Sagar, I20= Near Manddeep Industrial area Bhopal.

Table -4a Correlation coefficient (r) among various water quality parameters (Physico-chemical characteristics of Ground water in Industrial area of East Zone Central India during Summer Season.)

Parameters	Temperature	pH	Turbidity	Hardness	TDS	DO	BOD	COD	Nitrate	Sulphate	Phosphate
Temperature	1										
pH	0.348 1.574	1									
Turbidity	0.070 0.300	0.396 1.834	1								
Hardness	0.271 1.195	0.443 2.099	0.269 1.188	1							
TDS	0.034 0.148	0.156 0.670	-0.044 -0.188	0.689 4.035**	1						
DO	-0.084 -0.359	-0.454 -2.161*	-0.187 -0.810	-0.177 -0.766	-0.247 -1.031	1					
BOD	0.457 2.182*	0.269 1.186	0.206 0.893	0.172 0.743	0.150 0.646	-0.611 -3.279**	1				
COD	0.313 1.402	0.609 3.258**	0.484 2.351*	0.391 1.806	0.163 0.701	-0.602 -3.202**	0.698 4.136**	1			
Nitrate	0.205 0.880	0.342 1.548	0.089 0.382	0.055 0.236	-0.005 -0.025*	-0.469 -2.258*	0.521 2.591*	0.148 0.637	1		
Sulphate	0.251 1.103	0.209 0.906	0.092 0.393	0.011 0.048	0.119 0.510	-0.461 -2.206*	0.448 2.127*	0.128 0.548	0.713 4.320**	1	
Phosphate	0.097 0.417	0.057 0.243	0.341 1.538	0.140 0.601	-0.126 -0.541	-0.375 -2.717	0.177 0.766	0.191 0.827	0.182 0.789	0.117 0.502	1

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

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 thirteen time and positive fifty three times, this showed that positive relationship in the present ground water studied.

During summer season correlated different parameters each other statically which shows great variation negative to positive for 5% significant value (2.101) and 1% significant value (2.878). In the case of BOD and temperature, COD and turbidity, nitrate and BOD and sulphate and BOD, we established a correlation which were positive and value were 2.182, 2.351, 2.591 and 2.127 respectively, which was greater than 5% significant level. For DO and pH, nitrate and DO, and sulphate and DO shows negative relationship i.e.-2.161,-2.258 and -2.206 relationship with each other at 5% significant level, While COD and pH, TDS and hardness, COD and BOD and sulphate and nitrate, we established a correlation ship which were positive and value were 3.258, 4.035, 4.136 and 4.320 respectively, which was more than 1% significant level. BOD and DO and COD and DO show negative relationship i.e. -3.279 and -3.202 respectively with each other at 1% significant level. It showed that BOD, temperature, COD, turbidity nitrate, sulphate, DO, pH, TDS, hardness, COD play major role in the physico chemical characteristics of ground water in Industrial area of east zone central India during summer season.

The average physicochemical characteristics of ground water in Industrial area of east zone central India presented in **table-5**. The variation of temperature in this district was observed to be 23.07⁰C minimum to 29.23 maximum. pH was ranging from 6.80 to 9.07. The range of turbidity was found to be 0.20 to 7.50 NTU. Total hardness was observed to be 185.33 of 638.33mg L⁻¹ and TDS was ranged between 212.0 to 531.33 mg L⁻¹. Dissolved oxygen was found to be 1.3 to 5.07 mg/l. BOD and COD were in the range of 2.93 to 14.27, 5.67 to 32.0 mg/l respectively. In the case of nitrates, sulphate and phosphate, the values were ranged between 0.10 0.61 and 0.07 to 12.07, 142.0 and 1.38 mg L⁻¹ respectively.

Table 5: Average Physico -chemical characteristics of Ground water in Industrial area of East Zone Central India

Parameters	Sampling Location									
	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10
Temperature	28.23	27.83	27.50	26.50	29.23	24.30	25.87	29.10	23.90	26.33
SD (±)	4.12	8.11	4.50	6.14	3.67	4.25	7.17	5.22	6.55	4.04
pH	8.03	8.50	7.77	7.37	7.87	7.93	9.07	7.80	6.80	8.17
SD(±)	0.15	0.10	0.15	0.15	0.12	0.06	0.51	0.20	0.10	0.15
Turbidity	2.53	4.47	0.40	1.27	0.37	5.67	1.00	0.63	1.50	7.50
SD(±)	0.55	0.99	0.10	0.64	0.31	1.33	0.53	0.35	0.70	1.04
Hardness	253.67	453.67	305.00	383.00	232.67	274.33	638.33	340.00	232.00	451.33
SD(±)	7.77	50.00	7.00	10.54	21.01	24.01	6.51	10.15	15.72	12.58
TDS	319.33	330.33	411.33	301.33	265.33	352.33	488.67	297.67	324.00	321.67
SD(±)	3.51	3.51	5.03	6.66	3.51	5.86	12.10	4.51	14.53	7.02
DO	1.87	1.13	2.70	3.93	4.27	3.23	2.83	5.07	4.90	2.50
SD(±)	0.15	0.23	0.17	0.25	0.31	0.25	0.35	0.60	1.13	0.35
BOD	10.50	13.53	8.60	4.33	3.67	6.57	9.57	4.10	4.43	8.77
SD(±)	2.52	3.10	0.10	1.53	3.06	0.12	0.81	0.70	2.57	0.64
COD	23.17	32.00	11.43	7.13	14.93	18.10	27.50	8.50	7.17	21.17
SD(±)	1.77	3.82	2.44	0.59	3.79	2.52	0.70	1.65	1.12	2.25
Nitrates	7.80	3.99	5.71	3.67	5.86	1.03	3.24	0.00	0.57	7.60
SD(±)	0.31	0.27	0.53	0.50	0.80	0.20	0.35	0.00	0.07	0.53
Sulfates	50.00	26.33	11.77	6.77	23.70	17.07	48.37	20.83	0.66	32.50
SD(±)	7.94	3.51	3.22	1.08	5.06	4.41	2.80	3.50	0.11	5.50
Phosphates	0.07	1.23	0.14	0.10	0.10	0.18	1.23	0.08	0.13	0.69
SD(±)	0.05	0.25	0.05	0.03	0.06	0.05	0.25	0.02	0.01	0.50

Continue Table: 5

Parameters	Sampling Location									
	I11	I12	I13	I14	I15	I16	I17	I18	I19	I20
Temperature	23.07	20.93	28.77	29.17	24.80	27.57	28.40	23.50	25.17	26.37
SD (±)	4.47	6.05	4.46	4.85	4.30	4.41	5.05	5.07	6.29	5.05
pH	7.40	7.23	7.63	7.83	6.87	7.93	6.87	7.53	8.33	6.87
SD(±)	0.20	0.23	0.32	0.06	0.06	0.15	0.06	0.31	0.15	0.40
Turbidity	0.57	0.20	0.67	1.40	0.00	0.60	0.57	0.77	3.80	0.53
SD(±)	0.15	0.12	0.15	0.20	0.00	0.36	0.55	0.21	0.44	0.25
Hardness	205.67	252.00	185.33	327.67	189.67	289.33	327.33	486.00	309.33	241.33
SD(±)	7.51	15.10	7.02	8.14	4.04	9.02	13.65	4.00	12.50	6.51
TDS	212.00	330.67	215.67	422.33	222.67	317.33	336.67	531.33	306.67	334.33
SD(±)	10.44	14.01	5.86	8.50	4.73	6.11	4.16	9.45	9.61	7.02
DO	2.23	3.70	4.10	2.83	3.77	2.53	4.80	2.43	3.07	1.63
SD(±)	0.07	0.10	0.17	0.21	0.25	0.25	0.36	0.42	0.21	0.15
BOD	7.90	4.07	3.87	8.57	2.93	8.10	5.57	5.33	5.00	14.27
SD(±)	0.89	0.12	2.11	0.40	0.21	0.36	2.02	0.84	0.20	1.51
COD	18.43	10.70	5.97	15.17	5.67	10.20	6.27	8.57	9.43	13.80
SD(±)	3.13	1.39	1.63	0.91	0.99	2.20	1.70	2.65	1.16	0.96
Nitrates	0.85	0.10	0.35	1.30	0.11	8.16	3.23	1.97	8.57	12.07

SD(±)										
	0.04	0.08	0.12	0.15	0.06	0.99	0.25	0.13	0.31	1.36
Sulfates SD(±)	0.92	0.61	0.46	77.97	18.23	36.83	7.63	12.40	92.67	142.00
	0.39	0.17	0.22	9.60	4.45	3.88	1.65	2.62	15.14	17.78
Phosphates SD(±)	0.26	0.07	0.20	0.21	1.38	1.36	0.10	0.37	0.18	0.71
	0.22	0.10	0.28	0.31	1.19	0.98	0.11	0.21	0.08	0.07

Industrial Area- I1= Near J.P. Cement Plant Rewa, I2= Near Birla Cement Plant Satna, I3= Near Madariya Industrial area Sidhi, I4= Near N.T.P.C. Singurauli, I5= Near Ramnagar Coal Mince area Shahdol, I6= Near beersinghpur Coal Mince area Umaria, I7= Near Ardinance Factory Katni, I8= Near Majhgama Mince area Panna, I9= Near Mince area Chhatarpur, I10= Near Khamaria Industrial area Jabalpur, I11= Maneri Industrial area Mandala, I12= Mining area Dindori, I13 Near Keleri Tehsil Mince area Siwani, I14= Near Amabana Coal Mince area Chhindwada, I15= Near Oil Mills Gadarwara Narsinghpur, I16= Near Itarsi Industrial area hosangabad, I17= Near Oil Plant Betul, I18= Near Gandhi Ashram Industrial area Damoh, I19= Near Belai Industrial area Sagar, I20= Near Manddeep Industrial area Bhopal.

APPLICATIONS

The results are useful to know the quality of water in study area to public.

CONCLUSIONS

The ground water samples of Industrial area in East Zone of Central India were collected and analyzed for various physico-chemical parameters i.e., temperature 14.5^oC -36.2^oC, pH 6.5-9.2, Turbidity 0.1-8.7 NTU. Total hardness 178-645mg/l TDS 542-205 mg/l, DO 1.0-6.2 mg/l BOD1.8-17.1 mg L⁻¹ COD4.6-35.6 mg L⁻¹ Nitrate 0.05-12.9 mg L⁻¹ Sulphate0.21-162 mg L⁻¹ and phosphate 0.009-2.38 mg L⁻¹ in water of industrial area in East Zone central India were found. Temperature, pH, turbidity, TH, TDS, nitrate and sulphate of all the samples of study area were found within the permissible limit except some samples of BOD, COD, and phosphate in industrial area in the study period mostly exceed the permissible limit of WHO. The high access of contamination may be the outcome of high human and industrial activities in their locality. All the above results confirm that the ground water quality is not up to the mark and is slowly degrading. Even though at present the condition is not very bad but if the same continues in future, the ground water source will be completely polluted and becomes unfit for portability and other purposes. Proper monitoring is needed to avoid anthropogenic contamination.

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