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Assessment of industrial discharge on water quality of Yamuna River at Kalpi region, Jalaun, (U.P.) with special reference to fish

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Abstract
The present study aimed to evaluate the impact of small scale industrial effluent especially paper mills effluents on river Yamuna at Kalpi region, Jalaun, U.P. The industrial effluent discharged in the river caused a significant alteration in pollution indicating parameters of river water. The physico-chemical parameters such as Temperature, pH, DO, FCO_2, Alkalinity, Hardness, TDS, BOD, COD, Chloride, Nitrate and Sulphate as well as heavy metals of river water showed seasonal variations. Most of the parameters of the Yamuna River at Kalpi are within the permissible limit and suitable for the growth and development of fishes but some pollution indicating parameters especially TDS, BOD and COD were found much higher than the tolerance limit recommended by WHO. pH shows that Yamuna River water is alkaline in nature. The heavy metals also shows seasonal variations but these were present within the permissible limits.

Keywords: Physico-chemical parameters, heavy metals, Yamuna River

Introduction
Water is fundamental to life on our planet, but this precious resource is increasingly in demand and under threat. The availability and quality of water have always played an important role in determining the quality of life. The earth's surface is made up of 70% water including rivers, beels, lakes, streams, seas, oceans, ground water and all these forms are very important in life cycle (Arimieari *et al.*, 2014) [8]. Of the waters occupying 70% of the earth's surface, only 3% is considered fresh water and approximately 5% of this fresh water or 0.15% of the entire global water is used for beneficial purposes (Usharani *et al.*, 2010) [32]. Access to clean and safe water for human consumption was declared a human right by the United Nations General Assembly in July 2016 (UN, 2016) [33].

Industrial discharges have been a major cause environmental pollution and hazardous contamination to soil and surface as well as ground water. In developing countries surface water may be affected by severe pollution due to its easy accessibility for disposal of wastewater. Once water is contaminated, it's very difficult, costly, and often impossible to remove the pollutants. Still today, 80 per cent of global wastewater releases untreated into the water bodies, containing everything from human waste to highly toxic industrial effluents. It causes harmful effects to aquatic biota including fishes and planktons (Prakash *et al.*, 2015a; Verma *et al.*, 2016; Verma and Prakash, 2016; Prakash and Verma, 2017; Verma, 2017) [21, 35, 37, 20, 36]. The disposal of untreated wastewater of various small scales industries, domestic sewage waste water and agrochemical wastes may reached into river.

The increasing pollution of rivers and streams have attracted the attention of many scientific and administrative authorities globally (Hassan and Amadi, 2013) [12]. Due to rapid industrialization many rivers in India are facing the problems of chemical pollution because these Indian rivers act as temporary reservoirs for drainage of water and industrial effluent and often are highly contaminated with anthropogenic materials (Singh and Verma, 2016) [30]. In Kalpi, rapid increase of small scales industries increasing the volume of industrial effluent which is released into Yamuna river through Ganda Nallaha. Aboyeji (2013) [2] reported that fresh water resources are important but are being contaminated uncontrollably through industrial effluent and anthropogenic activities. The rate at which industrial wastewaters are released into river Yamuna is high so there is the need to check their quality before releasing

them into the environment. The result of the present study provide baseline information for aware the people and government to take action for the conservation of aquatic biodiversity.

Materials and Methods

Study Area: The present study area, Kalpi is a historical city of district Jalaun of Uttar Pradesh located in between Jhansi and Kanpur on NH-25 lies to the south-east bank of Yamuna and falls under 260 7' 14" N latitude to 790 44' 59" E longitude with an average elevation of 112 meters. The river Yamuna runs between Kalpi City to Marayan Village of District Jalaun, U.P. After entering the river Yamuna (Upstream) in the Kalpi city near Vyas mandir, travel about 4 Km length in the city than it (Downstream) receive Ganda Nallah, a polluted small perennial lotic fresh water body that receives a huge amount of small scale industries effluents industries especially handmade paper mills as well as domestic sewage.

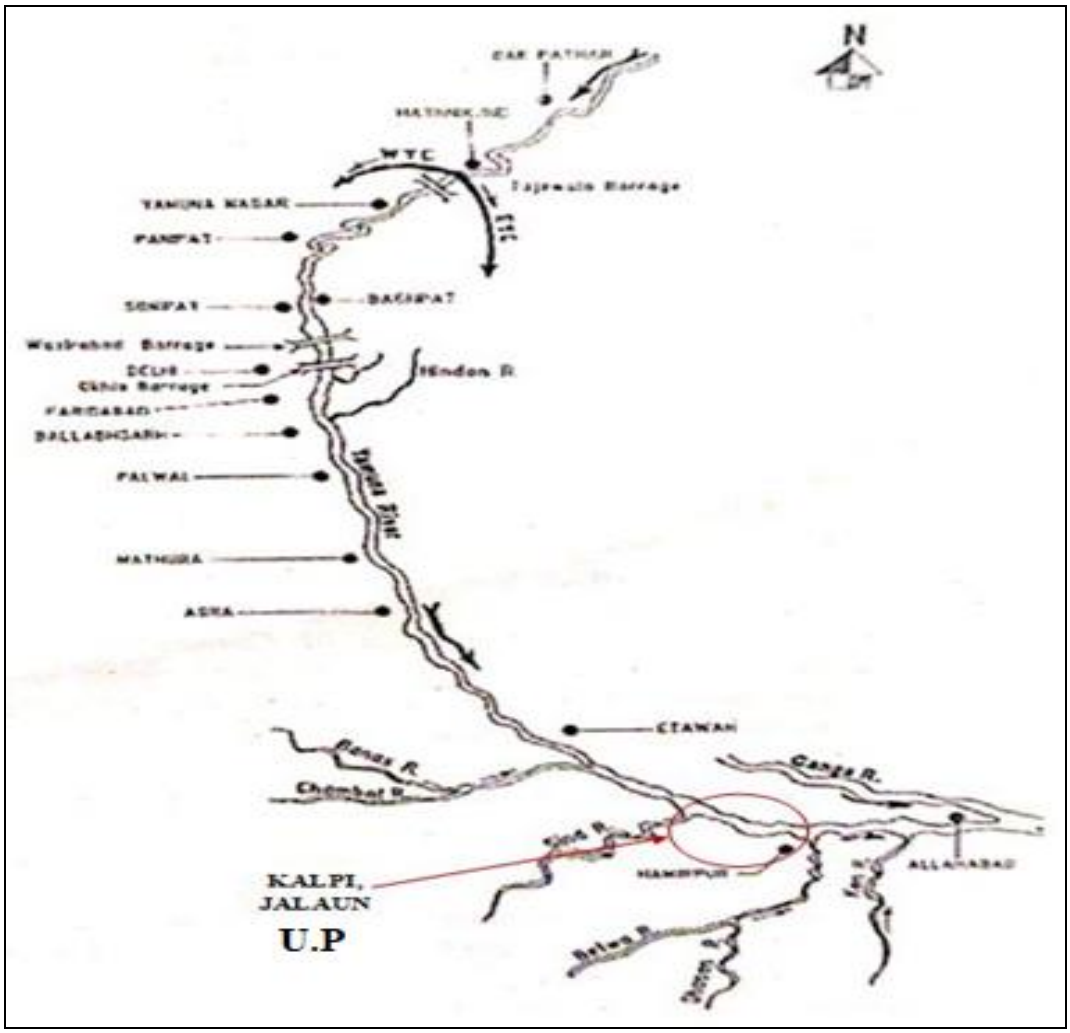

Fig 1: The Yamuna River Basin showing study area (Kalpi region, Jalaun, U.P.)

The water sample of river Yamuna were collected from four site. At each sampling sites, surface water was collected at the middle of the river and stored in clean polyethylene bottles that have been pre-washed with deionized water. Water temperature, pH and dissolved oxygen were determined on spot because of their unstable nature.

The selected sites were

Site 1: Entering Point of Yamuna River in Kalpi city *i.e.* in front of Vyas mandir (Upstream).
Site 2: Peela Ghat, located in the middle of Kalpi city.
Site 3: Discharge point of Ganda Nallaha.
Site 4: 300 meter away from site 3 (Down Stream).

The collected samples were transported immediately to the laboratory for the estimation of physico-chemical properties of sample water. The collected samples were analyzed for Biological Oxygen Demand (BOD), Chemical Oxygen demand (COD), Free CO_2 and TDS, DO, BOD, COD, Nitrate, Sulphate, chloride and heavy metals like chromium, lead, nickel, copper, zinc & cadmium by following standard methods given by APHA (2005) [7].

Results and Discussion

The monthly samples collected from four sites of river Yamuna were subjected to physicochemical characterization for parameters such as Temperature, pH, DO, FCO_2, TSS, TDS, BOD, COD, nitrate, sulphate, chloride and heavy metals as per standard methods. The results of the various physico-chemical parameters of river Yamuna of three seasons (Summer, monsoon and winter) from Feb, 2017- to Junary-2018 are summarized in Table-1 &2. The result of the present study shows wide variations were observed in measured parameters at all stations.

Table 1: Seasonal Variation in Physico-chemical Parameters of river Yamuna at Kalpi region, Jalaun, U.P. (During Summer Feb-May, 2017; Monsoon June- August, 2017; Winter Oct 2017-Jan,-2018)

Parameters	Season	Site-1	Site-2	Site-3	Site-4	Average
Temp^{0}C	Summer	28.7±0.73	30.4±0.23	32.3±1.23	31.4±0.34	30.7
	Monsoon	26.4±0.32	27.5±0.56	26.8±0.32	26.2±0.54	26.73
	Winter	15.2±0.44	16.5±0.33	17.5±0.32	16.6±0.55	16.45
pH	Summer	8.12±0.08	7.87±0.06	7.11±0.08	7.25.±0.07	7.59
	Monsoon	8.14±0.03	7.85±0.03	7.58±0.04	7.77±0.05	7.84
	Winter	7.77±0.05	7.69±0.07	7.36±0.08	7.45±0.07	7.57
DO	Summer	7.20±0.13	6.60±0.23	5.20±0.14	5.60±0.12	6.15
	Monsoon	6.95±0.13	6.65±0.11	6.00±0.17	6.50±0.16	6.53
	Winter	8.52±0.12	8.45±0.13	7.25±0.11	7.62±0.16	7.96
FCO_2	Summer	52.8±0.54	59.4±0.43	69.5±0.81	60.2±0.52	60.48
	Monsoon	42.4±0.54	44.7±0.34	47.3±0.32	45.4±0.76	44.95
	Winter	38.4±0.52	38.7±0.22	44.4±0.21	41.24±0.44	40.69
Alkalinity	Summer	215.5±1.23	205.3±1.33	189.4±2.01	203.2±1.23	203.35
	Monsoon	202.4±1.22	198.3±1.25	171.4±1.46	197.4±1.38	192.38
	Winter	138.6±1.11	109.2±1.42	99.2±1.54	104.6±1.43	112.90
Hardness	Summer	121.0±1,50	124.0±1.25	145.0±1.34	131.0±1.45	130.25
	Monsoon	85.5±1.40	88.5±1.32	135.5±1.22	99.5±1.21	102.25
	Winter	105.5±1.12	107.8±1.22	122.4±1.43	111.3±1.11	111.75
TDS	Summer	465.0±1.50	475.5±1.8	605.5±1.8	515.5±1.6	515.38
	Monsoon	615.0±1.50	638.5±1.7	675.0±1.6	645.0±1.9	643.38
	Winter	465.0±1.4	482.5±1.8	550.5±1.7	505.5±1.6	500.88
BOD	Summer	8.0±1.4	8.6±1.6	11.50±1.8	10.55±1.4	9.66
	Monsoon	5.5±1.2	6.5±1.4	10.50±1.3	9.5±1.4	8.00
	Winter	5.5±1.4	6.4±1.5	7.4±1.8	6.8±1.6	6.53
COD	Summer	21.0±1.0	23.0±1.5	27.0±1.4	25.0±1.3	24.0
	Monsoon	10.50±1.4	13.50±1.5	16.50±1.4	14.20±1.4	13.68
	Winter	19.5±1.2	20.5±1.1	24.0±1.5	22.5±1.5	21.63
Chloride	Summer	28.5±1.5	34.5±1.4	47.5±1.7	37.0±1.6	36.88
	Monsoon	14.5±1.2	17.5±1.5	38.5±1.4	20.4±1.6	22.73
	Winter	16.50±1.5	17.50±1.4	25.50±2.1	19.5±1.7	19.75
Nitrate	Summer	0.68±0.11	0.95±0.12	3.03±0.15	1.50±0.4	1.54
	Monsoon	0.45±0.12	0.68±0.14	4.5±1.2	1.5±1.3	1.78
	Winter	0.55±0.15	0.70±0.13	2.95±2.4	1.75±1.6	1.49
Sulphate	Summer	24.50±1.4	24.80±1.4	26.80±1.8	25.75±1.8	25.46
	Monsoon	11.50±1.6	18.00±1.6	26.75±1.2	22.45±1.5	19.68
	Winter	17.50±1.5	21.50±1.5	25.00±1.4	22.5±4.3	21.63

Notes: All values are in mg/l except water temp and pH.

The water temperature varied with variation of season as lowest in winter and highest in summer, these finding is supported by the finding of (Singh and Gupta, 2004) [29] in Yamuna river. Water temperature directly or indirectly influences many abiotic and biotic components of aquatic ecosystem. It also reflects to the dynamics of the living organism such as metabolic and physiological behaviour of aquatic ecosystem (Singh, 2014). In the present study average temperature was ranging 16.45-30.7^{0}C of which maximum average temperature (30.7^{0}C) was noticed in summer season and the minimum average temperature (16.45^{0}C) in winter season. Many workers observed similar trends while working on different water bodies (Sen *et al.*, 2011; Srivastava and Srivastava, 2011; Singh, 2014) [26, 28]. As fishes require moderate temperature for growth and reproduction, the temperatures were found suitable for the survival and growth of fish fauna (Ansari and Prakash, 2000) [5].

pH is considered an important chemical parameter that determines the suitability of water for various purposes. pH of water important for the biotic communities because most of the aquatic organism are adapted to an average pH. The average pH values during the summer, monsoon and winter seasons were 7.59, 7.84, 7.57 respectively. The lowest pH value was found during winter due to heavy rainfall in winter months. In the present investigation pH recorded ranges between 7.57-7.84 shoes slightly alkaline conditions. The pH of Yamuna river was alkaline in nature, which is a good indicator for fish survival (Prakash. 2001; Khanna *et al.*, 2013) [19].

Dissolved oxygen is one of the most important parameter in assessing the quality of water, directly affecting survival and distributing flora and fauna in an aquatic ecosystem. Average value of recorded DO for the observation period was about 7.00 mg/l. This average is positive for a healthy fish growth. In the present study dissolved oxygen was recorded maximum in winter 7.96 mg/L and minimum in summer 6.40 mg / L, may be due to the low solubility at high temperature and high degradation of organic substances by Rajagopal *et al.* (2010) [23], this result supported by the finding of Ansari and Prakash (1999) [6]. The quantity of D.O. in water is directly or indirectly dependent on water temperature, partial pressure of air etc. Similar result were observed by Kamal *et al.*, 2007 [14] in Mouri river, Carbon di oxide is the chief parameter required for photosynthesis process in plants. In water bodies CO_2 react with water and forms carbonic acid, which soon dissociates into carbonates and bicarbonates, which alters pH of water (Prakash, 2001) [19]. Interestingly CO_2 showed varied behaviour in different season in all the four sampling sites.

Average Free CO_2 in the present study varied from 40.69 – 60.48 mg/L in different seasons and at different sites also. The lowest values (40.69 mg/l) of free CO_2 was recorded in winter season, whereas the highest values (60.48 mg/L) in summer season. Similar results were observed by Singh (2014) [28]. The increase in CO_2 level during summer may be due to decay and decomposition of organic matter, addition of industrial waste (Joshi *et al.*, 1995) [13].

Alkalinity of water is the capacity to neutralize strong acids that gives primarily a function of carbonate, bicarbonate and hydroxide content and formed due to the dissolution of CO_2 in water. In the present investigation average alkalinity values varied from 112.90-203.35 mg/L in all the three season, of which maximum value (203.35 mg/L) was observed in summer season and minimum value (112.90 mg/L) in winter season. Similar trend of fluctuations of alkalinity was also noticed by some researcher (Sahni and Yadav, 2012; Sen *et al.*, 2011 and Khanna *et al.*, 2011) [24, 26, 16] in river water. Process of decomposition of bottom sediments which probably resulted in conversion of insoluble carbonates to soluble bicarbonates (Tabrez *et.al.* 2010) [31]. Alikunhi (1957) [3] reports that in highly productive water, the alkalinity ought to be higher than 100 mg/l. As in the Yamuna water alkalinity was higher than that level through the year, so it was suitable for fish production in terms of alkalinity.

Total hardness value ranged from 102.25- 130.25 mg/L in different season of which higher value (130.25 mg/L) in summer and lowest (102.25 mg/L) in monsoon season. This may be due to the presence of high content of calcium and magnesium in addition to sulphate and nitrates (Singh, 2014) [28]. The increase in hardness can be attributed to the decrease in water volume and increase in the rate of evaporation at high temperature, high loading organic substances, detergent, chloride and other pollutants (Prakash *et al.*, 2015b; Verma, 2016) [22, 35]. According to some classification, water having hardness upto 75 ma/l is classified as soft, 76-150 mg/l is moderately soft, 151-300 mg/l as hard and more than 300 mg/l as very hard (Saravanakumar and Kumar, 2011) [25]. On the basis of classification the selected water samples of Yamuna River can be considered as moderately soft except the sample S3.

A high content of dissolved solid elements affects the density of water, influences osmoregulation of freshwater organisms, reduces solubility of gases (like oxygen) and utility, of water for drinking, irrigational, and industrial purposes. Waters can be classified based on the concentration of TDS as, desirable for drinking (up to 500 mg/L), permissible for drinking (up to 1,000 mg/L), useful for irrigation (up to 2,000 mg/L), not useful for drinking and irrigation (above 3,000 mg/L) (Lokhande, *et al.* 2011.) [18]. In the present study the average total dissolved salts (TDS) was ranged between 500.88 mg/l (in winter) to 643.38 mg/l (in Summer) which was higher than the desirable limit of drinking water.

The average biological oxygen demand (BOD) values of Yamuna river water varied from 6.53 mg/L to 9.66 mg/L. All the samples exceeded the permissible limit (EPA, 2001) [10]. The permissible limit of BOD for drinking water is 0.2 mg/L, for recreation 3 mg/L, for fish 6mg/L and 10 mg/L for irrigation DoE (1997) [9]. So as for the BOD values of Yamuna river (except site 1) was not suitable for fish production. Chemical Oxygen Demand (COD) of the Yamuna river water was varied in between 13.68 mg/l to 24.00 mg/l. It was also under the limit for fish growth and reproduction. High BOD and COD is due to the presence of chemicals that may be organic or inorganic caused by the inflow of industrial and domestic waste that contains high levels of organic pollutants (Abaidooan, 2015) [1].

In the present study the average chlorides level were ranged from 19.75 to 36.88 mg/L of which maximum value (36.88 mg/L) was noticed in summer season and the minimum value (19.75 mg/L) in winter season. The low concentration of chloride was also observed in winter season in the freshwater bodies by other workers (Shiddamallaya and Pratima, 2008) [27]. Venkatesharaju *et.al*. (2010) [34] observed that the higher concentration of chloride in the summer period may be due to increased temperature, low level of water and sewage mixing. The higher concentration of chloride at site 3 is considered to be an indicator of higher pollution due to discharged of industrial and sewage effluents through Ganda Nallaha.

In the present study the average nitrates concentration was ranged from 1.49 mg/l (in winter) to 1.78 mg/l (in Summer). According to Aboyeji (2013) [2], nitrate is relatively nontoxic for fish health, except when the concentration of nitrate exceeds 90 mg/L in water. Sulphate levels in the Yamuna ranged from 19.68 mg/l (in winter) to 25.46 mg/l (in summer). These values when compared to EPA value of 2.0 mg/L showed that sulphate level of Yamuna river was not suitable for fish growth.

Table 2: Seasonal Variation in Heavy metals of river Yamuna at Kalpi region, Jalaun, U.P. (During Summer Feb-May, 2017; Monsoon June- August, 2017; Winter Oct 2017-Jan,-2018)

Parameters	Season	Site-1	Site-2	Site-3	Site-4	Average
Chromium (mg/l)	Summer	0.0033	0.0039	0.0055	0.0045	0.0043
	Monsoon	0.0025	0.0032	0.0045	0.0040	0.0036
	Winter	0.0029	0.0035	0.0050	0.0042	0.0039
Nickel (mg/l)	Summer	0.0034	0.0045	0.0060	0.0049	0.0047
	Monsoon	0.0027	0.0039	0.0045	0.0040	0.0038
	Winter	0.0029	0.0041	0.0050	0.0045	0.0041
Copper (mg/l)	Summer	0.0014	0.0016	0.0035	0.0027	0.0023
	Monsoon	0.0011	0.0014	0.0024	0.0019	0.0017
	Winter	0.0012	0.0014	0.0025	0.0022	0.0019
Cadmium (mg/l)	Summer	0.0011	0.0014	0.0017	0.0015	0.0014
	Monsoon	0.0005	0.0006	0.0006	0.0005	0.0006
	Winter	0.0006	0.0006	0.0008	0.0007	0.0007

In the present study the range of heavy metals concentration in Yamuna river water were as follows: Chromium 0.0036 – 0.0043 mg/l, Nickel 0.0038-0.0047 mg/l, Copper 0.0017-0.0023 mg/l and Cadmium 0.0006 -0.0014 mg/l. It was also observed that the concentration of heavy metals was maximum in summer and minimum in monsoon seasons. All the estimated heavy metals were maximum at the site 3 because at this site the Ganda Nallaha having industrial as well as domestic waste water discharged into the Yamuna River. These values of heavy metals are within the permissible limits of drinking water but these are potentially toxic and in long term they accumulate in the tissues and may be harmful. According to Amomeso *et al.*, (2010) [4] the heavy metals have been associated with the industrial effluents and linked with the heavy metal contamination of an area to industrial effluent discharge.

Most heavy metals in aquatic ecosystems eventually become associated with particulate matter, which settles and accumulate in the bottom sediments (Linnik *et al.*, 2000) [17]. The accumulation of pollutants in the bottom sediments of water bodies and the remobilization of these substances from

the sediments are considered as the two most important mechanisms in the regulation of pollutant concentrations in an aquatic environment (Fouzia and Khan, 2013) [11].

On the basis of comparative study of BOD, COD, TDS, Chloride, nitrate and heavy metals concentrations in the water samples of Yamuna River at all the four sites it can be concluded that except site 3 all three sites *viz*. site 1,2 and 4 are suitable for aquatic biodiversity. The water of site 3 was moderately polluted due to discharged of waste water of small scales industries and domestic sewage at that site of Yamuna River through Ganda Nallaha.

Conclusion

This study was conducted to assess the physicochemical properties of surface water collected from four different sampling sites of river Yamuna at Kalpi region of Jalaun District of U.P. This experiment confirmed that some physicochemical parameters like temperature, pH, DO, FCO_2, Alkalinity and hardness met the standard acceptable limit in India while TDS, BOD and COD were very high in concentration compared to the national and international standards. Thus from the data obtained on physicochemical parameters, it was found that the water quality of River Yamuna at Kalpi region was good to sustain life and also the water was in a condition to be used for different purposes. Although surrounding pollution does not have any serious effect on the river and their aquatic life except site3 yet it is recommended that Government of India has made it mandatory for all small scale industries to treat their effluents properly before their discharge. However, accidental discharge or inadequate management of untreated effluents may have disastrous effect on aquatic organisms.

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