

Temporal Study of Physicochemical Characteristics and Qualitative Plankton Diversity of a River Kosi, a Tributary of West Ramganga in Reference to the Habitat of *Garra gotyla gotyla*

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ABSTRACT

The river, Kosi originates from the western slope of the Kaushani range and flows (mountains of Almora, Nainital and Udham Singh Nagar) in the southern direction and joins the river, Western Ramganga at tarai region. Along with the total catchment area of 3,420 sq.km., river Kosi covers a distance of 240 km. The present study determines the habitat at of *Garra gotyla*, physicochemical parameters of water and plankton diversity of river Kosi from January 2019 to December 2019. During the study, various physicochemical parameters such as air temperature, water temperature, pH, dissolved oxygen, dissolved free carbon dioxide, electrical conductivity, velocity, transparency, total dissolved solids, and total alkalinity were analyzed. The biological study was focused on the qualitative assessment of phytoplankton and zooplankton diversity. A total of 34 species of phytoplankton as well as 13 species of zooplankton were recorded during the present study and among phytoplankton, the dominant group was the members of the class- *Bacillariophyceae*.

Keywords: Physicochemical analysis, Phytoplankton, Qualitative study, Velocity, Zooplankton
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INTRODUCTION

Water, "the ambrosia of life" is the basic need for all aquatic as well as terrestrial life forms.^[1] The aquatic ecosystem is the most diverse and productive ecosystem on earth. Optimum physicochemical characteristic and biological diversity represent a healthy aquatic ecosystem.^[2] Water quality not only indicates the general health of an aquatic ecosystem but also influence habitat suitability for the survival of fish. It influences the development of plankton^[3] which determines the productivity of an aquatic water body. Plankton acts as an ecological indicator and increases the primary productivity which directly increases the production of fish.^[4] In a lentic and lotic ecosystem, phytoplankton provides food for primary as well as secondary consumers and balances the aquatic ecosystem.^[5] Water quality and phytoplankton compositions have a great impact on fish growth including health. Uttarakhand is a rich water state blessed with many major and minor freshwater resources. This includes 2700 km of rivers and their tributaries in addition to several lakes, natural ponds, and manmade reservoirs. Quite a several rivers that drain in the northern plain originate from Uttarakhand.

The main rivers of Uttarakhand are the Alaknanda, Ganga, Kali, Ladhya, Kosi, Pindar and East Ramganga. The amount of heavy annual rainfall in Uttarakhand is 1606 mm but due to high slopes, about 95% of the rainwater is drained off into rivers and lakes. Most of the rivers harbor pristine clean water naturally but subsequently receives loads of organic material and suspended impurities directly due to heavy rain and storm. Extensive work on physicochemical properties of rivers, lakes, and reservoirs has been carried out by various scientists for studying the relationship among physicochemical and biological parameters of aquatic water bodies for the development of aquaculture:^[6-14]

However, as per the literature, few studies have been conducted on the physicochemical parameters and plankton

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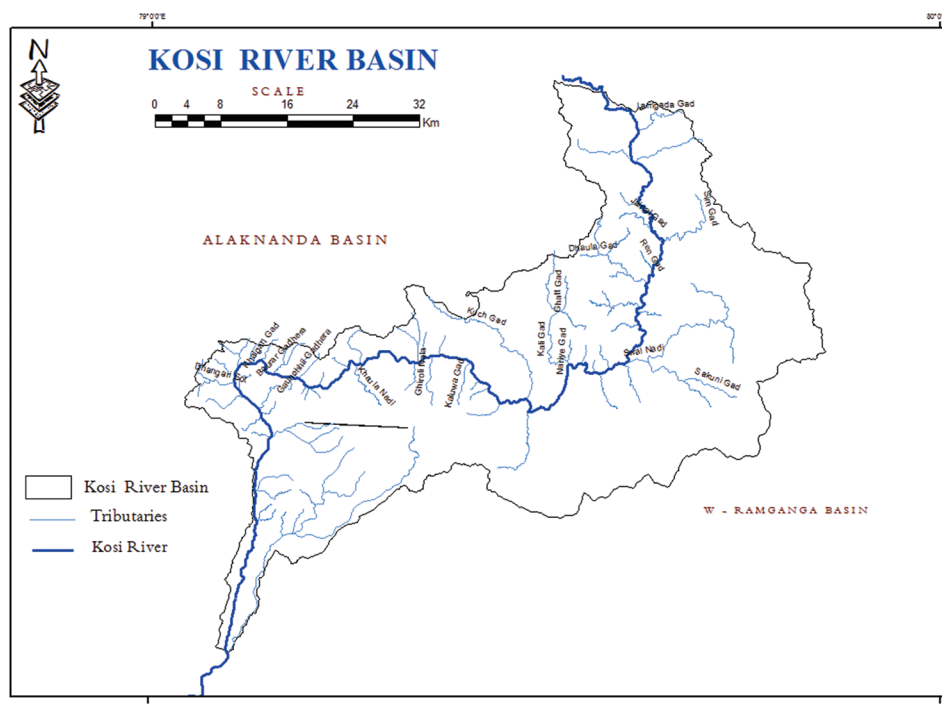
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diversity of the Kosi River. Hence, the present study has been aimed to assess the physicochemical parameters and plankton diversity of the Kosi River to as these are the indicators of the productiveness of an aquatic ecosystem.

Study Area

The climate of Uttarakhand is mostly cold and the area of study is located in the western part of Central Himalaya. Kosi River originates from Dharpani Dhar (Rudrahari) near Kausani, Almora in Kumaun Uttarakhand and flows through Someshwar to reaches Khwarb where it merges with Suyal River. Then, it moves to the west direction at Khairna, Garampani, and Dhikuli followed by its entry into plains at Ramnagar to join the Ramganga River in tarai region. The total length of Kosi is 240 km, covering 3420 sq. km. of the catchment area. The river plays an important role in irrigation, drinking water supply, and aquaculture activities. The Kosi river of



Uttarakhand serves as a natural habitat for several indigenous fish such as *Garra sp.*, *Schizothorax sp.*, Mahseer, loaches, and catfishes.

MATERIALS AND METHODS

The analysis of the physicochemical profile of the river Kosi was conducted from January 2019 to December 2019. The labile parameters such as air temperature ($^{\circ}\text{C}$), water temperature ($^{\circ}\text{C}$), pH, total dissolved solids (TDS) (mg/l), and conductivity ($\mu\text{mho/cm}$) were analyzed and recorded at the sampling site to obtain a more accurate reading. The parameters such as temperature, pH, transparency, and TDS were analyzed with the help of a digital thermometer, pH meter, Secchi disk and digital TDS meter, "HM Digital TDS-3," respectively. The water sample from Kosi river was collected using a dissolved oxygen (DO) bottle of Winkler and was taken to the laboratory for analysis of other important physical parameters such as total alkalinity (mg/l), nitrate (mg/l), and phosphate (mg/l) by following methods.^[15,16]

For plankton analysis, the sample was collected with the assistance of a plankton net and kept in a 125 ml reagent bottle. Two drops of Lugol's solution were added to the collected sample for fixation of the plankton and then the sample in the bottle was left undisturbed for at least 24 h for sedimentation. The supernatant was then siphoned out and the sediments were examined under the microscope (Olympus CKX53) and the plankton was identified by Adoni *et al.*,^[17] Edmondson,^[18] Pennak.^[19]

RESULTS AND DISCUSSION

The current study determines the physicochemical analysis and plankton diversity of river Kosi. During the study, numerous physicochemical parameters such as air temperature, water temperature, pH, electrical conductivity, velocity, and total alkalinity were analyzed and the values are summarized in Table 1.

Temperature

During the study, the air temperature was ranged between 10°C (January) and 27.9°C (July) whereas the water temperature varied from 12.4°C to 23.3°C . Air temperature has a great impact on water temperature because changes in air temperature also make a change in water temperature. "Water temperature was high in summer due to high air temperature and low water level."^[20] Singhal *et al.*^[21] the recorded average temperature of water bodies in India is ranged between 7.8°C and 38.5°C . Temperature plays a central role in the growth, dispersal and reproduction of aquatic flora and fauna.^[1] The temperature has an immense effect on the DO, that is, higher the temperature, the lower the DO, and vice versa.^[1] FW PAC (1967) has given the quality characteristic of temperature, as a catalyst, an activator, a stimulator, a killer, and a controller of life in water.^[22]

pH

pH scale determines the intensity of acidic and basic character of water and is estimated by the negative logarithm of hydrogen ion concentration. During the study, the pH has fluctuated between 7.3 and 8.1. The highest pH was recorded in February and September while the lowest in July. The pH was recorded as alkaline, which was in the similar line observed by Bouslah *et al.*,^[23] Lkr,^[24] Thakre *et al.*^[25] The alkaline pH indicates the unpolluted nature of water and flourishes the growth of plankton. The change of pH of the water is mostly due to biogenic activity such as microbial integrity and photosynthesis.^[22] During the process of photosynthesis, the plant consumes CO_2 for their food production, which in turn increases the pH of water.^[11] On the other hand, the decrease in pH is mainly due to the decomposition of organic matter. The fish production generally flourish in the 6.5–7.8 pH range and at 7.5–8.5, average fish are being produced.^[26]

Table 1: Physicochemical analysis of river Kosi (Uttarakhand)

Parameter	Air Tem.	water Tem.	pH	T.D.S.	D.O.	Dissolved free CO ₂	Total alkalinity	Nitrate	Conductivity	Velocity	Transparency	Phosphate
January	10.3	12.4	8	47.1	9.2	0.4	43.3	0.021	87.2	0.532	65.2	0.017
February	14.8	15.6	8.1	49	8.4	NIL	46.1	0.037	82.4	0.489	61.4	0.029
March	16.4	13.3	8	35	6.7	NIL	50	0.085	85.1	0.572	61	0.022
April	21.9	16.5	7.6	39.1	6.5	NIL	51.8	0.13	77.9	0.492	57.2	0.021
May	25.7	20.3	7.4	40.3	6.8	1.2	47.3	0.096	72.2	0.631	53.8	0.025
June	26.7	21.6	7.6	42.3	7.2	1.25	45.4	0.082	79	0.689	51.1	0.019
July	27.9	23.3	7.3	44	6.1	1.73	42.3	0.45	65.7	0.832	47.3	0.023
August	23.8	21.7	7.5	46	8.4	1.32	40	0.29	62.3	0.875	49.7	0.093
September	25.7	22.5	8.1	52.7	9.1	1.25	39.7	0.64	69.8	0.783	51.3	0.013
October	22.3	19.8	8	56.1	9.5	1.17	37.2	0.31	71.6	0.611	53.2	0.083
November	19.8	16.2	7.8	62.1	10	0.95	38.4	0.152	75.5	0.523	56.3	0.13
December	12.3	15.2	7.7	57.3	9.6	0.71	38.6	0.1	77.3	0.457	62.9	0.27
SD	5.91	3.76	0.28	8.16	1.38	0.38	4.80	0.18	7.54	0.14	5.73	0.07

SD: Standard deviation

DO

DO is essential for all organisms that live in water and earth. Optimum DO content is essential to maintain the aquatic life in water. During the study, DO range between 6.1 (July) and 10 (November) and its variation may be due to several biological processes.^[27] The DO content of water shows an inverse relationship with temperature and is low in summer due to the high disintegration of organic matter,^[28] and the activity of flora and fauna, inorganic reductants such as H₂S, Fe²⁺, NO₂⁻, and NH₄⁺.^[29] In the Indian subcontinent, DO ranges from 3.41 to 6.21 mg/l which is higher than 5.00 mg/l is favorable for flourishing the flora and fauna.^[30] Tarzwell^[31] observed that 3 mg/l is the minimum DO requirement for a healthy aquatic ecosystem and a healthy ecosystem generally represent the DO concentration higher than 4 mg/l.^[32] In the present study, during winter season highest DO content has been observed due to the low water temperature, similar result was obtained by Dey^[33] in Kamladhar of Kosi Zone (Bihar).

Transparency

Transparency represents the cleanliness of the water and is affected by various factors such as rainfall, clouds, visibility, angle of incidence of rays, and planktonic growth.^[34] During the study, the transparency was ranged from 47.3 (July) to 65.2 (January). Low transparency was recorded in July due to high rainfall and flood in monsoon whereas high in January due to settling of the suspended particle in the absence of rain. A similar finding was observed by Kadam,^[35] Manjare *et al.*,^[36] Medudhula *et al.*^[37]

Dissolved Free CO₂

Dissolved free CO₂ is the major substrate for photosynthesis along with water. The gas has a significant role in aquatic water bodies but its level should be optimally limited. During the study, the dissolved free CO₂ ranged between 0.0 and 1.73 mg/l. The minimum concentration was observed during February, March and April, due to the lower activity of life forms because of lower water temperature, while higher in July due to an increase in the disintegration of biological stuff.^[38] Elevation of water temperature, increase in chemical and biological activity in the aquatic system reduces the solubility of gases.^[39] The CO₂ is highly soluble in water as compared to oxygen and it is antagonistic to oxygen.^[11]

TDS

The TDS comprise the dissolved substances such as salts, a small amount of organic matter, nitrate, carbonate, sulfate, chloride and phosphate ion of calcium, magnesium, potassium, and manganese,^[40] which eventually results in the change of hardness and taste of water. During the study, TDS was ranged between 35 (March) and 62.1 (November).

Total Alkalinity

Alkalinity is the degree of the concentration of liquefied salts such as carbonate, bicarbonate, and hydroxide (SRAC 2013). During the investigation of the river, the total alkalinity was ranged between 37.2 mg/l (October) and 51.8 mg/l (April). The maximum value of alkalinity during April may be outstanding action of photosynthetic by the phytoplanktons. Manjare *et al.*^[36] suggested that, it was due to an increase in bicarbonates. Due to rainfall, Alkalinity decrease in the monsoon. The same result was found by Mahajan and Billore,^[1] Mishra and Mishra,^[11] Shinde *et al.*^[41] Total alkalinity below 20 mg/l limits the primary productivity of water (SRAC 2013).

Electrical Conductivity

It is the degree of a solution or substance to conduct electricity through the medium and a high concentration of salt in water indicates higher electrical conductivity. During the study, electric conductivity ranged between 62.3 (August) and 87.2 (January) with the highest conductivity recorded during pre-monsoon^[24] may be due to low water temperature resulting in less dissolution of salts in water. The electrical conductivity is affected by impurities dissolves in water^[42] and normally it gives an idea about rough TDS, as half of the electrical conductivity represents the value of TDS in mg/l (SRAC 2013).

Nitrate

Nitrogen occurs in water found in multiple forms such as nitrate, nitrite, and ammonia. During the study, the nitrate was ranged between 0.10 (December) and 0.64 (September) and it has been observed that a wide range of nitrate is non-toxic to fish. A similar kind of wide range of nitrate concentration from 0.49 to 0.84 mg/l has been recorded in the Doyang river, Nagaland.^[24] The low concentration of nitrate represents that the water is clean and

contain a very low amount of fertilizer with plant and animal debris.^[43] The low nitrate level in the freshwater system may be due to the fixation of nitrogen by blue-green algae and some bacteria.

Velocity

The velocity of river water is generally more during the rainy season and flood conditions while less during the dry winter season. During the study, the range of water velocity was recorded between 0.457 and 0.875 m/s with the highest and lowest velocity during July (monsoon season) and December, respectively. On the other hand, the maximum water velocity of 0.578 m/s was recorded from the Kosi river in August^[44] maybe due to more prevalence of intense rainfall with flooding condition during that time.

Phosphate

Phosphate is one of the most dynamic nutrients for the development of algae. During the study, the phosphate was ranged between 0.013 (September) and 0.27 mg/l (December) with a recorded maximum value during September, which may be due to the existence of the bioavailable form of this nutrient in the river water. A similar finding was recorded by Manjare et al.^[36] A very low quantity of this nutrient is critical for maintaining optimum primary productivity level in water but it indicates that the water is free from heavy domestic and industrial waste.

Qualitative Analysis of Phytoplankton

Plankton is considered a natural indicator and food for primary as well as secondary consumers residing in the water ecosystem. During the present study, the recorded planktonic community consists of 34 members of Phytoplankton [Table 2] and 13 members of Zooplankton [Table 3]. Phytoplankton species consists of 17 Species of *Bacillariophyceae*, 14 species of *Chlorophyceae*, and three species of *Cyanophyceae* whereas the zooplankton community consists of four species of *Protozoa*, four species of Rotifer, three species of *Cladocera*, and two species of *Copepoda*.

The abundance of plankton recorded lowest during monsoon season, may be due to heavy rain and high water current. In the present study, *Bacillariophyceae* was the dominant group and among the group, *Diatom* sp. and *Navicula crytocephala* were recorded as abundant species in all the seasons. The most dominant group of plankton in temperate water bodies is *Bacillariophyceae* because it can flourish under low temperature and weak light.^[45,46] Sharma and Rao^[47] and Kumar^[48] also recorded that *Bacillariophyceae* is the dominant group in the freshwater ecosystem of Uttarakhand. *Chlorophyceae* was the second dominant group with *Chlorella* sp., *Cladophora* sp., *Desmidium* sp., *Hydrodictyon* sp., *Microspora* sp., and *Spirogyra* sp. were the common species. However, Kumar et al.^[49] and Malik and Bharti^[50] recorded *Chlorophyceae* as the dominant group in Garhwal Himalaya, which may be due to the availability of some of the important nutrients required for their growth and reproduction. During the study, *Cyanophyceae* accounted for a minor share with only three genera and their abundance generally correlated with the contamination of water. The present study revealed that Kosi river water is safe for aquaculture. For overall high planktonic growth in water, the optimum water and air temperature ranged between 18°C and 22°C.^[49]

In this study, the recorded zooplanktonic diversity of river Kosi consists of 13 species of zooplankton with *Protozoa* and Rotifers as

Table 2: Phytoplankton's abundance and diversity were found in Kosi River (Uttarakhand) during 2019

Phytoplankton	Winter	Summer	Monsoon
<i>Bacillariophyceae</i>			
<i>Achnanthes</i> sp.	++	+	-
<i>Amphora clevei</i>	++	++	+
<i>Amphora ovalis</i>	++	++	+
<i>Cocconeis</i> sp.	+	+	-
<i>Cymbella</i> sp.	+++	++	+
<i>Denticula</i> sp.	++	+	-
<i>Diatom vulgare</i>	+++	+++	++
<i>Fragilaria</i> sp.	++	+++	-
<i>Gomphonema</i> sp.	+++	+	-
<i>Melosira</i> sp.	+	+	+
<i>Navicula cryptocephala</i>	+++	+++	++
<i>Navicula tumida</i>	++	++	+
<i>Nitzschia</i> sp.	+	++	-
<i>Nitzschia palea</i>	++	+	-
<i>Pinnularia</i> sp.	+	+	+
<i>Synedra</i> sp.	+	+	-
<i>Tabellaria</i> sp.	+++	+	-
<i>Chlorophyceae</i>			
<i>Ankistrodesmus</i> sp.	+	+	-
<i>Chlorella</i> sp.	++	++	+
<i>Cladophora</i> sp.	++	++	-
<i>Cosmerium</i> sp.	+	-	-
<i>Desmidium</i> sp.	++	++	+
<i>Gonatozygon</i> sp.	++	+	-
<i>Hydrodictyon</i> sp.	++	++	-
<i>Microspora</i> sp.	+++	++	+
<i>Pediastrum</i> sp.	+	-	-
<i>Scenedesmus</i> sp.	++	+	+
<i>Selenastrum</i> sp.	+	-	+
<i>Spirogyra</i> sp.	++	++	+
<i>Ulothrix</i> sp.	+	++	+
<i>Zygonema</i> sp.	+	+++	+
<i>Cyanophyceae</i>			
<i>Anabaena</i> sp.	+	+	-
<i>Oscillatoria</i> sp.	++	+	+
<i>Tolipothrix</i> sp.	+	+	-

+++ : Abundant; ++ : Common; + : Rare; - : Absent

Table 3: Zooplankton's abundance and diversity found in Kosi river (Uttarakhand) during 2019

Zooplankton	Winter	Summer	Monsoon
<i>Protozoa</i>			
<i>Arcella</i> sp.	++	++	+
<i>Diffugia</i> sp.	+	+	-
<i>Didinium</i> sp.	+	+	+
<i>Vorticella</i> sp.	++	++	+
Rotifera			
<i>Asplancha</i> sp.	+	+	-
<i>Brachionus</i> sp.	+	++	+
<i>Keratella</i> sp.	++	+	+
<i>Philodina</i> sp.	++	+	-
<i>Cladocera</i>			
<i>Bosmina</i> sp.	++	+	+
<i>Dephnia</i> sp.	++	++	+
<i>Moina</i> sp.	++	+	+
<i>Copepoda</i>			
<i>Cyclops</i> sp.	+++	++	+
<i>Diatomus</i> sp.	++	+	+

+++ : Abundant; ++ : Common; + : Rare; - : Absent

dominant groups. Rotifers are also recorded as a dominant zooplankton species from the various freshwater systems of Uttarakhand.^[51-54] Rotifers not only indicate the pollution status

(42) but are also recorded as dominant and natural water purifiers in lentic and lotic systems.^[51,55] The occurrence of most of the zooplankton was common in the winter season whereas some of the species such as *Diffugia* sp. of Protozoa and *Asplancha* sp.; *Philodina* sp. of Rotifer were absent during the monsoon season. Zooplankton population is influenced by some hydrological factors^[56] with a positive correlation between zooplankton growth and water temperature while a negative correlation with DO, nitrate and alkalinity.^[53] Among zooplankton, copepod and *Cladocera* constitute important communities for serving as basic food to planktivorous fish.

CONCLUSION

The physicochemical and biological analysis of Kosi river water indicate that the suitable habitat of *Garra gotyla* and river belongs to freshwater stretches of Uttarakhand. The information on physicochemical parameters from the Kosi river will be useful in determining the quality of water and developing fisheries management programs accordingly. The hillstream river Kosi carried diverse biological communities of phytoplankton and Zooplankton. Physicochemical quality of water control biological diversity, which is essential for balancing and maintaining aquatic life. Physicochemical analysis of river Kosi has measured with 12 parameters along with the qualitative study of planktons and the result reveals that the water is suitable for fish culture to date.

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