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Diversity and season alvariation of plankt on inkosi River of State Uttarakhand, India

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Abstract:

Thisstudyexaminestheseasonalvariations and planktondiversityintheKosiRiverintwodistricts of the state of Uttarakhand. One of the most crucial ecological factors in determining the quality of water is plankton diversity, which also serves as a reliable indication of alterations in water quality. Since they are at the base of the food chain and represent a large source of organic carbon that is physiologically significant, planktons are fundamental components of the aquatic community. Samples were taken between January and December of 2021 in order to determine the plankton's diversity. At sampling points, phytoplanktonbelongingto61generaandzooplanktonbelongingto25genera.Thehuman activities in and around the river have resulted in a sharp decline in biodiversity overall. Present study examined the potential for algal bio-monitoring across a gradient of agriculturally impacted streams and to conserve the planktons which are declining day by day. In phytoplankton diversity bacillariophyceae (58%) was most dominant group which is followed by chlorophyceae (39%) and Cyanophyceae (3%). In terms of zooplankton, rotifera (44%) was most dominant followed by protozoa (36%) cladocera (16%) and Copepoda (4%).

Key words: Phytoplankton, zooplankton, Kosi river, chlorophyceae, bacillariophyceae

1. Introduction

Rivers play a major role in commerce, society, ecology, and economy, either directly or indirectly. The majority of India's water bodies are transient, shallow, or show such drasticyearly fluctuations in water level that a sizable section of the basin is vulnerable to drying out. Plankton, which can be classified into a broad range of taxonomic categories, are tiny, free- swimming, heterogeneous assemblies of minute floating animal forms that are found in aquatic systems. Whereas zooplankton serves as an intermediary between fish and phytoplankton, phytoplankton is the producer. Therefore, zooplankton research, both qualitative andquantitative, is very important. These are the most prevalent and frequently control the whole consumer communities. They have a lot of amazing characteristics, and pines cover them, which keeps higher organisms from preying on them. Studies on zooplankton communities have been conducted in a variety of lakes, reservoirs, and shallow water bodies **Sugunan (1980).** Zooplankton

communities have been investigated in numerous reservoirs, lakes, and shallow water bodies. **Moitraand Bhowmik (1968).** The survival strategies of the zooplankton have been reported inafewstudiesandexaminedinsomedetailrecentlyby**(Shyamet.al.,2020).**Thishasled to the excessive generation of algae and cyanobacteria in fresh water and thus has had a huge impact upon recreational water quality **(Srivastava et al., 2010).** There are several significant ways in which algae contribute to water contamination. Algae development in aquatic bodies is caused by the enrichment of inorganic phosphorus and nitrogen. There is a dearth of research on the freshwater ecology of algae linked to water pollution, making in-depth investigation of indicator species vital. The uses of algal communities correlating water pollution **(Sonneman et al., 2001).** Algae are one of the most rapid bioindicator of water quality changes due to theirshort life spans, quick response to pollutants and easy to determine their numbers **(Plafkinet al., 1989).** The fishery potential is fully related to the presence of zooplankton. The availability of food is more due to decomposition of organic matter and the density of zooplankton might be high due to fewer predators **(Shivashankar and Venkataramana, 2013**). The primary nutrients that cause eutrophication, or the acceleration of zooplankton and phytoplankton development,are nitrogen and phosphorus. This may result in the lavish development of peculiar plankton blooms, which may or may not be poisonous but deplete the water's oxygen supply during their decomposition. They react quickly to limnological change of aquatic environment. They can be listedandusedaspollutionindicators**(Telkhadeet al., 2008).**Researchonfisherieshascometo focus on zooplankton because they help transform phytoplankton into food that fish and other aquatic animals can eat. In addition, plankton can be a significant indicator of the presence or absence of particular fish species and a factor in population densities. Because of how much the environment affects them and how fast these populations adapt to changes in the environment and water quality, they are ideal indicators of the quality of the water.

The village of Budha Peenath in the Kausani region of the District Almora in the state of Uttarakhand is where the river Kosi begins. It emerges near Ramnagar in the Gangetic plains after passing through the lower Himalayas for roughly 100 kilometers. It draws water from several large streams in the first section that passes through the Shivalik range of the Himalayas, with most of the water being redirected into canals for irrigation. It runs to the Kashipur after Ramnagar, where a lot of polluting companies release their effluent into the Kosi River. Industrial discharge and home sewage are the main causes of river pollution.

Man made activities influence the water quality of river significantly. All the life forms such as planktonic diversity have been influenced due to the water quality **(Bhutiani and Khanna, 2014). Joshi (2022)** studied on water quality of Nanak Sagar Dam in Uttarakhand and described that water quality is important factors for diversity and density of aquatic organisms.

The known places situated near by Kosi river are Bhujan, Betal Ghat, Corbett National Park, Garjiya Devi temple, Ramnagar, Ringhor, Kashipur, Sultanpur Patti and finally it meets to the Ramganga River in Chamraul in Uttar Pradesh. In District Udham Singh Nagar huge amount of industrial waste is discharged directly in to the Kosi. The current study is carried out to find out the plankton diversity of Kosi River in two different districts of Uttarakhand state.

Materials and Methods Sampling Stations

The investigation was carried out by collecting water samples from four locations: Site-I i.e. Gargiya

(coordinates 29.47° N, 79.15° E), Site-II i.e. Ringhor (coordinates 29.39^{0}N, 79.12^{0}E), Site-III i.e. Kosi Barrage (coordinates 29.40^{0}N, 79.120E), and Site-IV i.e. Sultanpur Patti (29.24^{0}N and 80.10^0 E). The planktonSamples were collected from selected sites of river forone year from January 2021 to December 2021 to calculate diversity of Plankton in foursampling stations.

Sample collection

Collection and preservation of plankton was done at the study site while method of identification of plankton was applied in the laboratory. Samples were collected seasonally from four different sampling stations in one year (January 2021 to December 2021). The samples were collected for planktonic population net at 9 am -11pm during each month. November, December, January and February regarded as Winter Season, March, April, May and June regarded as summer seasons and July, August, September and October regarded as Monsoon seasons. Under qualitative analysis of planktonic communities the identification was done; as for as possible to species level. For the quantitative studies of the plankton samples were collected by following the guidelines of **Lind (1979); Welch (1953); Wetzel (1975)**byfiltering20Litresofwaterthroughplanktonnethaving pore size 64 µm. The concentration plankton samples were fixed in 4% formalin and Lugal's solutionforzooplanktonandphytoplanktonstudyrespectively.Zooplanktonwereidentifiedwith the help of keys provided by **Pennak (1978), Sehgal (1980), Needham and Needham (1962), Tonapi (1980).**

MapoftheKosiriversshowingstudysitesfromGarjiyatoSultanpur Patti

RESULTS AND DISCUSSION

To assess phytoplankton diversity and abundance, samples were collected seasonally during the study period, from January 2021 to December 2021 at four spots (spot-1, Garjiya, spot-2, Ringhor, spot-3-Kosi Barrage, spot-4, Sultanpur Patti) within a stretch of 50 km in the Kosi river. During the study period, the qualitative estimation of phytoplankton revealed the following observations and results.

Theobtainedplanktonformswererepresentedbytwogroupphytoplanktonandzooplankton, wherephytoplanktonconsistofthreegroupsviz.Bacillariophyceae,Chlorophyceaeand Cyanophyceae& zooplankton consist of Phylum, Rotifera, Cladocera, Copepoda, and Protozoa. Phytoplankton were represented by three families, Bacillariophyceae is the most diverse family consist of 35 genera Chlorophyceae consist of 24 species, Cynophyceae have 2 genera. All thedominant group of plankton were present throughout the year. A Total of 23 genera belonging to fourgroupshavebeenidentified.Amongthese,Protozoacomprise10Rotiferacompriseof7 genera, Cladocera 4 genera andCopepoda 5 genera.

Bacillariophyceae

ThegroupBacillariophyceaeisabundantlyfoundintheriversystemthatconstitutesthediatoms. They were represented by 35 genera (Achnanthes, Achnanthidium, Amphipleura, Amphora, Bacillaria, Biddulphia, Brebissonia, Caloneis, Cocconeis, Cyclotella, Cymatopleura, Cymbella, Denticula, Diatoma, Diatomella, Encyonema, Epithelmia, Eunotia, Fragillaria, Fragilariforma, Frustulia, Gomphoneis, Gyrosigma, Melosira, Meridion, Navicula, Nedium, Nitzschia, Pinnularia, Rhoicosphenia, Rhopalodia, Rhicosphenia,Surrirella, Synedra, Tabellaria) and dominated the phytoplankton population throughout the study in river Kosi. These constituted 58% of the total population. **Sharma et al., (2011)** reported maximum density during December while low in numbers during rainy seasons due to high velocity of water. During the present study Nitzschia species is most dominant species while Diatoma species was the leastdominating species among the Bacillariophyceae group.

Chlorophyceae

The group chlorophyceae is second most dominant group found in the river system that constitutes the green algae. They were represented by 24 genera (Chlorella, Cladophora, Chlorococcus, Closterium, Cosmarium, Debarya, Desmidium, Hormidium, Hydrodictyon, Mesotaenium, Microspora, Micrasterias, Pediastrum, Rhizoclonium, Spirogyra, Stigeclonium, Tetradesmus, Ulothrix, Uronema, Zygnema) which constituted 39% of the total population. **Shyam, et. al. (2014)** reported maximum density during winter while low in numbers during monsoon seasons.

Cyanophyceae

Blue green algae possess ability to grow in polluted waters. In present study blue green algae contributed 3% of the total phytoplankton. Blue green algae were represented by 2 genera (Anabaena andOcillotoria) and Oscillatoria were the most dominant.

ZooplanktonDiversityProtozoa

The major portion of the zooplankton populations were shared by Protozoa. During the present

investigation, 9 genera of protozoa (Arcella, Centrophyxis, Didinium, Difflugia, Loxodes, Paramecium, Stentor, Tetrahymina, Volvox) were recorded. The maximum number ofprotozoans were reported November to December and the minimum during July to August. The minimum diversity during rainy season may be due to rainfall and heavy floods, poor water quality and less food availability.

Rotifera

The major portion of the zooplankton species were shared by Rotifers. The population of rotifers was maximum in December may be due to abundance in food. 11 genera of Rotifera (Asplanchna, Brachionus, Dipleuchlanis, Filinia, Keratella, Lepidella, Monostyla, Notholca, Philodina, Polyarthra, Tricocera) were recorded during the study period. This group dominated during winter months and considerably were very low in number during rainy months. The less diversity of this group was from July to Septembermonths due to rainfall and heavyfloods, poor water quality and less food availability. **Mola (2011)** mentioned that the high number of Brachionus species indicates eutrophication in water body and this genus has ability to tolerate pollution but its only one species was found in all four sampling stations that indicate less pollution in river Kosi.**Joshi and Tripathi (2010)** studied on biotic factors of Nanak Matha reservoir and found the similar results.

Cladocera

During the present investigation, 4 genera of Cladocera (Bosmia, Ceriodaphnia, Chydorus and Daphnia) were recorded from river Kosi at four sites. The Cladocera showed abundance from October to January.

Copepoda

During the present investigation, one genera were recorded. The maximum abundance of Copepods were reported in October and the minimum during July and September. The living copepods constitute an essential link in the aquatic food chain. Though they are not as important element in fish diet as the Cladoceran Species however they are in intermediate trophic level among bacteria, algae and protozoa on one hand and small and large plankton predators on the other.Similarly, **Pathani and Joshi (2008)** described the similar pattern of plankton diversity.

Table-1:-
PhytoplanktondiversityandseasonalvariationatthefoursitesinKosiriverduringJanuary,2021toDecember,2021

	WINTER				SUMMER				MONSOON			
Genera	**Garjiya**	**Ringhor**	**Kosi Barrage**	**ltanpur Patti**	**Garjiya**	**Ringhor**	**Kosi Barrage**	**ltanpur Patti**	**Garjiya**	**Ringhor**	**Kosi Barrage**	**ltanpur Patti**
Bacillariophyceae												
Achnanthes	+++	+++	+++	+	+++	+++	+	+	-	-	-	-
Achnanthidium	+	+++	+++	+	+	+	+	+	+	+	++	+
Amphipleura	+	-	++	++	++	++	++	++	-	-	++	-
Amphora	+++	+	+	+	+++	+++	+++	++	+	+	++	+
Bacillaria	+++	+++	+++	+	+++	+++	+++	++	-	-	-	-
Biddulphia	+++	-	-	+	+++	+++	+++	++	++	-	-	+

Brebissonia	+++	-	-	+	+++	+++	+++	++	+	-	-	-
Caloneis	+++	+++	+++	+	+++	+++	+++	+	-	-	-	++
Cocconeis	+++	-	-	+	+	+	+	+	+	-	-	++
Cyclotella	+++	++	+	+	+	+	-	-	++	+	+	++
Cymatopleura	++	++	-	+	+	+	+	+	-	-	+	++
Cymbella	++	++	++	++	+	+	++	+	+	+	-	++
Denticula	++	-	++	++	+	+	++	+	-	-	+	-
Diatoma	++	+	++	++	+	+	++	+	+	+	-	+
Diatomella	++	-	-	++	-	+	-	-	-	-	+	-
Encyonema	+++	+	+	++	++	+	+	+	+	+	+	++
Epithelmia	+++	-	+	+	+	-	+	+	++	-	-	++
Eunotia	+++	-	-	+	-	++	-	-	-	-	-	++
Fragillaria	+++	-	+	+	-	++	+	+	-	-	+	++
Fragilariforma	+++	+	+	+	+	++	-	-	++			
Frustulia	+++	++	-	-	+	++	-	-	++	-	-	++
Gomphoneis	+++	++	+	++	+	++	+	+	++	+	-	++
Gyrosigma	+++	++	+	++	+	+	-	-	++			
Melosira	+++	+	-	-	+	+	-	-	-	-	-	-
Meridion	+++	-	-	+	-	++	++	+	-	-	-	-
Navicula	+++	+	+	+	+	++	++	+	+	+	++	++
Nedium	+++	-	-	++	-	++	++	+	-	-	++	++
Nitzschia	+++	-	-	++	+	++	++	+	-	-	++	++
Pinnularia	+	+	-	++	+	++	++	+	+	-	-	+
Rhoicospheni a	+	+	+	++	+	+	-	-	+	+	+	+

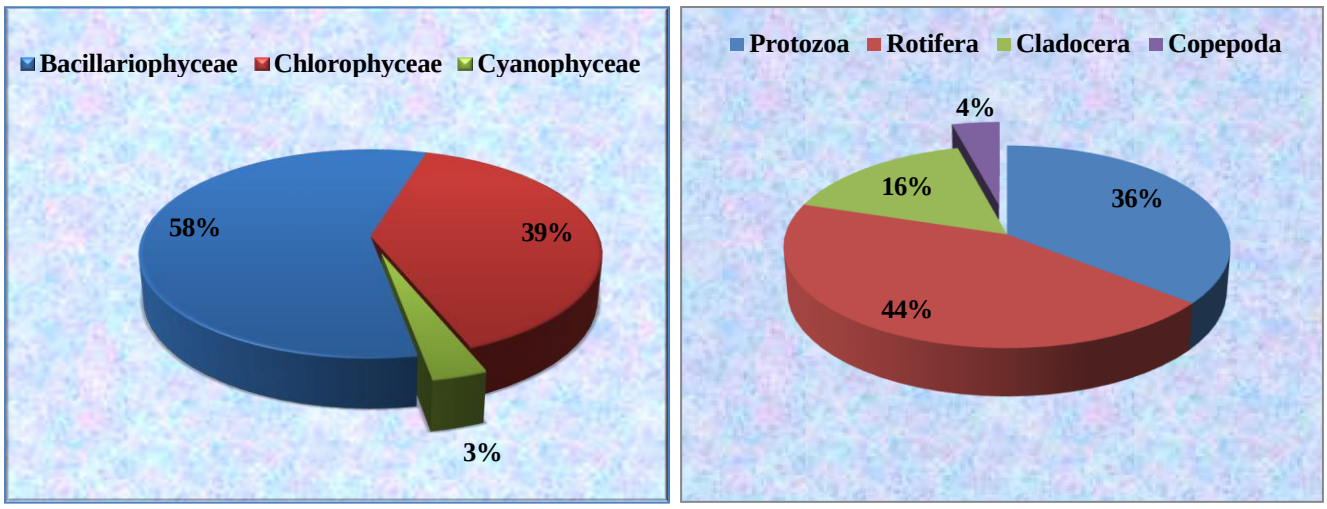
Rhopalodia	+++	+	+	-	+	+	-	-	-	+	+	-
Rhicosphenia	++	+	+	+	++	++	+	+	-	-	-	-
Surrirella	++	++	+	+	++	++	-	-	+			
Synedra	++	++	-	-	+	+	-	-	-	+	+	+
Tabellaria	++	+	+	+	+	+	+	+	+	+	+	+
Chlorophyceae												
Chlorella	+++	-	-	+	++	-	+	+	+	-	-	+
Cladophora	+++	-	-	++	++	+	-	-	+	-	-	-
Chlorococcus	+++	+	+	++	++	+	-	-	+	++	++	++
Closterium	+++	+	-	-	++	+	-	-	-	-	-	-
Cosmarium	+++	+	+	+	++	+++	-	-	+++			
Debarya	+++	++	-	-	++	+++	-	-	+++	-	-	+
Desmidium	+++	++	+	+	++	+++	-	-	+++			
Hormidium	+++	++	-	-	++	+++	-	-	+++	-	-	+
Hydrodictyon	+++	++	+	+	+	+	-	-	+++			
Mesotaenium	+++	+	-	-	+	+	-	-	-	-	-	+
Microspora	+	-	-	+	++	-	-	+	+	-	-	-
Micrasterias	+	+	+	+	++	+	-	-	+	++	++	++
Pediastrum	+	+	-	-	++	+	-	-	-	-	-	+
Rhizoclonium	+	-	-	+++	++	-	-	+	-	-	-	-
Spirogyra	+	++	+	+++	++	+	+	+	-	-	-	+
Stigeclonium	+	++	+	+++	++	+	+	+	+	++	++	++
Tetradesmus	+	++	+	+	++	+	++	+	-	++	++	++
Ulothrix	+++	++	+	+	++	+	+	+	+	-	-	-
Uronema	+++	++	+	+	++	+	++	+	-	-	-	-
Zygnema	+++	+	+	+	++	+	+	+	++	-	++	++
Cyanophyceae												
Anabaena	-	-	-	++	-	-	-	++	-	++	++	++
Ocillotoria	++	-	-	-	-	-	-	-	-	-	-	++

(+= present, ++= Frequent, +++= Abundant, - = Absent)Table-2:- ZooplanktonicDiversityatfourspotsinKosiRiverduring2021

	Winter				Summer				Monsoon			
Genera	**Garjiya**	**Ringhor**	**Kosi Barrage**	**ltanpur Patti**	**Garjiya**	**Ringhor**	**Kosi Barrage**	**ltanpur Patti**	**Garjiya**	**Ringhor**	**Kosi Barrage**	**ltanpur Patti**
	Protozoa											
Arcella	+++	+	+	+	+++	+	+	+	+	+	+	+
Centrophyxis	+++	+	-	+	+++	-	-	+	+	-	+	+
Didinium	+++	-	-	+	+++	-	-	+	+	+	-	-
Difflugia	+++	+	+	+	+++	+	+	++	++	+	+	+

Loxodes	+++	+	+	+	+++	+	+	+	+	+	-	-
Parameciu m	+++	-	-	+	+	+++	+	+	+	-	+	-
Stentor	+	-	-	-	+	-	-	++	+	+	-	-
Tetrahymin a	+	+	+	+	+	+	+	+	+	+	+	-
Volvox	+++	-	-	+	+	+	-	+	+	+	+	-
Rotifera												
Asplanchna	+++	-	-	+	++	+	+	+	+	-	+	+
Brachionus	+++	+	+	+++	++	+	+	+	+	+	+	+
Dipleuchlani s	+++	+	+	+++	++	+	+	++	+	+	+	-
Filinia	++	-	+	+	+	+	-	+++	-	+	+	-
Keratella	+++	-	-	+++	+	-	+	+++	+	+	+	-
Lepidella	+++	+	+	++	++	+	+	++	+	+	++	-
Monostyla	++	-	-	+++	+	-	+	+	+	+	+++	-
Notholca	+++	+	+	++	+	+	+	+	+	+	++	+
Philodina	+++	+	+	+++	++	-	+	+	+	+	+++	+
Polyarthra	+++	-	-	+	+	-	-	-	+	+	+	-
Tricocera	+++	-	-	+	+	-	+	+	+	+	+	+
Cladocera												
Bosmia	+++	-	-	+++	+	+	-	+	-	+	+++	+
Ceriodaphn ia	+++	++	-	++	+	+	+	+	+	+	+	-
Chydorus	+++	-	+	++	+	-	-	+	+	+	++	-
Daphnia	+++	++	+	++	+	+	+	+	+	+	++	-
Copepoda												
Cyclops	+	-	-	+	+	-	+	+	+	+	+	+

(+= present, ++= Frequent, +++= Abundant, - = Absent)



(A) **(B)**

Graphs(A&B) showing planktondiversityofKosiRiverduringstudyperiodi.e.2021

CONCLUSION

One of the essentials for assessing the ecological and fishery status of freshwater ecosystem is plankton. Since it may assist in evaluating environmental changes in the water bodies, biological monitoring using algae and zooplankton is a helpful substitute technique for evaluating the water qualityofanyaquaticecosystem. Under the current investigation study, Cymbella, Navicula, Nitzschia, Oscillatoria, Melosira, Microcystis, Synedra, and Gomphonema served as markers of the pollution. The pre-monsoon period is when phytoplankton density is at its highest because of the high temperatures and decreased water volume. The weather and river water conditions have an impact on phytoplankton diversity. Plant plankton diversity is significantly impacted by anthropogenic activity. Programs for raising public awareness should be started to educate the public about human activity in any aquatic habitat.

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