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Research Article

IMPACT OF INDUSTRIAL EFFLUENTS ON THE WATER QUALITY OF VRISHABAVATHI RIVER AND BYRAMANGALA LAKE IN BIDADI INDUSTRIAL AREA, KARNATAKA, INDIA

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ABSTRACT
In developing as well as underdeveloped countries, industrial effluents are released directly or indirectly into the natural water resources, mostly without proper treatment, thus posing a serious threat to the environment. Environmental pollution is an extremely important issue today, affecting all of us in one way or the other. Due to rapid growth in human population and industrialization, the demand for natural raw materials and source of energy are increasing day by day. Many natural water bodies of the world receive flux of sewage, domestic waste, industrial effluents and agricultural waste which contain substances varying from simple nutrients to highly toxic chemicals.
Over the years rising industrial and mining activities plus a lack of proper environmental control measures demand the continuous monitoring of the water quality for environmental impact assessment studies of that area. Thus, an attempt has been made to evaluate the surface water quality of Vrishabhavathi River and Byramangala lake as well as effluent channels of different industrial area in and around Bidadi industrial area to access the suitability and causes for deterioration of the water quality in the region. Industrial effluents were collected from three different sampling stations during the year 2011 and 2012 for three different seasons and analysed. It is observed from the study that, most of the stations in the effluent channel were very poor quality. The large variation was mainly due to the seasonal variation in magnitude of pollutants coming through the effluent and volume of water dilution.

INTRODUCTION
The problem of environmental pollution due to toxic metals has begun a big concern now in most of the major metropolis. Many of the rivers, lakes and oceans have been contaminated by pollutants. Some of these pollutants are directly discharged by industrial plants, municipal sewage treatment plants, and heavy increase in vehicles using petroleum fuel and polluted runoff in urban and agricultural areas. The areas where no alternative source of clean water exists, peoples will adopt urban waste water for irrigation of agricultural lands to increase the production of crops. It has been reported that sewage effluents from municipal origin contain appreciable amount of major essential plant nutrients, therefore the fertility levels of the soil is improved considerably under sewage irrigation of crop fields. Treated sewage water, also contains variable amounts of heavy metals such as Zn, Cd, Mn, Cr, Pb, and Fe etc.
The toxic heavy metals entering the ecosystem may lead to geo-accumulation, bioaccumulation and bio-magnifications. The nature of effects can be toxic, neurotoxic, carcinogenic, mutagenic and teratogenic and becomes apparent only after several years of exposure, as there is no good mechanism for their elimination from the body. In the present context, River carries sewage and industrial effluents from various industries across western part of Bangalore which is the largest watershed as well as most polluted. It receives treated and untreated effluents from treatment plants of Bangalore water supply and sewerage board, containing various organic contaminants, toxic heavy metals etc. In the recent years ground water pollution across Vrishabhavathi River has emerged as a severe environmental issue, constraining its use drastically. The polluted river water is extensively used for agricultural activities across the river on either side from Kengeri to Byramangala lake for about forty five kilometers away from the origin of the river. In this background, the present study was made an attempt to quantify the level of heavy metals and the degree of pollution of the Vrishabhavathi river water and ground water near Bidadi Industrial area of Bangalore city, where waste water is used for irrigation of agricultural activities.

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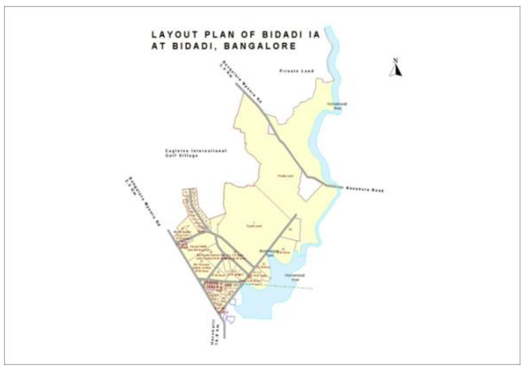
MATERIALS AND METHODS

Study Area

The present study was conducted in the Bidadi Industiral Area, of Bangalore, capital city of South Indian state, Karnataka. Bangalore is located at a latitude 12^o.58'N and longitude of 77^o.35'E at an altitude of 921 m above mean sea level. Vrishabhavathi River is one of the tributaries of the river Cauvery. It carries largest drainage watersheds out of other three viz., Vrishabhavathi, Bellandur and Nagavara watersheds of Bangalore. The main water shed of Bangalore, Vrishabhavathi watershed carries polluted effluents from two major industrial areas, Peenya and Rajajinagar, domestic sewage effluents of both treated and untreated water, directly discharged in to it from a large part of city. It also carries Industrial effluents along Bangalore-Mysore state highway factories and Bidadi Industrial area.



Sampling and Analysis

In order monitor and estimate the contamination hydrological investigations of river vrishabhavathi and Byramangalalake and effluent channel of industrial area samples from 5 different locations including effluent channel were collected during three different seasons of 2011 and 2012. In each season samplings was carried out for three different times and mean was taken for evaluation during pre-monsoon, monsoon and post-monsoon season. The physico-chemical characteristics along with maximum, minimum and average are calculated. The values were also compared with Indian and World River averages as well as permissible limits of the drinking water standard prescribed by WHO and ISI. The seasonal variations of different physic-chemical parameters of river vrishabhavathi and effluent channel of the industry are also presented in Figure 1.

RESULTS AND DISCUSSION

pH

The pH of water samples of study area effluent channel ranged between 7.3 to 8.4 in pre-monsoon, 7.2 to 8.1 in monsoon and 8.4 in post-monsoon season during both year 2011 and 2012 sampling stations. The effluent channel showed alkaline nature irrespective of the season and seasonal variation of pH during pre-monsoon and post-monsoon 2011 and 2012 were significant. The pH of the present study area was quite within the permissible limit of IS 10500, 2012 and WHO.

Electrical Conductivity

Electrical Conductivity was found substantially ranging from 542 to 1481 µS/cm in pre-monsoon, 550 to 1345µS/cm in monsoon and 492 to 1251µS/cm in post-monsoon season indicating the high degree of fluctuation in the pollution status of the river. The seasonal variation showed that the EC of water during post-monsoon showed lower values, where as pre-monsoon showed higher values. This was due to high and low dissolution corresponding to high and low temperature of the river.

Dissolved Oxygen

The Dissolved Oxygen (DO) concentration of VrishabhavathiRiver as well as the effluent channel of study area for the both year 2011 and 2012 varied from 2.7 to 6.1 mg/l in pre-monsoon, 3.5 to 6.3mg/l in monsoon and 3.6 to 6.2mg/l in post-monsoon. The DO concentration in the effluent channel was always less than 5 mg/l reflected high rate of organic contamination, which leads to high microbial activity and depletion of oxygen in the water body. The total depletion in DO was because of addition of oxygen depleting waste from the industrial effluent. There was no significant variation of DO concentration in different seasons except post-monsoon. The lower values of DO concentration in post-monsoon may be due to temperature and low solubility of oxygen in water as well as reduction in the dilution of flowing water.

Chemical Oxygen Demand

The concentration of COD was found ranging between 10 to 86 mg/l in pre-monsoon, 7 to 73 mg/l in monsoon and 7 to 76 mg/l in post-monsoon for both the sampling periods of the years 2011 and 2012. All the sampling points of effluent channel and river vrishabhavathi recorded comparatively high value in pre-monsoon due to increased temperature and reduction in dilution of water.

Total Suspended Solids

The concentration of TSS was found ranging from 72 to 294 mg/l in pre monsoon, 231 to 388 mg/l in monsoon and 98 to 348 mg/l in post monsoon. The monsoon water showed higher level of TSS concentration due to mixing of higher level of catchment washing through large number of discharges. Pre-monsoon and post monsoon showed comparatively low level of TSS concentration, which is due to less turbulence.

Total Dissolved Solids

TDS concentration varied from 362 to 987 mg/l in pre-monsoon, 231 to 897 mg/l in monsoon and 329 to 841 mg/l seasons during both 2011 and 2012 sampling periods. The samples of effluent channel was characterized with high TDS and most of the water samples in river vrishabhavathi was more than 500 mg/l of TDS indicating that water is not suitable for drinking purpose.

Alkalinity

Higher and lower values of alkalinity have been detected during pre-monsoon and monsoon seasons respectively. The alkalinity values ranges from 118 to 561 mg/l in pre-monsoon, 97 to 476 mg/l in monsoon and 83 to 514 mg/l in post-monsoon seasons for both 2011 and 2012.The alkalinity of vrishabavathi river water was much higher than the world river average (62.2ppm) as well as Indian river average (74 ppm, Subramanian, 1987).

Hardness

The study area effluent channel was characterized as very hard (greater than 300 mg/l of hardness), whereas vrishabavathi river water was characterized by moderately hard (92 - 504 mg/lt of hardness) to hard (88 – 523 mg/l of hardness). The monsoon water samples showed lower hardness values, which may be due dilution effect. The hardness of the present study area in all the seasons was mainly due to $CO^{2-}_{3,}$ which inferred that alkalinity in most of the stations were more than hardness values.

Dissolved Metals

The concentration of the metal ions like Zn, Cd, Pb, Cr, Mn and Fe of river Vrishabavathi and lake Byramangala as well as effluent channel of study area was analyzed for both the year 2011 and 2012 and represented in Table 1&2. The concentration of Zn for the samples varied from 0.0437 to 2.835 mg/l in pre-monsoon, 0.18 to 1.875 mg/l in monsoon and 0.189 to 2.275 mg/l in post-monsoon. The lower value of Zn concentration was found in monsoon season due to dilution effect. The concentration of Cd varied from 0.007 to 0.019 mg/l in pre-monsoon, 0.004 to 0.012 mg/l in monsoon and 0.005 to 0.014 mg/l. Spatial and temporal variation of Cd in effluent channel was insignificant. The effluent channel stations were exceeding the maximum permissible limit of Cd. The concentration of Pb in the effluent channel was varied from 0.059 to 0164 mg/l in pre-monsoon, 0.032 to 0.026 mg/l in monsoon and 0.033 to 0.136 mg/l in pre-monsoon. In general the concentration of Pb was lower in monsoon and higher in pre-monsoon and post monsoon. The concentration of Cr in the study area was varied from 0.006 to 0.029 mg/l in pre-monsoon, 0.001 to 0.02 mg/l in monsoon and 0.0017 to 0.02 mg/l in post-monsoon.

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Table 1: Physico- chemical parameters of different sampling stations during three different seasons in 2011

Seasons	Sample Locations	Zn	Cd	Pb	Cr	Mn	Fe	pH	DO	COD	TSS	TDS	EC	Total Hardness	Alkalinity
Pre Monsoon	S1	2.039	0.019	0.123	0.024	0.507	1.631	7.9	3.1	84	268	952	1429	492	497
	S2	2.451	0.018	0.145	0.028	0.426	1.399	7.8	2.8	82	294	868	1302	504	561
	S3	2.282	0.01	0.123	0.027	0.481	1.138	7.5	2.9	73	237	935	1407	454	521
	S4	1.927	0.012	0.126	0.019	0.472	1.578	8.2	3.4	68	251	824	1231	438	456
	S5	0.437	0.007	0.059	0.006	0.219	0.712	7.3	6.1	10	72	362	542	113	118
	Min	0.437	0.007	0.059	0.006	0.219	0.712	7.3	2.8	10	72	362	542	113	118
	Max	2.451	0.019	0.145	0.028	0.507	1.631	8.2	6.1	84	294	952	1429	504	561
	Avg	1.444	0.013	0.102	0.017	0.363	1.172	7.7	4.45	47	183	657	985.5	308.5	339.5
Monsoon	S1	1.73	0.009	0.09	0.016	0.304	1.093	7.8	3.7	63	379	897	1345	416	456
	S2	1.529	0.011	0.098	0.018	0.331	1.34	7.5	4.3	58	388	821	1229	368	424
	S3	1.216	0.009	0.085	0.001	0.285	0.81	8.1	4.8	49	337	736	1098	309	366
	S4	0.973	0.008	0.079	0.012	0.301	0.85	7.8	4.4	54	296	754	1127	319	382
	S5	0.18	0.006	0.032	0.016	0.208	0.478	7.3	6.3	7	231	376	558	87	102
	Min	0.18	0.006	0.032	0.001	0.208	0.478	7.3	3.7	7	231	376	558	87	102
	Max	1.73	0.011	0.098	0.018	0.331	1.34	8.1	6.3	63	388	897	1345	416	456
	Avg	0.955	0.009	0.065	0.01	0.27	0.909	7.7	5	35	309.5	636.5	951.5	251.5	279
Post Monsoon	S1	2.034	0.01	0.093	0.022	0.358	1.114	7.5	3.8	59	348	841	1251	486	427
	S2	2.075	0.014	0.128	0.018	0.397	0.993	7.9	4.1	67	326	702	1039	442	451
	S3	1.983	0.01	0.12	0.021	0.317	1.149	7.8	4.7	51	259	774	1149	366	346
	S4	1.673	0.008	0.104	0.014	0.312	0.873	8.4	4.5	47	263	743	1108	389	387
	S5	0.189	0.007	0.048	0.003	0.207	0.512	7.2	6.2	7	98	329	492	92	83
	Min	0.189	0.007	0.048	0.003	0.207	0.512	7.2	3.8	7	98	329	492	92	83
	Max	2.075	0.014	0.128	0.022	0.397	1.149	8.4	6.2	67	348	841	1251	486	451
	Avg	1.132	0.011	0.088	0.013	0.302	0.831	7.8	5	37	223	585	871.5	289	267

All parameters are expressed in mg/L, except pH, turbidity (NTU) and electrical conductivity (µmhos/cm)

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Table 2: Physico- chemical parameters of different sampling stations during three different seasons in 2012

Seasons	Sample Locations	Zn	Cd	Pb	Cr	Mn	Fe	pH	DO	COD	TSS	TDS	EC	Total Hardness	Alkalinity
Pre Monsoon	S1	2.539	0.019	0.164	0.027	0.651	1.892	7.8	2.7	86	283	987	1481	523	542
	S2	2.835	0.018	0.143	0.029	0.607	1.642	8	3.1	81	252	936	1389	479	498
	S3	2.683	0.01	0.12	0.023	0.512	1.379	7.9	3.8	73	261	918	1372	454	413
	S4	2.215	0.011	0.125	0.024	0.538	1.567	8.4	3.3	78	238	873	1291	463	430
	S5	0.737	0.007	0.063	0.007	0.25	0.867	7.3	5.5	12	92	467	686	113	121
	Min	0.737	0.007	0.063	0.007	0.25	0.867	7.3	2.7	12	92	467	686	113	121
	Max	2.835	0.019	0.164	0.029	0.651	1.892	8.4	5.5	86	283	987	1481	523	542
	Avg	1.786	0.013	0.1135	0.018	0.4505	1.3795	7.85	4.1	49	187.5	727	1083.5	318	331.5
Monsoon	S1	1.875	0.011	0.097	0.018	0.314	1.513	7.4	3.8	68	386	843	1265	369	476
	S2	1.579	0.012	0.091	0.02	0.283	1.103	7.5	3.5	73	329	788	1178	337	416
	S3	1.639	0.008	0.066	0.015	0.226	0.884	7.9	3.7	54	341	814	1220	313	358
	S4	1.314	0.01	0.072	0.016	0.249	0.673	7.8	3.9	61	327	727	1085	326	383
	S5	0.258	0.004	0.26	0.014	0.132	0.401	7.2	5.7	7	244	375	550	93	97
	Min	0.258	0.004	0.066	0.014	0.132	0.401	7.2	3.5	7	244	375	550	93	97
	Max	1.875	0.012	0.26	0.02	0.314	1.513	7.9	5.7	73	386	843	1265	369	476
	Avg	1.0665	0.008	0.163	0.017	0.223	0.957	7.55	4.6	40	315	609	907.5	231	286.5
Post Monsoon	S1	2.185	0.014	0.136	0.02	0.421	1.691	8.1	3.6	76	314	791	1186	421	514
	S2	2.275	0.011	0.118	0.019	0.284	1.273	7.9	4.1	69	286	828	1239	388	427
	S3	1.873	0.012	0.102	0.02	0.325	1.315	8.2	3.8	61	294	746	1108	317	456
	S4	1.997	0.01	0.109	0.017	0.306	1.113	8.4	4.2	64	277	711	1062	334	398
	S5	0.225	0.005	0.033	0.02	0.231	0.614	7.4	5.9	10	121	342	506	88	106
	Min	0.225	0.005	0.033	0.017	0.231	0.614	7.4	3.6	10	121	342	506	88	106
	Max	2.275	0.014	0.136	0.02	0.421	1.691	8.4	5.9	76	314	828	1239	421	514
	Avg	1.25	0.0095	0.0845	0.0185	0.326	1.1525	7.9	4.75	43	217.5	585	872.5	254.5	310

All parameters are expressed in mg/L, except pH, turbidity (NTU) and electrical conductivity (µmhos/cm)

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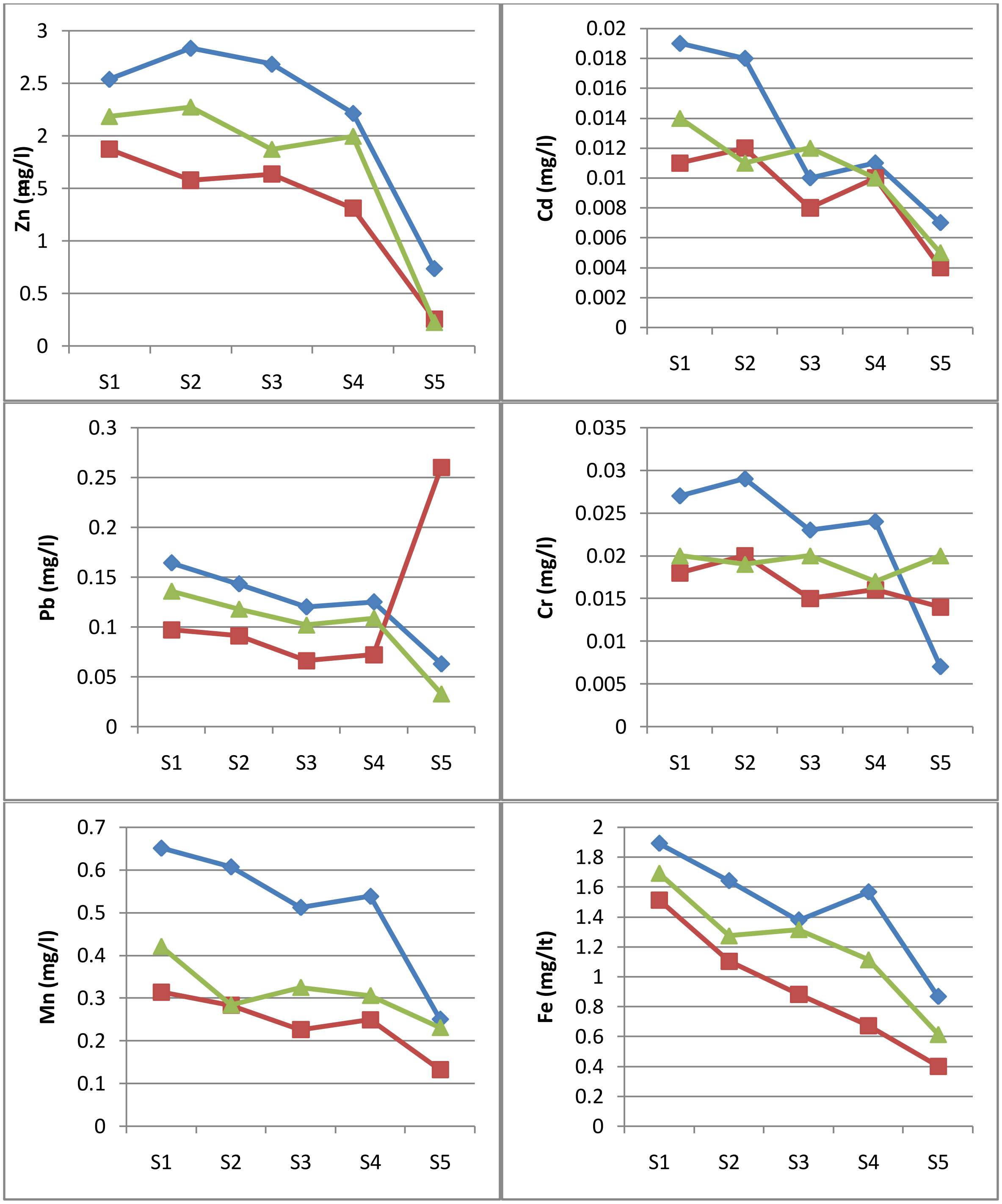

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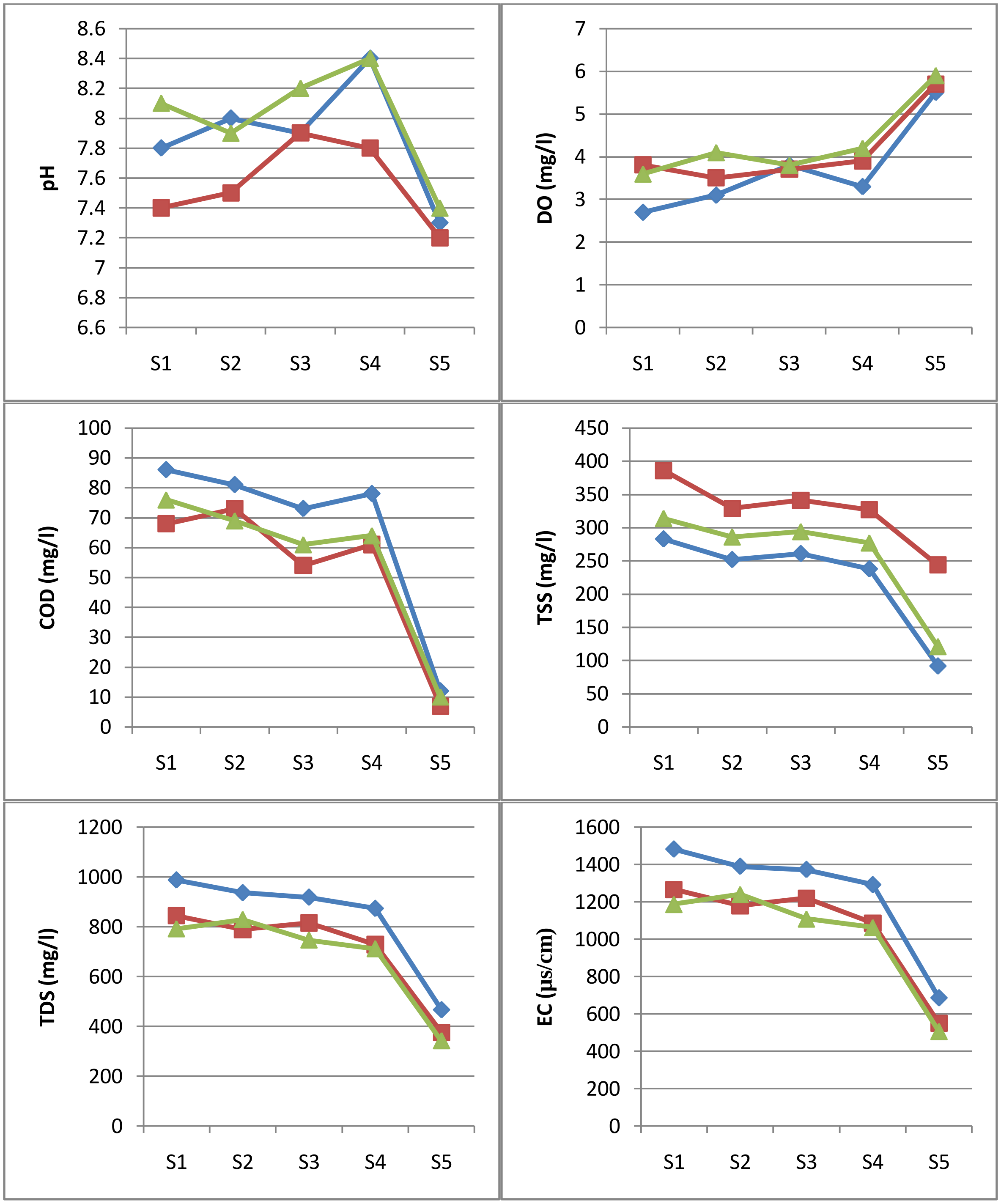

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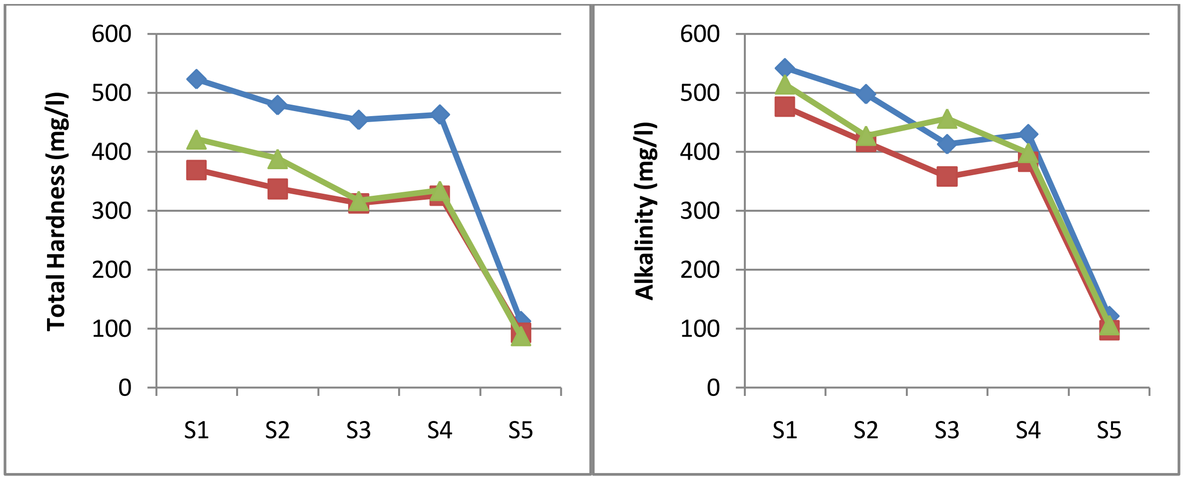

Figure 1: Graph showing seasonal variation of different physico-chemical parameters in different stations of study area

The concentration of Cr in most of the stations during pre-monsoon season showed high values while monsoon showed low values. The concentrations of Mn for the period of 2011 and 2012 varied from 0.219 to 0.651 mg/l in pre-monsoon, 0.132 to 0.331 mg/l in monsoon and 0.231 to 0.421 mg/l in post-monsoon. The permissible and excessive limit of Mn in drinking water is 0.1 mg/l and o.0.3 mg/l respectively (WHO and IS10500-2012). It was found that the Mn concentration in the present study was much higher than the permissible limit. Concentration of Fe in the study area ranges from 0.712 to 1.892 mg/l in pre-monsoon, 0.401 to 1.513 mg/l in monsoon and 0.512 to 1.691 mg/l in post-monsoon season for both 2011 and 2012. The present study reveals that Fe concentration in all the stations was found greater than the permissible limit. The area is under environmental risk due to the presence of high concentration of Fe and Mn due to industrial activities.

Conclusion

The pH of the vrishabavathi and Byramangalalake near industrial area is quite moderate. COD concentration recorded was comparatively high during pre-monsoon seasons due to high temperature and low dilution. TSS and TDS comparatively low level within the permissible limit. The alkalinity of water body was much higher than the world and Indian standard.Hardness is quite less than the level specified in the standard. Dissolved Zn, Cr were less than the prescribed limit. Some stations of study area during pre-monsoon were exceeding the maximum permissible limit of Cd. The concentration of Pb, Mn and Fe in some stations were much higher than the prescribed limit.

From the above conclusion it has been made evident that the industrialization in Bidadi industrial area was responsible for the present deteriorating condition. The mitigation majors along with long term monitoring network will improve in that region. It is seen that improvement can be achieved in water quality, health, aquatic life, flora and fauna etc. with implementation of mitigation measures.

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