Assessment of surface water and soil quality along the coastal region of Mangaluru

D.A. Kiran and H.K. Ramaraju

Abstract-- **Majority of the industries located in the Mangaluru Coastal region, discharge their waste directly or indirectly into the Arabian Sea through the west flowing rivers of the region and also, due to the addition of municipal and sewage wastes, the surface water quality and soil quality were affected and causing the Physicochemical characteristics to alter. 10 Surface water samples and six soil samples were collected from selected locations of the study area and analyzed for various parameters by adopting standard methods. High values of Hardness, BOD and COD were found in the surface waters near Baikampady industrial area. With respect to soil samples, most of samples were acidic in nature and not met the sufficient range for agricultural activities.**

Key words -- Mangaluru Coastal region; surface water; soil quality; physico-chemical characteristics; conductivity.

I. Introduction

Coastal environment is persistently stressed from anthropogenic activities and other developmental activities. Improper and excessive use of natural resources has resulted in long term environmental degradations for short term economic benefits. Human settlement and the developmental activities along the coastal regions have greatly accelerated environmental pressure on downstream estuarine and coastal ecosystems. Anthropogenic nutrient loads from coastal watersheds to the near shore waters are dramatically altering aquatic habitats (GESAMP, 1990). In estuarine and coastal marine waters, increased nitrogen loads stimulate eutrophication (Galloway, 1995), and as a consequence, the assemblage of primary producers found in these waters often changes.

A few coastal areas in India are persistently threatened by sewage and effluent discharges from the metropolis and industrialized areas. Various studies carried out so far in the Indian coastal environment indicate that the coastal environments of Mumbai and Gujarat (Zingde and Govindan, 2000; Zingde and Desai, 1987) along the west coast and Pondicherry along the east coast (Govindasamy and Azariah, 1999; Panigrahy et al., 1999) of India are degraded due to discharges from industrial and domestic outfalls. Since a decade, Baikampady industrial area has been subject to environmental degradation. The industrial wastes from this area are discharged into the coastal water through pipelines, while, the municipal wastes of Mangalore city are discharged into a nullah adjoining the Gurpur River, which empties into the coastal sea off Mangalore. Such discharges may cause aquatic pollution, resulting in severe ecosystem modifications, including depletion of fishery resources.

Department of Civil Engineering, Dayananda Sagar College of Engineering (DSCE), Bangalore-78, Karnataka, South India
Email: dakiran07@gmail.com and hkramaraju@gmail.com

The available information indicates that Mangalore Refineries and Petrochemical Ltd (MRPL) discharges 7,200 m^3/d, BASF India Ltd., discharges 3,600 m^3/d, Mangalore Chemicals and Fertilizers (MCF) discharges 13,000 m^3/d, south of Mangalore harbor. All these wastes are likely to impinge on the coastal environment (Shirodkar, 2009).

Either directly or indirectly, effluents from the various industries situated nearby coastal area pump their toxic load to the rivers or to the sea and finally everything enter the marine water. Rivers running through various land-use activities are exposed to a combination of pollutants from point to non-point sources of various strengths (Samanta, 2005).

By the anthropogenic activities and other activities, the quality of the water and other resources were getting worsened. Since watershed hydrology is dependent on many factors like land use, climate, and soil conditions it very important to know the relationship between the land use characteristics and the surface water quality (Tong, 2002 and Chang 2008). The present study focused on the deviation of the values of the different physicochemical parameters of water and soil in the coastal area of Mangaluru.

II. Methodology

Mangaluru is located at 12.87°N 74.88°E in the Dakshina Kannada district of Karnataka. It has an average elevation of 22 m (72 ft) above mean sea level. Mangaluru coast is a belt of about 22 Kms with Arabian Sea in the West and the Western Ghats in the East. The topography of the city is plain up to 30 km (18.64 mi) inside the coast, and changes to undulating hilly terrain sharply towards the east in Western Ghats. The geology of the city is characterised by hard laterite in hilly tracts and sandy soil along the seashore. Mangaluru receives about 95 percent of its total annual rainfall within a period of about six months from May to October. The average annual precipitation in Mangaluru is 3,796.9 millimetres. Humidity is approximately 75 per cent on average. Average depth of the Groundwater table in the region is 6.56 mbgl (2008-2018) (CGWB, 2012). Weathered and fractured gneiss, granite and schist are the major water bearing formations. Alluvial formation of limited thickness and aerial extent is found along the courses of major rivers.

The study area for the present work includes Baikampady Industrial area, where majority of industries were located, areas nearby coastal belt and Netravathi-Gurupur river mouth. The major rivers i.e Gurupura is located adjacent to the boundary of Baikampady Industrial cluster & Nethravathi is located at a distance of 20 km from the Baikampady Industrial cluster towards South. Baikampady Industrial cluster is located at 8 km away on Northern side of Mangalore city.

The Baikampady Industrial cluster consists of a major Refinery, storage of crude and finished petroleum products, LPG storage & bottling, Fertilizer plant, Pharmaceutical industry, Brewery, Edible oil processing units, Sea food processing units, Paint & Dispersion unit, Iron ore pelletization plant etc.

Ten Surface Water samples and six soil samples were collected from selected locations of the study area during the month of May 2019. The sampling of water was done during the morning hours and samples were protected from direct sunlight during transportation. The water samples from the sampling locations were collected in well cleaned polythene bottles. Before collection of the water samples, the bottles were washed with freshwater. Finally, the bottles were tightly closed and brought to the laboratory for further analysis. The samples of soil were taken at a depth of 10-30cm and collected separately in polythene bags as per the standard procedures recommended (Srinivasamurthy, 2010) and the soil samples were air dried, crushed and sieved through 2mm sieve for the analysis. Analysis of the soil samples were done by adopting standards methods (Jackson, 1958 and Lindsay, 1978). Physicochemical analysis of the collected water samples was done by adopting standard methods (APHA, 1995).

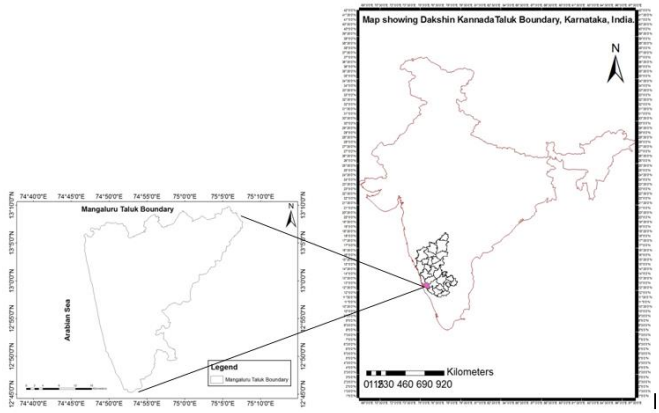

Fig. 1 Map Showing the study area-Mangaluru

TABLE 1
Surface Water Sampling Detail

Sl. No.	Sample Code	Sampling Locations	Geographical Position	
			Latitude	Longitude
Stream water and marshy land				
1	SW/1	Bridge near Thokur	12° 57' 31.6" N	74° 50' 28.2" E
2	SW/2	Panambur	12º 56 ' 16" N	74º 48 ' 21" E
3	SW/3	Stream near Total Oil India Limited, TOIL	12º 57 ' 2.13" N	74º 50 ' 24.21"E
4	SW/4	Stream near Adani Wilmar, AWM	12º 52 ' 40" N	74º 51 ' 27" E
5	SW/5	Chitrapura	12º 57 ' 19" N	74º 48 ' 7" E
River Water				
6	SW/6	Gurupura river near Total Oil India Limited, TOIL	12º 56 ' 35" N	74º 50 ' 5" E
7	SW/7	Gurupura river near Hindustan Unilever Limited, HLL	12º 52 ' 54.7" N	74º 49 ' 29.7" E
Sea Water				
8	SW/8	Chitrapura	12º 57 ' 16.6" N	74º 48 ' 2.3" E
9	SW/9	Panambur	12º 56 ' 19.4" N	74º 48 ' 26.7"E
10	SW/10	Gurupura-Nethravathi Estuary ,G-N Estuary	12º 50 ' 52.46" N	74º 49 ' 47.42" E

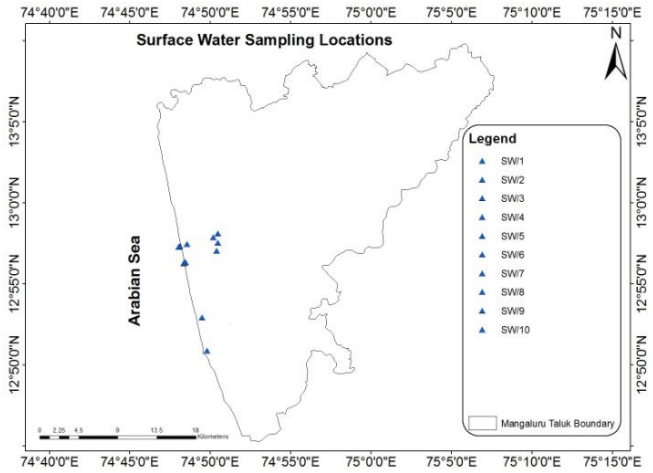

Fig. 2 Map Showing the Surface water sampling Locations in the study area

TABLE 2
Soil Sampling Details

Sl. No.	Sample Code	Sampling Locations	Geographical Position	
			Latitude	Longitude
1	S/1	Near Mangalore Refinery and Petrochemicals Limited MRPL, Thokur	N12º 57 ' 51.6"	E074º 50 ' 10.9"
2	S/2	Near Adani Wilmar Ltd	N12º 57 ' 10.1"	E074º 50 ' 10.9"
3	S/3	Near Total Oil India Pvt Ltd, TOIL	N12º56 ' 48.0"	E074º 50 ' 12.7"
4	S/4	Chitrapura	N12º57'16.1"	E74º48'13.7"
5	S/5	Near New Mangalore Port Trust , NMPT	N12º 56 ' 23.0"	E074º 48 ' 33.7"
6	S/6	Near Indian Oil Corporation Limited , IOCL	N12º54 ' 54.9"	E074º 49 ' 00.1"

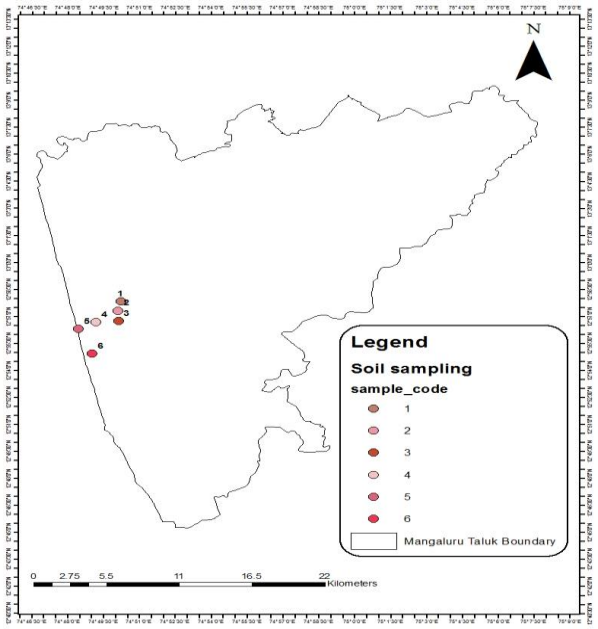

Fig.3 Map showing the Soil Sampling Locations

III. Result And Discussion

3.1 Analysis of Surface Water Samples

The physicochemical characteristics of the water indicate mainly the concentration of organic and inorganic constituents. Obtained results are compared with the standard limits (table 4).

1) pH: It is a measure of hydrogen ion concentration in water. Its value tells whether water is acidic or alkaline. In the present study pH ranges between 7.2 to 8.45. . For fish culture, pH range of 7 to 8 has been considered as good range (Jhingran, 1997).

2) Turbidity: Turbidity of samples depends on the quantity of solid matters present in the suspension state. Turbidity in surface water samples ranges from 0.2 NTU to 2.1 NTU. In the biological productivity of water bodies, Clay particles, silt particles, organic matter, plankton and other microscopic organisms can cause turbidity in water; this is recognized as a valuable limiting factor (Kishore, 2005). In the present study high turbidity value is recorded in the sample SW/1.

3) Electrical Conductivity (EC): Electrical conductivity is a measure of capacity of a substance or solution to conduct electric current. It mainly depends on the amount of dissolved solids in water. Its values range between 10600 µs/cm to 38700 µs/cm. High values of E.C. was found in the sample SW/4 (36200 µs/cm), SW/6 (36900 µs/cm) and SW/10 (38700 µs/cm). Usually the large variation in EC is mainly attributed to geochemical process like ion exchange, reverse exchange, evaporation silicate weathering, rock water interaction, sulfate reduction and oxidation processes (Ramesh K, 2008).

4) Total Dissolved Solids (TDS): The various kinds of minerals present in the water denote the amount of dissolved solids. The total dissolved solids varied from 6890 mg/l to 25155 mg/l. High values of TDS is recorded in the samples SW/4 (23530 mg/l), SW/6 (23985 mg/l) and SW/10 (25155 mg/l). It has been reported that TDS might reduce the hydraulic conductivity of irrigated area and that growing concerns are met as total dissolved solids content in water surpasses 480 mg/l (C Zidi, 2017).

5) Alkalinity: Alkalinity in natural water is due to free hydroxyl ions and hydrolysis of salts formed by weak acids and strong bases. Higher alkalinity favours the growth of phytoplankton (Francis Andrade, 2011). In the present study the total alkalinity ranges from 196 mg/l to 528 mg/l and high value is observed in the sample SW/2 (528 mg/l).

6) Total Hardness: It is a measure of variable complex mixtures of anions and cations Calcium and magnesium play an important role in antagonizing the toxic effects of various ions and neutralizing the excess acid produced (Das and Srivastava, 2003). The total hardness in the study varies between 340 mg/l to 7434 mg/l. High value of total hardness was observed in the sample SW/4 (3440 mg/l), SW/7 (3461 mg/l) and SW/9 (7234 mg/l). The high levels of hardness increases toxicity of zinc to fish (Lloyd, 1960).

7) Chlorides: Chlorides are mineral salts and, so are not affected by biological action of sewage. It naturally occurs in all types of water. The chloride content in the water sample varied from 490 mg/l to 13554 mg/l. Highest chloride content was recorded in the sample SW/5 (1526.1 mg/l), SW/6 (8401.2 mg/l) and SW/8 (13554.1 mg/l).

8) Dissolved Oxygen: It is the amount of oxygen dissolved in water. In the present study DO values ranged from 1.2 mg/l to 5.3 mg/l. surface water near thokur and panambur were recorded lowest DO value of 1.8 mg/l and 1.2 mg/l respectively. DO is of predominant importance in restricting maintenance of aquatic life (Francis A, 2011). The minimum value observed was may be due to the discharge of untreated sewage that causes Eutrophication and other harm effects.

9) Biochemical Oxygen Demand (BOD): Biochemical oxygen demand gives the content of microorganisms and its organic matter load present in the sample. In the present study BOD ranges from 5 mg/l to 32 mg/l and high value of BOD was observed in the sample SW/5 (22 mg/l) and SW/6 (32 mg/l).

10) Chemical Oxygen Demand: COD is a measure of oxygen equivalent of the organic matter content of water that is susceptible to oxidation by a strong chemical oxidant. Thus, COD is a dependable parameter in giving a conclusion regarding extent of pollution in water (Amirkolaie, 2008). In the present study COD values ranged from 150 mg/l to 708 mg/l. High value of COD is recorded in the SW/5 (340 mg/l), SW/6 (654 mg/l) and SW/8 (708 mg/l).

3.2 Analysis of the Soil Samples

The chemical composition of the soil is the major factor affecting the plant growth, besides water quality and climatic features. As the infiltrating surface waste water migrating to the soil media, it is attenuated by ion exchange, dilution, dispersion, complexing and filtration. Fine textured soils such as clay and loam have a high capacity of retaining the dissolved solids in the infiltrating water (Ramaraju, 2000).

The soil samples were considered as indicative elements for pollutants. The observed results of analysis are compared with the rating chart for soil test values (table 5).

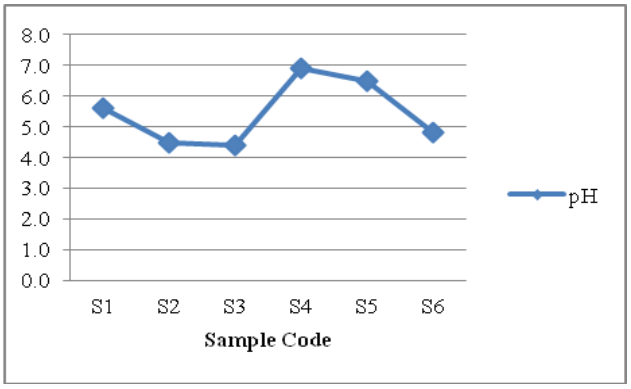

Fig. 4 Variation of pH of the soil samples

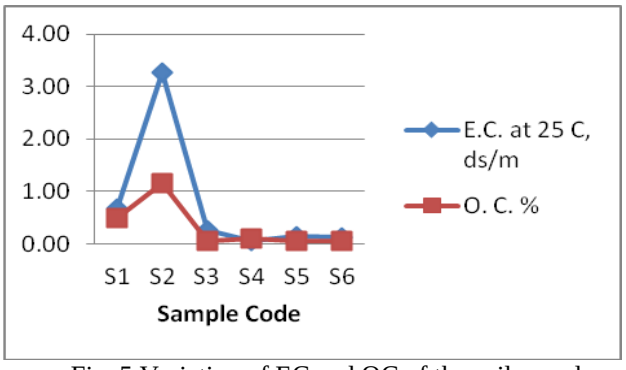

Fig. 5 Variation of EC and OC of the soil samples

TABLE 5
Rating chart for soil test values (Ramaraju, 2000)

Sl. No.	Parameters	Unit	Range and Category		
1	pH	-	Below 6 acidic	6-8 neutral	Above 8 Alkaline
2	EC	dS/m	Below 1.0 Normal	1.0-2.0 Critical	Above 2 Injurious
3	OC	%	Below 0.5 Low	0.5-0.75 Medium	Above 0.75 High
4	Available P_2O_5	Kg/ha	Below 22 Low	22-54 Medium	Above 54 High
5	Available K_2O	Kg/ha	Below 123 Low	123-296 Medium	Above 296 High
9	Available Zn	mg/kg	Below 0.5 Low	0.5-1.0 Marginal	Above 1.0 Adequate
10	Available Fe	mg/kg	Below 0.2 Low	- Marginal	Above 0.2 Adequate
11	Available Cu	mg/kg	Below 2.5 Low	2.5-4.5 Marginal	Above 4.5 Adequate
12	Available Mn	mg/kg	Below 1.0 Low	- Marginal	Above 1.0 Adequate

1) Soil pH : It is a measure of the concentration of hydrogen ions in the soil solution. pH of soils plays an important role in making the nutrients available to plants. Acidity increases the availability of iron, manganese and copper where as alkalinity increases the availability of molybdenum (Katval, 2003). pH values from ranges from 4.4 to 6.9 and highest value was found in the sample 4. In this study Most of the samples were acidic in nature with mean value of 5.45 which is not suitable for the agricultural activities.

2) Electrical conductivity (EC): It is a measure of soil's salt content or salinity level. The measurement of the EC can be directly related to the soluble salts concentration of the soil at any particular temperature. EC values of all the soil samples were within 1 dS/m except sample no.2. Under the study EC at 25°C ranges between 0.1 ds/m to 3.3 ds/m.

3) Organic Carbon (OC): The amount of mineralizable N in soils is closely related to soil organic carbon (OC) content. All the soil samples were in the low range as their OC content is below 0.5 % except sample 2. OC content in the soils is important parameter from the fertility and physical properties points of view. The low OC can be attributed to continuous cultivation, removal of crops residues without return, effects of water and wind erosion which preferentially remove the soil colloids including the humidified organic fractions (Sanda, 2012). Under the study OC ranges between 0.1 % to 1.2% and highest value found in the sample no. 2.

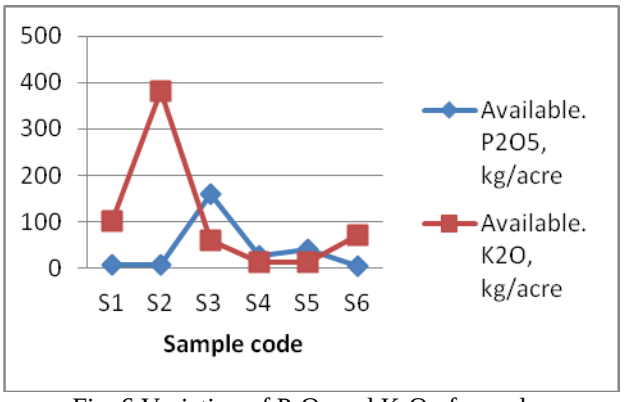

Fig. 6 Variation of P_2O_5 and K_2O of samples

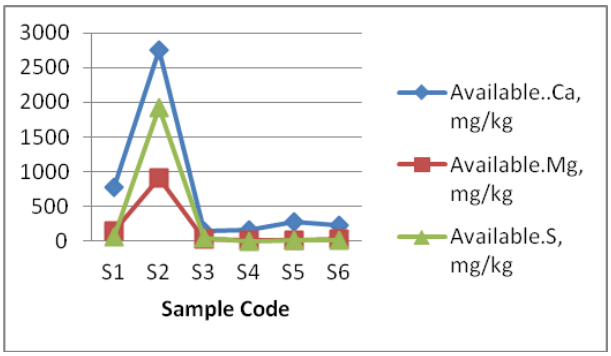

Fig. 7 Variation of Ca, Mg and S of samples

4) Available phosphorus ($P_2O_{5)}$: It is the second key plant nutrient and is required by all living organisms and every living cell. Its values ranged from 5 to 160 kg/acre with a mean value of 40.67 kg/acre. Most of the samples were fall under low to medium value category as per the soil rating chart.

5) Available potassium (K_2O): Potassium is important in the photosynthesis process. The term 'available potassium' incorporates both exchangeable and water soluble forms of the nutrient present in the soil. Its value ranged from 12 to 382 kg/acre with a mean value of 106.5 kg/acre. Most of the samples were fall under the low range category.

6) Available calcium (Ca), Available magnesium (Mg) and Available Sulphur (S): Ca and Mg are called lime elements; Its values ranges from 148 to 2756 mg/kg and 14 to 910.5 mg/kg respectively and also highest value was found in the sample no. 2 in both the cases. Available S ranged from 0.57 to 1928 mg/kg. Low range values (<10.01 mg/kg) were observed in the sample no. 4 and 6.

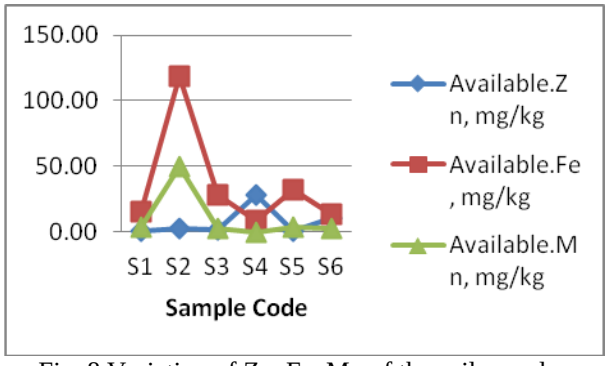

Fig. 8 Variation of Zn, Fe, Mn of the soil samples

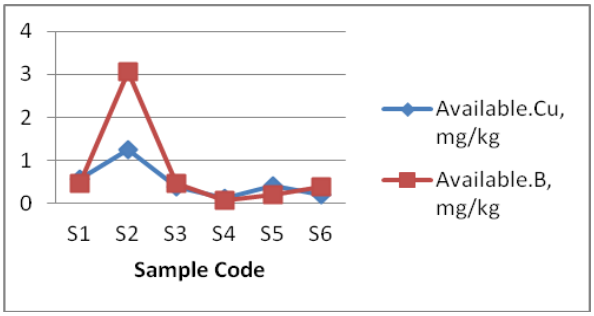

Fig. 9 Variation of Cu and B of the soil samples

7) Available micronutrients: Plants need very small quantities of micronutrients the so called trace or minor elements for their nutrition among them are zinc (Zn), iron(Fe), manganese (Mn), copper (Cu) and boron (B).

Among the micronutrients, Zn has been reported to be a limiting nutrient for the normal yield.

Under the study, Zn varied from 0.3 to 28 mg/kg, 8.2 to 118.7 mg/kg, 0.2 to 49.6 mg/kg, 0.1 to 1.3 mg/kg and 0.1 to 3.1 mg/kg respectively. All the micronutrients in the soil samples were in the adequate range. It is possible that high levels of Zn, Cu, Mn, and Cu may be exerting some toxic effect on the root zone or may be responsible for creating nutrient imbalance (Ramaraju, 2000).

IV. Conclusion

The present study was carried out with a view to identify anthropogenic activities and their impacts along the coastal region of Mangaluru, and the conclusions of the same are as follows.

The study reveals that Electrical conductivity, Total Dissolved Solids and Chlorides concentration of most of surface water samples (streams) were met above the standard limits as per IS: 2296-1982 Standard: Inland Surface Water Class – E. Electrical conductivity, Chlorides, Sulphates and TDS concentration in Gurupura river exceeds limits as per IS: 2296-1982 Standard: Inland Surface Water Class – E. Low values of DO were found in almost all the stream samples, this is may be because of excessive algae and phytoplankton growth driven by high levels of phosphorus and nitrogen. High values of BOD and COD were also found in almost all the collected surface water samples. High values of soil physico chemical parameters were found in the sample collected near Adani wilmar limited in Baikampady industrial area. Except for available Fe, most of the soil samples were not met the sufficient range for the agricultural purposes.

It is evident from study that anthropogenic activities near the coastal region have resulted in the deviation in the values of physicochemical characteristics of the samples. Thus there is an urgent need to arrest the spread of pollution of water near the coastal area.

On one side, we are having shortage of water, whereas on the other side, large quantity of water is just flowing into the sea. This necessitates to explore new ways to tap at least a small amount of runoff water to meet the water demands of people by giving primary treatment to the runoff.

The surface runoff can also be arrested by constructing check dams, vented dams etc throughout the district at appropriate places. This can assure availability of water during peak requirement period. Such measures are necessary in areas of Bantwal and Mangalore taluks which are categorised as critical. Coastal reservoirs have the potential to increase India's fresh water supply for generations to come by effectively tapping the excess waters from rivers flowing into Arabian Sea.

V. Acknowledgement

The authors are thankful to the Ministry of Earth Sciences (MoES), Govt. of India for supporting this work.

VI. References

Ahmad, S. R., & Ismail, Y. M. (2012). Soil Fertility Assessment of Research and Teaching Farm of Audu Bako College of Agriculture Danbatta, Kano State, Nigeria. *Nature Environment and Pollution Technology*, *11*(4), 639.

APHA, (1995). Standard Methods for the Examination of Water And Wastewater. American Public Health Association, New York.

Chang, C.L., Kuan, W.H., Lui, P.S., & Hu, C.Y. (2008). Relationship between landscape characteristics and surface water quality. *Environ Monit Assess.* 147(1-3):57-64

CGWB, (2012). Ground water information booklet, Dakshina Kannada District

Das, A. K., & Shrivastava, N. P. (2003). Ecology of Sarni Reservoir (MP) in the context of Fisheries. *Pollution Research*, *22*(4), 533-540.

Francis Andrade, H., Aravinda, B., & Puttaiah, E. T. (2011). Studies on Mangalore coastal water pollution and its sources. *Ind. J. Sci and Technol*, *4*(5), 553-557.

Galloway, J. N., Schlesinger, W. H., Levy, H., Michaels, A., & Schnoor, J. L. (1995). Nitrogen fixation: Anthropogenic enhancement environmental response. Global biogeochemical cycles, 9(2), 235-252.

GESAMP, (1990). The State of the Marine Environment. Blackwell Scientific Publication, Oxford,UK, pp. 146.

Govindasamy, C., & Azariah, J. (1999). Seasonal variation of heavy metals in coastal water of the Coromandel coast, Bay of Bengal, India.

Jackson, M. L. (1958). Soil chemical analysis prentice Hall. *Inc., Englewood Cliffs, NJ*, *498*.

Jhingran, A.G.(1997). Optical Appearance And Interpretation Of Annceli On Scales Of Gadeesia Chapra (Ham). *J. Inland Fish Soc. Ind*. 91, 138-153

Katyal, J. C. (2003). Soil fertility management: A key to prevent desertification. *Journal of the Indian Society of Soil Science*, *51*(4), 378-387.

Kishore, K., Joshi, B. D., & Deepali, K. (2005). Physicochemical characteristics of pond water at Kanpur village in Bareilly district (UP). *Himalayan Journal of Environmental Zoology*, *19*, 89-92.

Lindsay, W. L., & Norvell, W. A. (1978). Development of a DTPA soil test for zinc, iron, manganese, and copper 1. *Soil science society of America journal*, *42*(3), 421-428.

Lloyd, R. (1960). The toxicity of zinc sulphate to rainbow trout. *Annals of Applied Biology*, *48*(1), 84-94.

Mishra, P. C., Pradhan, K. C., & Patel, R. K. (2003). Quality of water for drinking and agriculture in and around a mines in Keonjhar District, Orissa. *Indian journal of environmental health*, *45*(3), 213-220.

Panigrahy, P. K., Das, J., Das, S. N., & Sahoo, R. K. (1999). Evaluation of the influence of various physico-chemical parameters on coastal water quality, around Orissa, by factor analysis.

Ramaraju, H.K. (2000). Studies on environmental problems of septic tank systems in peri-urban and rural areas and mitigative measures. Ph.D thesis. Bangalore University, Bangalore.

Shirodkar, P. V., Mesquita, A., Pradhan, U. K., Verlekar, X. N., Babu, M. T., & Vethamony, P. (2009). Factors controlling physico-chemical characteristics in the coastal waters off Mangalore—a multivariate approach. *Environmental Research*, *109*(3), 245-257.

Srinivasamurthy, C.A, Ramakrishna Parama V.R, Hanumantharaju, T.H and Sudhir Practical manual for hands on training/experimental learning, (Department of soil science and agricultural chemistry, College of Agricultural Sciences, GKVK, Bangalore, 2010).

Tong, S. T., & Chen, W. (2002). Modeling the relationship between land use and surface water quality. *Journal of environmental management*, *66*(4), 377-393

Zidi, C., Jamrah, A., & Al-Issai, L. (2017). Assessment of groundwater quality in Al-Buraimi, Sultanate of Oman. *J Mater Environ Sci*, *8*(4), 1266-1276.

Zingde, M. D., & Desai, B. N. (1987). Pollution status of estuaries of Gujarat-an overview. Goa: National Inst of Oceanography.

Zingde, M. D., & Govindan, K. (2000). Health status of the coastal waters of Mumbai and regions around.