ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 9, Issue, 01, pp.44520-44528, January, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

PHYSICO-CHEMICAL STUDY OF SURFACE WATER QUALITY USING STATISTICAL TECHNIQUE: A CASE STUDY OF WEST ZONE CENTRAL INDIA

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ARTICLE INFO

Article History:
Received 20th October, 2016
Received in revised form
23rd November, 2016
Accepted 12th December, 2016
Published online 31st January, 2017

Key words:

Surface water, West zone central India, Sulphate, Nitrate, Phosphate, Physico-chemical characteristics, Contamination.

ABSTRACT

The surface water quality of west zone in central India prescribed, the physicochemical parameter such as, temperature, pH, total hardness, total dissolved solid, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, nitrate, sulphate, phosphate, was analyzed. The physicochemical parameter for some samples showed that the values are deviating from the prescribedlimites for the domestic purpose, the results analyzed by correlation has been used to suggest models for predicting water quality. The water quality in all the study areas surveyed was found to be unfit for human consumption, the lack of water quality different diseases freaquently affect for local people. Hence suitable water management is essential to avoid contamination.

Citation: Tripathi, I. P., Sangam Lal Dwivedi, Arvind Dwivedi and Renu Prajapati, 2017. "Physico-chemical study of surface water quality using statistical technique: A case study of west zone central India", *International Journal of Current Research*, 9, (01), 44520-44528.

INTRODUCTION

The central India plateau is environmentally very important to understand the rich Indian biodiversity and diffuse chemical pollution (David, 2008). The number of problems worldwide related with the lack of clean and fresh water is well known 1.2 billion people lack access to safe on clean drinking water; 2.6 billion have little or no sanitation a day, from diseases transmitted through unsafe water or human faces (Mantgomery and Elimelech, 2007). The extensive use of fertilizers, agrochemicals, fuel and other chemicals, along with growing industrial and urban activities have put in severe strain on the river ecosystem. Generally, increasing population and subsequently, Industrial and urban activities are main cause of unabated pollution of water sources in the world. About 40% population of the world resides in the urban areas which occupy only about 0.30% of the worlds geographical area (Dhwajendra Nath Das *et al.,* 2013). High level of pollutants mainly organic matter in river water cause on increase in biological oxygen demand (Kulkarni, 1997) chemical oxygen demand total dissolved solid, total solid and faecal coliforms. They make water unsuitable for drinking, irrigation or any other use (Hari *et al.,* 1994). Rivers play an important role not only in balancing the hydrological cycle but also for augmenting water supply for drinking, municipal, industrial and agricultural use, power, generation, water way transport and other purposes. Rivers are highly complex systems influenced by several variables associated with the quality of water. Extensive literature on River water quality is available throughout the world (Adebisi, 1981; Subramnian and Datta, 1997; Robson and Neal, 1997; Konhauser *et al*., 1994). Water hardness has no known adverse effects; however some evidence indicates its role in heart disease (Schroeder, 1960). 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 (Chindah *et al*., 2004). Natural phenomena such as volcanoes, algae blooms, storms and earthquakes also cause major change in water quality and the ecological statues of water (Ankita Parikh and Limnology of Sama Pond, 2012). People in this area mainly depend on well and bore well water frothier domestic purpose and Kaveri and Kalleduam river water for agricultural purposes. Thus the present study involves the analysis of water samples for the following physical, chemical, and biological parameters (Santhi *et al*., 2014). Especially 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 chemical toxicity presence of acids, alkalis and various organic pollutants (Srivastava, 2006; Blanch *et al*., 2004; Sharma *et al*., 2009a; Sharma *et al*., 2009b; Singh *et al*., 2004; Malviya *et al*., 2009; Chandra *et al*., 2006; Kannel *et al*., 2007; SavitaDubey,

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2013; Patel *et al*., 2014; Sharma *et al*., 2011; Trivedi and Kataria, 2012; Suthar *et al*., 2009; Dutta, 1994). The Chemical contamination do not cause immediate acute health problems uncles they are present in massive quantities through some accident and use of chemical fertilizer and pesticides in crop near the drinking water sources (Bhuyan and Sharam, 2004). According to WHO, nearly 80% of all the diseases in human beings are caused by water (Venkateswarlu *et al*., 2011).

Study area

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 west Zone of Central India on the basis of surface water We have designed twenty sampling stations district for thisbstudy in west zones i.e. Gawalior, Shivpuri, Ashok Nagar, Datiya, Muraina, Bhind, Guna, Tikamgarh, Vidisha, Raisen, Sihora, Rajgarh, Sajapur, Dewash, Ujjain, Ratlam, Indore, Khandawa, Burhanpur and Harda. Twenty sampling locations consisting of bore wells and hand pumps were selected in the study area.

MATERIALS AND METHODS

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 litter 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 hours. 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 (Hasan *et al*., 1981; ICMR, 1975). During sampling from hand pumps and bore wells, the water pumped to waste for about five minutes and sample was collected directly.

Table 1. Location of Sampling Station with Code for Surface Water in West Zone Central India (year 2013 to 2014)

S. No.	Surface Water Area
1	$S_{1=}$ Gawalior, Near Madhav Sagar Lake
2	$S_{2=}$ Sindha River Shivpuri
3	$S_{3=}$ TulsiSarovar Ashok Nagar District
4	$S_{4=}$ Sindha River Near Datia City
5	$S_{5=}$ SitaSagar Lake Near Muraina City
6	$S_{6=}$ Balsamand Lake Bhind
7	$S_{7=}$ Ganga Sagar Lake Near Guna City
8	$S_{8=}$Betwa River Near Tikamgarh
9	$S_{9=}$Betwa River Near City Vidisha
10	$S_{10=}$Dhasan River, Near Raisen City
11	$S_{11=}$Bhojtal from Bhopal Division Shiore District
12	$S_{12=}$Parvati River Near N.S.C.B. Govt, P.G, College Biora
13	$S_{13=}$Parvati River, Near Shajapur city
14	$S_{14=}$ Kali Sindha river, Near Dewas City
15	$S_{15=}$ Chhipra river near Mahakaleswer
16	$S_{16=}$Chambal River Near Ratlam City
17	$S_{17=}$ NearJanapav River Chambal
18	$S_{18=}$Narmada river Near Omkareswar, Khandwa
19	$S_{19=}$ Tapti River NearBurhanpur City
20	$S_{20=}$Pond Near Khirkiya, Harda

All the samples were refrigerated at 40C in the laboratory (Hasan *et al*., 1981; ICMR, 1975; NEERI, 1988; WHO, 2002) and procedures were followed as per the standard methods (American Public Health Association (APHA) 1998; De, 2002) and different physicochemical parameters like, temperature, pH, turbidity, TDS hardness dissolved oxygen, BOD, COD, nitrate, sulphate and phosphate were analyzed. The locations of sampling stations are shown in Table-1.

RESULTS AND DISCUSSION

In the present investigation, surface water samples were collected from West Zone of Central India. These water samples subjected for the analysis of various physico-chemical parameters. Surface water samples collected from twenty different locations and analyzed for the physico-chemical characteristics. The physico Chemical characteristics of the surface water samples of ponds, lake and river near city in west zone of central India during the three seasons are given in Table-2, 4, and 6. The correlation coefficient (r) among various water quality parameters of the surface water samples of ponds, lake and river near city in west Zone Central India during the three seasons. The results of physico-chemical characteristics of surface water in river and lake near city in west zone central India is represented in Table-2. The results obtained in the present study showed that temperature in all the surface water samples in raged between 26.9^0C to 34.6^0C with a mean value of 28.8^0C. Maximum temperature 34.6^0C was found at sampling station S_{12} (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 S_5 (12.0) and S_{12} (10.2) NTU are higher than the limit set by WHO 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-2.

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) SD value have greater deviation together all the each parameters, but in the case of total (190.06), TDS (86.13) and sulphate (40.6) SD value have greater deviation together all the each as shown in Table-2. 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.

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

Parameters	Sampling Location																						
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20	Mean	S.D	C.V
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.

Table 3. 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	1									
	0.121										
Turbidity	0.632	-0.125	1								
	3.460**	-0.583									
Hardness	0.152	-0.246	0.430	1							
	0.650	-1.075	2.019								
TDS	0.220	0.242	0.034	0.334	1						
	0.957	1.057	0.144	1.301							
DO	0.196	-0.200	0.252	0.372	-0.210	1					
	0.848	-0.867	1.105	1.831	-0.911						
BOD	0.148	0.301	0.060	-0.127	0.345	-0.444	1				
	0.635	1.339	0.255	-0.545	1.557	-2.100*					
COD	0.157	-0.237	0.374	0.497	0.012	0.101	0.235	1			
	0.675	-1.033	1.711	2.430*	0.052	30.43	0.234				
Nitrate	0.178	-0.005	0.420	0.559	0.298	0.546	-0.193	0.394	1		
	0.769	-0.019	1.964	2.861*	1.324	2.764*	0.832	1.816			
Sulphate	0.317	-0.259	0.570	0.545	0.028	0.055	0.242	0.491	0.129	1	
	1.416	-1.136	2.943**	2.760*	0.120	0.232	1.058	2.388*	0.550		
Phosphate	0.168	-0.177	0.133	0.360	-0.051	0.084	0.350	0.433	-0.030	0.665	1
	0.724	0.571	0.571	1.635	-0.215	0.358	1.586	2.038*	-0.128	3.772**	

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

Table 4. Physico-chemical characteristics of Surface water in River and Lake near City in West Zone Central India during Winter Season

Parameters	Sampling Location																					
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20	Mean	S.D	C.V
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	0.02	0.016	0.004	0.017	0.007	0.041	0.046	112.19

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

Table 5. 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	1									
	0.066										
Turbidity	0.459	0.039	1								
	2.194*	0.164									
Hardness	-0.062	-0.175	0.182	1							
	-0.264	-0.730	0.784								
TDS	0.265	0.357	-0.022	0.150	1						
	1.167	1.619	-0.095	0.642							
DO	0.061	-0.163	0.121	0.291	-0.135	1					
	0.261	-0.701	0.516	1.292	0.577						
BOD	0.400	0.282	0.075	-0.116	0.253	-0.565	1				
	2.409*	1.246	0.318	-0.495	1.103	2.904**					
COD	0.110	-0.236	0.343	0.414	0.036	0.028	0.303	1			
	0.478	-0.973	1.551	1.931	0.151	0.117	1.350				
Nitrate	0.045	0.067	0.310	0.209	0.231	0.590	-0.197	0.260	1		
	0.191	0.285	6.692**	0.906	0.000	3.100**	-0.854	1.141			
Sulphate	0.414	-0.232	0.486	0.502	-0.055	-0.041	0.304	0.499	-0.025	1	
	1.927	-0.956	2.361*	0.000	-0.233	-0.176	1.351	2.442*	-0.106		
Phosphate	0.251	-0.273	0.045	0.405	-0.033	-0.013	0.433	0.463	-0.088	0.644	1
	1.098	-1.203	0.190	1.877	-0.140	-0.054	2.036	2.442*	-0.375	3.567**	

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

Table 6. Physico -chemical characteristics of Surface water in River and Lake near City in West Zone Central India during Summer Season

Parameters	Sampling Location																					
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20	Mean	S.D	C.V
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 are expressed in mg/l.

Table 7. 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	1									
	0.996										
Turbidity	0.632	0.004	1								
	3.459**	0.017									
Hardness	0.020	-0.017	0.203	1							
	0.084	-0.072	0.878								
TDS	0.388	0.333	0.194	0.216	1						
	1.786	1.498	0.858	0.938							
DO	-0.016	-0.098	0.258	0.321	-0.055	1					
	-0.067	-0.417	1.132	1.391	-0.234						
BOD	0.279	0.131	-0.019	-0.184	-0.026	-0.577	1				
	1.234	0.559	-0.078	-0.793	-0.111	-2.996**					
COD	0.296	-0.225	0.423	0.404	-0.090	0.086	0.307	1			
	1.314	-0.977	1.982	1.870	-0.381	0.366	0.317				
Nitrate	0.363	0.011	0.422	0.182	0.277	0.438	0.108	0.340	1		
	1.651	0.048	1.974	0.786	1.221	2.066	0.461	1.384			
Sulphate	0.417	-0.146	0.516	0.478	-0.025	0.004	0.333	0.502	0.033	1	
	1.947	-0.626	2.554*	0.207	-0.104	0.015	1.497	2.463*	0.139		
Phosphate	0.126	-0.085	0.021	0.389	-0.042	-0.107	0.432	0.454	-0.067	0.619	1
	0.538	-0.687	0.090	1.792	-0.178	-0454	5.055**	2.160*	-0.283	3.339**	

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

Table 8. Average Physico-chemical characteristics of Surface water in River and Lake near City in West Zone Central India

Parameters	Sampling Location																			
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
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(+)																				

The correlation coefficient (r) among carious water quality parameter is given in Table-3.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 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 correlationship 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 correlationship at 5% significant level i.e. 2.100. For turbidity and temperature, sulpahte and turbidity and phosphate and sulphate we have found positive value of correlationship 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 19^0C to 08.2^0C. Maximum temperature was recorded at sampling station S_{12} (Parvati River near N.S. C.B Govt P.G College Biora) and minimum 19.0^0C was recorded at sampling station S_2 (Sindha River Shivpuri) as given in Table-4. pH was ranging 6.2 to 8.6. pH concentration at sampling station S_8 (8.6), S_{13} (8.5) and S_7 (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 S_{10} (Dhasan River, Near Raisen City). Values of total hardness at sampling station S_9 (604), S_{10} (620) and S_7 (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 S_1, S_3, S_5, S_{10}, S_{12} and S_{14} 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-4. 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) SD value have greater deviation together all the each parameters. CV 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-5. 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, sulpahte 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 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 showed significant positive relationship with temperature, turbidity, total hardness, TDS, DO, BOD, COD, nitrate, sulphate and phosphate shows 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, sulpahte 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 correlationship 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 correlatonship at 1% significant level i.e. 6.692, 3.100 and 3.567 while BOD and DO show negative corelationship 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 samples ranges from 26.0^0C to 37.0^0C with a mean value of 31.9^0C. Maximum temperature 37.0^0C was observed at sampling station S_{32} (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 S_8 (9.0) and S_{13} (8.6). The observed turbidity of the surface water samples in summer season varied from to 1.9 to 10.2 NTU (mean value 4.4 NTU). Values of

turbidity at sampling stations S_5 (10.2), S_9 (6.8), S_{10} (5.3), S_{12} (9.8) and S_{15} (5.2) NTU are higher than the limit prescribed by WHO as 5.0 NTU. Total hardness in surface water samples shows total hardness with in the permissible limit except three location S_9 (617), S_{10} (639) and S_{17} (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 were 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-6. 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 S_9 (Betwa River near City Vidisha), all the samples of sulphate concentration were below the permissible limit prescribed by WHO. 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 S_7 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 SD 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) SD 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-7. 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 phosphateand 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 physico 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 correlalationship 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

Conclusion

The variation of temperature in this study area was observed to be 24.83 ^{0}C minimum to 33.27 ^{0}C 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 harness 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 and 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.

Acknowledgement

The authors were grateful to University Grant Commission (No.F41-855/2012(SR), New Delhi for the provision of financial support to carry out this research work.

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