

Analysis of Physico-chemical Characteristics of Surface Water Samples Collected from West Zone of Central India

Arvind Prasad Dwivedi*, Indra Prasad Tripathi**

*Lecturer, Department of chemistry, Govt. Sanjay Gandhi Smrati College Sidhi M.P.

**Pro-Vice-Chancellor and Dean, Faculty of Science and Environment
M.G.C.G.V. Chitrakoot, Satna (Madhya Pradesh)

Abstract: *In the present study we are intended to find out the diffuse chemical pollution in central India on the basis of surface water bodies. We have designed twenty sampling stations district for this study in east zone i.e. Rewa, Satna, Sidhi, Singrauli, Shahdol, Umaria, Katni, Panna, Chhatarpur, Jabalpur, Mandala, Dindori, Siwani, Chhindwara, Narsinghpur, Hosangabad, Betul, Damoh, Sagar and Bhopal. Various water quality parameters such as temperature, pH, turbidity total hardness, TDS, DO, BOD, COD, nitrate, sulphate and phosphate were determined using standard analytical methods. All the values were compared with the WHO Standard. Seventy five percent (75%) samples of BOD and COD were observed higher than the permissible limit during three different season set by WHO. Temperature, TDS, nitrate, sulphate and phosphate were found well within the prescribed limit. The access of contamination may be the outcome of high human, industrial and agricultural activities in their locality. Proper Monitoring is needed to avoid anthropogenic contamination.*

Keywords: *Physico- chemical parameters, Surface water, Statistical Analysis, West Zone and Central India.*

1. INTRODUCTION

Water is vital for life activities and is indispensable for human existence. It can be obtained from a number of sources like lakes, rivers, streams ponds etc. unfortunately, clean, and pure and safe water only exists briefly in nature and is immediately polluted by prevailing environmental factors and human activities. This is the reason that the water quality is a current environmental Issue worldwide^[1-2]. In many developing countries availability of water has become a critical and urgent problem and is a matter of great concern to families and communities that depends on non-public water supply systems^[3]. In India about 36% of urban and 65% of rural population is without access to safe drinking water^[4]. water is a vital resources used for various activities such as drinking, irrigation, fish production, power generation, etc. increased human activities over the last 25 years are impairing a greater stress on these ecosystem resulting change in their features. There is a need of scientific management of exploitation and conservation of this natural resource. Rivers are primary sources of potable water for mankind all over the world. They are sources of food as millions of tons of edible fish, lobsters, crabs and other aquatics animals and plants are taken from them^[5].

In some countries lakes and rivers have been polluted with an assortment of waste, including untreated or partially treated municipal sewage, industrial effluents, and harmful chemical and agricultural wastes^[6-7]. The degradation of both surface and ground water resources had adverse impact on the quality of drinking water for the human use, as well as harmful effects on aquatics life^[8-9]. The contamination of water is directly related to the degree of contamination of our environment. Rain water collects impurities while passing through the air. Streams and rivers collect impurities from surface run off and through the discharge of sewage and industrial effluents; these are carried to the rivers, lakes or reservoirs that supply our drinking water. All of the chemical generated by man will eventually end up in our water supplies. These dangerous products from industry, agriculture and other human activities enter the rivers, lakes and underground water, and can contaminate our drinking water. In most of the developing countries have huge debt burdens and due to population explosion and rapid urbanization, people rely heavily on water resources and polluting in the absence of better alternatives^[10-11]. In India, the water quality of the rivers has been extensively studied particularly with respect to the rivers of north India^[12-13] and South India. These have highlighted the water quality and documented the changes brought about by rapid developmental and urbanization^[14].

Specially the riwes of rivers of drinking water supplies drawn from the river of drinking water supplies drawn from the river polluted by dyeing waste water may become unfit or otherwise unsuitable for human consumption due to odor, color, turbidity, presence of chemicals etc. The potential for hazards arises from chemicals etc ^[15-22]. The potential for hazards arise from chemical toxicity presence of acids, alkalis and various organic pollutants. Water harness is caused primarily by the presence of actions such as calcium, and magnesium and anions such as carbonate, bicarbonate, chloride and sulphate in water. Water hardness has no known adverse effects; however some evidence indicates its role in heart disease. In urban areas, the careless disposal of industrial effluents and other wastes in rivers estuaries and lakes may contribute greatly, to the poor quality of river water ^[23]. Present study is aimed to evaluate the surface water quality in surface water area of west zone of central India covering various physical and inorganic nonmetallic constituent i.e. Temperature, pH, Turbidity, Total dissolve solids, Hardness, Dissolved Oxygen (DO) Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrate, Sulphate and Phosphate.

1.1. Study Area

The Central India Covers the seven states of our country, it has long industrial development and also has deep cultural heritage. 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.

2. MATERIAL AND METHODS

In the present study we are intended to find out the diffuse chemical pollution in central India on the basis of surface water bodies. We have designed twenty sampling stations district for this study in east zone i.e. Rewa, Satna, Sidhi, Singrauli, Shahdol, Umaria, Katni, Panna, Chhatarpur, Jabalpur, Mandala, Dindori, Siwani, Chhindwara, Narsinghpur, Hosangabad, Betul, Damoh, Sagar and Bhopal.

Twenty sampling locations consisting ponds, lake and rivers, sampling location were selected in the study area. Sampling was done during summer, rainy and winter seasons. The months of April- May, July –August and December- January, were selected as representative month of summer, rainy and winter season respectively. All reagents used were analytical grade and solutions were collected in polythene containers of 1 liters capacity for physico-chemical analyses. Various water quality parameters such as temperature, pH, turbidity total hardness, TDS, DO, BOD, COD, nitrate, sulphate and phosphate were determined using standard analytical methods ^[24]. The instruments used were calibrated before use for observing readings. The repeated measurements were made to ensure precision and accuracy of results. The location of sampling station are shown in **table –A**

S. No	Surface Water Area
1	S ₁ =Bihar River Rewa City Near Cholipur,
2	S ₂ = Bichhiya River Rewa City near Bichhiya,
3	S ₃ = Tamas River Satna City near Madhogarh,
4	S ₄ = Gopad River Near Sidhi City,
5	S ₅ = Sone River Near Singrauli,
6	S ₆ = Ban Ganga Shahdol City,
7	S ₇ = River Mudwara Near Katni City,
8	S ₈ = Ken River Near Panna City,
9	S ₉ = Bari Pond Near Chhayarpur City,
10	S ₁₀ = Narmada Rivers Jabalpur City Near Bhedaghat,
11	S ₁₁ = Narmada Rivers Mandala City Near Polytechnic College,
12	S ₁₂ = Kochouphung Lake Near Dindori City,
13	S ₁₃ = Talab Siwani City Near Bus Stand,
14	S ₁₄ = Bohani Talab Near Harsinghpur City,
15	S ₁₅ = Narmada River Hosangabad City Near Govt. Girls P.G. College,
16	S ₁₆ = Tapti River Betul City Near Multai Bus Stand,
17	S ₁₇ = Gandhi Sagar Risaviour Near Sagar City,
18	S ₁₈ = Bhopal Talab Near Hamidiya Hospital,
19	S ₁₉ = Mandakin River Chitrakoot Near Ramghat,
20	S ₂₀ = Narmada River Near Amarkantak City.

3. RESULTS AND DISCUSSION

The results of physico-chemical Characteristics of surface water in river and lake near city in west zone central India is represented in **table-1**. The results obtained in the present study showed that temperature in all the surface water samples in ranged between 26.9°C to 34.6°C with a mean value of 28.8°C. Maximum temperature 34.6°C was found at sampling station S₃₂ (Parvati river Near N.S.C.B Govt. P.G. College). The analytical data revealed that the surface water in the study area with pH values ranging from 6.0 to 8.9 with a mean of 7.4 during monsoon season. turbidity of the surface water in the study area ranges from 1.6 to 12.0 NTU with an mean values of 4.3 NTU values of turbidity at sampling station S₂₅ (12.0) and S₃₂ (10.2) NTU are higher than the limit set by WHO^[25] as 5.0 NTU. The total hardness of water shows variation lower to higher level 150-770 mg/l, but most of the samples the hardness lies below 600 mg/l. TDS was observed ranged between 115 to 492 mg/l. All the samples of TDS were found within the permissible limit. Dissolved oxygen is varied from 1.5 to 7.6 mg/l with an mean value of 3.6 mg/l seven samples exceeded the permissible limit of 4.0 mg/l. BOD values varied from 5.6 to 22.6 with an mean value of 9.4 mg/l. Eighty seven percent samples had BOD values are higher than the permissible limit during monsoon season as shown in **table-1**. Chemical oxygen demand varied from 6.0 to 118.0 mg/l (mean value 40.8 mg/l). Seventeen samples exceeded the permissible level of 10.0 mg/l In the case of nitrates, sulphate and phosphate, the mean values were found as 0.22, 51.1 and 0.03mg/l respectively, the nitrate, sulphate and phosphate values observed in the present study were well within the limit prescribed by WHO. The S.D. value of temperature (2.57), pH (0.84), turbidity (2.73), DO (1.74), BOD (3.7), COD (32.6), nitrate (0.18) and phosphate of each parameters between very little deviation together all the each parameters, but in the case of total hardness (190.06), TDS (86.13) and sulphate (40.6) S.D. value have greater deviation together all the each parameters, but in the case of total (190.06), TDS (86.13) and sulphate (40.6) S.D. value have greater deviation together all the each as shown in **table-1**. CV values of temperature (8.90), PH (11.21), hardness (49.95), TDS (35.10), DO (48.27), BOD (39.87) showed wide fluctuations with each other with respect to relation of these parameters between stations, but in the case of turbidity (63.18), COD (81.33), nitrate (80.8), sulphate (79.50) and phosphate (123.07) which was greater than 50% coefficient variation its indicate their significant variation between stations.

The correlation coefficient (r) among carious water quality parameter are given in **table-1a**. Temperature showed significant positive relationship with turbidity total hardness, TDS, DO, BOD, COD, nitrate, sulpahte and phosphate and negative relationship with pH. PH showed significant positive relationship with pH, TDS, and BOD and negative relationship with temperature, turbidity, total hardness, DO, COD, nitrate sulphate and phosphate.

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

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

Nitrate showed negative relationship with PH, BOD and phosphate and positive relationship with temperature, turbidity, total hardness, TDS, DO, COD nitrate and sulpahte. Sulphate showed positive relationship with temperature, turbidity, total hardness TDS, DO, BOD, COD, nitrate, sulphate and phosphate and negative relationship with PH. Phosphate in the present investigation showed significant positive relationship between temperature, turbidity, total hardness, DO, BOD, COD, sulphate and phosphate and negative relationship with PH, TDS, and nitrate.

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 fourteen times and positive fifty tow

times this showed that positive relationship in the present surface water studied. During monsoon season, we have investigated the different physico-chemical characteristics of surface water of west zone central India and stabilized the correlation by using ANOVA statistical software. The table value of 5% significant level Turbidity and temperature and COD and BOD we have found was 2.101 and at 1% level were 2.878. In the case of COD and hardness, nitrate and hardness BOD, and TDS, COD and TDS, phosphate DO, sulphate and COD and hardness sulphate and hardness, nitrate and DO, sulphate and COD and phosphate and COD we established a relationship which were negative and value were 2.430, 2.760, 2.764, 2.388 and 2.038 respectively which was greater than 5% significant level, while BOD and DO we have found negative value of relationship at 5% significant level i.e. 2.100. For turbidity and temperature, sulphate and turbidity and phosphate and sulphate we have found positive value of relationship at 1% significant level i.e. 3.460, 2.943 and 3.772. It showed that COD, hardness, sulphate nitrate, DO, phosphate, BOD, turbidity temperature play major role in the physico-chemical characteristics of surface water from surface water area in west zone of central India during monsoon seasons.

The temperature varies between 19.0°C to 38.2°C. Maximum temperature was recorded at sampling station S₃₂ (Parvati River near N.S. C.B Govt P.G College Biora) and minimum 19.0°C was recorded at sampling station S₂₂ (Sindha River Shivpuri) as given in **table 2**. PH was ranging 6.2 to 8.6. pH concentration at sampling station S₂₈ (8.6), S₃₃ (8.5) and S₃₇ (8.5) are more than the permissible limit set by WHO. The turbidity of surface water was observed to be 1.2 to 9.0 NTU and the mean value of 3.50 NTU, three samples exceeded the permissible limit of 5.0 NTU. Total hardness varied from 175.0 to 620 mg/l. The Maximum hardness (620 mg/l) was observed at sampling stations S₃₀ (Dhasan River, Near Raisen City). Values of total hardness at sampling station S₂₉ (604), S₃₀ (620) and S₃₇ (605) mg/l are higher than the recommended level set by WHO. The TDS values ranged from 130.0 mg/l to 480 mg/l. All water samples show TDS within permissible limit. Dissolved oxygen of surface water samples analyzed varied from 1.3 to 3.8 mg/l samples S₂₁, S₂₃, S₂₅, S₃₀, S₃₂ and S₃₄ shows high values of DO. Bio Chemical oxygen Demand values were recorded in between 4.8 to 22.0 mg/l. Sixty percent samples are higher than the permissible limit prescribed by WHO. Chemical oxygen demand values were recorded in between 6.8 to 113.0 mg/l. fourteen samples exceeded the permissible limit of 10.0 mg/l. In the case of nitrates, sulphate and phosphate mean values were found as 0.25, 50.90 and 0.04 mg/l respectively, the nitrate, sulphate and phosphate values observed in the present study were well within the limit prescribed by study were well within the limit prescribed by WHO as show in **table- 2**.

The S.D. value of temperature (2.70), PH (0.80), turbidity (1.89), DO (1.72), BOD (3.87) nitrate (0.15) and phosphate (0.04) of each parameters between very little deviation together all the each parameters, but in the case of total hardness (154.84), TDS (80.69), COD (33.92) and sulphate (37.35) S.D. value have greater deviation together all the each parameters. C.V. values of temperature (11.49), PH (10.58), total hardness (41.14), TDS (31.96), BOD (41.18) showed wide fluctuation with each other with respect to relation of these parameters between stations, but in the case of turbidity (54.12), DO (67.73), COD (86.25), nitrates (58.36), sulphate (73.38) and phosphate (112.19) which was greater than 50% coefficient variation, its indicate their significant variation between stations.

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

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

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

relationship with temperature, turbidity, total hardness, TDS, DO, BOD, COD, nitrate, sulphate and phosphate and negative relationship between with PH.

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

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 seventeen times and positive forty nine times, this showed that positive relationship in the present in the present surface water studied. During winter seasons, 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 turbidity and temperature and BOD and temperature we established a relationship which was positive and values were 2.194 and 2.409 respectively, which was greater than 5% significant level. For nitrate and turbidity, nitrate and DO and phosphate and sulphate we have found positive value of correlation at 1% significant level i.e. 6.692, 3.100 and 3.567 while BOD and DO show negative correlation i.e. - 2.904 respectively with each other at 1% significant level. It showed that turbidity, temperature, BOD nitrate, DO phosphate, sulphate play major role in the physico chemical characteristics of surface water in west zone of central India during winter seasons.

The observed temperature of all the sample range from 26.0°C to 37.0 °C, with a mean value of 31.9°C. Maximum temperature 37.0°C was observed at sampling station S₃₂ (Parvati River near N.S. C.B Govt. P.G. College Biora). The analyzed pH of all the samples during summer seasons ranged from 6.6 to 9.0 with mean value of 7.80. PH of all the samples were below the permissible limit except two stations S₂₈ (9.0) and S₃₃ (8.6). The observed turbidity of the surface water samples in summer season varied from 1.9 to 10.2 NTU (mean value 4.4 NTU). Values of turbidity at sampling stations S₂₅ (10.2), S₂₉ (6.8), S₃₀ (5.3), S₃₂ (9.8) and S₃₅ (5.2) NTU are higher than the limit set by WHO as 5.0 NTU. Total hardness in surface water samples shows total hardness within the permissible limit except three location S₂₉ (617), S₃₀ (639) and S₃₇ (670.0) mg/l. TDS values varied between 148.0 to 372.0 mg/l (mean value 271.2 mg/l). TDS of all the samples were below the permissible limit. Dissolved oxygen values varied from 1.0 to 6.9 mg/l, five samples exceeded the permissible limit of 5.0 NTU. Biochemical oxygen demand in surface water samples of the study area varied from 4.0 to 21.3 mg/l (mean value 10.2 mg/l). Eighty seven percent samples of BOD were higher than the limit set by WHO. Chemical oxygen demand was found ranged between 6.4 to 104.0 mg/l with a mean value of 39.5 mg/l. Eighty percent samples of COD was more than the permissible limit prescribed by WHO.

Nitrate content was found to vary from 0.08 to 0.6 67 mg/l (Mean value 0.297) as given in **table-3**. Nitrate in all samples sources are generally low when compared with WHO. Sulphate concentration was analyzed during summer seasons varied from 20.0 mg/l to 179.0 mg/l. The maximum sulphate 179.0 mg/l was observed at samples S₂₉ (Betwa River Near City Vidisha), all the samples of sulphate concentration were below the permissible limit prescribed by WHO²⁵. Concentration of phosphate was observed during summer season in study area varied from 0.05 to 0.142 mg/l with a mean value of 0.043 mg/l. The maximum values were recorded during summer seasons in the samples S₂₇ collected from Ganga Sagar Lake Near Guna city). It is observed that all the surface water samples were below the permissible limit set by WHO. The S.D. value of temperature (2.40), PH (0.60), Turbidity (2.31), dissolved oxygen (1.54) BOD (4.5) nitrate (0.17) and phosphate (0.04) of each parameters between very little deviation together all the each parameters but in the case of hardness (155.40), TDS (84.54), COD (32.71) and sulphate (37.15) S.D. value have greater deviation together all the each parameters. C.V. values of temperature (7.52), PH (7.79), total hardness (39.56), TDS (31.17), DO (44.77), BOD (44.01) showed wide fluctuations with each other with respect to relation of these parameters between stations, but in the case of turbidity (52.42), COD (82.62), nitrate (58.24), sulphate (68.36), and phosphate (102.32) which was greater than 50% coefficient variation, its indicate their significant variation from station to stations.

The correlation coefficient (r) among various water quality parameters are presented in **table-3a**. Temperature showed significant positive relationship with pH, turbidity, total hardness, TDS, BOD,

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

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

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

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

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 sixteen times and positive fifty nine times, this showed that positive relationship in the present surface water studied. During summer seasons we have investigated the different physic-chemical Characteristics of surface water of west zone central India and stabilized the correlation by using ANOVA statistical software. The table values of 5% significant level were 2.101 and at 1% significant level were 2.878. In the case of turbidity and temperature sulphate and COD and phosphate and COD i.e. 2.554, 2.463 and 2.160 we established a correlation other at 5% significant level. Turbidity and temperature, phosphate and BOD and phosphate and sulphate shows positive relationship i.e 3.459, 5.055 and 3.339 respectively with each other at 1% significant level while BOD and DO we have found negative value of correlation ship at 1% significant level i.e. -2.996. It showed that sulphate, turbidity, COD, phosphate, temperature, BOD play major role in the physico-chemical characteristics of surface water of west zone central India during summer season.

The average physico- chemical characteristics in surface water area of west zone central India are presented in **table-4**. The variation of temperature in this study area was observed to be 24.83⁰C minimum to 33.27⁰C maximum. The average pH was ranging from 6.27 to 8.70. The average range of turbidity was observed to be 1.57 to 10.40 NTU and total hardness was ranged from 171.7 to 676.3 mg/l. TDS was observed 162.3 to 496.0 mg/l. Dissolve oxygen was found to be 1.27 to 7.43 mg/l. BOD and COD were in the range of 4.60 to 21.97, 7.10 to 111.67 mg/l respectively. In the case of nitrates, sulphates and phosphates, the values were ranged between 0.05, 15.33, 0.004 to 0.64, 180.0, 0.151 mg/l respectively.

Table1. Physico -chemical characteristics of Surface water in River and Lake near City in West Zone Central India

During Monsoon Season

Parameters	Sampling Location																				Mean	S.D	C.V
	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30	S31	S32	S33	S34	S35	S36	S37	S38	S39	S40			
Temperature	29.0	26.0	28.4	25.6	31.2	32.4	30.2	27.6	30.6	25.3	26.9	34.6	27.0	31.0	27.5	29.0	30.0	26.0	32.0	27.0	28.865	2.571	8.90
pH	8.1	8.9	6.3	6.6	7.2	6.0	7.9	8.5	6.8	6.2	6.5	7.6	8.4	7.8	8.1	7.3	8.0	7.6	8.2	7.8	7.490	0.840	11.21
Turbidity	4.9	2.4	1.6	2.8	12.0	4.7	3.9	2.6	7.2	4.6	1.9	10.2	2.3	3.4	3.7	4.9	5.8	2.6	3.0	2.1	4.330	2.736	63.18
Hardness	472	190	366	286	470	364	306	600	640	770	496	630	460	260	150	168	740	240	206	156	398.500	199.068	49.95
TDS	206	115	220	136	143	190	328	265	158	286	229	316	300	243	310	285	492	186	276	223	245.350	86.139	35.10
DO	7.6	3.2	5.5	2.8	4.8	3.6	1.7	4.0	2.6	5.1	4.6	6.2	2.5	5.7	2.0	1.5	2.0	1.8	2.0	3.1	3.615	1.745	48.27
BOD	9.8	5.6	6.0	9.2	9.4	6.4	22.6	9.0	9.6	5.0	7.2	8.6	13.0	7.8	9.5	12.5	10.2	10.6	9.0	7.1	9.405	3.750	39.87
COD	40.0	46.0	10.0	30.0	50.0	70.0	106.0	50.0	82.0	118.0	06.0	54.0	25.0	21.8	14.2	23.3	27.4	7.8	12.5	7.6	40.080	32.601	81.33
Nitrate	0.59	0.25	0.11	0.06	0.20	0.24	0.10	0.31	0.09	0.57	0.12	0.54	0.05	0.18	0.14	0.35	0.41	0.09	0.04	0.03	0.224	0.181	80.80
Sulphate	066	013	059	032	082	026	090	021	185	060	032	083	026	018	023	030	084	047	011	035	51.150	40.667	79.50
Phosphate	0.058	0.021	0.033	0.012	0.013	0.007	0.134	0.049	0.166	0.027	0.125	0.058	0.007	0.014	0.005	0.016	0.011	0.002	0.012	0.003	0.039	0.048	123.07

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

Analysis of Physico-chemical Characteristics of Surface Water Samples Collected from West Zone of Central India

Surface Water Area- S₂₁= Gawalior, Near Madhav Sagar Lake, S₂₂= Sindha River Shivpuri, S₂₃= Tulsi Sarovar Ashok Nagar District, S₂₄= Sindha River Near Datia City, S₂₅= Sita Sagar Lake Near Muraina City, S₂₆= Balsamand Lake Bhind, S₂₇= Ganga Sagar Lake Near Guna City, S₂₈= Betwa River Near Tikamgarh, S₂₉= Betwa River Near City Vidisha, S₃₀= Dhasan River, Near Raisen City, S₃₁= Bhojtal from Bhopal Division Shiore District, S₃₂= Parvati River Near N.S.C.B. Govt, P.G, College Biora, S₃₃= Parvati River, Near Shajapur city, S₃₄= Kali Sindha river, Near Dewas City, S₃₅= Chhipra river near Mahakaleswer, S₃₆= Chambal River Near Ratlam City, S₃₇= Near Janapav River Chambal, S₃₈= Narmada river Near Omkareswar, Khandwa, S₃₉= Tapti River Near Burhanpur City, S₄₀= Pond Near Khirkiya, Harda.

Table 1a. Correlation coefficient (r) among various water quality parameters (Physico-chemical characteristics of Surface water in River and Lake near City in West Zone Central India

During Monsoon Season

Parameters	Temperature	pH	Turbidity	Hardness	TDS	DO	BOD	COD	Nitrate	Sulphate	Phosphate
Temperature	1										
pH	-0.029 0.121	1									
Turbidity	0.632 3.460**	-0.125 -0.583	1								
Hardness	0.152 0.650	-0.246 -1.075	0.430 2.019	1							
TDS	0.220 0.957	0.242 1.057	0.034 0.144	0.334 1.301	1						
DO	0.196 0.848	-0.200 -0.867	0.252 1.105	0.372 1.831	-0.210 -0.911	1					
BOD	0.148 0.635	0.301 1.339	0.060 0.255	-0.127 -0.545	0.345 1.557	-0.444 -2.100*	1				
COD	0.157 0.675	-0.237 -1.033	0.374 1.711	0.497 2.430*	0.012 0.052	0.101 30.43	0.235 0.234	1			
Nitrate	0.178 0.769	-0.005 -0.019	0.420 1.964	0.559 2.861*	0.298 1.324	0.546 2.764*	-0.193 0.832	0.394 1.816	1		
Sulphate	0.317 1.416	-0.259 -1.136	0.570 2.943**	0.545 2.760*	0.028 0.120	0.055 0.232	0.242 1.058	0.491 2.388*	0.129 0.550	1	
Phosphate	0.168 0.724	-0.177 0.571	0.133 0.571	0.360 1.635	-0.051 -0.215	0.084 0.358	0.350 1.586	0.433 2.038*	-0.030 -0.128	0.665 3.772**	1

1% Level of significance = **

5% Level of significance = *

Table 2. Physico-chemical characteristics of Surface water in River and Lake near City in West Zone Central India

During Winter Season

Parameters	Sampling Location																				Mean	S.D	C.V
	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30	S31	S32	S33	S34	S35	S36	S37	S38	S39	S40			
Temperature	24	19	23.2	21.4	25	24.5	27	20	26.2	19.5	21.3	28.2	23	26	21.5	26	25	20	25.6	24	23.520	2.704	11.49
pH	7.9	8.5	6.4	6.7	7.6	6.2	7.8	8.6	6.9	6.4	6.3	7.7	8.5	8	8.2	7.5	8.5	7.9	8	7.6	7.560	0.800	10.58
Turbidity	3	2.3	1.2	2.4	9	4	3.1	2.8	5.6	3.5	1.6	7.3	2	2.6	3.4	3.7	4.2	3.4	3.2	1.8	3.505	1.897	54.12
Hardness	467	196	378	260	450	389	326	570	604	620	511	324	495	310	175	180	605	255	223	188	376.300	154.841	41.14
TDS	233	160	185	165	130	224	338	267	155	291	241	346	270	250	322	267	480	206	260	259	252.450	80.695	31.96
DO	7.8	2.8	5.1	3	5	3.4	1.6	3.8	2.4	5.3	3.8	5.7	2.8	6.2	2.3	1.3	2.4	1.8	2.2	3.7	3.620	1.728	67.73
BOD	7.6	8.3	5.6	7.4	8.5	6.9	22	9.6	11.2	4.8	8.3	8.8	11.5	7.3	7.6	16.4	10	10.8	8.6	6.9	9.405	3.873	41.18
COD	34.3	49.1	7.4	26.2	47	73.4	112	54.3	85.2	113	10	56	19.5	16.2	9.6	26	22.3	8.6	9.7	6.8	39.330	33.925	86.25
Nitrate	0.65	0.32	0.13	0.09	0.26	0.37	0.16	0.24	0.12	0.43	0.19	0.48	0.08	0.31	0.23	0.28	0.35	0.26	0.12	0.06	0.257	0.150	58.36
Sulphate	54	18	64	41	78	29	91	25	176	57	35	71	33	21	16	38	80	49	15	27	50.900	37.352	73.38
Phosphate	0.06	0.018	0.042	0.021	0.018	0.005	0.14	0.055	0.149	0.031	0.128	0.054	0.008	0.02	0.007	0.016	0.004	0.017	0.007	0.041	0.046	112.19	

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

Surface Water Area- S₂₁= Gawalior, Near Madhav Sagar Lake, S₂₂= Sindha River Shivpuri, S₂₃= Tulsi Sarovar Ashok Nagar District, S₂₄= Sindha River Near Datia City, S₂₅= Sita Sagar Lake Near Muraina City, S₂₆= Balsamand Lake Bhind, S₂₇= Ganga Sagar Lake Near Guna City, S₂₈= Betwa River Near Tikamgarh, S₂₉= Betwa River Near City Vidisha, S₃₀= Dhasan River, Near Raisen City, S₃₁= Bhojtal from Bhopal Division Shiore District, S₃₂= Parvati River Near N.S.C.B. Govt, P.G, College Biora, S₃₃= Parvati River, Near Shajapur city, S₃₄= Kali Sindha river, Near Dewas City, S₃₅= Chhipra river near Mahakaleswer, S₃₆= Chambal River Near Ratlam City, S₃₇= Near Janapav River Chambal, S₃₈= Narmada river Near Omkareswar, Khandwa, S₃₉= Tapti River Near Burhanpur City, S₄₀= Pond Near Khirkiya, Harda.

Table2a. Correlation coefficient (r) among various water quality parameters

(Physico -Chemical characteristics of Surface water in River and Lake Near City in West Zone Central India During Winter Season)

Parameters	Temperature	pH	Turbidity	Hardness	TDS	DO	BOD	COD	Nitrate	Sulphate	Phosphate
Temperature	1										
pH	0.016 0.066	1									
Turbidity	0.459 2.194*	0.039 0.164	1								
Hardness	-0.062 -0.264	-0.175 -0.730	0.182 0.784	1							
TDS	0.265 1.167	0.357 1.619	-0.022 -0.095	0.150 0.642	1						
DO	0.061 0.261	-0.163 -0.701	0.121 0.516	0.291 1.292	-0.135 0.577	1					
BOD	0.400 2.409*	0.282 1.246	0.075 0.318	-0.116 -0.495	0.253 1.103	-0.565 2.904**	1				
COD	0.110 0.478	-0.236 -0.973	0.343 1.551	0.414 1.931	0.036 0.151	0.028 0.117	0.303 1.350	1			
Nitrate	0.045 0.191	0.067 0.285	0.310 6.692**	0.209 0.906	0.231 0.000	0.590 3.100**	-0.197 -0.854	0.260 1.141	1		
Sulphate	0.414 1.927	-0.232 -0.956	0.486 2.361*	0.502 0.000	-0.055 -0.233	-0.041 -0.176	0.304 1.351	0.499 2.442*	-0.025 -0.106	1	
Phosphate	0.251 1.098	-0.273 -1.203	0.045 0.190	0.405 1.877	-0.033 -0.140	-0.013 -0.054	0.433 2.036	0.463 2.442*	-0.088 -0.375	0.644 3.567**	1

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

Table3. Physico-chemical characteristics of Surface water in River and Lake near City in West Zone Central India

During Summer Season

Parameters	Sampling Location																				Mean	S.D	C.V
	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30	S31	S32	S33	S34	S35	S36	S37	S38	S39	S40			
Temperature	31.5	29.5	30.2	27.6	33	32.8	35	30	34	31	28.5	37	31.2	34	30.6	32	33.5	32	35.3	30	31.935	2.402	7.52
pH	8.3	8	6.9	7.4	7.8	6.6	8.1	9	7.4	6.8	7.2	8	8.6	7.9	8.4	7.9	8.2	7.7	7.8	8	7.800	0.608	7.79
Turbidity	3.7	2.8	1.9	2.5	10.2	5	4.2	2.7	6.8	5.3	2.1	9.8	3.4	3.9	5.2	4	6	3	3.4	2.5	4.420	2.317	52.42
Hardness	492	241	358	285	425	363	341	595	617	639	518	338	510	334	190	200	670	278	242	220	392.800	155.408	39.56
TDS	242	148	227	181	169	228	350	282	174	304	253	372	288	259	348	310	516	226	284	263	271.200	84.545	31.17
DO	6.9	2.3	4.6	3.6	5.1	3	1.4	3.2	2.1	5.7	3.2	5.3	3.4	4.7	2.5	1	3.1	1.5	2.6	3.9	3.455	1.547	44.77
BOD	12.6	10.5	7.9	7	8.8	10.9	21.3	10.2	14.6	4	9	9.3	8.2	6.5	6.8	20.5	7.4	15.2	8.1	7	10.290	4.529	44.01
COD	46.2	53	11.9	22.5	55.3	76	98	58.5	88.4	104	12.4	60.3	15.2	11.8	6.4	29.7	17.4	9.5	8.4	6.9	39.590	32.710	82.62
Nitrate	0.67	0.33	0.18	0.013	0.3	0.41	0.2	0.28	0.16	0.49	0.22	0.62	0.09	0.35	0.26	0.43	0.39	0.31	0.15	0.08	0.297	0.173	58.24
Sulphate	63	24	68	37	85	32	93	28	179	52	40	80	42	27	22	35	79	51	20	30	54.350	37.156	68.36
Phosphate	0.064	0.02	0.044	0.03	0.023	0.005	0.142	0.058	0.138	0.035	0.131	0.05	0.008	0.025	0.007	0.024	0.021	0.006	0.022	0.009	0.043	0.044	102.32

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

Surface Water Area- S₂₁= Gawalior, Near Madhav Sagar Lake, S₂₂= Sindha River Shivpuri, S₂₃= Tulsi Sarovar Ashok Nagar District, S₂₄= Sindha River Near Datia City, S₂₅= Sita Sagar Lake Near Muraina City, S₂₆= Balsamand Lake Bhind, S₂₇= Ganga Sagar Lake Near Guna City, S₂₈= Betwa River Near Tikamgarh, S₂₉= Betwa River Near City Vidisha, S₃₀= Dhasan River ,Near Raisen City, S₃₁= Bhojtal from Bhopal Division Shiore District, S₃₂= Parvati River Near N.S.C.B. Govt, P.G, College Biora, S₃₃=Parvati River, Near Shajapur city, S₃₄= Kali Sindha river, Near Dewas City, S₃₅= Chhipra river near Mahakaleswer, S₃₆=Chambal River Near Ratlam City, S₃₇= NearJanapav River Chambal, S₃₈=Narmada river Near Omkareswar, Khandwa, S₃₉= Tapti River NearBurhanpur City, S₄₀=Pond Near Khirkiya, Harda.

Table3a. Correlation coefficient (r) among various water quality parameters

(Physico -chemical characteristics of Surface water in River and Lake Near City in West Zone Central India During Summer Season)

Parameters	Temperature	pH	Turbidity	Hardness	TDS	DO	BOD	COD	Nitrate	Sulphate	Phosphate
Temperature	1										
pH	0.086 0.996	1									
Turbidity	0.632 3.459**	0.004 0.017	1								
Hardness	0.020 0.084	-0.017 -0.072	0.203 0.878	1							
TDS	0.388 1.786	0.333 1.498	0.194 0.858	0.216 0.938	1						

Analysis of Physico-chemical Characteristics of Surface Water Samples Collected from West Zone of Central India

DO	-0.016 -0.067	-0.098 -0.417	0.258 1.132	0.321 1.391	-0.055 -0.234	1														
BOD	0.279 1.234	0.131 0.559	-0.019 -0.078	-0.184 -0.793	-0.026 -0.111	-0.577 -2.996**	1													
COD	0.296 1.314	-0.225 -0.977	0.423 1.982	0.404 1.870	-0.090 -0.381	0.086 0.366	0.307 0.317	1												
Nitrate	0.363 1.651	0.011 0.048	0.422 1.974	0.182 0.786	0.277 1.221	0.438 2.066	0.108 0.461	0.340 1.384	1											
Sulphate	0.417 1.947	-0.146 -0.626	0.516 2.554*	0.478 0.207	-0.025 -0.104	0.004 0.015	0.333 1.497	0.502 2.463*	0.033 0.139	1										
Phosphate	0.126 0.538	-0.085 -0.687	0.021 0.090	0.389 1.792	-0.042 -0.178	-0.107 -0.454	0.432 5.055**	0.454 2.160*	-0.067 -0.283	0.619 3.339**	1									

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

Table 4. Average Physico-chemical characteristics of Surface water in River and Lake Near City in East Zone Central India

Parameters	Sampling Location																			
	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30	S31	S32	S33	S34	S35	S36	S37	S38	S39	S40
Temperature	28.17	24.83	27.27	24.87	29.73	29.90	30.73	25.87	30.27	25.27	25.57	33.27	27.07	30.33	26.53	29.00	29.50	26.00	30.97	27.00
SD (±)	3.82	5.35	3.64	3.16	4.20	4.68	4.03	5.22	3.91	5.75	3.78	4.55	4.10	4.04	4.63	3.00	4.27	6.00	4.93	3.00
pH	8.10	8.47	6.53	6.90	7.53	6.27	7.93	8.70	7.03	6.47	6.67	7.77	8.50	7.90	8.23	7.57	8.23	7.73	8.00	7.80
SD(±)	0.20	0.45	0.32	0.44	0.31	0.31	0.15	0.26	0.32	0.31	0.47	0.21	0.10	0.10	0.15	0.31	0.25	0.15	0.20	0.20
Turbidity	3.87	2.50	1.57	2.57	10.40	4.57	3.73	2.70	6.53	4.47	1.87	9.10	2.57	3.30	4.10	4.20	5.33	3.00	3.20	2.13
SD(±)	0.96	0.26	0.35	0.21	1.51	0.51	0.57	0.10	0.83	0.91	0.25	1.57	0.74	0.66	0.96	0.62	0.99	0.40	0.20	0.35
Hardness	477.0	209.0	367.3	277.0	448.3	372.0	324.3	588.3	620.3	676.3	508.3	430.7	488.3	301.3	171.7	182.7	671.7	257.7	223.7	188.0
SD(±)	13.2	27.9	10.1	14.7	22.5	14.7	17.6	16.1	18.2	81.7	11.2	172.8	25.7	37.8	20.2	16.2	67.5	19.1	18.0	32.0
TDS	227.0	141.0	210.7	160.7	147.3	214.0	338.7	271.3	162.3	293.7	241.0	344.7	286.0	250.7	326.7	287.3	496.0	206.0	273.3	248.3
SD(±)	18.7	23.3	22.5	22.8	19.9	20.9	11.0	9.3	10.2	9.3	12.0	28.0	15.1	8.0	19.4	21.6	18.3	20.0	12.2	22.0
DO	7.43	2.77	5.07	3.13	4.97	3.33	1.57	3.67	2.37	5.37	3.87	5.73	2.90	5.53	2.27	1.27	2.50	1.70	2.27	3.57
SD(±)	0.47	0.45	0.45	0.42	0.15	0.31	0.15	0.42	0.25	0.31	0.70	0.45	0.46	0.76	0.25	0.25	0.56	0.17	0.31	0.42
BOD	10.00	8.13	6.50	7.87	8.90	8.07	21.97	9.60	11.80	4.60	8.17	8.90	10.90	7.20	7.97	16.47	9.20	12.20	8.57	7.00
SD(±)	2.51	2.45	1.23	1.17	0.46	2.47	0.65	0.60	2.55	0.53	0.91	0.36	2.46	0.66	1.39	4.00	1.56	2.60	0.45	0.10
COD	40.17	49.37	9.77	26.23	50.77	73.13	105.33	54.27	85.20	111.67	9.47	56.77	19.90	16.60	10.07	26.33	22.37	8.63	10.20	7.10
SD(±)	5.95	3.51	2.26	3.75	4.20	3.01	7.02	4.25	3.20	7.09	3.23	3.22	4.91	5.01	3.92	3.21	5.00	0.85	2.10	0.44
Nitrates	0.64	0.30	0.14	0.05	0.25	0.34	0.15	0.28	0.12	0.50	0.18	0.55	0.07	0.28	0.21	0.35	0.38	0.22	0.10	0.06
SD(±)	0.04	0.04	0.04	0.04	0.05	0.09	0.05	0.04	0.04	0.07	0.05	0.07	0.02	0.09	0.06	0.08	0.03	0.12	0.06	0.03
Sulfates	61.00	18.33	63.67	36.67	81.67	29.00	91.33	24.67	180.00	56.33	35.67	78.00	33.67	22.00	20.33	34.33	81.00	49.00	15.33	30.67
SD(±)	6.24	5.51	4.51	4.51	3.51	3.00	1.53	3.51	4.58	4.04	4.04	6.24	8.02	4.58	3.79	4.04	2.65	2.00	4.51	4.04
Phosphates	0.061	0.020	0.040	0.021	0.018	0.006	0.139	0.054	0.151	0.031	0.128	0.054	0.008	0.020	0.006	0.020	0.016	0.004	0.017	0.006
SD(±)	0.003	0.002	0.006	0.009	0.005	0.001	0.004	0.005	0.014	0.004	0.003	0.004	0.001	0.006	0.001	0.004	0.005	0.002	0.005	0.003

4. CONCLUSION

Physico-chemical analysis was performed on surface water samples collected from various locations of west zone of central India. The temperature of the surface water samples was recorded range between 19.0°C to 37°C. PH of all the samples was found below the permissible limit except sampling station S₂₂, S₂₃ and S₃₃. Turbidity was found at all the samples of study area during all the season were below the permissible limit. Total hardness was ranging from 150 to 770 mg/l. Values of total hardness at sampling station S₂₉, S₃₀, and S₃₇ are higher than the limit of WHO standards. DO values was found at sampling station S₂₇, S₃₆ and S₃₈ are very below of the limit and indicate the polluted point of the study. Seventy five percent (75%) samples of BOD and COD were observed higher than the permissible limit during three different season set by WHO. Temperature, TDS, nitrate, sulphate and phosphate were found well within the prescribed limit. The access of contamination may be the outcome of high human, industrial and agricultural activities in their locality. Proper Monitoring is needed to avoid anthropogenic contamination.

ACKNOWLEDGEMENT

Authors would like to thanks the University Grant Commission, New Delhi (Project No. - No.F41-855/2012(SR)) for the financial Support

REFERENCES

- [1] Y. Ouyang, Evaluation of river water quality monitoring by principal component analysis, water research, v.39, pp 2621-2635, 2005.
- [2] S. Shrestha, F. Kazama, Assessment of Surface Water quality using multivariate statistical technique: A Case study of the Fuji River Basin Japan. Environmental modeling and software. v.22, pp 464-475 (2007).

- [3] E.A. Fajobi, Shittu, Microbiological and Physico-Chemical analysis of different water sample used for domestic purpose in Abeokuta and Ojata, Lagos, Stat. Nigeria. Afr. J. Biotechnol. v.7, pp 617-621, 2008.
- [4] World Health Organization, Guidelines for drinking water quality. v.1 third ed., WHO Press Switzerland. 2009.
- [5] N.I. Dike, A.U. Ezealor, S.J. Oniye and V.O. Ajibala, Pollution Studies of River Jakara in Kano Nigeria, using Selected Physico- Chemical Parameters, International Journal of Research in Environmental Science and Technology. V.3, pp 122-129, 2013.
- [6] S.Y. Aftab Begum, C.M. Noorjahan, and S. Sharif Dawood, Physico- Chemical and fungal analysis of a fertilizer factory effluent, J. Environ. Poll. Technol., v.4, pp 529-530, 2005.
- [7] A. Chetna, A. Pratima and C. Rina, Bacteriological water quality status of river Yamuna in Delhi, J. Environ. Bol., v.27, pp 97-101, 2006.
- [8] N. Jaiprakash, K. Vijaya and E.T. Puttaiah, Assessment of ground water quality of Magadi Taluk, Bangalore Rural District, J. Environ. Poll. v.27, pp 717-720, 2000.
- [9] A. Kaushik, water quality index and suitability assessment of urban ground water of Hisar and Panipat in Haryana, J. Environ. Bol. v.23, pp 325-333, 2002.
- [10] E. O.A. Aina and N.O. Adedipe, water quality monitoring and environment status in Nigeria, FEPA Monograph 6, FEPA, Abuja, Nigeria, pp 239, 1996.
- [11] D. Calamari and H. Naeve, Review of pollution in the African aquatic environment. Committee for Inland Fisheries of Africa (CIFA) Technical Paper No-25, FAO, Rome, pp118, 1994.
- [12] B. N. Singh and S. Rai, Physico-chemical Studies of Ganga River at Varanasi, Journal of Environ. Pollution, v.6, pp 4 – 46, 1999.
- [13] L. James, Distribution of Trace Heavy Metals in Two Tributaries of Rivers Cauvery, Int. Journal Environmental Protection, v.10, pp 350 – 352, 1990.
- [14] V. K. Srivastava, Population Dynamics' of Benthic Micro invertebrates in Relation to Water Quality and Silt load of Siang River of Arunachal Pradesh, Journal. Appl. Biosc., v.32, pp 44 – 53, 2006.
- [15] A. Sharma, S. K. Singh and L. Kori (2009a). Molecular Epidemiological Characteristics of Shigella Spp. Isolated from River Narmada During 2005 – 2006, J. Environ. Health, v.71, pp 61 – 66, 2009.
- [16] A. Sharma, S. K. Singh and D. Bajpai (2009b). Phenotypic and Genotypic Characterization of Shigella spp. with Reference to its Virulence Genes and antibiogram Analysis from River Narmada. Indian Journal of microbiology, v.49, pp259–265, 2009.
- [17] N. Malviya, S. Malik, A Bajpai, Water Quality Assessment of Newaj River at Rajgarh, Madhya Pradesh India, Current world Environment, v.4, pp 425 – 427, 2009.
- [18] Savita Dubey, Analysis of Physico-chemical Parameters of Kshipra River Water at Ujjain, India. International Journal of Environment Sciences, v.2, pp1-4, 2013.
- [19] S. Patel, S. Singh. V. Patel Seasonal Effect of Physico-chemical of Beehar River Rewa District M.P. Indian journal of Applied Research, v. 4, pp 498 – 500, 2014.
- [20] S. Sharma, R. Vishwakarma. S. Dixit. P. Jain, Evaluation of Water Quality of Narmada River with Reference to Physico-chemical Parameters at Hosangabad City, MP, India, Res. J. Chem. Sci.,v. 1, 2011.
- [21] S. Trivedi. H.C. Kataria, Physico-chemical Studies of Water Quality of Shahpura Lake, Bhopal (M. P.) with Special Reference to Pollution Effects on Ground Water of its Fringe Areas. Current World Environment.v.7, pp 139 – 144, 2012.
- [22] S. Suthar, J. Sharma, M. Chabukdhara, A. K. Nema, Water Quality Assessment of River Hindon at Ghaziabad, India: Impact of Industrial and Urban Waste Water. Environ. Monit. Assess. 2000.
- [23] H. A. Schroeder, Relations between Hardness of Water and Death Rates from Certain Chronic and Degenerative Diseases in the United States. Journal Chronic Disease, v.12, pp 586 – 591, 1960.
- [24] APHA Standard Methods for the Examination of Water and Waste Water (ed. 20th). American Public Health Association, 1015 Fifteenth Street, NW Washington, DC 20005-2605, 1998.
- [25] WHO, Guideline for Drinking Water Quality, v. 2. Geneva, 1984.