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Impact of Pollutants on Water Quality of River Sutlej in Nangal Area of Punjab, India

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ABSTRACT: The present study involves physico-chemical analysis of water samples collected monthly from three sites near Nangal wetland for a period of one year. The main purpose of study is to provide baseline data regarding potability and self purification of water along the industrial belt. Hydrobiological parameters include water temperature, colour, turbidity or total suspended solids, total dissolved solids, pH, free CO_2, DO, free ammonia, nitrates, phosphates, sulphates, BOD and population dynamics. The present investigations showed that water was crystal clear with high values of pH and DO at upstream Nangal dam (S_1) while at effluent nallah of NFL (S_2) has high values of BOD, free ammonia, nitrates, sulphates, chlorides, free CO_2, turbidity, TDS, but low values of DO with more alkaline nature of wastewater. This site is mesosaprobic with eutrophic conditions. After confluence with NFL at (S_3) all parameters were slightly beyond desirable limits may be due to self purification capacity of water. Water is not potable along downstream course but can be used for other activities.

Key Words: Pollutants, Physico-chemical dynamics, Pollution load, Water quality, Self purification.

INTRODUCTION

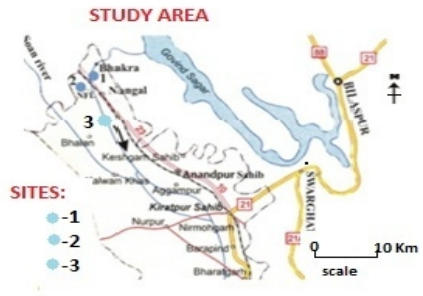
In the present era of modernization there is advancement in every phase of industrialization which leads to generate pollutants from alteration of aquatic ecosystem. The wide array of pollutants discharged into aquatic environment may have physico-chemical, biological, toxic and pathogenic effects (Goel, 2000). The life of aquatic ecosystem is directly or indirectly depends on the water quality (Contreras et al., 2009). Water pollution is a major threat to human population and dumping of pollutants into water body resulted in rapid deterioration of water quality and effect the ecological balance in the long run. Sutlej is one of the major rivers in the Northern region of India. It starts providing water to run industrial units in Punjab after Bhakhra dam and also receives large quantity of wastewater from these industries as well as domestic wastes and sewage of Nangal city while its downstream course towards Ropar wetland.

The present study was undertaken to assess pollution load from point source near Nangal wetland in the laps of Shivalik foot hills. Attempt was made to understand the rate of dumping of pollutants and its impact on water quality of river which ultimately affect human, ecology and material.

MATERIAL AND METHOD

Area of Study: After preliminary survey of entire stretch of river Sutlej, initial point of water pollution near Nangal wetland was selected for present study as shown in map and photographs. The pollutants of different types especially from National Fertilizer Limited (NFL) were discharged into downstream course of river Sutlej at this place as three sampling sites were selected S_1: upstream Nangal wetland, S_2: on effluent nallah of NFL but after treatment plant and S_3: downstream river Sutlej 2km after confluence with wastewater of NFL. Water samples were collected during the period of July, 2010 to June, 2011.

Physico-chemical analysis of water samples were done by using standard methods given in APHA (1998); Trivedy and Goel (1986). Physical and chemical parameters viz water temperature, pH, turbidity, TSS, TDS, colour, DO, free CO_2, alkalinity, hardness, chlorides, BOD, free ammonia, nitrates, phosphates, sulphates were analyzed and compared with drinking water standards for various uses as prescribed by ISI, ICMR, CPCB and WHO.



Map showing river Sutlej in Nangal area

S1: River Sutlej u/s Nangal Wetland

S2: Effluent Nallah of NFL at treatment plant

S3: River Sutlej d/s Nangal Wetland

RESULT AND DISCUSSION

Sutlej river near Nangal wetland was particularly affected by a mild range of pollution owing to increased effluents of NFL as well as sewage disposal of city area. Results reported on physico-chemical factors are influenced by change in rainfall and seasonal variations in hydrology. It was found that inflow of freshwater altering water quality frequently in this foot hill zone with continuous discharge of pollutants into river basin. All parameters were well within desirable limits at S_1 with crystal clear water having high values of DO (7.2-9.3 mg/L) and pH (8.0-8.7mg/L) but there was slight fluctuations in values of turbidity, hardness and alkalinity in monsoon period due to high rainfall and rocky silted surface run-off of water.

pH: pH of water is an important indication of its quality and provides information about various geochemical equilibrium. The large variation in pH of water was indicator of a high productivity of natural water (Sreenivasan, 1976). Higher value of pH is normally associated with high photosynthetic activity in water (Hujare, 2008) and natural waters are alkaline due to presence of sufficient quantities of carbonates (Trivedy and Goel, 1984). (Krishnaram *et al.*, 2007), documented that pH range of 6.7 to 8.4 is considered to be safe for aquatic life to maintain productivity and pH below 4.0 and above 9.6 found hazardous to life. Higher value of pH (9.2-11.7mg/L) was observed at S_2 throughout investigations. This may be due to presence of large quantity of black ash slurry produced from nitrogenous pollutants. Relatively low value of pH (6.2-7.7 mg/L) has been observed at S_3 due to inflow of freshwater but it becomes acidic (4.5-5.0mg/L) in pre-monsoon period as shown in Fig.1.

Table1: Physico-chemical dynamics observed from July 2010 to June 2011.

S.NO.	Parameters	Variation of ranges recorded at			
		S_1: U/S Nangal Dam	S_2: Effluent Nallah of NFL	S_3: D/S River Sutlej after confluence with NFL Nallah	Desirable limits of CPCB
1	Water temperature(^oC)	15.2-24	30-37	18-30.2	>40
2	Water colour	----------	Blackish	----------	-----
3	Turbidity (NTU)	4.5-11.2	15.7-23.3	7.5-20	>5
4	Free Ammonia (mg/L)	----------	4.0-6.2	0.75-1.2	1.5mg/l is lethal
5	TDS (mg/L)	15.6-32.0	625.0-710.0	255.0-430.0	>500
6	pH	8.0-8.7	9.2-11.2	6.2-7.7	6.5-8.5
7	DO (mg/L)	7.2-9.3	3.0-4.2	5.0-8.3	<6
8	Free CO2 (mg/L)	BDL	55.4-78.3	12.3-18.6	-----
9	Total Hardness (mg/L)	40.0-75.2	72.0-127.4	35.2-62.3	>300
10	Total Alkalinity (mg/L)	69.7-118.4	132.4-198.2	82.2-141.3	>200
11	Chlorides (mg/L)	2.7-6.8	22.0-47.5	188.2-240.0	>250
12	BOD (mg/L)	1.2-1.5	5.0-6.0	2.0-4.6	>2
13	Nitrates (mg/L)	BDL	95-120	30-55.6	>45
14	Phosphates (mg/L)	----------	----------	0.04-0.26	------
15	Sulphates (mg/L)	----------	15.4-40.06	4.6-7.5	>200

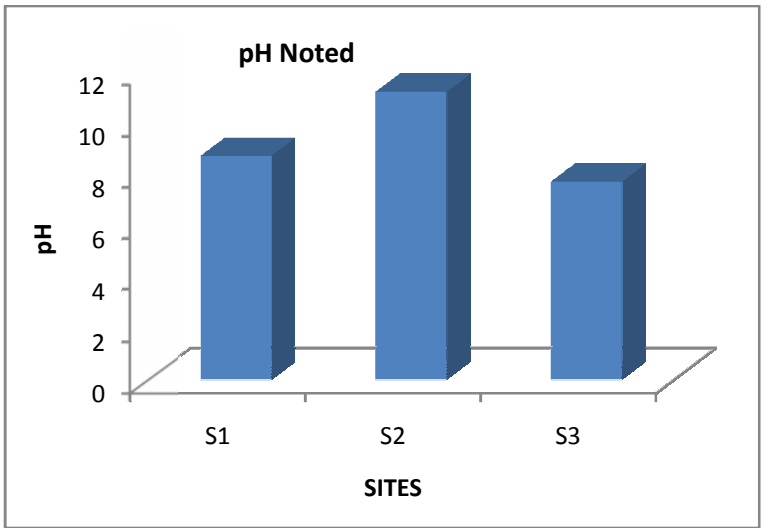


Fig.1. Variations recorded in pH at Selected sites.

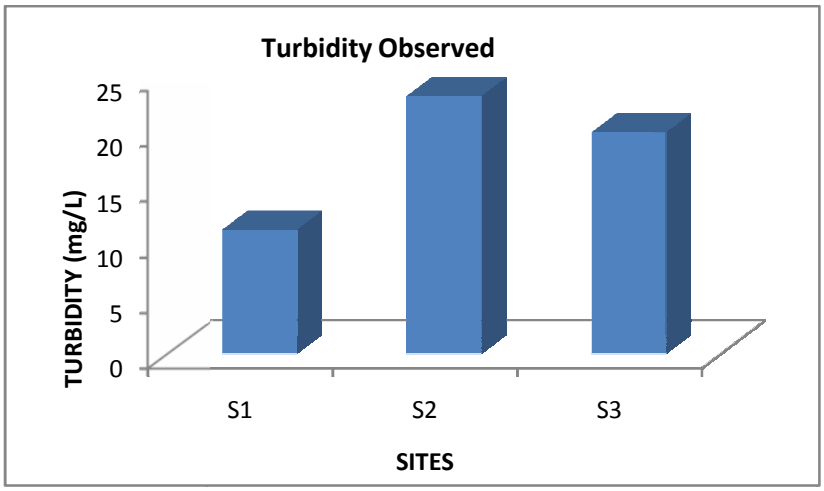


Fig. 2. Showing fluctuations in turbidity at three sites.

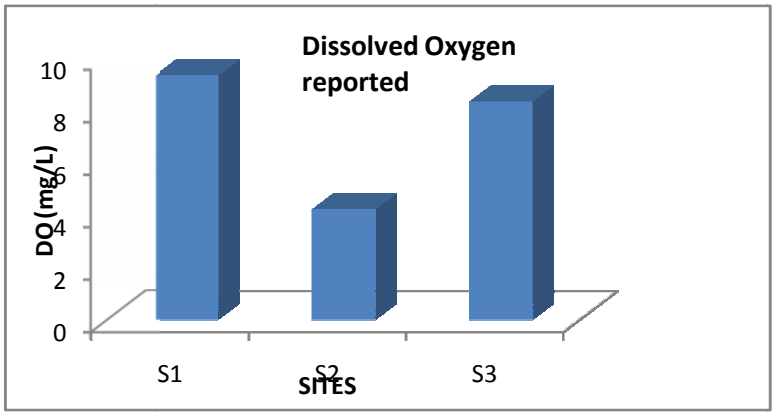


Fig. 3. Showing variations in dissolved oxygen content at S_1, S_2 and S_3.

Dissolved Oxygen: The effect of wastewater released in a water body largely determined by discharge of oxygen demanding waste and oxygen balance of the system. The exchange of oxygen across the air, water interface depends upon temperature, partial pressure of gases, solubility, photosynthetic activity of plant and respiration by bacteria, plants and animals in the water (Krishnaram *et al.*, 2007). Temperature and salinity affect the dissolution of oxygen (Vijaya Kumar *et al.*, 2000). The rate of oxidation of organic matter increases as oxygen get consumed and at higher temperature oxygen holding capacity of water decreases (Welch, 1952). High dissolved oxygen concentration observed during monsoon season may be due to cumulative effects of higher wind velocity joined with heavy rainfall and the resultant freshwater mixing (Sundaramanicham *et al.*, 2008; Damotharan *et al.*, 2010).

At suvaw Nala (Balrampur) dissolved oxygen ranged from 2.02 mg/L to 7.8 mg/L, the lowest value was found mainly because of industrial organic effluents as well as sewage load (Tripathi *et al*., 2008). As the concentration of dissolved oxygen deplete it imposes thrust on aquatic life. The DO ranged (3.0-9.3mg/L) during study period at three sites as shown in Fig.4. The maximum valuse of DO was noted at S_1 during winter in the month of December, 2010; January, 2011 as there is constant aeration of water due to water currents generated at lotic terrain, low temperature, better illumination, low turbidity and free from impact of human activities. The low DO (3.0-4.2mg/L) at effluent nallah of NFL (S_2) was estimated due to high organic sludge and nitrification.

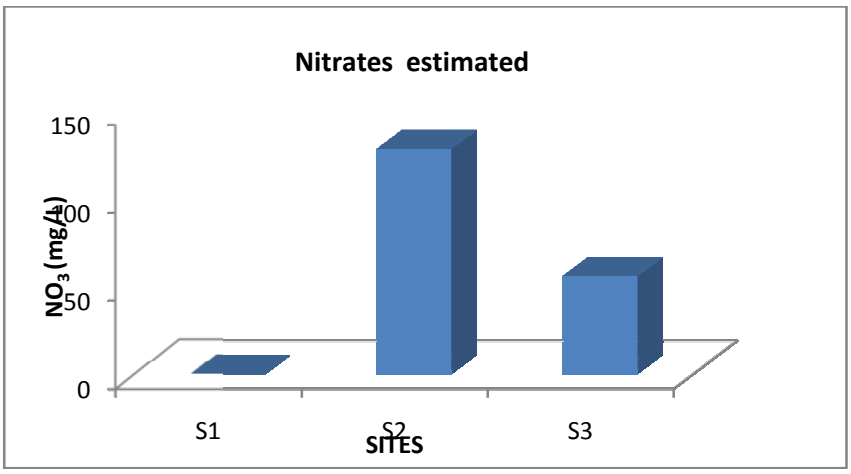


Fig. 4. Estimation of nitrates at selected sites.

Free Carbondioxide: The amount of free CO_2 in stagnant water is generally maintained by diffusion from atmosphere, respiration by animals along with plants and bacterial decomposition of organic matter (Misra et al., 1993). The CO_2 content of water depends upon the water temperature, depth, rate of respiration, decomposition of organic matter, chemical nature of bottom and geographical features of the terrain surrounding the water body (Sakhare and Joshi, 2002). The high values of free CO_2 ranged (55.43-78.32mg/L) has been recorded at S_2. This may be due to decay of organic matter and presence of carbon as ash particles in wastewater.

Total Hardness: High value of hardness in summer season was mainly attributed due to rising temperature, increasing solubility of Ca^{++} and Mg^{++} salts (Garg, 2003). Hardness in water is derived from CO_2 released in bacterial action and also by metabolic ions dissolved in wastewater. (Meshram, 2005) has noticed that hardness is essential for normal growth of aquatic ecosystem. (Krishnaram *et al.,* 2008b) noted that calcium as cation causes water hardness in natural water and favors to zooplankton production, alkalinity and phosphate content of water body. The total hardness of Sutlej water was observed in the range (35.22-62.34mg/L) at S_3 and (72.0-127.4mg/L) at S_2 due to alkaline nature of wastewater.

Total Alkalinity: Alkalinity of natural water is generally due to presence of bicarbonates and it favors to zooplankton populations (Singh et al., 2002; Kiran *et al.,* 2007).The high value of alkalinity indicates the presence of bicarbonate, carbonate, and hydroxide in the water body (Jain, 2000). pH has direct relationship with total alkalinity as reported by (Bharadwaj and Sharma, 1999). Total alkalinity was (69.70-118.40mg/L) at S_1; (132.40-198.22mg/L) at S_2 and (82.2-141.3mg/L) at S_3. Maximum value of alkalinity was recorded in summer (May-June 2011) and minimum during monsoon (July-August 2010) in conformity with the findings of Sankar et al. (2002) who explained that during summer increased concentration of salts in water was due to evapouration. The values recorded during present investigations were above the permissible limit stipulated by ICMR (120 mg/L) especially at S_2 throughout the year.

Water Temperature: Temperature influences the growth and distribution of flora and fauna as it is the most variable factor of environment and play a vital role in chemical and biological activities. The excessive amount of nutrients in water bodies along with higher temperature favors the growth of algae and aquatic weeds (Welch, 1952). The range of variations recorded in hydrological factors has been depicted in table and also shown in graphs of most significant parameters. Surface water temperature ranged (28-37.5^{o}C) during pre-monsoon and (15.2-18.0^{o}C) during winter season. Water colour was blackish with white coloured fertilizer particles suspended at S_2 while at S_3 it was transparent.

Turbidity: Turbidity a measure of water clarity is inversely proportional to penetration of light in water was ranged (15.7-23.3mg/L) at S_2 and (7.5-20.0mg/L) at S_3 while at S_1 it was (4.5-11.2mg/L) as shown in Fig.2 Site S_3 was found to be significantly turbid from July 2010 to September 2010 due to muddy silted water inflow from Gobindsagar reservoir while at S_2 it may be due to presence of slurry of carbon ash and chalk granules in the form of mat at surface of wastewater. Suspended solids of fertilizer industry are of inorganic solids, they do not cause oxygen demand when discharged in receiving water.

(Jain, 2000) reported that disposal of sewage and industrial effluents contribute suspended matter to the rivers. High value of turbidity reported during monsoon period was similar with results of Garg *et al.,* (2006) and Upadhyay *et al.,* (2010). Turbidity showed inverse relation with plankton production (Vasisht and Jindal, 1980).

Total Dissolved Solids: The total concentration of dissolved solids or ions in a water body found useful parameter in describing the chemical density as a fitness factor (Jhingran, 1982). Water with a high total dissolved solids indicated more ionic concentration which is of inferior palatability and can induce unfavourable physicochemical reactions in the consumers. Kataria e*t al.,* (1996) reported that increase in value of TDS indicate pollution by extraneous sources and adversely affects the quality of running water. High content of dissolved solids has elevated the density of water, influencing osmoregulation, reducing gas solubility and utility of water for drinking, irrigation and industries reported by (Edmondson, 1959 and Manivasakam, 2003). In present investigation slightly high values of TDS was reported at S_2 (625-710 mg/L) may be due to use of raw water with high TDS, high temperature and alkaline nature of wastewater but TDS do not exceed normal limits at S_3 during rainy season in conformity with findings of Verma and Saksena, (2010) while working on pollution status of river Kalpi, Gwalior.

Chlorides: The most important source of chloride in natural water is discharge of sewage and it play vital role in photophosphorylation reaction in autotrophs. Sreenivasan, (1665) documented that chloride concentration between 4-10 ppm indicates purity of water. Chlorides ranged (2.7-6.8mg/L) at S_1 and (22.0-47.5mg/L) at S_2 may be due to use of brine as raw material in the production of ammonium chloride and chlorinated effluent but at S_3 it ranged nearly upto desirable limits (188.2-240.0 mg/L) due to directly discharge of city sewage and domestic waste.(Kamble and Sakhare, 2013) also reported maximum value of chlorides (411.8 mg/L) and indicated that site-I was contaminated due to organic content of sewage, agricultural wastes including fertilizers and discharge by surrounding area.

Biochemical Oxygen Demand: Biochemical Oxygen Demand (BOD) is an index of organic pollution to measure the amount of DO required by microbial community in decomposing the organic matter present in a water sample by aerobic biochemical action (Boyd,2000). Singh and Rai (1999) observed that high BOD was indication of organic pollution in river Ganga at Varansi. Chavan et al., (2005) also observed the creek water of Thane Maharashtra and showed that high value of BOD was mainly due to entry of effluents from surrounding industries. In the present study, BOD was observed in between (5.0-6.3mg/L) at effluent nallah of NFL (S_2) due to microbial activity of protozoan, rotifers, dipterans larvae and presence of algal blooms. High value of BOD between (2.0-6mg/L) was observed at S_3 after mixing with wastewater from S_2 and dumping of domestic waste and sewage as shown in Fig. 5.

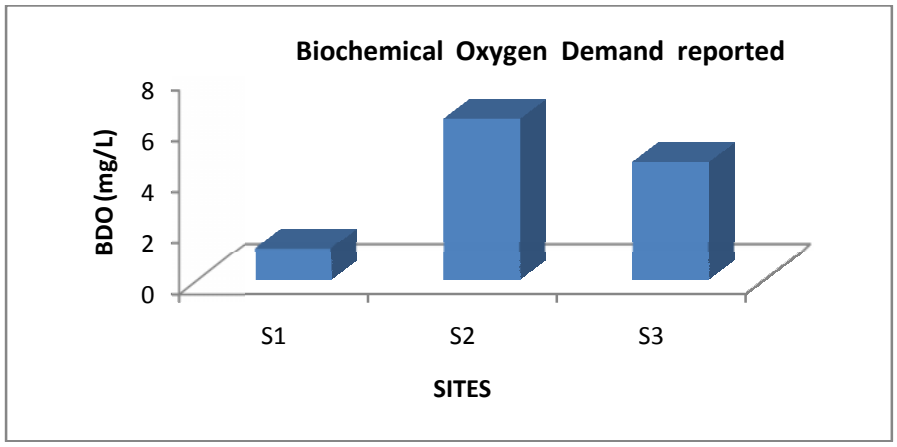


Fig. 5. Changes observed in biochemical oxygen demand at study sites.

Nitrates: Nitrates are formed in water due to oxidation of ammonia by bacterial action and their presence indicates that nitrogenous organic matter is under nitrification. The presence of little higher value in water is an indication of pollution in the river and will cause eutrophication as a nutrient, hence reducing water quality. Algal bloom and aquatic plant growth will reduce oxygen, pH, alkalinity, increases TSS, reduce penetration of light so less rate of photosynthesis but denitrification needs addition of biodegradable organic carbon in fertilizer industry. High level of nitrate in drinking water was due to excessive use of fertilizers in agriculture, decayed vegetable, animal matter, domestic effluents, sewage or sludge disposal, industrial discharges, leachable from refuse dumps, atmospheric washout and precipitation has become serious problem (Makhijani and Manoharan, 1999). Bhadauria (1997) reported nitrate in effluents from Mathura refinery that are ultimately poured into river Yamuna. Nitrates ranged (95-120.0 mg/L) at effluent nallah of NFL (S_2) indicating eutrophic conditions throughout the year due to presence of nitrogenous based pollutants but at S_3 it decreases to range (32.0-55.6 mg/L) as depicted in Fig. 4 in concurrence with the findings of Nath and Srivastava (2001) on river Narmada.

Free Ammonia: Ammonia is produced by microbial activity of organic nitrogenous matter and its presence is mainly due to decaying plants, sewage, industrial discharge and fertilizer containing ammonia. High concentration of free ammonia (1.5 mg/L) is toxic to fish and aquatic biota.

The distribution of free ammonia is fluctuating and dependent on the pH and temperature of water. Average ammoniacal nitrogen content of effluent and sewage in a channel near Mathura refinery was 2.29 mg/L (Bhadauria, 1997). The security paper mill effluent at Nalaghat Hosangabad contained high concentration of free ammonia which may be harmful for aquatic animals reported by Nath and Srivastva, (2001). Begum and Harikrishna (2008) also observed high level of ammonia 15.2 mg/L at highly polluted zone of Cauvery river mainly due to anthropogenic activities and municipal sewage. Free ammonia content ranged (4.0-6.2 mg/L) at S_2 due to residual content of fertilizer in liquid effluent along with alkaline pH and at S_3 (0.75-1.2 mg/L) as shown in Fig.6.

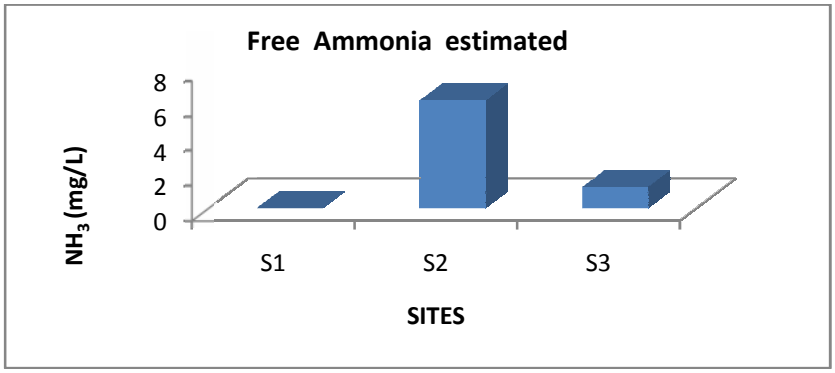


Fig. 6. Estimation of free ammonia at selected sites.

Phosphates: Phosphates act as nutrient for plant growth and high concentration of it is also an indication of eutrophy. Phosphates were only present at S_3 in between 0.04-0.26 mg/L similar with the findings of Rai (1974) on river Yamuna at Delhi and Srivastva and Singh (1995) on river Ami.

Sulphates: The hydrobiology of river Beas was studied by Gill *et al.,* (1993) and reported that phytoplankton were associated with increased level of sulphate, phosphate, bicarbonate, nitrite and alkalinity. Ghavzan *et al.,* (2006) analyzed river Mutha in Pune city in relation to phytoplankton and also revealed that river developed eutrophication with high values of BOD, COD, chlorides, phosphates, nitrates, sulphates and CO_2. Sulphates ranged at S_2 (15.40-40.06 mg/L) and (4.6-7.5 mg/L) at S_3 found to be within desirable limits of BIS and CPCB.

Pollution status and its impact:

Studies on population dynamics of plankton in relation to physico-chemical characteristics was essential aspect of biomonitoring for evaluation of polluted habitat or water. Based upon saprobity index, prevailing conditions in the selected stretch of river Sutlej was estimated on the basis of BOD_5 (organic pollution load) and Palmer's Algal Index (Palmer, 1969). Pathogenic analysis indicates presence of coliforms at S_2 only and rarely observed individuals of *Hydropsyche* at S_1 while bioindicators of water pollution include phytoplankton : *Coelastrum* sp., *Cladophora* sp., *Pinnularia* sp., *Cosmarium* sp., *Cymbella* sp., *Selenastrum* sp., *Spirulina* sp., *Spirogyra* sp., *Anabaena* sp., *Gyrosigma* sp., and zooplankton : *Bosmania* sp., *Gerris* sp., *Keratella* sp., *Notholca* sp., *Rantara* sp., *Daphania* sp., *Cyclops* sp., *Nauplius* larvae, *Alona* sp., *Macrothrix* sp., *Deronectes* sp. And site S_2 to be found tolerant to mesosaprobity.

Hence, water quality can be classified as A at S_1 (u/s Nangal wetland); E at S_2 (on Effluent nallah of NFL) and C-D at S_3 (d/s Sutlej river after confluence) as per standards given by CPCB. River water was moderately polluted in Nangal area due to inflow of silted muddy water from hilly terrain, physico-chemical dynamics and frequently dumping of pollutants. On the basis of primarily study, it was apparent that water was not potable but can be used for propagation of wild life, fisheries and irrigation.

REFERENCES

APHA, 1998. Standard Methods for the Examination of Water and Waste Water. **24**th Ed. American Public Health Association, Washington.

Begum, A. and Harikrishna 2008. Study on the quality of water in some streams of Cauvery River. *J.Chem.,**2(5):***377-384.

Bhadauria, Seema 1997. Characterization of agricultural soils irrigated with petroleum refinery effluents physico-chemical analysis. *J. Enviorn. Pollu.,***4**(4):295-302.

Bharadwaj, K. and Sharma, L. 1999. Study of some physico-chemical characteristics of a sewage fertilized seasonal pond of Udaipur (Rajasthan). *J. Env.Poll. **6***(4):255-260.

Boyd, C.E. 2000. *Water quality: An introduction*. Kluwer.

Chavan, R.P., Lokhande, R.S. and Rajput, S.I. 2005. Monitoring of organic pollutants in Thane creek water. *Natl. Environ Pollu. Technol.,* **4**(4):633-636.

Contreras, J., Sharma, S., Merino-Ibarra, M. and Nandini, S. 2009. Seasonal changes in the rotifer (Rotifera) diversity from a tropical high altitude reservoir (Valle de Bravo, Mexico). *J. Environ.Biol.,* **30**: 191-195.

Damotharan, P., Perumal, N.V. and Perumal, P. 2010. Seasonal variation of physico-chemical characteristics of point Calimere coastal waters. (South east coast of India). Middle-East *J.Sci.Res.,* **6**(4): 333-339.

Edmonson, W. 1959. *Freshwater Biology*, Second Ed. John Wiley and Sons. Inc., London in the Rushikulya estury, east coast of India. *Mahasagar- Bull. Natl.Oceanogr*.,**26**(2): 73-85.

Garg, R.K., Saksena, D.N. and Rao, R.J. 2006. Assessment of physicochemical water quality of Harsi Reservoir, District Gwalior, Madhya Pradesh. *J. Ecophys. occup. Health,* **6**: 33-40.

Garg, S. 2003. Water quality of wells and bore wells of 10 selected locations of chitrakoot region. *Indian J. Env.protec*.**23**(9):966-974.

Ghavzan, N.J., Gunale, V.R. and Trivedy, R.K. 2006. Limnological evaluation of an urban freshwater river with special reference to phytoplankton. *Poll. Res.,* **25**(2):259-268.

Gill, S.K., Sahota, G.P.S., Sahota, B.K. and Sahota, H.S. 1993. Physico-chemical characteristics and phytoplankton occurrence frequency of Beas water at Shah Nehar Barrage. *IJEP*, **13**(7): 528-532.

Goel, P. 2000. *Water Pollution : Causes, effects and control*. New age International Publishers, Ltd. New Delhi.

Hujare, M. 2008. Limonological studies of the perennial waterbody, Attigre tank, Kolhapur Dist. Mahareshtra. *Nature environment and Poll. Tech., **7***(1): 43-48.

Jain, C. 2000. Groundwater quality in sugar districts Madhya Pradesh, India. *Jr.Env.Health*, **42**(4):151-158.

Jhingran, V. 1982. "*Fish and fisheries of India*". Hindusthan publishing crop. (India) Delhi.

Kamble, N.A and Sakhare, S.S. 2013. Pollution status of Freshwater Bodies from Gadhinglaj Tehsil, District Kolhapur. *Biological Forum- An international Journal* **5**(1): 50-61.

Kataria, H.C., Qureshi, H.A., Iqbal, S.A. and Shandilya, A.K. 1996. Assessment of water quality of Kolar Reservoir in Bhopal (M.P). *Pollution Research,* **15**:191-193.

Kiran, B., Puttiaiah, E. and Kamath, D. 2007. *Zoos. Print J.*, **22**: 29-35.

Krishnaram, H., Mohan, M. and Ramchandra 2008b. Limnological studies on Thalli lake Krishnagiri District Tamil Nadu. *Env. Ecol.,**26***(4):1518-1522.

Krishnaram, H., Mohan, M., Ramchandra and Vishalkashi, Y. 2007. Limnological studies on Kolaramma lake Kolar, Karnataka . *Env. Ecol.,***52**(2): 364-367.

Makhijani, S.D. and Manoharn, A. 1999 *Nitrate pollution problem in drinking water sources: Monitoring and surveillance*. Paper presented in the workshop Water Quality Field Test Kits for Arsenic, Fluoride and Nitrate held from 8-9 Sept. *at ITRC*, Lucknow.

Manivasakam, N. 2003. *Physico-chemical Examination of Water, Sewage and Industrial Effluents.* Pragati Prakashan, New Delhi.

Meshram, C. 2005. Macro-invertebrate fauna of lake Wadali Amaravati, Maharashtra. *J. Aqu. Bio.* **18** (2): 47-50.

Mishra, S., Panda, D., Panigraphy, R.C. 1993. Physico-chemical characteristics of the Bahuda estuary (odissa), East cost of India. *Indian J. Mar. Sci*., **22**:75-77.

Nath, D. and Srivastava, N.P. 2001. Physico-chemical characteristics of Narmada for the stretch Sandia to Mola in M.P. state in the context of construction of reservoirs on the river or its tributaries. *J. Inland Fish Soc. India*, **33**(1):17-24.

Palmer, C.M. 1969. A Composite Rating of Algae Tolerating Organic Pollution. *J. Phycol*., **5**:78-82.

Rai, H. 1974. The dynamics of potamoplankton populations in river Yamuna. *Arch. Hydrobiol.*, **73**(4):492-517.

Sakhre, V.B., Joshi, P.K. 2002. Ecology of Palas-Nilegaon Reservoir in Osmanabad District, Maharastra. *J. Aquat. Biol*. **18**(2):17-22.

Sankar, P., Jayaraman, P.R. and Ganga, Devi. 2002. Studies on the Hydrography of a lotic ecosystem 'Killi Ar' at Thiruvanam Kerala, India. *Poll. Res.*, **21(**2**):**113-121.

Shrivastava, G.K. and Singh, B.B. 1995. Physico-chemical evaluation of Ami river water. *Poll. Res.*, **14**(4): 503-506.

Singh, S., Pathak, D. and Singh, R. 2002. Reprints in *Eco. Environ. Cons.* **8**: 289.

Singh, B.N. and Rai, Seema 1999. Physico-chemical status of Ganga river at Varansi. *J. Environ. And Pollu.*,**6**(1):43-46.

Sreenivasan, A. 1965. "Limnology of tropical impoundments III, limnology and productivity of Amrawathy reservoir Madras, India. *Hydrobiologia*, **26:**501-516.

Sreenivasan, A. 1976. Limnology of tropical impoundments III, Limnology and productivity of Amrawathy reservoir Madras, India. *Hydrobiologia*, **26**(2):501-2.

Sundaramanicham, A., Sivakumar, T., Kumaran, R., Ammaiappan, V. and Velappen, R. 2008. A comparative study of physico-chemical investigations along parangipettai and Cuddalore coast. *J. Environ, Sci.technol,*. **1**(1):1-10.

Tripathi, V.M., Tewari, D.D., Tewari, H.D., Tewari, S. and Uppadhya, M.P. 2008. Physico-chemical characteristics of river Rapti nearby industrial area Balrampur of UP, India. *Natl. Envirron. and pollu. Technol.,***7**(1):73-77.

Trivedy, R.K. and Goel, P.K. 1984. *Chemical and Biological Methods for Water Pollution Studies.* Environmental publications, Karad:104

Trivedy, R.K. and Goel, P.K. 1986. *Chemical and biological methods for water pollution studies.* Environmental Publications, Karad.

Upadhyay, K., Mishra, P. and Gupta, A.K. 2010. Study on the physicochemical status of two ponds at Varanasi and Bhadohi under biotic stress. *Plant Arch*., **10**(2): 691-693.

Vasisht, H.S. and Jindal, R. 1980. Rheological survey of pucka stream of Patiala (Punjab, India). *Limnologica* (*Berlin*), **12**(1):77-88.

Verma, A.K. and Saksena, D.N. 2010. Assessment of water quality and pollution status of Kalpi (Morar) river Gwalior, Madhya Pradesh: with special reference to conservation and management plan. *Asian J. Exp. Biol. Sci.*,**1**(2): 419-42.

Vijayakumar, S.K., Rajesh, K.M., Mendon, R. and Hariharan, V. 2000. Seasonal distribution and behavior of nutrients with reference to tidal rhythm in the Mulki estuary, Southwest coast of India. *J. Mar. Biol. Assoc. India.*, **42**: 21-31.

Welch, P. 1952. *Limnology*, 2nd ed. Mc Graw Hill Book Co. NewYork.