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Water pollution assessment of Kali River at Muzaffarnagar (UP), India

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ABSTRACT

The river Kali is an important tributary of river Yamuna, lifeline of thousand peoples in north India. Like all other rivers in the country, the Kali too has been subjected to the onslaught of the negative impact of industrialization and urbanization. The problem has aggravated because of uncontrolled flow of a large quantity of untreated industrial, municipal and domestic liquid waste directly drained into river, the present pollution load significantly contributed to carry a lot of toxic heavy metals merged into river water, sediments and ultimately accumulated into various living organisms.In the present study, water samples were collected from five sampling zones of the river Kali and analysed for physico-chemical parameters. The present work reveals that there is a tremendous pollution discharge into river Kali at downstream zone of Muzaffarnagar city and high pollution was recorded, which was slightly restored by river ecosystem at further downstream.

Key words: *Physico-chemical parameters, River ecosystem, Water quality, Kali river, Industrial Pollution*

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Introduction

Rivers are the most important water resources in the world in general and India in particular great civilization developed along the bank of rivers and even today most of the development has taken place in the cities or in the location near the rivers (Bharti and Malik, 2005). The rivers provide water for industry, agriculture commercial aquaculture and domestic purposes. Unfortunately the same rivers are being polluted by indiscriminate disposal of sewage and industrial wastes as a plethora of human activities. River pollution has already acquired a serious dimension in India, with most of its fourteen rivers being grossly polluted. The situations are more or less same in small rivers and associated tributaries. The available natural freshwater resources today are threatened by hazards of pollution; particularly rivers are greatly polluted due to release of untreated effluents and waste materials from agriculture concerns and industries located around rivers. The poor living conditions of people in settlements around rivers, non availability of treatment from urban areas and negligence of industries for treatment of effluents before release in natural water bodies are the major reason for pollution of Indian rivers (Chavan and Wagh, 2005). The river water quality is deteriorated not only by increasing domestic and industrial waste water discharges but also due to excessive abstraction of water from river mainly for irrigation rendered then dry or with meager flow in non-monsoon periods followed by increasing waste water (Sastry *et al.*, 1972, Bhalla and Bharti, 2014). On the banks of river Kali, several towns, major cities and industries are situated, which have very less or no proper management of sewage drains and effluents are being discharged directly or indirectly into the river which is deteriorating the water quality of river Kali day by day.

The river western Kali is polluted at several points the main pollutants come from the discharge of domestic and industrial waste the industrial units of U.P. are supplied with the water from small perennial streams from foothills of Shivalik Himalaya. Although there are several large cities all along the bank of Kali river and serve as water source to supply water to these cities and towns. The rivers has been indiscriminately polluted and misused over the years, despite of its extra ordinary resilience and recuperative capacities severely polluted. Due to increase of population and industrialization, the water quality of river Kali has been degraded from domestic sewage and industrial effluents that contains large number of chemicals. Increased industrialization and chemical based agriculture within the catchments of the Kali river east in western U.P is identified as being responsible for considerable pollution in the river. Muzaffarnagar town is developing very fast in term of business and small scale industries, it’s situated on the eastern bank of river Kali and all the waste water of the town is directly discharged into the river through three major drains (Tomar, 2011). At present, the water quality of river Kali is degrading day by day therefore, regular monitoring is essential for the maintenance of ecological balance and assessment of self purification capacity. Hence, the monitoring and assessment program of Kali River was executed by evaluating physico-chemical characteristics of river water and the heavy metal content in water of Kali River at western Uttar Pradesh, India.

Study area:

The river Kali in western Uttar Pradesh is a small perennial river having a basin area of about 750 Km and lies between altitude 29º 33’’ N to 29º 21’’ N and longitude 77º 43” to 77º 39”E in the Muzffarnagar district of Uttar Pradesh. The climate in this region is moderate subtropical monsoonal. The average annual rainfall in the area is about 1000 mm, a major part of which is receiving during the monsoon period.

The following sampling locations have been selected for the study:

Sampling Zone-A: **Rohana**

Sampling Zone-B: **Muzaffarnagar City**

Sampling Zone-C: **Sujru**

Sampling Zone-D: **Bagrajpur Industrial Area**

Sampling Zone-E: **Mandawali**

Material and Methods:

Sampling methods:

Water samples were collected in BOD bottles and polypropylene bottles for laboratory experiments. Some parameters were determined immediately on sampling sites, for rest parameters samples were preserved and stored in refrigerator at 4°C.

Analytical methods:

All chemicals and reagents used were of analytical reagent grade (Merck). Double distilled water was used throughout the study. All glassware and plastic ware were soaked in 10% HNO3 for 24 h. The washing was completed with double distilled water rinse. Stock standard solutions of metals were prepared by dissolving ultra pure metals/compounds (99.99 % pure) obtained from Merck India Ltd. Heavy metals were estimated by using AAS 4129.

The sampling was done during 2008-10 in morning period from the each selected sampling zones. The water samples were taken in BOD bottles and polypropylene bottles for physical and chemical analysis. Following materials were used in sampling process: Sampling bottles, Pipettes, Reagents and Glassware, Chemical bottles, Bag, Polythene bag, Plastic cane, Thermometer, pH meter.

The samples of Kali water were analyzed using standard methods (Wetzel, 1975; Trivedi and Goel, 1984; APHA, 1998).

Results and Discussion:

The river Kali is an important tributary of river Yamuna originating in the lower Himalayas in Saharanpur district (U.P.) and flows 260 km through six districts including Muzaffarnagar, Meerut, Bhaghpat, Ghaziabad and Gautam Buddha Nagar, until its confluence with the Yamuna. In highly populated and pre-dominantly rural catchments, the river is heavily utilized as water resources for domestic, agricultural and industrial uses. The waste from different industries i.e. Distilleries, Sugar, Paper, Steel, Iron, Pharmaceutical, Electroplating and Municipal liquid waste are discharged it two different sampling sites of river Kali. The present study were undertaken to determine the heavy metals in water river Kali at Muzaffarnagar during the years 2008-10.

Physico-chemical characteristics of river water

Temperature plays a vital role in chemical, biological processes and also for the life of aquatic organisms in the stream environment. Microorganisms affecting the breakdown of organic matter in stream are profoundly influenced by temperature changes, then lower temperature. The rate of oxidation of organic matter was as much as greater during summer than winter. During the present study period (mean value of three seasons i.e. winter, summer & monsoon) it was observed in the range of 24.7 °C to 27.6 °C with minimum value at Zone A and Maximum value at Zone D. The higher value in temperature was due to the addition of sugar industry and paper mill effluents along with municipal waste at few zones. The finding was similar to that observed by Palharya *et al.*, (1993) for the river ecosystem. They reported that the sensitivity of many organisms of toxic wastes is also influenced by change in water temperature is very important of aquatic life flora and fauna and was moderate (15.04°C to 21.89°C) throughout the season at river Ravi. Prasad and Patil (2008) and Kumar and Dua (2009) reported similar trends as observed for river Ravi. Bharti (2012a) also indicated the similar trend for surface water temperature of a small river in the lower Himalaya.

pH determination is an important factor for realizing the nature and extent of pollution. An increase in value of pH by one unit means a tenfold decrease in H+ ion concentration (i.e. in the intensity of acidic nature). It means that a small change in pH is a considerable change in H+ ion concentration. Many important chemical and biological processes only take place at a certain pH values or within a narrow range. pH is the indicator of acidic and alkaline condition of water status. The pH of water body indicates degree of deterioration of the water quality (Singh and Bharti, 2015, Bharti, 2012a, Bharti, 2013). BIS have recommended 6.5-8.5 range of pH for the use of water for various purposes. Below 5.00 or above 8.80 are definitely detrimental to aquatic life. The literature cited suggests that the industrialization and urbanization are modifying the pH of natural water by effluents. The pH values of river Kali during the present study period was found both acidic and alkaline in nature. During the present study period (mean value of three seasons i.e. winter, summer & monsoon) it was observed in the range of 6.21 to 8.13 with a minimum value at Zone D and Maximum value at Zone E. The similar findings have been observed by the David (1956) in river Bandra. Khadse *et al*., (2008) have reported higher pH at some sites that could be due to bicarbonates and carbonates of calcium and magnesium in water. The main source of such chemicals may be because of urban runoff or industrial waste water. Bharti (2012b) also indicated the similar trend for surface water pH of a Sahastradhara river in the Shivalik Himalaya.

During the present study period (mean value of three seasons i.e. winter, summer & monsoon), total dissolved solids were found in the range of 157.5 mg/l to 1364.7 mg/l with a minimum value at Zone E and Maximum value at Zone D. This situation was comparable to the findings as observed by the Singh *et al.,* (2005) in river Gomti due to the addition of waste effluents in the river at Lucknow. Khadse *et al.,* (2008) reported similar findings due to waste effluents being discharged into the river Kanhan. Bharti et al., (2012a) also indicated the similar trend for TDSs in surface water of a river in Meghalaya.

Dissolved oxygen (DO) is the utmost need for all the aquatic organisms. Oxygen is sparingly soluble in water and its solubility is low at higher temperature .The oxygen is likely to be due to depletion of dissolved oxygen that depends upon the biodegradability of the organic matter in the ecosystem .The molecular diffusion from air and production of oxygen due to photo synthetic activity of the phytoplankton, try to replenish oxygen in the stream. When the rate of de oxygenation is more than the rate of re-oxygenation, the oxygen budget of the river water reduces. The reduced dissolved oxygen level can be detrimental to the aquatic life. Inhabiting there in, the minimum concentration of dissolved oxygen should be 5.0 mg/l at 20°C or 57% dissolved oxygen saturation for healthy condition of aquatic life (Gupta and Bharti, 2016, Bharti et al., 2012a). According to the Manivasakam, (1980), the dissolved oxygen in the water is essential for aquatic life. Deficiency of dissolved oxygen gives bad odor to water due to anaerobic decomposition of organic wastes.

During the present study period (mean value of three seasons i.e. winter, summer & monsoon), DO was observed in the range of 4.08 mg/l to 7.36 mg/l with a minimum value at Zone C and Maximum value at Zone D. The change in DO is due to the mixing of sugar industry effluents, municipal, domestic wastes with Kali river. Bhaskaran *et al., (*1963) reported oxygen relationship between BOD and DO contents in river Gomti. A similar observation has been reported by Verma *et al., (*1984) that BOD and DO have significant relationship and directly indicate organic pollutant load in surface water system in river Kali (east). The quality of the water in terms of DO content is always of primary importance because of waste discharge point in water (Bharti, 2012b). The DO is required for aerobic oxidation of the wastes by Mukherjee *et al.*, (1993) in Ganga river. DO may be a potential indicator of river quality in assessing urban impacts on river ecosystem (Kannel *et al.*, 2007). The similar trends have been reported for Hindon river by Suthar et al., (2009), the worst condition of DO of river being between 3.10 to 4.03 mg/l at Ghaziabad. Bharti (2014) found a maximum value of DO in the surface water of Sahastradhara river at Dehradun.

The hardness of water is caused by multivalent metallic cations calcium and magnesium that are most abundant in natural water. Water with <50 mg/l hardness is considered soft, >150 mg/l moderately hard and >300 mg/l very hard. A relationship between carbonate hardness and organic pollution has been reported by Parkash and Rawat (1981). Laiman and Dixit (1989) observed an increase in the total hardness up to about 350 mg/l in Ganga and Bhagirathi river waters due to the mixing of industrial effluents. According to Sinha, (1988) the river water with hardness ranged from 20 mg/l to 150 mg/l may be considered as moderately hard while that of the effluent water with range of 150 mg/l to 300 mg/l as hard. During the present study period (mean value of three seasons i.e. winter, summer & monsoon), hardness was observed in the range of 215.87 mg/l to 683.64 mg/l with a minimum value at Zone C and Maximum value at Zone D. Similar observations have been reported by Chandra *et al*., (1996) who reported higher value of hardness in river Ramganga and Sabarmati due to mixing of sewage, industrial and domestic effluents in to the river. Bharti et al., (2012c) also indicated the similar trend for hardness of surface water of a small river in southern Bhutan.

Alkalinity is a measure of its capacity to neutralize acids. The determination of alkalinity aids in understanding of the buffering capacity and interpretation of the treatment process. The major portion of alkalinity in natural water is caused by bicarbonates and carbonates. Hydro-oxide alkalinity is seen only if industries discharge their waste in to a stream of water or in case of high algal activity in it. During the present study period (mean value of three seasons i.e. winter, summer & monsoon), alkalinity was observed in the range of 269.42 mg/l to 1295.05 mg/l with a minimum value at Zone A and Maximum value at Zone C. The total alkalinity was lower in monsoon months probably due to the dilution of the concentration of nutrients during monsoon and to rise in water level. It is quite clear from the data obtained from Kali water samples that total alkalinity is frequently increased by the addition of industrial and domestic waste of drain inputs and attains maximum value of total alkalinity. The similar trend has been reported by Ramesh *et al.* (1992), for the river Damodar in Bihar, the alkalinity being much higher. Bharti (2012a) also indicated the similar trend for surface water alkalinity of a Sahastradhara river at Dehradun (Uttarakhand), India.

The biochemical oxygen demand (BOD) is one of the most important tests for determining the strength of the polluting water, sewage industrial wastes, effluents etc. BOD is defined as the quantity of oxygen required by the bacteria in stabilizing the decomposable organic matter under aerobic conditions. The effect of BOD depends on other factors and it is not always safe to accept any definite oxygen limit without considering other hazards. BOD value increase after mixing of waste discharge is usually due decomposition of organic degradable matter in the river water that indicates the organic pollution load into the water. A higher increase in the BOD value due to the mixing of industrial and domestic wastes has been observed by the Agarwal (1990).

During the present study period (mean value of three seasons i.e. winter, summer & monsoon), BOD was observed in the range of 12.51 mg/l to 58.18 mg/l with a minimum value at Zone C and Maximum value at Zone D. A trend of decrease in BOD in downstream site was observed, which further indicated the self purification capacity of this river as also observed by Suthar et al., (2009) in Hindon river at Ghaziabad. According to the Royal commission (1972) of sewage disposal water having BOD more than 5mg/l is unsafe for domestic use. Similar trends have been studied by Paythkin and Krivoshein (1980) and Golterman *et al., (*1983). It was concluded that increase flow rate, temperature and sedimentation load reduced BOD. Bhutiani and Khanna, (2007) have reported a similar pattern for river Suswa. Bharti (2012a) also indicated the similar trend for BOD in surface water of a small river in the lower Himalaya. BOD standard for in land surface water in India is 2, 3 and 4 different purposes. In river Kali BOD exceeded to a great extent due to mixing of waste effluents at different sampling sites.

The chemical oxygen demand (COD) is the measurement of oxygen required for the oxidation of organic matter in the sample. It is especially useful when the BOD cannot be determined on account of the presence of toxic substances. The use of river water with high value of COD may cause health hazards to both humans and domestic animals as suggested by Bermejo *et al., (*1981).The observation made by workers like Sinha *et al.*, (1989), Gautam *et al., (*1989), Saxena, (1994) have indicated that the measurement of COD is of great importance for water having unfavorable conditions for the growth of microorganisms such as presence of toxic chemical.

During the present study period (mean value of three seasons i.e. winter, summer & monsoon), COD was observed in the range of 41.12 mg/l to 178.15 mg/l with a minimum value at Zone C and Maximum value at Zone D. Similar finding have been reported by Motwani *et al.*, (1956) who also observed the similar pattern of COD, BOD and DO distribution in river Sone in Bihar due to addition of Rohtash Industrial area wastes. Similar findings were reported by Alam *et al., (*2007) for the river Surma and by Khadse *et al., (*2008) for the river Kanhan. Mukherjee *et al.*, (1993) have reported that about 47% COD comes from industrial sources in Indian River system. In present study in Kali river, the COD was higher due to discharge of Industrial wastes.

High chloride content indicates heavy pollution. It is observed that chloride is positively correlated with calcium hardness, salinity, alkalinity, Sulphate and nitrates. The chloride content remains more in summer followed by winter and monsoon season. Earlier high values of chloride have been reported by Murthy *et al.*, (1994) and Singh and Mahaveer (1997) in Tungabhadra and Ganga river water because of the mixing with domestic waste-effluents. During the present study period (mean value of three seasons i.e. winter, summer & monsoon), chloride was observed in the range of 30.94 mg/l to 165.61 mg/l with a minimum value at Zone A and Maximum value at Zone D. The present finding is similar to that of Murthy *et al.*, (1994) and Singh and Mahaveer (1997) in Tungabhadra and Ganga river water because of the mixing of domestic sewage with water. Higher concentration of chloride content indicates heavy pollution (Bhalla and Bharti, 2014).

The phosphate like nitrogen is also an essential nutrient for living organisms. Effect of phosphate has been widely reported by various workers (Rounse and Nelso, 1966). The phosphates are gradually hydrolyzed in water to the stable form the kind of matter as decomposed and biologically to release phosphate into the river body (Harmer, 1977). During the present investigation period (mean value of three seasons i.e. winter, summer & monsoon), phosphate was observed in the range of 0.71 mg/l to 3.61 mg/l with a minimum value at Zone C and Maximum value at Zone D. Phosphate concentration decreased due to the dilution of river water. The present trend was similar to that as reported by Bhadra *et al.*, (2005) in North Bangal Terai River Kaljani- A tributary of river Torsa. It was observed that phosphate contamination is due to the disposal of detergent contaminated sewage and direct washing of cloths in to the river. The higher values at different sampling points were due to mixing of waste effluent and agriculture runoff.

The presence of nutrient nitrates in all the living matter explains the intimate association of environmental chemistry in the biological system. The biological system transformation of nitrogen in aquatic ecosystem appears to the qualitatively similar in many respects to those occurring in the soil ecosystem. Urea and uric acid have been shown responsible for the aquatic nitrate for fresh water phytoplankton (Syrett, 1962 and Guillard, 1963). During the present investigation period (mean value of three seasons i.e. winter, summer & monsoon), nitrate concentration was observed in the range of 1.85 mg/l to 3.82 mg/l with a minimum value at Zone C and Maximum value at Zone D. The similar findings have been observed by Mitchell et al., (2001) for the river Logger and by Suthar et al., (2009) on water quality assessment for the river Hindon at Ghaziabad.

Waste material reacts with each other as a result the river water is being polluted and many toxic substances which ultimately make the water pollution and also severely affect the productivity of the aquatic ecosystem (Bharti and Khoud, 2013; Bharti, 2013). Metals such as arsenic, lead, cadmium, nickel, mercury, chromium, cobalt, zinc and selenium are highly toxic even in minor quantity. Increasing quantity of heavy metals in water resources is currently an area of greater concern especially since a large number of industries are discharging their metal containing effluents in to fresh water without any adequate treatment (Canter, 1996; Bharti, 2012b; Bharti, 2012c).

It was observed that the main cause of river Kali pollution mainly due to the addition of various industrial wastes (Sugar, Distillery, Chemical, Rubber, Paints, Paper, Dairies and City Municipal wastes), which finally merge into the river throughout its course. Among various industrial wastes, the distillery and paper effluents were the main polluting sources, because of their higher BOD, COD and TDS and low pH and DO concentration and significant quantity of heavy metals (Bharti, 2007b).

Table 1: Physico-chemical variables (mean values) of water of river Kali

SN	Parameter	Zone A	Zone B	Zone C	Zone D	Zone E
1	Temperature (°C)	24.7	27.12	25.72	27.64	25.38
2	pH	7.7	7.86	8.1	6.21	8.13
3	TDS (mg/l)	374.96	609.77	170.68	1364.69	157.49
4	DO (mg/l)	6.72	4.91	7.36	4.08	6.48
5	Free CO2 (mg/l)	1.31	1.78	2.45	3.56	2.46
6	Hardness (mg/l)	320.67	326.48	215.87	683.14	223.10
7	Total Alkalinity (mg/l)	269.42	274.56	1295.05	353.12	290.45
8	BOD (mg/l)	21.36	17.09	12.51	58.18	17.52
9	COD (mg/l)	61.15	52.10	41.12	178.15	46.3
10	Chloride (mg/l)	30.94	136.86	41.56	165.61	48.99
11	Phosphates (mg/l)	0.94	1.22	0.71	3.61	0.91
12	Nitrates (mg/l)	2.9	2.96	1.85	3.82	2.0
13	Calcium (mg/l)	37.36	144.64	48.98	220.83	50.11
14	Magnesium (mg/l)	28.85	26.96	41.18	159.54	25.20

Conclusion

In terms of different pollution indicator parameters, Kali river water is moderately polluted, which needs immediate attention. The river pollution is mainly of organic, due to the discharge of untreated wastewater from the towns on the banks in the river basin. The river Kali has a significant quantity of several pollutants, which are highly toxic in nature and significantly contributed to create environmental and biological hazards among the stack holders i.e. human beings, cattle, and other livestock. High contamination in river water was observed as reflected by disposal of industrial wastewater directly without any treatment.

It has been suggested to adopt some environmental biotechnological options i.e. phyto-remediation, bio-adsorbents, bio-composting, waste water recycling technology and other economically treatment technology by the corporate sector to combat the pollution load at point source. Environmental ethics should be developed among industrialist, supervisors and workers for maintaining the environmental standards to preserve, protect and manage the sustainable river ecosystem.

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