ASSESSMENT OF SEWAGE POLLUTION OF LENTIC AND LOTIC ECOSYSTEMS FROM GADHINGLAJ TAHSIL, DISTRICT KOLHAPUR, MAHARASHTRA.

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ABSTRACT:

For survival of living organisms, all must have to adjust with changing physical and chemical conditions of the environment. Present study revealed with seasonal analysis of various physico-chemical parameters from six water bodies, subjected to physico-chemical analysis during December, 2012 to November, 2013. Physico-chemical parameters like pH, Temperature, Dissolved Oxygen, Free Carbon dioxide, Hardness, Chemical Oxygen Demand, Total Solids, Total Dissolved Solids, Suspended Solids, Chloride, Alkalinity, Nitrate, Phosphate and base level contamination of heavy metals like Fe^+, Na^+ and K^+ were determined. Physico-chemical parameters and heavy metal contamination found impact over the animal diversity in the study region.

KEY WORDS: Freshwater bodies, Physico-chemical parameters, Pollution status, Water quality.

INTRODUCTION:

Population growth and elevated living standards have been coupled with ever increasing demands for clean water (Akinnibosun *et al.,* 2009). Natural water resources such as rivers, lakes and streams contain sufficient factors responsible for growth of various organisms in the aquatic body (Dhasarathan *et al*., 2006). Life in aquatic environment is largely governed by physico-chemical characteristics and their stability. Fresh water is essential for agriculture, industry and human existence it is a finite resource of earth. The healthy aquatic ecosystem is depends on the biological diversity and Physico-chemical characteristics (Venkatesharaju *et al.*, 2010). Without adequate quantity and quality of fresh water, sustainable development will not be possible (Kumar 1997, Mahananda *et al.*, 2005). Living organisms which evolved in water has to adjust with its physical and chemical contamination of water. It is an essential source for its existence. Water is essential for survival of all living things is also the source of economic wealth and the creator of beautiful environment. Due to negative impact of human activities, water get polluted from various sources as domestic sewage, industrial effluents, heat from thermal power plants, radioactive waste material, agricultural runoff water containing chemical, pesticides, fertilizer, hazardous biomedical waste, reduces the quality of water. Assessment of water quality from by any region is an important aspect for the developmental activities. The rivers, lakes and manmade reservoirs are used for water supply to the domestic, industrial, agricultural processes. Huge contamination can cause changes in physiology, behavior and histology of aquatic flora and fauna including human being (David *et al,* 2003). Water quality index is one of the most effective tools to communicate information in the quality of water to the concerned citizens.

Today is major consideration for all socio-economic, cultural, industrial and technological developments, that hardly 1% of the global water is available for direct use to the infrastructure associated with life. Fresh water resource day by day becoming deteriorated and is now became a global problem (Mahananda, 2005). A water body receives microorganisms from air, soil, sewage, organic wastes, dead plants and from animals. Indiscriminate dumping of industrial wastes into streams and rivers impair the physico-chemical composition of the receiving water and ultimately it will have an adverse effect on an aquatic life (Effler and Doerr1996, Rao and Prasad, 2002). Discharge of organic wastes human excreta, sewage, polythenes, municipal garbage and toxic discharge from the factories has increased severe pollution in the river, ponds and lake. This waste flow into the storm drains, mixing with common water and subsequently posing a serious threat to the living biota of water.

Water is one of the important natural resources useful for development purposes in both urban as well as rural areas for their domestic as well as agricultural needs, whereas urban people depends on these water sources for domestic and industrial purposes. But it is a common practice for people living along the river catchments to discharge their domestic as well as human excreta into rivers. Wild and domestic animals can also contaminate the water through direct defecation and urination. Many rivers and lakes in India was grossly polluted due to untreated industrial waste discharge (Trivedi, 1986; Shsh, 1988). Thus, water pollution is the biggest means of urbanization, industrialization and agriculture practices. It leads to alteration in physical, chemical and biological properties of water with environmental conditions. A regular monitoring of water bodies with required number of parameters in relation to water quality prevents the outbreak of diseases and occurrence of pathology.

Increased nutrients are expected to have an impact over the biological community and water quality. Therefore, to assess the quality of water physico-chemical parameters of aquatic bodies in relation to health have been studied by number of workers, (Vijaykumar, 1996; Reddy, 2001; Nagaraja, 2005), but less attention has been paid to compare data with river, reservoirs, lake and pond systems. In the present investigation, physico-chemical parameters from six freshwater sites (Nool pond, Yenechiwandi lake and four riverine zones Nangnur, Niligi, Harali and Mahagoan respectively from Gadhinglaj tahsil, District Kolhapur, Maharashtra were assessed.

MATERIAL AND METHODS

I. Study area:

Gadhinglaj is important tahsil of Kolhapur district, state Maharashtra. Geographically has latitude 16°13´26"N and longitude 74°26´9" E. Hiranyakeshi River (Figure I) is one of the important rivers flowing in two states of India (Maharashtra and Karnataka). The River originates at Amboli hill station from Sindhudurg district of Maharashtra and after a few kilometers, it enters into district Kolhapur of Maharashtra. Again continue into district Belgaum of Karnataka. Overall has about 140 KM distance and finally meets to Ghataprabha River. Geographically the area is flat except some part of Sawantwadi and Ajara Tahsil.

The climate is moderate subtropical with average rainfall 1500 mm annually. Major area of the basin of river is under agricultural practice, whereas remaining is forest covered. The quantity and quality of water from this river is affected by municipal, industrial as well as agricultural discharge.

River Hiranyakeshi and 40 to 45 small or larger water reservoirs were distributed in the Gadhinglaj tahsil. Local inhabitants use water for their daily needs along with agriculture and industrial processes. For present study, six sites were selected as, site I (Nool pond N 16° 12´ 36" E 74° 25´ 56"), site II (Yenechwandi lake N 16° 10´ 24" E 74° 25´ 46") These are two small fresh water bodies located in Gadhinglaj Tahsil. The local inhabitants depend on these for their daily needs like drinking, cloth washing, cattle washing and agriculture use etc. Four riverine sites viz., site III (Nangnur spot N 16°14'3" E 74° 29'46"). site IV (Nilgi spot N 16° 14´ 16" E 74° 25´ 41"), site V (Harali spot N 16°9'54" E 74°19'58") and site VI (Mahagoan spot N 16°9'54" E 74°19'58"). At all sites agricultural waste being added.

II. Water Sampling:

Water samples were collected from all sites in the period of December (2012) to November (2013). The samples were collected at the morning in between 8:00 am to 10:00 am. Samples were brought to the laboratory by plastic containers for analysis of physico-chemical parameters along with detection of metal concentration in it.

III. Laboratory analysis:

Different physico-chemical parameters were applying by following standard physico-chemical methods (APHA, 1985, Trivedi *et al* 1987). Heavy metal analysis was carried out by using Atomic Absorption Spectrophotometer (AAS) (Kemito company- 201).

RESULTS:

The seasonal physico-chemical parameters of six different sites were analyzed and presented in Table No. 1, 2, 3, 4, 5 and 6 along with mean and standard deviation.

1. Temperature:

Temperature is an important parameter, with vital role in chemical and biological activities and is one of the essential and changeable environmental factors, since it has major influence the growth and distribution of flora and fauna. We found that, surface water temperature ranged between 22°C to 26°C. It was recorded minimum during rainy and maximum in summer. Thus on an average the maximum range of temperature was seen at site VI (26.25ºC) while minimum at site I (22.75 ºC) throughout the year (Table No. 6, 1 and Graph I).

2. pH:

During the assessment, we recorded the pH concentration values ranged between 6.15 in winter at site III and 7.92 at site VI. Thus acidic pH 6.15 at site I where as alkaline pH 7.92 at site V in winter season. (Table No.3, 6 and Graph II).

3. Alkalinity:

The average range of maximum value of alkalinity was (150 mg/l) at site I in winter, while minimum (28 mg/l) at site VI in rainy (Graph III and Table No. 1, 6). Results indicated that, in river water carbonate and bicarbonate ions were less dissolved.

4. Hardness:

Hardness results from the presence of divalent cations of which Ca^{++} and Mg^{++} which are most abundant in groundwater. The average range of total hardness was maximum at site I (200.5mg/l) in summer season due to higher concentration of metallic ion while minimum recorded at site VI (47.5mg/l) in rainy season (Table No.1, 6 and Graph IV). Recorded reading indicated that, in river water metallic ions are less dissolved.

5. Chloride:

The most important source of chloride in natural water is discharge of sewage. The minimum value of chloride is 11.49 mg/l at site VI in rainy, whereas maximum 288.72 mg/l in winter season at site I. Water analysis from site I indicated that it was contaminated due to organic content of sewage, agricultural wastes inducing fertilizers etc. with discharge by surrounding areas (Table No.1, 6 and Graph V).

6. Sodium:

The maximum range of sodium seen at site I (86.5mg/l) in summer season while minimum at site VI (5mg/l) in winter (Table No. 1, 6 and Graph VI). Maximum sewage discharge was found at site I leading to its pollution as compared to others.

7. Potassium:

The high concentration of potassium content was noted at site I (79.75mg/l) in rainy season while minimum at site VI (0.5 mg/l) in rainy (Table No. 1, 6 and Graph VII).

8. Iron:

Iron is the vital element of life. It is a natural component of soil and its concentration can be influenced by industrialization. Iron content of water was high at site V (3.53125mg/l) in winter while minimum at site VI (0.02 mg/l) in winter season (Table No.5, 6 and GraphVIII).

9. COD:

Chemical Oxygen Demand found reliable parameter for analysis of water pollution. The maximum COD was found at site V (834 mg/l) in summer season while at site VI (2.75 mg/l) in rainy season (Table No.5, 6 and Graph IX).

10. Total Solids:

Water as a universal solvent it can dissolve different type of materials as compare to other solvents. The average range of total solid content was maximum at site I (708 mg/l) in summer season while minimum at site VI (60 mg/l) in rainy season (Table No. 1, 6 and Graph X).

11. Total Dissolved Solids:

In the present investigation the concentration of total dissolved solid found high at site I (666 mg/l) in summer season which has decreased potability and reduced utility of water for drinking, irrigation and industrial purposes. Minimum range of TDS was seen at site VI (52.5 mg/l) in rainy season (Table No. 1, 6 and Graph XI).

12. Suspended Solids:

The higher concentration of total suspended solids was found due to insoluble organic matter in sewage. The average range of suspended solids was maximum at site I (51.5 mg/l) in winter while minimum at site VI (5 mg/l) in summer season (Table No. 1, 6 and Graph XII). Results Indicated enrichment of suspended solids at site I found unfit for drinking, irrigation and also for industrial purpose.

13. Dissolved Oxygen:

Oxygen is an index of the physical, chemical and biological processes. It also acts as an indicator of trophic status and magnitude of eutrophication in freshwater ecosystem. The concentration of dissolved oxygen ranged between 4.5 mg/l to 8.75 mg/l. It was minimum during summer at site II (4.5 mg/l) and maximum (8.75 mg/l) during rainy at site VI (Table No. 2, 6 and Graph XIII).

14. Free CO_2:

Free CO_2 concentration in water indicates the presence of decomposable organic matter, bacterial action on organic matter and physiological activities of biotic components. The concentration of carbon dioxide values ranged between 7.425 mg/l to 23.8 mg/l. It was minimum during rainy at site VI (7.425 mg/l) and maximum (23.8 mg/l) during summer at site I (Table No. 1, 6 and Graph XIV).

15. Nitrate:

The nitrate concentration values ranged from 0.0725mg/l to 1.92 mg/l. It was maximum at site III in summer season (1.92 mg/l) and was minimum (0.0725mg/l) at site VI during winter season (Table No. 3, 6 and Graph XV).

16. Phosphate:

The phosphate concentration (Table No. 3, 6 and Graph XVI) ranged from 0.04 mg/l to 2.57 mg/l. It was maximum at site III in summer season and minimum at site VI during rainy season.

DISCUSSION:

Thus physico-chemical variables of the present study areas (site I to VI) are subjected to wide variations shown in Table No. 1, 2, 3, 4, 5 and 6 with the mean and standard deviation clearly exhibits that all the sixteen physico-chemical parameters between sites and seasons were significant.

The importance of water as resources is not only tied to its availability and quantity, but also to its quality as it supports the aquatic and terrestrial lives. The qualities of water therefore are explained by its physico-chemical; and biological properties (Ajibade, *et al.,* 2008, Akinnibosun, *et al.,* 2009). Physical parameters including light penetration, temperature and ionic strength, while chemical parameters include dissolved gases, major cations, anions and nutrients viz. nitrogen, phosphorus, potassium and other major and minor nutrients which play significant role in maintaining the quality of water bodies (USEPA, 2005). Domestic waste water effluents and agricultural land use could be raising nutrient levels in water bodies.

Temperature is one of the essential and changeable environmental factors, since it influence the growth and distribution of flora and fauna. The maximum water temperature was recorded during the summer season owing to the clear sky with more solar radiation. Less solar radiation with cloudy sky and more rainfall during the monsoon season greatly reduced the air temperature, as evidenced by Sampathkumar and Kannan (1998) and Karuppasamy *et al*., (1999). The pH is an important factor in determining productivity of ecosystem. pH remained alkaline throughout the study period at all sites indicating that, the water having high buffering capacity resulting limited change of pH values as stated by Jameel, (1998). The acidic pH (below 7) occurs during the summer season could be explained by the uptake of Co_2 by the photosynthesizing organisms, especially phytoplankton.

The high value of alkalinity indicates the presence of weak and strong base such as carbonates, bicarbonates and hydroxides in the water body. The high values of alkalinity may also be due to increase in free carbon dioxide in the river, which ultimately results in the increase in alkalinity. In our investigation the average range of maximum value of alkalinity was (150 mg/l) at site I in winter. So high alkalinity may cause problems if, water is used for irrigation purposes because high alkalinity leads to increase in relative proportion of sodium in soil by precipitating Ca and Mg ions. The values having 40 mg/l and more levels of total alkalinity was considered to be more productive. (Sonawane *et. al.,* 2009). Total hardness of water is not a polluting parameter, but indicates water quality in terms of Ca^{++} and Mg^{++} cations. We found hardness of the Hiranyakeshi River was within the permissible limit of WHO as below 300 mg/l is considered for potability but, beyond this limits cause gastrointestinal irritation (ICMR, 1975). Normal water hardness does not pose any direct health problems. Due to addition of sewage and large scale human use, which might cause elevation of hardness (Dakshini & Soni, 1997; Kumar, 2000; Mohanta & Patra, 2000). The total hardness above 200 mg/l found to be not suitable for domestic use like drinking and cleaning.

Chloride reported to be an indication of pollution when present in higher concentration. As per suggestions of Royal Commission that, water having 30 mg/l of chloride is reported to be fairly clean. Sources of chloride pollution in water include fertilizers, sewage, effluents from drainage, salts and human as well as animal wastes. High chloride content cause high blood pressure in people (Subin *et.al.* 2011). Chlorides are toxic to most plants so they should be checked for irrigation water. The tolerance limit for surface water used for irrigation is 600 mg/l (Fadtare *et. al.,* 2007). The values obtained from above investigation site I, II and from four sites of river Hiranykeshi can be suitably used for irrigation.

Higher values of sodium during summer season and lower during in monsoon was recorded. Evaporation of water had significant factor in increasing sodium level during summer season. Potassium found vital role in the metabolism of freshwater organisms (Krishna Ram *et al.,* 2007). Cell membrane in aquatic animals continually pumps the potassium and sodium, which requires the expenditure of large amount of energy (Goldman and Horne, 1983). Sodium when present in high concentration limits the biological diversity due to its osmotic stress (Adoni *et al.,* 1985). Like, sodium potassium was also a naturally occurring element, but the concentrations in freshwater bodies remained quite lower than the sodium and calcium.

Under low potassium concentration, the growth rate and photosynthesis of algae especially blue green algae becomes poor and respiration get increased (Wetzel, 1983). In present study higher concentration of potassium was recorded in rainy season at site I and lower concentration in rainy season at site VI.

Sedimentation and utilization of potassium by biota caused decrease in its content during winter season (Garg *et al.,* 2006a and b).

In general, concentration of sodium remained quite higher than the potassium in natural water, thus high values being an indication of pollution by domestic sewage (Trivedi & Goel, 1984). The concentration of sodium was higher than that of potassium in the present study. Iron is an essential element in human nutrition. Ridgway (1979) showed that dissolved oxygen decreases with increase in concentration of iron in water. Similar results were found at all sites in our investigation.

Chemical oxygen demand (COD) is a measure of the oxygen equivalent of the organic matter content of water that is susceptible to oxidation by a strong chemical oxidant. Thus, COD was a reliable parameter for judging the extent of pollution in water (Amirkolaie, 2008). The COD of water increases with increasing concentration of organic matter (Boyd, 1981). In our investigation COD concentration is comparatively high at site III and V due addition of chemical waste from Municipal waste of Sankeshwar city and effluent of Hira sugar mills, has being added into river water at site III and site V at this site effluent from Gadhinglaj sugar mill as well as municipal waste of Gadhinglaj city has being discharged. The industrial waste has effect over the hatching, failure of trout eggs, and effect over diurnal and seasonal behavior, changed migration capacity. Overall leads to decrease the tolerency of species. It has been observed that, because of pollution of chemicals, domestic wastes, metal pollution cause change in the species diversity.

EPA, (1976) stated that, total dissolved solids (TDS) in water found mainly in the form of sodium, potassium, calcium, magnesium, carbonates, bicarbonates, chlorides, nitrates and sulphates. They influence the taste, hardness and corrosive property of water. In the present high investigation we found dissolved content of water at site I which was unfit.

In the present study, dissolved oxygen concentration was higher during the monsoon

season at site VI was due to the monsoon floods. The saturation of atmospheric oxygen is more intense in running water than confined water (Singh *et. al*. 2009). The occurrence of high oxygen values suggested that, photosynthesis by phytoplankton acted as the major factor influencing the oxygen distribution as opinioned by Gouda and Panigrahy, (1993). The dissolved oxygen was found to decrease with increasing COD. Higher dissolved oxygen is found in higher pH suggesting the abundant growth of phytoplankton and related zooplankton, leading to high biological activity. In summer season, dissolved oxygen decreased due to increased temperature of water (Naz and Turkmen, 2005). The carbon dioxide content of water depends upon the water temperature, depth, rate of respiration, decomposition of organic matter, chemical nature of the bottom and geographical features of the surrounding water body (Sakhare and Joshi, 2002).

In the present study, higher nitrate content was recorded at site III in summer. This could be possible, as site III found as polluted station with the direct discharges of organic wastes, in addition to the discharge of industrial wastes, the input from the nearby Hirasugar mill waste and munciple waste. Most of the nitrate might have been derived from the decomposition of organic wastes (Satpathy, 1996). The importance of nitrate and phosphate content present in water bodies showed a direct relationship with phytoplankton. Content of nitrate and phosphate also favored good growth of blue green algae. Some of the parameters were also act as indicators of sewage pollution such as chloride, phosphate and nitrate. Trivedy and Goel, (1986) showed increased concentration of chloride, nitrate and phosphate during summer and winter by which plankton population found to be increased which also act as bioindicator of pollution.

The total phosphate content in water due to mixing up of agricultural runoff. From above investigation it showed that on the both the sites of river banks and two reservoirs (site I and site II) the agricultural activities resulted in contamination of water.

CONCLUSION:

The present study revealed that, water quality of site I was found to be more polluted due to huge amounts of pollution. Site III and site V which are near sugar mill found contaminated due to higher concentration of total dissolved solids, chloride, COD, and alkalinity which were recorded greater than permissible limits of WHO. Site VI was found least polluted as that of remaining sites. All the sites found more or less contaminated. It was found that water pollution has direct impact over the animal diversity. The study is in progress for the assessment of water contamination and needs major action for to avoid further contamination and pollution for the better development and survivility of aquatic flora and fauna.

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Fig.1: Map of study area

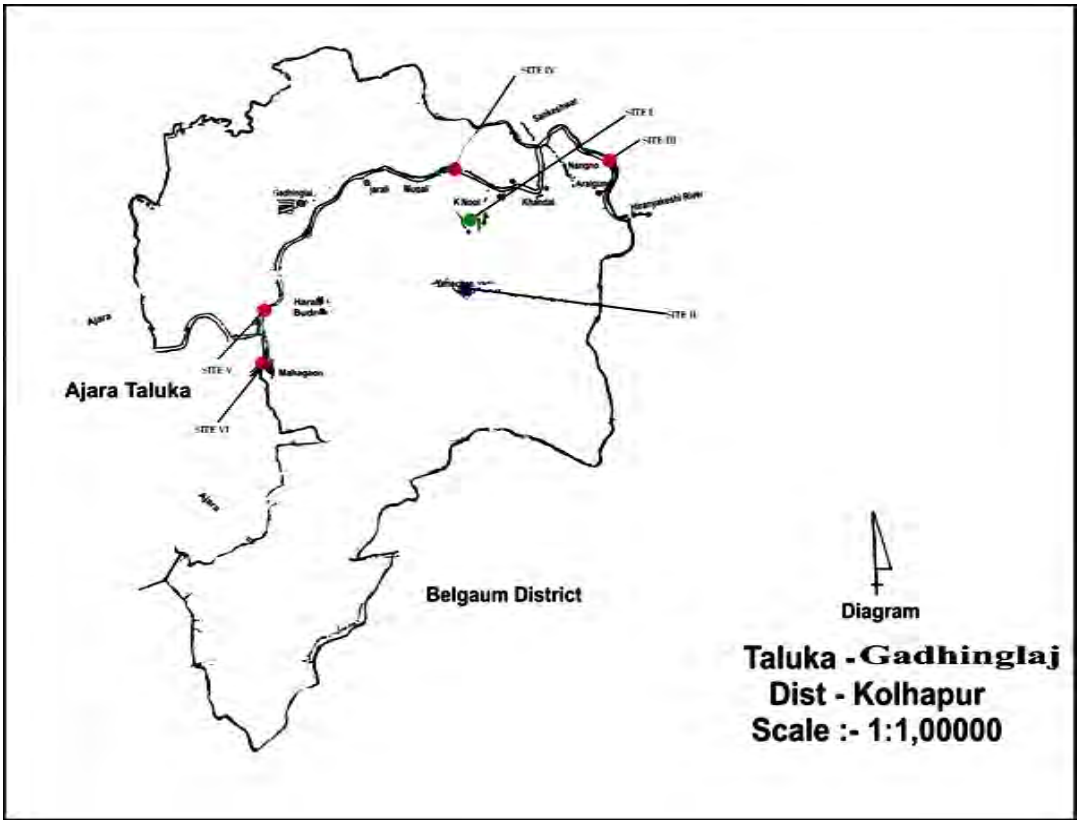
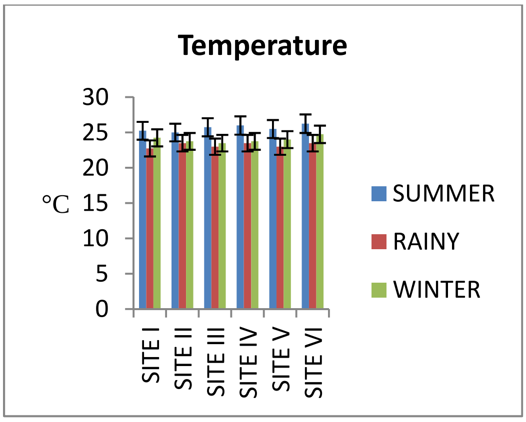
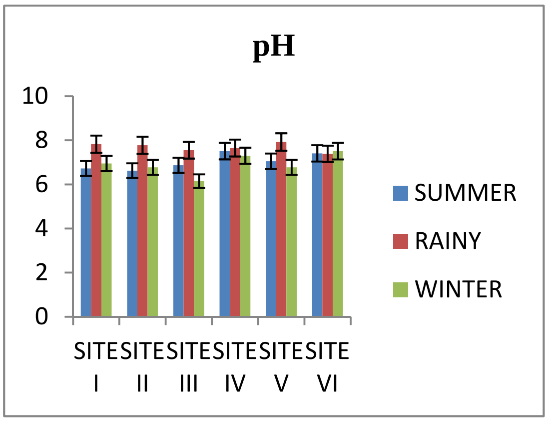


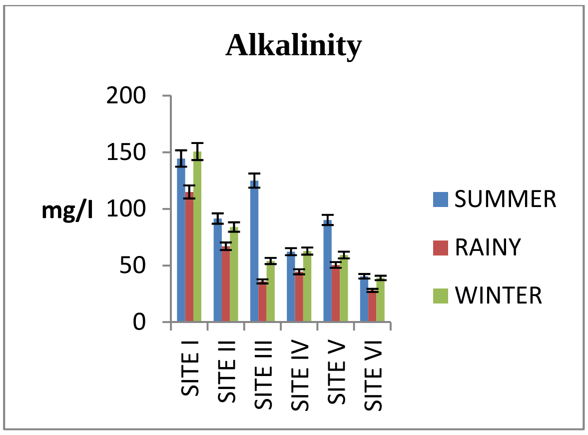
Fig II: Graphical representation of physico-chemical parameters from selected sites.



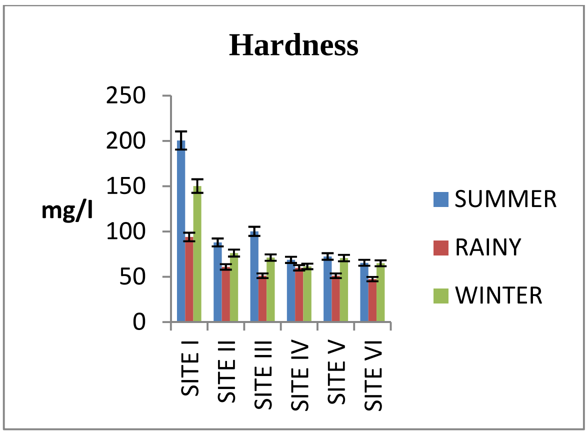
Graph I: Seasonal variation in water temperature



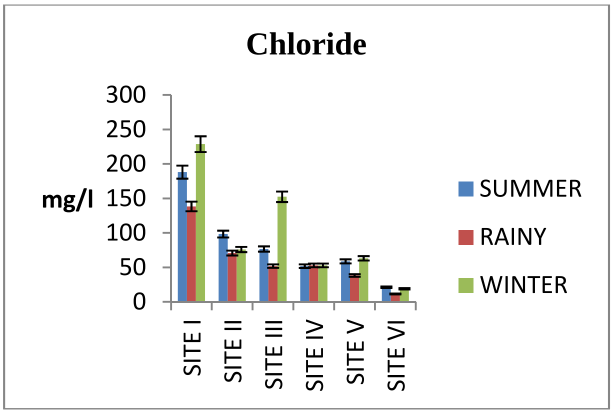
Graph II: Seasonal variation in pH



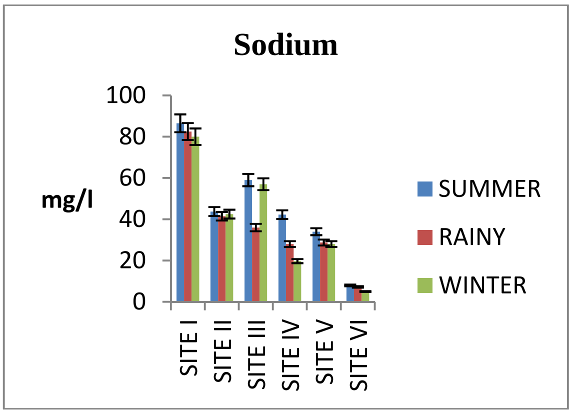
Graph III: Seasonal variation in Alkalinity



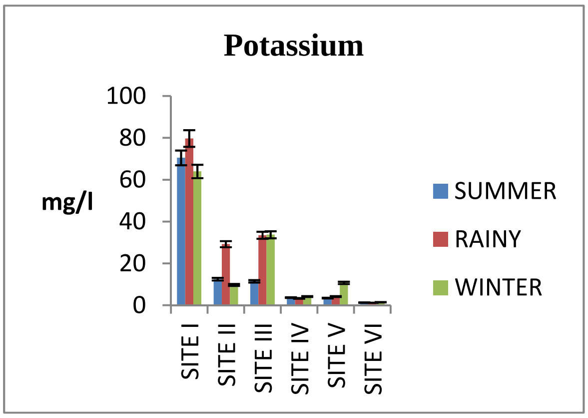
Graph IV: Seasonal variation in Hardness



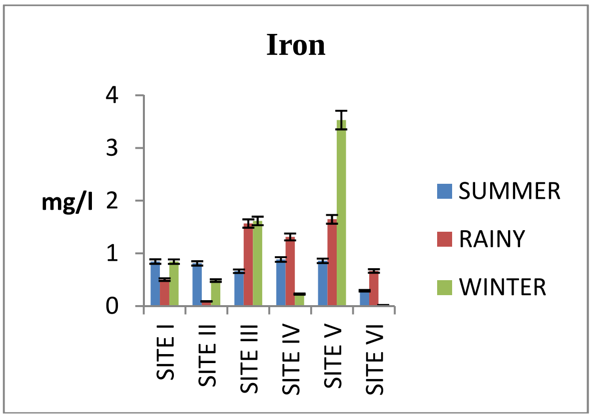
Graph V: Seasonal variation in Chloride



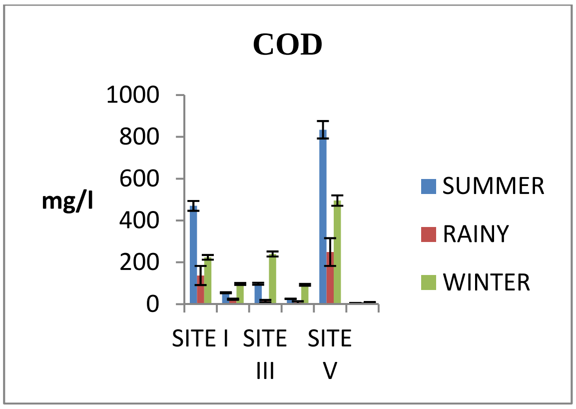
Graph VI: Seasonal variation in Sodium



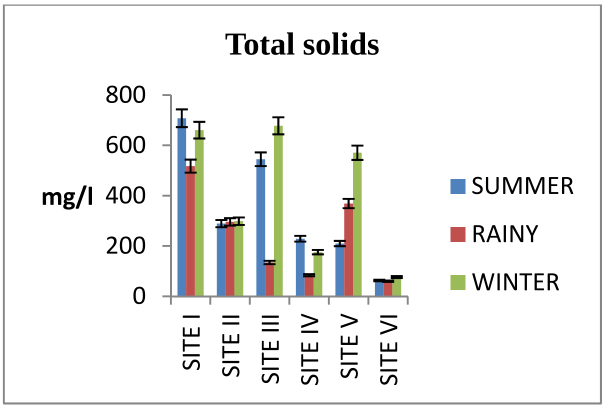
Graph VII: Seasonal variation in Potassium



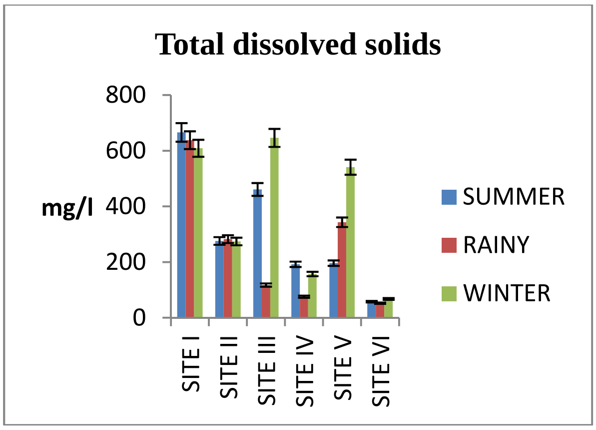
Graph VIII: Seasonal variation in Iron

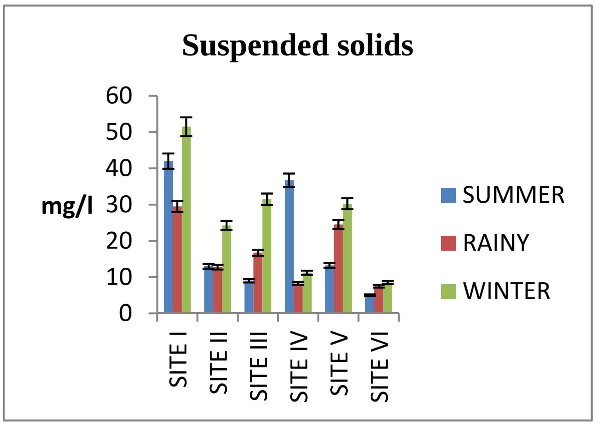


Graph IX: Seasonal variation in COD



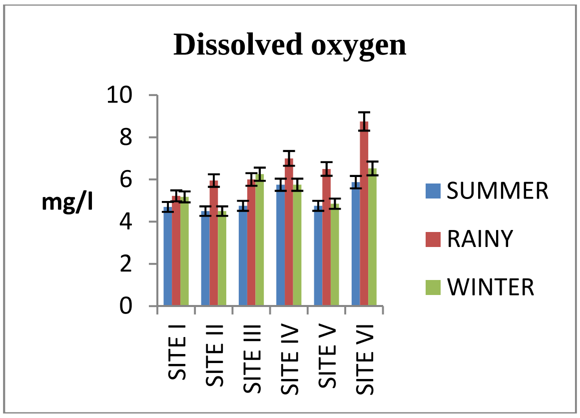
Graph X: Seasonal variation in TS

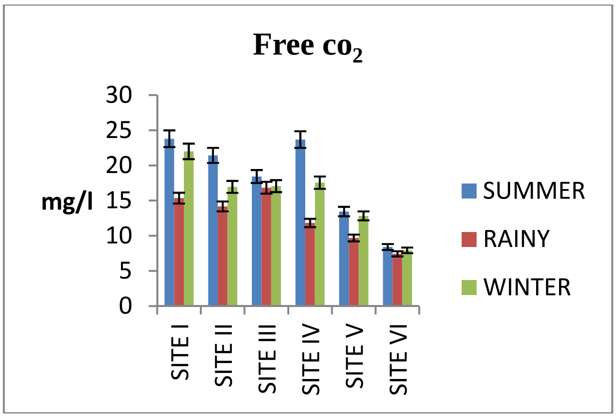




Graph XI: Seasonal variation in TDS

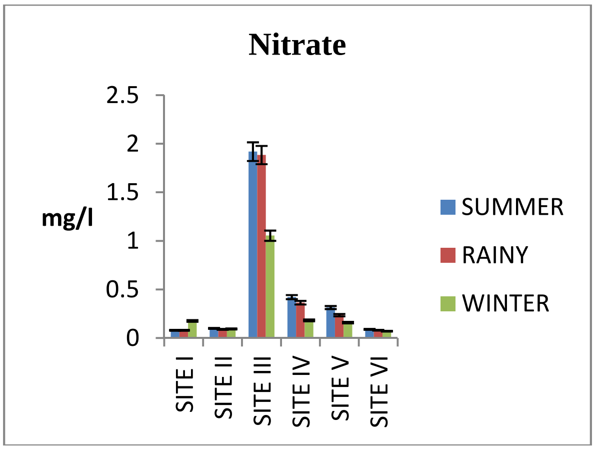
Graph XII: Seasonal variation in SS

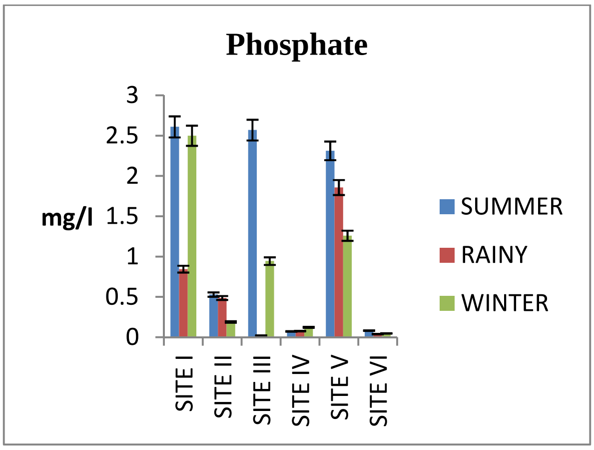




Graph XIII: Seasonal variation in DO

Graph XIV: Seasonal variation in Free CO_2





Graph XV: Seasonal variation in Nitrate

Graph XVI: Seasonal variation in phosphate

Table 1: Seasonal variation of physico-chemical parameter from site I

Parameter	**Seasons**		
	summer	**rainy**	**winter**
Temperature	25.25±0.9574	22.75±2.2173	24.25±0.957
pH	6.72±0.41129	7.825±0.9776	6.95±0.450
Alkalinity	144.5±13.40	115±32.7515	150.65±11.157
Hardness	200.5±48.2044	94±34.1857	150.25±54.603
Chloride	188.11±10.155	138.405±49.760	228.72±98.980
Sodium	86.5±28.172	82.5±8.962	80±12.355
Potassium	70.5±23.8397	79.75±12.763	64±22.405
Iron	0.84625±0.513	0.5035±0.220	0.844±0.357
COD	470±406.494	137±45.745	224±182.654
TS	708±115.250	517.5±324.96	660.5±74.732
TDS	666±94.456	638±33.5857	609±67.221
SS	42±29.988	29.5±9.433	51.5±31
DO	4.7±2.413	5.225±1.461	5.175±0.994
Free co_2	23.8±7.884	15.35±3.415	21.995±8.149
Nitrate	0.08125±0.038	0.08075±0.7997	0.177±0.072
Phosphate	2.61±0.537	0.845±0.656	2.5±0.601

Table 2: Seasonal variation of physico-chemical parameter from site II

Parameter	**Seasons**		
	Summer	**rainy**	**Winter**
Temperature	25±1.825	23.5±2.5166	23.75±2.217
pH	6.625±0.442	7.775±1.252	6.775±0.7675
Alkalinity	91.5±31.384	67±15.033	84±11.547
Hardness	88±24.27	61±21.694	76.25±23.753
Chloride	98.305±12.947	70.7725±17.128	75.9025±21.761
Sodium	43.75±8.808	41.5±4.932	42.5±15.438
Potassium	12.5±13.723	29.25±12.789	9.75±11.324
Iron	0.811±0.447	0.09025±0.0783	0.4845±0.416
COD	54.5±23.0144	23.75±2.8722	97±48.703
TS	289±35.270	296±51.562	298.5±25.370
TDS	276±30.670	282.75±53.5	274.25±34.989
SS	13±5.354	12.75±4.991	24.25±14.056
DO	4.5±1	5.95±1.754	4.5±1.290
Free co_2	21.425±5.216	14.17±3.228	16.95±5.797
Nitrate	0.101±0.0273	0.09075±0.0037	0.095±0.007
Phosphate	0.53±0.1055	0.4875±0.0984	0.19±0.165

Table 3: Seasonal variation of physico-chemical parameter from site III

parameter	**Seasons**		
	Summer	**Rainy**	**Winter**
Temperature	25.75±1.5	23±2.5819	23.5±1.2909
pH	6.8675±0.392	7.55±0.655	6.15±0.58023
Alkalinity	125±112.809	36±6.055	54±24.276
Hardness	100.25±24.1988	51.25±22.5	71.25±12.996
Chloride	76.6875±41.430	51.855±55.466	152.39±20.804
Sodium	59±15.705	36±16.753	57±16.451
Potassium	11.5±3.872	33.5±10.847	33.75±9.604
Iron	0.66225±0.716	1.56775±0.569	1.617±1.0933
COD	97.5±90.559	14.5±5.744	240±233.978
TS	545±266.755	134.5±106.61	677.75±649.965
TDS	461±341.582	117.75±96.347	646.25±645.043
SS	9±4.760	16.75±10.5	31.5±9.574
DO	4.75±1.5	6±1.4142	6.25±2.217
Free co_2	18.425±2.710	16.825±4.7077	17.055±4.534
Nitrate	1.92±0.0546	1.885±0.0714	1.055±0.526
Phosphate	2.57±0.105	0.022±0.0090	0.945±1.255

Table 4: Seasonal variation of physico-chemical parameter from site IV

Parameter	**Seasons**		
	summer	**rainy**	**winter**
Temperature	26±1.632993	23.5±1.732051	23.75±0.5
pH	7.51±0.463753	7.65±0.759386	7.3±0.391578
Alkalinity	62.25±19.6023	44.5±22.9855	62.75±11.44188
Hardness	68.75±14.77329	60±13.56466	61.5±14.27118
Chloride	51.83±35.95153	19.0275±2.699153	52.8775±17.74148
Sodium	42.25±19.36276	28±14.16569	19.75±2.872281
Potassium	3.75±2.872281	3.333333±0.57735	4.25±2.629956
Iron	0.885±0.876004	1.313±0.604442	0.228±0.075666
COD	25.5±5.196152	8±6.164414	92.5±62.55398
TS	229±149.7598	84±51.56226	175.5±111.4077
TDS	192.25±99.63391	75.75±51.77113	157.5±115.2432
SS	36.75±58.35166	8.25±0.5	11.25±4.99166
DO	5.75±2.061553	7±0.816497	5.75±2.217356
Free co_2	23.675±5.550601	11.815±3.936949	17.55±6.378997
Nitrate	0.4225±0.043493	0.365±0.259551	0.18325±0.129927
Phosphate	0.073±0.007703	0.0775±0.062383	0.12425±0.053842

Table 5: Seasonal variation of physico-chemical parameter from site V

Parameter	Seasons		
	Summer	**Rainy**	**Winter**
Temperature	25.5±1.732	23±1.8257	24±1.15470
pH	7.0475±0.5811	7.925±0.639	6.775±1.0843
Alkalinity	90.25±40.631	50.5±14.456	59.25±12.945
Hardness	72.5±17.253	51.25±2.5	70.75±27.4271
Chloride	58.75±1.3699	38.21±20.0514	63.16±7.0627
Sodium	34±17.435	28.75±9.358	28±7.0710
Potassium	3.5±2.645	4.25±4.03112	10.75±3.403
Iron	0.85975±0.961	1.64775±1.659	3.53125±2.1695
COD	834±748.16	249.25±66.269	495.5±514.049
TS	209.75±122.31	369±194.357	570.75±69.615
TDS	196.5±121.179	343.25±194.93	541±47.4833
SS	13.25±12.841	24.5±22.590	30.25±28.663
DO	4.75±0.5	6.5±1.7320	4.85±1.135
Free co_2	13.4425±8.888	9.675±3.896	12.825±3.704
Nitrate	0.315±0.06557	0.23725±0.194	0.16025±0.07585
Phosphate	2.3125±s0.0411	1.8575±0.633	1.26±0.698

Table 6: Seasonal variation of physico-chemical parameter from site VI

Parameter	Season		
	Summer	**Rainy**	**winter**
Temperature	26.25±2.0615	23.5±2.516611	24.75±1.5
pH	7.41±0.32104	7.3875±0.278014	7.5075±0.369989
Alkalinity	40.5±6.8068	28±14.76482	39±12.46328
Hardness	65.5±28.734	47.5±13.0767	65±9.69536
Chloride	21.3±8.8299	11.4925±1.894437	19.0075±0.849524
Sodium	8±3.1622	7.25±2.753785	5±0.816497
Potassium	1.333333±0.577	1.25±0.5	1.5±0.57735
Iron	0.291±0.213	0.6675±0.653102	0.02±0
COD	5.625±4.269	2.75±0.957427	9±10
TS	63±10.893	60±19.86622	76.5±18.64582
TDS	58±13.1656	52.5±13.27906	68±12.75408
SS	5±3.464	7.5±7.852813	8.5±6.608076
DO	5.87±1.314	8.75±0.5	6.525±1.147098
Free co_2	8.4±1.870	7.425±2.781337	7.925±3.781865
Nitrate	0.09025±0.014	0.0815±0.007724	0.0725±0.00755
phosphate	0.08325±0.006	0.04±0.014142	0.049±0.025742