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Impact of River Bhalla on Kosi river water quality at Rampur (India)

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Abstract
River Kosi an important tributary of river Ramganga is one of the important rivers of Uttrakhand & U. P. After traveling for about 100 kilometers in lower Himalayas with higher velocity, it emerges at Ramnagar in Indo-Gangetic plains. Here, the major portion of city sewage is discharged into it. Then, it flows through the famous rice belt area of Kashipur, where a large number of polluting industries discharge their highly polluted effluents into it. To determine the extent of pollution in downstream district Rampur a study was conducted. The aim of this study was to evaluate the effect of dilution caused by the merger of river Bhalla with Kosi River. For this samples were collected from three stations and analyzed for various parameters for the period of one year. The study revealed higher levels of industrial pollution as compared to domestic pollution. It also shows the alleviating effects of dilution caused by the merger of river Bhalla.

Keywords: industrial pollution, water quality, COD, BOD, DO

Introduction
Rivers and streams, in spite of occupying only a small portion of the land surface as compared to the relatively large 1.8% of land area occupied by lakes, have significant importance in human lives [1] and are involved in various anthropogenic activities, including cultural and traditional practices ad rituals [2]. The river Kosi is one of the major tributaries of river Ramganga and is one of the important rivers of northern part of Uttar Pradesh & Uttranchal. The major area which are parts of Kosi river basin, are Tota-aam and Garajiya in Almora, city Ramnagar (Distt. Nainital), Kashipur (Distt. Udhamsingh Nagar), Dadiyal, Swar, Lalpur and city Rampur. In terms of economic importance, the area lying of the banks of the river i.e. from Ramnagar to Rampur is renowned as Rice Belt and amongst the most prosperous agricultural regions for various products since centuries. However owing to the rapid development of local economy in last decade, the river is under severe pressure from various anthropogenic activities [3].
The river Kosi originates from village Budha Peenath of Kausani region of district Almora (U.A.). After traveling a distance of about 100 kilometers in lower Himalayas with higher velocity, it emerges at Ramnagar in Indo-Gangetic Plains, after which the velocity reduces considerably. In the initial stretch through the Shivalik range of Himalayas, it takes water from a number of major streams and a major portion is diverted into a canal for irrigation purposes. After Ramnagar, it flows through the famous rice-belt area of Kashipur, where a number of polluting industries discharge their highly polluted effluent into it.
The river has a masonry dam at Lalpur and most of the canals, which irrigate the major portion of the district, are dependent on its water. During lean periods, no discharge is released downstream of Lalpur dam and in stretches the river becomes nearly dry. The river recharge due to ground water sources and its tributary river Bhalla, which meets the Kosi at village Pranpur downstream of city-Rampur. After this city, the river traverses a distance of around 50 km. and meets river Ramganga. The total length of the river is about 250 km [4].
In order to achieve sustainable water quality management it is important to assess seasonal variations in water quality [5] so as to identify the influences of various anthropogenic activities on the overall water quality of the river in the study zone [6].

Materials and Method
Source of Pollution
At Kashipur, apart from domestic waste a large number of industrial units dump their toxic wastes into the river Kosi causing sever pollution [7].
Large quantities of fertilizers and pesticides are used for agricultural purposes in the river basin and particularly during rains or while flooding the fields for rice the run off/ excess water finds its way to the river. However during non-monsoon period, the magnitude of carry over the river is not significan t[8, 9]. In addition to the above a part of cattle generated wastes and agricultural resides also reaches to the river during monsoons as runoff. It is estimated that 10-15% of the nutrients added to the soil in the form fertilizers reaches to the surface, water system [10].
During survey it was observed that rural areas are situated on both the sides of Kosi, which are engaged mainly in the agriculture and cattle farming. These cattle's while wading in the river transfer fecal matter and other types

of pathogens in the river. Also the various movement and activities of the cattle inside the water disturb the river bed where the pollutants are settled in the form of sludge. This ultimately deteriorates the quality of the river water to a considerable extent. All these constitute the non point pollution sources [11, 12].

Study Area

In order to study the effects of various activities on the water quality of river Kosi, an area next to city Rampur was selected. In the study zone a smaller river Bhalla merges with river Kosi. The present study also underlines the alleviating effects of dilution on the overall river water quality (Map 2)

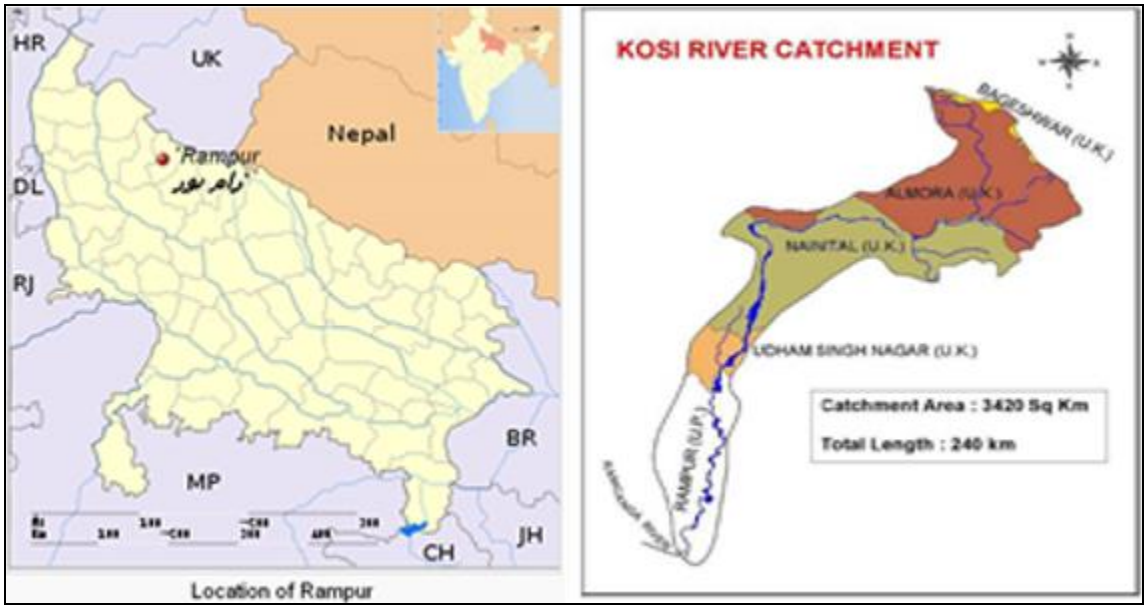

Fig 1

Sampling Sites and Sample Study

An extensive study was carried out on the physico-chemical and bacteriological quality of water of the rivers Kosi and Bhalla In all three sampling stations were fixed as given below for regular collection of water samples at the rates of once every month for one year. The overall study period was divided into three seasons mainly winter (Nov-Feb), summer (Mar-June), and Rain (July-Oct).

Sample Station I: River Kosi before merger

Sample Station II: River Bhalla before merger

Sample Station III: River Kosi after joining River Bhalla

All the samples were collected in clean white plastic containers. Parameters like pH, temperature, conductivity and D.O. were estimated on the spot. Rest of the parameters was analyzed as per standard methods [13, 14].

Result and Discussions

The physico chemical characteristics of water samples at different stations in the three consecutive seasons have been presented in Table 1. As is clear from the table and values of parameters station I is the most polluted along Kosi river. The colour of water sample was generally light brown along the Kosi River. However the intensity of colour diminishes at station III. This can be attributed to the merger of river Bhalla and subsequent dilution of Kosi river water [15]. It is also clear from Table 1 that parameters like conductivity show decreased values during rainy season which can be attributed to dilution by rain water [16].

The water samples gives out faint aroma which express a mixed odour of various chemicals, used as raw materials in industrial units. The odour is also caused by decomposing plant and animal debris and domestic sewage [17]. However, during rainy season no characteristic odour is found due to the dilution [18]. Temperature is an important factor for its effect on certain chemical reactions taking place in organisms inhibiting aquatic media and also on the soil-water inter phase.

A cursory inspection of the observed turbidity values shows that water at station I is most turbid throughout the study period. This may be attributed to the lower amount of water. The turbidity at station III was found to decrease may be due to the dilution effect of river Bhalla. The electrical conductivity decreases from station I to station III. This can be attributed to the decreased T.D.S. which also follows the same trend.

The relative higher values of C.O.D as compared to B.O.D. indicate higher level of industrial pollution caused by industrial units situated due north in Kashipur [19].

Calcium & magnesium are largely responsible for the hardness of water. The acidity of water used for industrial purpose is controlled by the use of lime. Here all the three have higher values at station I which decreases as river flows to station-III [20].

It is clear that MPN count is highest at station I in all three seasons, which indicates severe pollution. In general the values are higher during the rainy season; hence coliforms are maximum in river water during this season. On the other hand the minimum values are observed in winter season, therefore, the coliform are found least in this season.

W.Q.I values for three stations (Table-2) are also in accordance with the above results. This clearly shows the impact of relatively clean water of river Bhalla, which results in the higher values of W.Q.I. at station III as compared to station-I [20].

Table 1: Mean Values of Physico-Chemical and Biological parameters of River Kosi at Rampur showing seasonal variations

W: Winter (Nov. – Feb.) S: Summer (Mar.-Jun.) R= Rainy (Jul.-Oct.)												
	Temperature			**pH**			**Total solids**			**Conductivity**		
	W	**S**	**R**	**W**	**S**	**R**	**W**	**S**	**R**	**W**	**S**	**R**
Station 1	19.7	34	30.9	7.7	7.5	7.5	365	387	386	493	514	445
Station 2	20.1	33.5	30.7	7.9	7.4	7.6	325	351	366	461	482	421
Station 3	18.9	33.4	30.5	7.8	7.3	7.5	341	347	372	479	485	430
	Turbidity			Hardness			Chloride			Alkalinity		
	W	S	R	W	S	R	W	S	R	W	S	R
Station 1	32	41	75	205	209	199	25.3	21.0	18.8	195	158	111
Station 2	25	34	73	189	188	184	21.4	19.0	18.1	157	131	91
Station 3	29	36	74	211	207	205	23.8	20.0	18.2	197	153	98
	D.O			B.O.D.			C.O.D.			MPN		
	W	S	R	W	S	R	W	S	R	W	S	R
Station 1	6.7	6.8	6.3	5.9	5.7	5.8	39.0	33.0	36.0	121	134	190
Station 2	6.6	6.6	6.2	6.0	5.5	5.9	36.0	32.8	33.5	115	126	179
Station 3	6.5	6.4	6.3	6.0	5.5	6.0	40.0	36.0	36.5	114	129	189

Table 2: W.Q.I. range of for different classes of beneficial use

Designation	**Limits of WQI**	**Condition of River**
I	90 and above	Excellent
II	Between 65 & 89	Good
III	Between 35 & 64	Satisfactory
IV	Between 11 & 34	Poor
V	10 and below	Unacceptable

Table 3: Water quality index of river Kosi and river Bhalla at Rampur for different uses

	Bathing & Swimming			**Public Water Supply**			**Agriculture**		
	W	**S**	**R**	**W**	**S**	**R**	**W**	**S**	**R**
Station – 1	32	32	30	32	31	30	77	78	80
Station – 2	33	33	30	33	32	30	83	83	83
Station – 3	33	33	31	32	32	31	80	79	81
	Industry			Fish Culture & Wild Life			Over-All		
	W	S	R	W	S	R	W	S	R
Station – 1	15	15	15	77	61	62	47	43	43
Station – 2	16	16	16	82	57	61	49	44	44
Station – 3	15	16	16	79	58	61	48	43	44

Water Quality Index (W.Q.I)

The river water quality can be assessed using various methods including multivariate analysis. Another method is W.Q. I., here the individual values of a number of variables along with the relative importance of each variable, the water quality for a given use can be put in terms of a single number called the Water Quality Index (W.Q.I.) (Table-2). Though various expressions for W.Q.I. determination were given earlier, a simplified expression (1) for W.Q.I. is given here [21]. The W.Q.I values for three stations (Table-3) are also in accordance with the above results. This clearly shows the impact of relatively clean water of river Bhalla, which results in the higher values of W.Q.I. at station III as compared to station I.

$$WQI = \left[\prod_{i=1}^{i=n} f_i\right]^{1/n} \text{X } 100 \qquad (1)$$

Where f = sensitivity function, n = number of parameters used

Conclusion

From the above study it is clear that the water of river Kosi is very much polluted but still can be used for agriculture and fish culture. But there is an urgent need to control the further deterioration of river water quality [21]. It also underlines the need to control the quality and quantity of the waste water that is being discharged into the river, so as to maintain the desired quality of water. We further clarified the seasonal variation, irrigation system, and land use types may greatly effect the surface water quality fluctuations in rivers at this study.

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