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Assessment of Physicochemical characteristics of Kalyani River, Udham Singh Nagar, Uttarakhand, India

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***Abstract*: The current study aims to assess the water quality as well as potential sources of contamination in the Kalyani River by taking into account effluent discharged from SIIDCUL industries. Water samples were collected from three different sampling locations and analysed for physicochemical water quality parameters. The water quality was relatively better at upstream (site KR1) of the river, whereas physicochemical parameters became impaired at sites KR2 and KR3, implying significant pollution of the river from SIIDCUL industry effluents and municipal drains from Rudarapur city. Among the three sampling sites, site KR2 recorded high concentration of COD (1010 mg/l) and BOD (230 mg/l. These findings, however, indicated that site KR1 was the most polluted, most likely because it was the point of industrial effluent discharge. A comparison of the measured parameters to the national and international standards established by the EPA Rule (1986) and WHO (2008) reveals that all of the parameters measured (except TDS) exceeded the standards. This indicates that the river water was extremely polluted and thus unfit for domestic, agricultural, or industrial use. Therefore, it recommended that the government and other responsible authorities take appropriate corrective action and support further research on other physical, chemical, and untested biological parameters of significant health concern, as well as the identification of potential sources of the river's contaminants.**

***Keywords*: BOD, COD, Kalyani river.**

1. Introduction

Water is one of the most important natural resources that is abundantly available on Earth and is required by all living organisms. The existence of all forms of life on Earth is primarily dependent on the availability of pure and clean water. In nature, it distributed as surface and ground water in different forms and sources like ocean, seas, rivers, streams, lakes, ponds, wells, boreholes and springs. According to the WHO, 97 percent of the total amount of water on the planet is saline (ocean) water, which is difficult to use without treatment. The remaining 3% of water is fresh, but 70% of it is in glaciers and polar ice caps, the rest is in belowground aquifers and soil moisture, and only 0.3 percent exists as surface water. Most urban-rural communities in developing countries use surface water, particularly rivers, for a variety of purposes including agriculture, industry, transportation, and public water supply. They play a crucial role in human life by providing different benefits such as shipping, electricity generation, water supply, food and agricultural production[1]. Despite this, rivers have been used for cleaning and disposal purposes. Vast quantities of wastewater from industry, domestic sewage, intensive agriculture, and other pollution sources are discharged into surface water bodies particularly rivers, causing the river water to become severely polluted. This may causes decline in water quality which severely affect the aquatic environment, landscapes and human health. As a result, surface water pollution which primarily caused by anthropogenic activities such as domestic and industrial activities, as well as agricultural practices, continues to be a major issue around the world[2].

Water quality analysis in fresh water sources is essential because they can be the primary routes for the spread of persistent organic pollutants, toxic chemicals, and pathogenic microorganisms. To reduce the effects of these pollutants on aquatic ecosystems, landscapes, and human health, it is important to identify pollution sources and develop suitable management strategies.

The normal structure and function of a river ecosystem has been affected by intensive human activities like agricultural practice, urbanization and industrialization [3]. River Kalyani is one of the river in Uttrakhand state of India which is spring fed river originating from the Tanda forest area of Nainital district. It passes through agricultural field of Pantnagar followed by Integrated Industrial Estate (IIE), Pantnagar and flowing across the Rudarpur city from north east to south east. Due to the disposal of untreated or partially treated wastewater from industries in the State Infrastructure and Industrial

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Development Corporation of Uttarakhand Ltd (SIIDCUL) as well as municipal drains from the city's residential areas, the Kalyani river is at risk of severe pollution [4]. This, in turn has a negative impact on aquatic life, the landscape and human health. The purpose of this study is to investigate the water quality parameters of the Kalyani River in relation to the EPA Rule 1986 and WHO guidelines for surface water discharge. It also aimed to assess the level of pollution and potential sources of contaminants in river water, taking into account effluent from SIIDCUL industries.

2. Materials and Methods

A. Description of the Study Area

The study was carried out in Kalyani River in and around Rudrapur city, Udham Singh Nagar, Uttarakhand, India. The river originates in the Tanda forest area of the Nainital district. It is a spring-fed river that began flowing as a stream below Tanda forest in the area of Sainik farm colony Patharchatta, Udham Singh Nagar, at latitude 29º 02' 30" N and longitude 79º 25' 18 " E. It passes through agricultural field of Pantnagar followed by Integrated Industrial Estate (IIE), Pantnagar and flowing North-east to South-east direction across the Rudarpur city.

The IIE-Pantnagar has 431 industries, mainly of electroplating, automobile-manufacturing, food production along with their joint types spread over 1,310 hectares of land [5]**.** Treated and untreated industrial effluent from these industries coupled with municipal wastewater from Rudrapur city is directly discharged in to the Kalyani River water which has a huge potential to deteriorate the water quality of river and impose risk on the adjacent biodiversity as well as human health.

B. Sampling Sites Selection

A preceding survey of sampling location has conducted carefully for one day to select the relevant sampling location based on the objective of the study and potential source of pollution. Three sampling sites, which cover a length of about 12 Km were selected by considering the relative sources of pollution to the river (Fig.2). Site-1 (KR_1) lies in village Patharchatta, upstream of the river before starting of discharge of industrial effluents from IIE Industries. Site-2 (KR2) lies 4 to 5 km downstream from site 1 (KR1) at middle reach of the river where high amount of industrial effluents from SIIDCUL industries joined to the river. Site -3 (KR3) at 7 km downstream from site-2 (KR2) after the entry of discharges from industrial effluents and domestic wastewater.

Table 1
Details of sampling locations

1	Patharchatta bridge	29^0 1' 58" N and 79^0 24' 46" E
2	Jagatpura road, Rudrapur	28^0 58' 46" N and 79^0 24' 10" E
3	Khanpur	28^0 56' 50" N and 79^0 24' 19" E

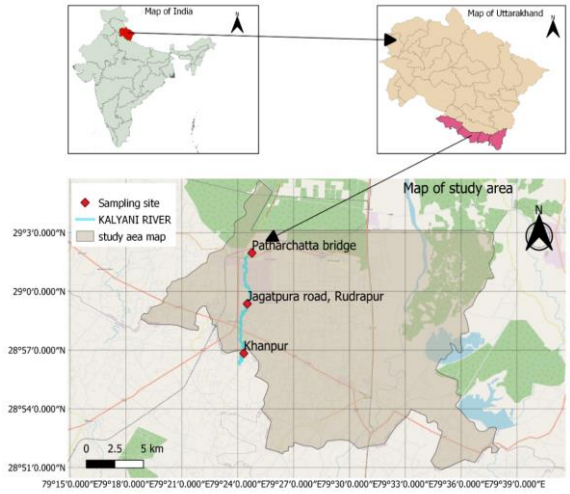

Fig. 1. Location map of the study area (Rudrapur subdivision) showing the location of sampling sites

Fig. 2. The three sampling sites of Kalyani River water

C. Sample Collection

The sampling of river water was done in the month of April 2021. Water samples from all three sampling sites were collected at a depth of 30 cm below water surface using 250 ml plastic bottles. Prior to sampling the bottles were cleaned using 10 % nitric acid. Sample bottles than labelled to indicate sample site. Finally, samples were collected and transported to the laboratory for analysis.

D. Analytical methodology for Kalyani River Water

The water samples were thoroughly analysed for pH, Electrical Conductivity, Total Dissolved Solids, Total

Suspended Solids, Total Solids, Chemical Oxygen Demand and Biochemical Oxygen Demand [6]. All the collected samples were stored in airtight plastic bottles and were analysed for above-mentioned parameters.

3. Result and Discussion

A. Physicochemical Characteristics of Kalyani River Water

Physico-chemical parameters analysed in this study for Kalyani River water samples include pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Total Solids (TS), Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD).

pH is an important parameter for analysis of river water quality, since most of the chemical reaction in aquatic environment are controlled through the change in its value. In this study, the pH of the River water sample at the three sample sites ranges from 6.3 (site KR*2*) to 8.1 (KR1). As it is indicated in Table 1, pH values at all sampling locations were slightly acidic to alkaline. Site KR1 showed higher pH value (8.1) during the study time which is within the maximum permissible limit of surface water discharge while the lowest pH value (6.3) was found at site KR2 which is also within the permissible limit. The highest value of pH at site KR1 might be contributed by the local discharges which contain alkaline effluents from surrounding institutions and households.

B. Electrical Conductivity

The EC value expresses the potential of water to transfer electric current and relies on the concentrations of ions in water [7]. The high level of inorganic pollution in the river water may be indicated by high electrical conductivity of water [8]. Electrical Conductivity value of Kalyani River water in this study was found in the range of 311 µ siemens/cm to 1260 µ siemens/cm (Table 2). The highest value of electrical conductivity recorded at Site KR3 followed by KR2 was probably associated with discharge of effluent which contain dissolved substance from SIIDCUL industries and municipal wastewater discharge from residential area of Rudrapur city.

C. Total Dissolved Solids

The availability of high inorganic and organic substances may contribute to the total dissolved solids in River water. Higher value of TDS increases salinity in the River water or changes its composition due to which it may become toxic to aquatic life. In Kalyani River water maximum value of TDS was recorded at KR3 (845 mg/l) and minimum at KR1 (210 mg/l) as shown in Table 2. TDS value through the downstream of Kalyani River shows spatial variability with increasing trend. This is expected due to discharge of wastes into the River which can be clearly observed through the downward gradient of the River.

D. Total Suspended Solids

The amount of suspended particle, soil and silt are the main factors that contribute for the total suspended solid content of River water which is directly related to clarity of water [9]. Suspended solids can serve as carriers for organic compounds. Suspended solids are objectionable in River for many reasons. Suspended Solids containing much organic matter may cause putrefaction and consequently the stream may be devoid of dissolved oxygen. In the present study, at Kalyani River the TSS values were in the range from 60 mg/l to 355 mg/l (Table 2). The highest values recorded at site KR3 (355 mg/l) followed by KR2 (263 mg/l). These high values could be attributed due to discharge of industrial effluent and disposals of domestic wastewater from Rudrapur city. River water having TSS values greater than 100 mg/l but less than 220 mg/l is classified as medium wastewater and above this comes under highly polluted water [9]. Thus, the overall TSS mean value for Kalyani River is 226 mg/l which can be considered as highly polluted water.

Table 2
Kalyani River water characteristics and discharge permissible limit

Parameters	**Concentration**			**Discharge permissible limit**	
	Site KR1	**Site KR2**	**Site KR3**	**EPA Rules 1986**	**WHO, 2008**
pH	8.1	6.3	6.97	5.5 to 9	5.5 to 9
TDS (mg/l)	210	737	845	2100	-
EC (µ siemens/cm)	311	1110	1260	-	-
TS (mg/l)	270	1000	1200	-	-
TSS (mg/l	60	263	355	100	-
COD (mg/l)	330	1010	830	250	250
BOD (mg/l)	168	230	180	30	50

E. Total Solids

In this study the maximum value of total solids was recorded at KR3 (1200 mg/l) and minimum at KR1 (270 mg/l). This might be due to deposition of solid particles and domestic wastes from the city through the river course which could lead to the reduction in the volume of water. Since, there are no such activities around the rural area compared to the urban areas, site KR1 has lowest value of TS concentration than the other sampling sites.

F. Chemical Oxygen Demand (COD)

COD concentration in river water reflects the extent of water pollution caused by non-biodegradable and biodegradable organic compounds, and its high value renders the water body unsuitable for aquatic life [7]**.** COD values in Kalyani River varied from 330 to 1010 mg/l (Table 2). The maximum concentration of COD was recorded at Site KR2 (1010 mg/l) followed by site KR3 (830 mg/l) and the minimum value was recorded at site KR1 (330 mg/l). The COD values recoded in all sampling sites are above the permissible limit (Table 2). These high COD values, particularly at site KR2, may be attributed to the discharge of untreated or partially treated industrial effluents from SIIDUL industries, as well as domestic wastewater from Rudrapur city's residential areas.

G. Biochemical Oxygen Demand (BOD)

Organic waste loads from domestic wastewater, industrial effluent, and agricultural manure are the main factors that raise BOD levels in wastewater[10]**.** The BOD concentration of Kalyani River in the present study ranges from 168 mg/l to 230 mg/l (Table 2). Site KR2 showed higher values of BOD (230

mg/l) followed by KR3 (180 mg/l). The discharge of untreated industrial wastewater from SIIDCUL industries as well as domestic wastewater from residence of Rudrapur city are responsible for the elevated level of BOD at sampling site KR2. The recorded values of BOD in all sampling sites are above the permissible limit of inland surface water discharge (Table 2).

4. Recommendation and Conclusion

The assessment of water samples from the river for physicochemical parameters revealed that the river is highly polluted and unfit for domestic, agriculture and industrial use. Among selected sites site KR2 polluted than the other two sites as it is being industrial effluent mixing point. In general, the following conclusions have been drawn from this study:

1. It can be seen that the concentrations of various studied physico-chemical parameters such as BOD, COD and TSS were higher than the permissible limits set by the EPA Rule, 1986 and WHO, 2008. According to the physicochemical parameters analysis results, there was quite a high level of water pollution particularly at the effluent discharge site, site KR2. This could be as a result of direct discharge of untreated or partially treated effluent from SIIDCUL industries as well as municipal discharge
2. The continued discharge of effluents into the river in addition to making the river unappealing, it rendered the water unsuitable for domestic use and had negative effects on the biotic community. This investigation revealed that effluent from SIIDCUL industries and municipal discharge had a severe negative impact on Kalyani river water quality parameters. Finally, we recommended that the government and any responsible authorities fund additional research on other physical, chemical, and untested biological parameters of significant health concern as well as the identification of potential sources of contaminants in this river.

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