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SURFACE WATER QUALITY OF THE RIVER KRISHNA, SANGLI DISTRICT, MAHARASHTRA, INDIA

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Abstract: Deterioration of water quality became challenging task before the scientific community. The only reliable way to counteract with this dreadful problem of water pollution is periodical monitoring of aquatic resources by means of evaluating its physical and chemical properties. Krishna River, Sangli is considered as one of the sacred and second largest river from the Maharashtra state, India. However, the river is now facing the severe problem of contamination. By keeping in view the need of periodical monitoring present investigation was carried out to assess the water quality of the river Krishna, Sangli Maharashtra, India. Different physicochemical parameters were periodically investigated during the assessment period in order to denote the level of contamination from the study region. Physicochemical properties showed significant variation and denote the better water quality along with continuously polluting status of the river Krishna at study region. Present investigation confirms the need of immediate action plan to keep check on the pollution and for maintaining the better water quality of the river Krishna.
Keywords: Krishna River; Physicochemical properties; Pollution; Water quality.
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INTRODUCTION

Water is important parameter for survivality of the life on earth. Rivers found immensely important, due to its higher water retaining capacity and widely distributed flow of water (Peel and Mcmahon, 2006). It plays vital role in concretion of biotic community along the marginal area and so forms main basis of topography of the area (Redmond and Koch, 1991). It contributes in hydrological cycle and confirms the regular availability of water. Large flow of river for thousands of miles across the land area provides valued freshwater, which get utilized for drinking, irrigation, agricultural, domestic and industrial activities (Sehgal, 2012). The total length of Indian riverine systems is 2900 km which flourishes huge floral and faunal diversity. The ample amount of freshwater resulted in to water associated activities such as farming, fishery etc. which forms the basis of Indian economy (CWC, 1997). India has the second largest population of the world, which requires tremendous amount of water per day (Hegde, 2011). But due to the limited and unevenly distributed aquatic resources, we face water crises and these conditions become worst day by day. Along with restricted resources, thickest population of India contributes large scale water contaminating activities, resulted in to the deterioration of these natural water resources (Central Pollution Control Board, 2005). Due to continuously deteriorated aquatic systems, millions of Indians did not have access to clean drinking water (Chitale, 1992). By upcoming each and every day, water pollution has becoming the dreadful concern to counteract with, which requires through investigation, curative methodologies and precautionary measures. Hence, deterioration of water quality becomes challenging task before the scientific community. The only reliable way to counteract with this dreadful problem of water pollution is periodical monitoring of aquatic resources by means of evaluating its physical and chemical properties, which describe the water quality and keep check on the level of contamination. Along with this, periodical monitoring also regulates the further contamination and provides vital information on the spreading of water born diseases.

Krishna River is one of the important and sacred river form Maharashtra, Karnataka, Telangana and Andhra Pradesh states. It originates at Mahableshwar and finally drains down in to the Bay of Bengal. During its 810 miles large flow it provides valuable freshwater, that found as a major source of drinking, irrigation and industrial activities for the nearby situated thousands of villages and cities. However, in return river get large amount of domestic and agricultural sewage along with industrial effluents. So, now the river is facing the serious problem of water pollution which further causes the severe health impairments to the human along with aquatic flora and fauna of the river. By keeping in view the above mentioned scenario of the river Krishna, present investigation was carried out to determine the water quality of the river Krishna at Sangli district, Maharashtra, India. Present investigation enlightens the level of contamination at the region and describes the status of the river in terms of its water quality.

EXPERIMENTAL

Study Area: The River Krishna originates at Mahableshwar near the village Jor of Wai Taluka, Satara District, Maharashtra, India. Delta of the river Krishna considered as one of the most fertile regions in India. River Krishna begins its journey, at Mahableshwar and continues in the large flow pattern until finally reaches to the Bay of Bengal. During the 1400 Km flow, it receives the waters from the tributaries and continued in a wider pattern. River water found most reliable source of freshwater for drinking, agricultural and industrial activities for the nearby areas, which in turns contaminates the river by dumping huge amount of waste produced per day. Its large catchment area provides ample amount water and forms the sinks for dumping of domestic waste and industrial effluents from nearby situated villages and industries. During the flow it covers 2, 58, 948 Km^2 area, which includes number of districts and states of India. During this huge flow, the river accumulates million liters of pollutants through number of sources, which contributed in the heavy polluting status of River.

Monitoring Stations: Five monitoring stations *viz*. Borgaon (K_1), Takari (K_2), Bhilawadi (K_3), Sangli (K_4) and Ankli (K_5) were selected for regular analysis. Amongst the selected stations K_1 and K_2 were from upstream and K_3, K_4 and K_5 were located to the downstream of the river (Figure 1). Latitude and longitudinal co-ordinates of these monitoring stations were expressed in the Table 1.

Table 1. Geographical distribution of the selected Monitoring Stations on River Krishna- Sangli

Code	Name	Longitude	Latitude	Elevation from Sea level
K_1	Borgaon	17º 05' N	74º 19' E	1836 ft.
K_2	Takari	17º 06' N	74º 21' E	1800 ft.
K_3	Bhilawadi	16º 59' N	74º 28' E	1804 ft.
K_4	Sangli	16º 48' N	74º 34' E	1774 ft.
K_5	Ankli	17º 05' N	74º 19' E	1773 ft.

Sampling: For all stations, monthly water sampling was carried out at early hours of the day *i.e.* before 10.00 AM during the assessment period.

Physicochemical Analysis: Water samples from each of sites were collected monthly by applying standard methods, in the period of March 2011 to February 2013. Sampling was carried using one litter acid leached polythene bottle. Physical parameters as Temperature and pH of the water were measured in situe at every monitoring sites using thermometer and calibrated pH meter (Hanna, pocket pH meter). Total Solids (TS) and Total Dissolved Solids (TDS) were determined by Hach's gravetric method. Other chemical parameters as-

Dissolved Oxygen (DO), (Wrinkler's Idometric Method), Total Hardness (TH), (EDTA method), Total Alkalinity (TA), (Simple titration method), Free Carbon Dioxide (CO_2), (Simple titration method), Inorganic Phosphate (IP), (Molybdophosphoric Blue Colour method), Nitrate, (Brucine method) and Total Chloride (TC), (Simple Titration method) were studied as standardized by APHA (2005).

Statistical Analysis: All the values were calculated, analyzed and tabulated. Data was summarized by applying standard deviations and presented graphically. Comparison was made by considering pollution status at different sites.

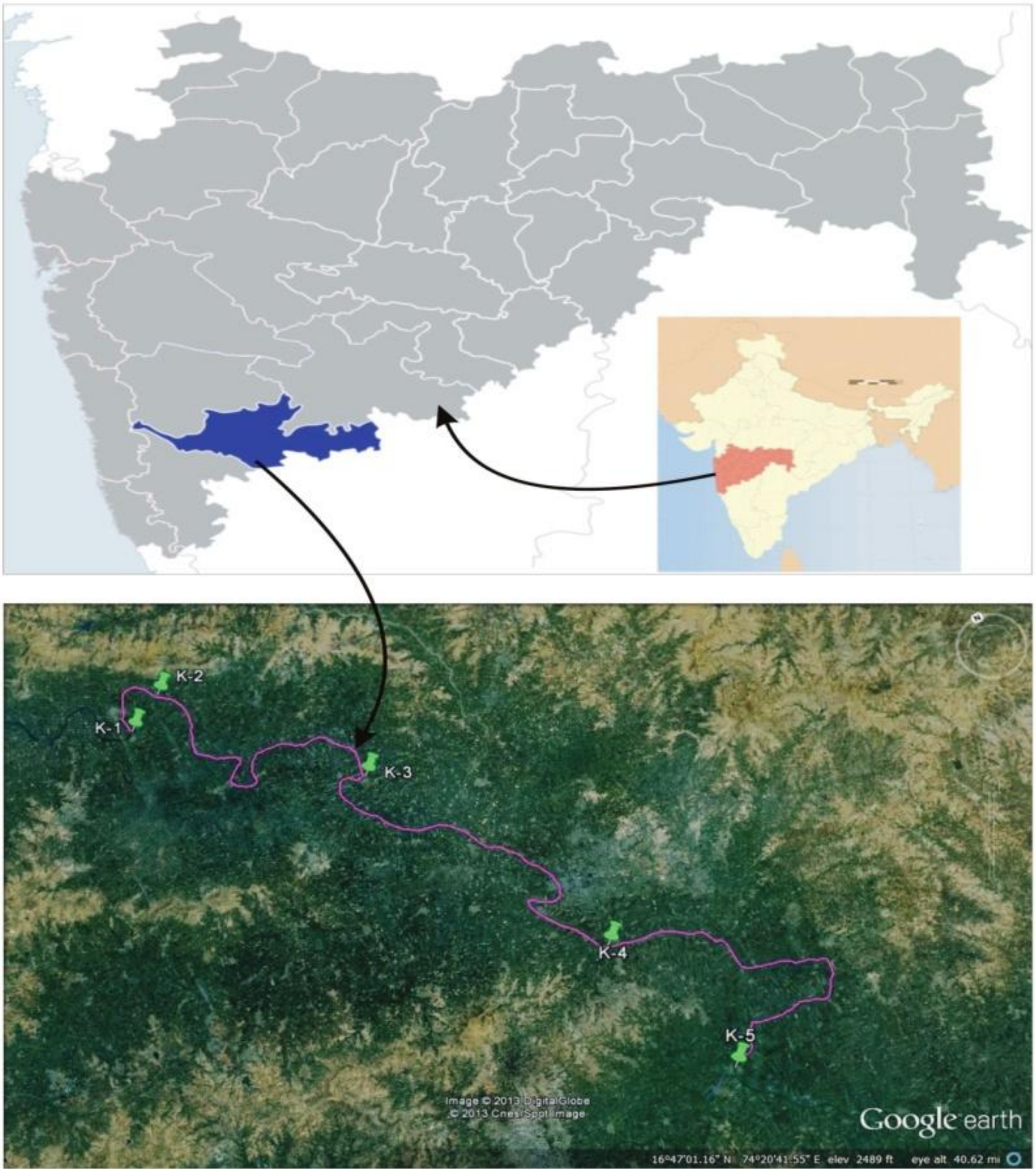

Figure 1. Graphical view of the Krishna River, Sangli, Maharashtra, India, representing the monitoring stations distributed along the length of the River

RESULTS AND DISCUSSION

Average values of physicochemical variables (± S.D) with WHO standards were showed in the Table 2.

The pH: Specific pH affects the chemical reaction in aquatic bodies, hence rewarded as crucial factor in aquatic ecosystem (Wang, 2002 and Fakayode, 2005). pH is measure of the intensity of acidity or alkalinity in the water and reflects the hydrogen ions concentration in the water. During the entire period of investigation, pH showed average alkaline nature and ranged between 7.7 to 8.2. For sustenance of aquatic life, the average range of pH required is 6.5 to 8.2 (Chapman, 1996 and Jena, 2013). During the investigation lowest pH values were recorded at monitoring station K_3 whereas maximum values were found at monitoring station K_5 (Figure 2). However, the observed values were below the WHO standards giving the positive remark of palatability of the water. Continuous fluctuation in pH at all the monitoring stations may be result of temperature variation, decomposition of organic matter and dilution of water through surface runoff as mentioned by Rajasegar, (2003); Juahir, (2009) and Budhlani and Nagarnaik, (2011).

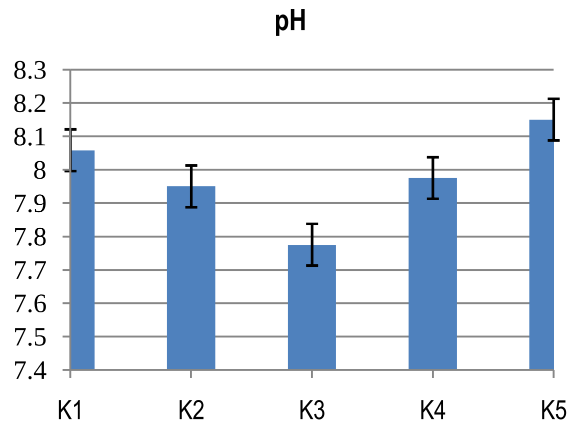

Figure 2. Average pH noted from different Monitoring stations

Table 2. Average Annual Distribution of the Physicochemical Variables from Krishna River

Parameter	WHO Standards	Monitoring Stations				
		K_1	K_2	K_3	K_4	K_5
pH	6.5-8.5	8.058333± 0.314667	7.95± 0.211058	7.788462± 0.286436	7.975± 0.313702	8.15± 0.3
Temp.° C	< 40	21.83333	21.75	21.67308	21.75	22.75
TS mg/L	500	241.3333± 60.33442	206.3333± 63.02573	249.7179± 51.79915	278.6667± 57.24165	351± 63.27142
TDS mg/L	2000	117.6667± 48.58607	93± 42.64441	137.3077± 43.32121	146.3333± 35.95789	174± 52.52878
DO mg/L	5-7	0.985± 0.369951	1.034167± 0.330026	0.945705± 0.394066	0.983333± 0.216725	0.816667± 0.248022
CO_2 mg/L	22	11.61167± 0.114765	9.589167± 1.809337	10.04686± 2.086443	9.901667± 2.034604	15.04± 1.794709
TH mg/L	300	242.8333± 03.85499	230.8333± 6.846809	229.2949± 6.630965	233± 5.22233	244.6667± 4.292347
TA mg/L	200	242.8333± 16.3936	233.3333± 19.5789	232.5641± 15	233± 14.27543	250± 16.92228
TC mg/L	200	75.73333± 2.861434	72.53833± 2.994473	65.98449± 2.302322	71.47333± 1.849803	74.43167± 2.38061
Ip mg/L	45	0.736667± 0.154115	0.613333± 0.137862	0.46± 0.167549	0.661667± 0.205242	0.751667± 0.099712
Nitrate mg/L	45	3.425± 0.619567	3.12± 0.832564	2.732308± 0.639602	3.258333± 0.566422	3.866667± 0.694568

Temperature: Temperature considered as immensely important factor and has key role in biochemical interactions (Gangwar, 2012). It affects the solubility of many compounds, which in turns interferes with the metabolic processes of aquatic organisms.Temperature was noted as the most critical factor affecting aquatic life and physicochemical parameters of the aquatic system (Tassaduqe *et al.*, 2003). The average range of fluctuation for temperature varied between 21 ºC to 23 ºC during the entire study period. The lowest temperature value was noted from the monitoring station K_3, whereas higher temperature picks were observed from the monitoring station K_5 of the river from overall assessment period (Figure 3). The observed values well were below the WHO standards denoting the suitability of the water form study region.

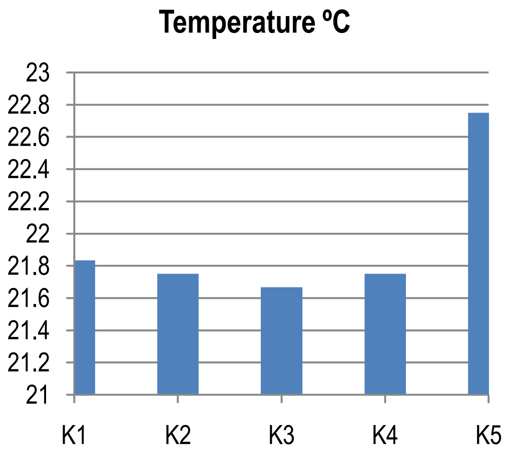

Figure 3. Average Temperature noted from different monitoring stations

The temperature range at station K_5 was noted as continuously altering, which should be the result of excess industrial effluents and sewage disposal in to the area as stated by the Joshi, (2009) for Ganga river.

Total Solids: Analysis of TS found as an important tool for the assessment of biological waste from the water sample. It is measure of the suspended particulate matter in the water body. It gets utilized in waste treatment plants of water, as it gives out level of turbidity (Singh, 2010). High level of turbidity amplifies the total surface area of the solids in suspension, which is fruitful for bacterial growth (Baghel *et al.*, 2005). Total solids concentration in the water denoted the total amount of inorganic chemicals in solution (Furhan *et al.*, 2004). The results for average TS concentration were noted with range of 200 to 360 mg/L. The lowest values were recorded at monitoring station K_2 and K_3, whereas maximum picks were noted for monitoring station K_5 (Figure 4). The values obtained were within the standards of WHO, presenting less turbidity of water and implies the low level of contamination at respective monitoring stations. The numerical values of TS were in agreement with the Patra, (1987).

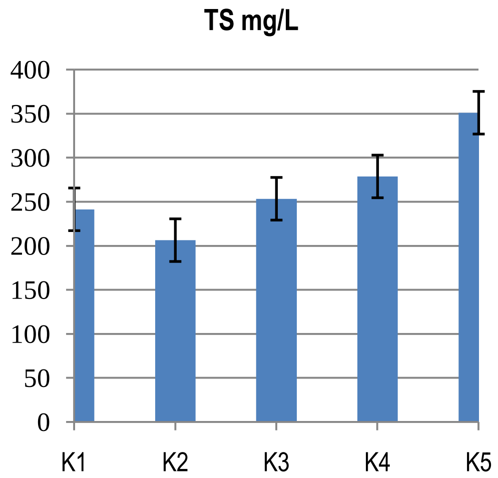

Figure 4. Average Total Solid content noted from different locations

Total Dissolved Solids: TDS found measure ofthe amount of dissolved material from the water body and served as parameter for pollution indicator, as higher TDS resulted in excess ionic concentration (Bhatt, 1999). Higher TDS in water may interfere with the clarity, color, odor and taste of the water. It depends upon several factors like rainfall, surface runoff and geographical characters of water area. Inorganic constituents contributed major proportion amongst total concentration of TDS (Kabir *et al.*, 2002). The average TDS concentration ranged between 80 to 180 mg/L. Maximum pick in the TDS was noted at monitoring station K_5, whereas least value was found at monitoring stations K_2 (Figure 5).

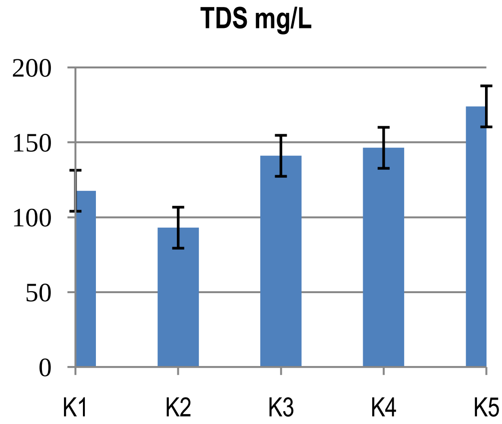

Figure 5. Average Total Dissolved Solid content at monitoring locations

Determined values were well within the WHO standards giving positive remark for suitability of water at respective monitoring stations.

Similar lines of results were noted by Payne, (1986) while studying the ecology of the John's river. The results confirmed that TDS content of river was well within the permissible limits, which made the river habitat favorable for regulation of aquatic biodiversity as previously mentioned by Mbalassa, (2014) for the river Ishasha.

Dissolved Oxygen: Dissolved Oxygen (DO) in water considered as essential factor for sustaining life forms in aquatic ecosystem (Patil *et al.*, 2012). Dissolved oxygen reflects the physical and biological processes prevailing in the waters and found essential to maintain the higher forms of biological life in the waters. Deficiency of dissolved oxygen gives bad odor to water due to anaerobic decomposition of organic waste (Manivasakam, 1980). Low oxygen concentration is generally associated with heavy contamination by organic matter (Majid, 2010). Adequate DO concentration found necessary for better water quality, survival of aquatic life and decomposition of waste by microbes (Islam et al., 2010). The average concentration of DO observed between 0.8 to 1.2 mg/L during entire sampling period. Maximum concentration of the DO were recorded at monitoring stations K_1 and K_2, whereas least concentration was noted for monitoring station K_5 during the study period (Figure 6). However, DO concentration was noted well below the WHO standards which may be the result of excess nutrients concentration and higher organic activities at the region. Low level of DO found related to temperature of the water and biological activities of the aquatic biota as previously mentioned by Chapman, (1992). The results obtained described the lower concentration of the dissolved oxygen, which may be major cause of worry in near future.

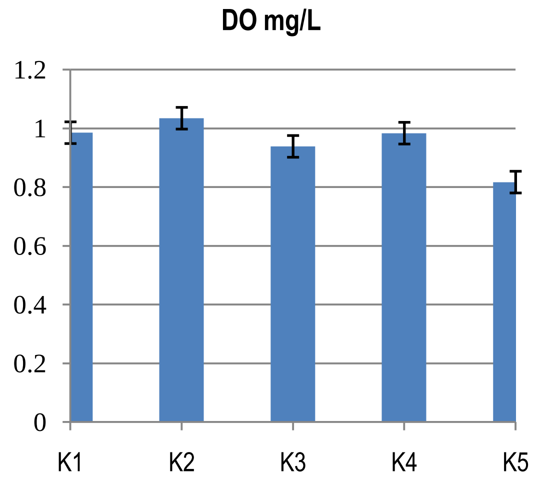

Figure 6. Average Dissolved Oxygen at different Locations

Free Carbon Dioxide: Carbon dioxide was produced in to the natural water as a result of respiratory activities of aquatic flora and fauna along with decay of organic matter (Parihar *et al.*, 2012). Concentration of free CO_2 provided direct evidences for polluting status of water. As excess concentration of CO_2 resulted from deoxygenation tends to enhance the water temperature, leading direct impact over aquatic biota, hence considered as limiting factor (Talling, 1957 and Joshi *et al.*, 2009). Increased CO_2 concentration found directly associated with the temperature, alkalinity and hardness of the river water and hence considered as crucial limiting factor for the well being of aquatic life (Trivedy *et al.,* 2009; Deepak and Singh, 2014). It exhibits reverse pattern to that of DO. The average range of CO_2 noted was 9 mg/L to 16 mg/L. during the investigation period. Maximum CO_2 concentrations were noted from monitoring station K_5, whereas lowest concentrations were achieved at monitoring station K_2 (Figure 7). Concentration of CO_2 found elevated up to maximum miscible limits of the WHO, which gives alarming indication of the increased aquatic contamination by the anthropogenic inputs. Similar lines of results were also noted by the Kumar and Bahadur, (2009) for the River Koshi.

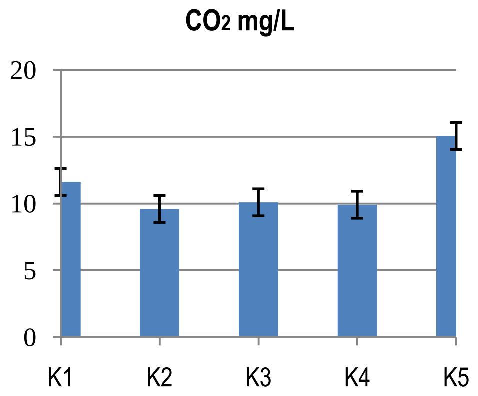

Figure 7. Average Free Carbon Dioxide concentration at monitoring locations

Total Hardness: Total hardness calculated as measure of polyvalent cations or complex organic constituent's capacity of forming soap (Shrivastava, 2002). Total Hardness can be effectively used as pollution indicator as Total Hardness greater than 500 mg/L has deleterious effects over the biota and becomes unsuitable for domestic usage (Edenam *et al.*, 2001 and Khan *et al.*, 2012). During the overall experimentation, average values recorded between 225 to 250 mg/L. The maximum pick in the TH concentrations were recorder at monitoring station K_5, while lowest concentration were noted at monitoring station K_3, during entire investigation period (Figure 8).

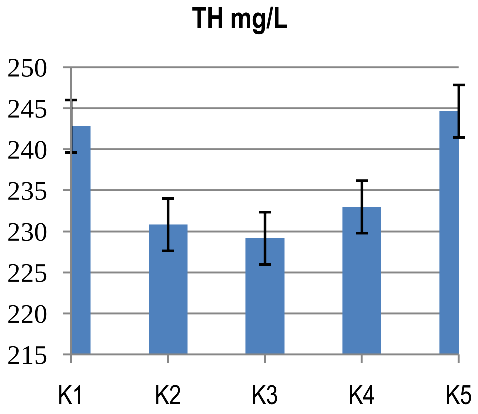

Figure 8: Average Total Hardness concentration at monitoring locations

The results obtained were well below the WHO standard, which confirmed the suitability of water for variety of usages. However, observed hardness values denoted the increasing level of contamination at river basin.

Total Alkalinity: The acid neutralizing capacity of water gets determined by the alkalinity of aquatic system (Murangan and Prabaharan, 2012). It is basic property of water to withstand with solubility of varieties of organic and inorganic substances (Aggarwal, 2012). Average range of 230 to 250 mg/L was recorded during experimentation. Maximum concentration of TA was noted at monitoring station K_5, while monitoring station K_2 and K_3 were noted with least concentration of TA (Figure 9). The values obtained for TA concentration were noted above the WHO standards, which remarked the increasing level of pollution or contamination of the river basin, as a result of deposition of sewage and agricultural waste along with industrial effluents in the study region as previously mentioned by Bhuyan *et al.,* (2010) and Mushahida and Kamruzzaman, (2013) for surface water of Bangladesh.

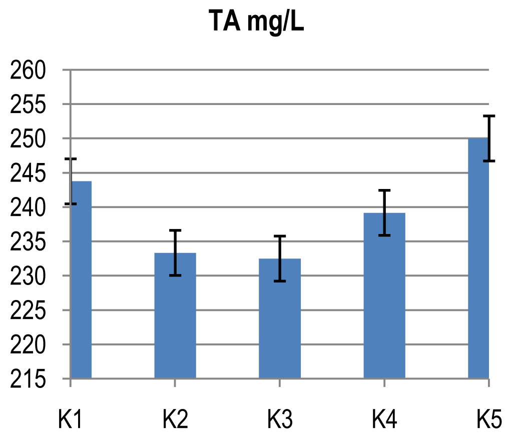

Figure 9. Average Total Alkalinity Concentration at monitoring locations

Total Chloride: In river waters, chloride concentration was noted as the most troublesome anion (Ojutiku and Koloanda, 2011). Increased chloride concentration causes toxic effects over to the plants and animals and became undesirable to use in steel boilers due to acceleration of corrosion by other factors (Bhadra, 2005). Excess chloride in water gives salty taste to water and has laxative effects in organisms (Das, 2003). Hence, excess chloride content considered as good indicator of water pollution. Average TC values were ranged in between 64 to 76 mg/L. The maximum concentrations were noted at monitoring station K_1 and K_5, while minimum was recorded at monitoring station K_3during the assessment period (Figure10).

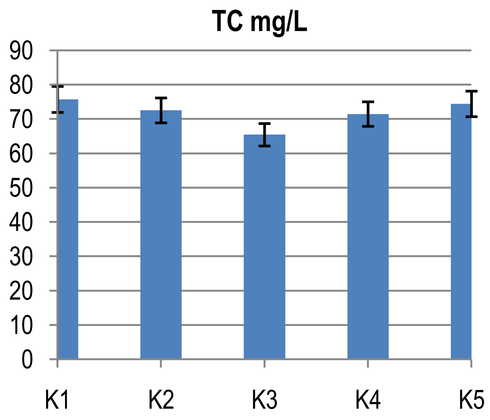

Figure 10. Average Total Chloride Concentration

The values noted were below the permissible limits of WHO standards, representing moderate contamination of aquatic system, reasons for which were continuous dumping of sewage and agricultural waste in the system (Heukelekian, 1957 and Kleain, 1957). The results obtained comply with the investigations of Ahmed, (2004) for river Padma.

Inorganic Phosphate: Inorganic phosphate found freely available in natural water bodies, but in very minute concentrations. It is amongst the few essential nutrients, which required for the plant growth, but in tiny fraction only (Thirumala *et al.*, 2011). Excess inorganic phosphate comes from disposal of detergent, contaminated sewage, washed cloths and also from use of fertilizer and pesticides (Grunning, 2011).Agricultural fertilizers containing phosphate, raw sewage and waste water containing detergents are the source of Inorganic phosphate and Nitrates in the water bodies (Murdoch, 2001). The results for Inorganic phosphate concentration were noted within the range of 0.4 to 0.8 mg Inorganic phosphate /L. The highest concentrations of Inorganic phosphate were noted from monitoring station K_5, while lowest were observed at monitoring station K_3 and remaining monitoring stations were found with average values of Ip concentration (Figure 11).

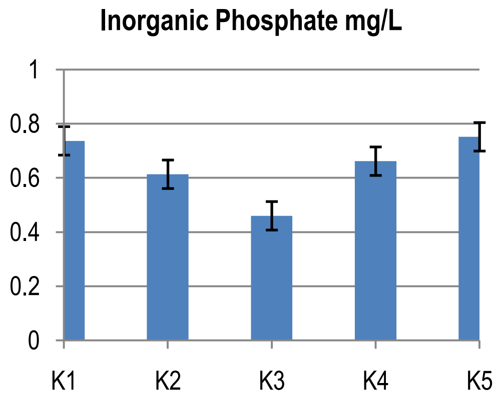

Figure 11. Average Inorganic phosphate concentration at different Locations

However, the observed values were below the WHO standards, denoting average water quality and palatability of the study regions. The results achieved were in conformity with the Zafar and Sultan's, (2008) observation of the Taghra Reserviors.

Nitrates: Fertilizers containing nitrate, along with ammonia, urea and amines were noted as chief source of the nitrate concentration in to the freshwater (Mandal *et al.,* 2012). When nitrogen fertilizers were applied in to the fields, they find their ways to the water bodies and severely affect the environment. As fertilizers should not degrade easily, they remained for longer duration and entered in to the body through drinking water (BCAS, 2004). During the investigation average nitrate, concentrations ranged between 2.5 to 4 mg/L. Their maximum concentrations were recorded from monitoring stations K_5; while least concentrations were noted form monitoring station K_3 throughout the period of investigation (Figure 12).

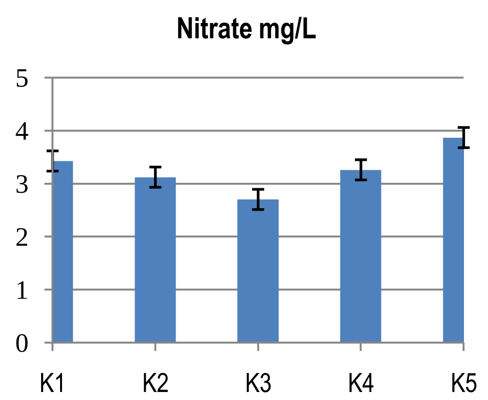

Figure 12. Average Nitrate Concentration

The average nitrate content obtained was below the WHO standards, representing less contamination aquatic system. Similar observations were also reported by Royer *et al.* (2004). Water quality assessment was noted as baseline of water quality management and thus periodical monitoring of water quality of the river, by applying physicochemical variables became necessary to regulate better water quality of the river (Rani *et al.,* 2011). Assessment of physicochemical parameters of river Krishna was noted as fascinating phenomenon caused due to imbalanced process of mineralization and its consumption as priorly mentioned by Morris, (2000) and Adeyemo, (2008) for number of rivers. During the entire flows of the river Krishna the monitoring station K_3 *i.e.* Bhilawadi and K_2 *i.e.* Takari were noted as comparatively very less polluted zones, whereas monitoring stations K_1 and K_4 *i.e.* Borgaon and Sangli were observed with moderate amount of pollution and noted as continuously contaminating zones of the river. However, monitoring station K_5 *i.e.* Ankali was noted as grossly polluted station as physicochemical parameters at the site exceeded or reaches the miscible limits of WHO.

CONCLUSION

Results confirmed favorable surface water quality of the river Kirshna. Seasonal variation in the assessed physicochemical parameters is results of environmental factors and anthropogenic inputs. Hence, in order to avoid further contamination of the river water periodic monitoring becomes necessary measure.

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