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Evaluation of Organic Pollution Using Palmer's Algal Pollution Index in Ami River, Gorakhpur, (Uttar Pradesh) India.

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Abstract

This study investigates the organic pollution status of the Ami River in the GIDA (Gorakhpur Industrial Development Authority) sector-13, Gorakhpur district through seasonal sampling conducted from 2021 to 2022. Utilizing the Palmer pollution index, the research assesses the algal genera as indicators of organic pollution across four selected sites during the rainy, winter, and summer seasons. 41 algal genera across 9 classes were identified, with Bacillariophyceae (14), and Chlorophyceae (14) being the most prevalent algal group and Microystis, Pinnularia. Synedra, Cosmarium, Spirogyra, Zygnemagiganteume, Zygnemaczurde, Anabaena, Nostoc, and Spirulina are most common species in all seasons. Results indicate a significant organic pollution load, with the Palmer pollution index revealing high levels: 12 in sites 1, 2, and 3, and 17 in site 4 during the rainy seasons. In summer, values escalated to 31 for sites 1, 2, and 4, and 32 for site 3, indicating very high organic pollution across all sites. Winter assessments showed a reduction to 26, yet they are still indicative of high pollution levels. The findings underscore the detrimental effects of industrial discharges on the river ecosystem and highlight the need for continuous monitoring to address the declining algal diversity and effectively manage pollution levels.

Keywords: Algal diversity, organic pollution, Palmer's index, Ami River.

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1 Introduction

Rivers are the lifelines of our planet, providing essential freshwater resources that power everything from agriculture to industry. Yet, these vital waterways face an unprecedented threat, particularly in urban areas where human activities have pushed many rivers to their breaking point (Khatri and Tyagi 2015; Nehme, et al. 2021). This threat leads to poor water quality and river degradation. It can also negatively disturb the living organisms that rely on it (Bassem 2020). In recent years, the health of our rivers has become increasingly concerning, with many showing signs of severe degradation due to rapid industrialization, municipal waste discharges agricultural runoff, and untreated sewage disposal (Maheshwari et al. 2014; Maheshwari, 2011; Abboud et al. 2021).

But nature has given us a remarkable tool to monitor these changes in algae (Omar 2010). Several studies have assessed the level of organic pollution in water bodies using algae as a bioindicator in rivers (Bhatnagar and Bhardwaj 2013, Noel and Rajan 2015, Salem et al. 2017). Various studies have demonstrated the utility of algal communities in assessing environmental changes (Omar 2010). Palmer's pollution index is a tool to describe changes in the organic pollution stage in freshwater bodies using algal population (Palmer 1969). Several researchers accessed the Palmer index to evaluate the water quality of various freshwater bodies, mostly rivers. In India, phytoplankton as a bioindicator of rivers has also been assessed using Palmer's algal pollution index (Wagh and Jondhale 2018; Singh and Sharma 2018).

This study marks the first comprehensive assessment of organic pollution in the Ami River using algal diversity as a bioindicator, contributing valuable insights into the river's ecological status. The findings will not only enhance our understanding of algal populations in this region but may also inform state governments and communities about necessary conservation efforts to protect the Ami River from ongoing pollution threats.

2. Material and Method

2.1 Ami River Description

Ami River originates from Sikhara Tal, Siddharthnagar, and flows further towards Basti, Sant Kabir Nagar, and Gorakhpur. Ami's journey starts from origin to end. It goes through a distance of about 102 km out of which the contaminated stretch lies between Basti to Sohgaura, Rudhauli, and Gorakhpur districts of approximate length of 80 km. Latitude is 26º33΄02″N, and longitude is 83º26΄45″E. The lethal effluents come from isolated large industries and GIDA. Nowadays, the Ami River is a holder for all the 5th, untreated sewage, and worst, all of them are centered in the industrial town in the Gorakhpur District. 266 industrial units were established, including paper mills, textile manufacturing, and food processing units. These discharge millions of untreated effluents into the drain every day. Captivating Decadal development into consideration, the expected population in 2019 was approximately 48,725, and the estimated generation of sewage was approximately 5.3 MLD (Mega liters Per Day).

2.2 Study area

Adilapar Village faces a high pollution load due to industrial discharges from GIDA through a drain into the river Ami, requiring urgent attention. 22 km from Gorakhpur, Bharsar Village, and industrial area sector, GIDA-13, Adhila Bazaar (Figure.1). It is excruciating to mention that the river gets victimized by industrial pollution. Beyond Adilapar, the GIDA drain meets the river, and it is converted into a river, which is a below-E category of CPCB (Central Pollution Control Board). It is noticed that the residents of more than 100 habitations downstream of the drain (Sarya) often complain of colds, mystery fevers, nausea, and high blood pressure. 158 units, including paper mills and textile manufacturing, which discharges some 45 million liters of untreated effluent into the drain every day.

2.2.1 Sampling sites:

Four selected sampling sites respectively shown as (Figures 2 and 3)

- Site 1: Near Ramlila Samiti (Effluent after Treatment)
- Site 2: Semrahwa Baba Mandir (Just Entry Point into the River)
- Site 3: 200 meter upstream river.
- Site 4: 200 meter downstream river.

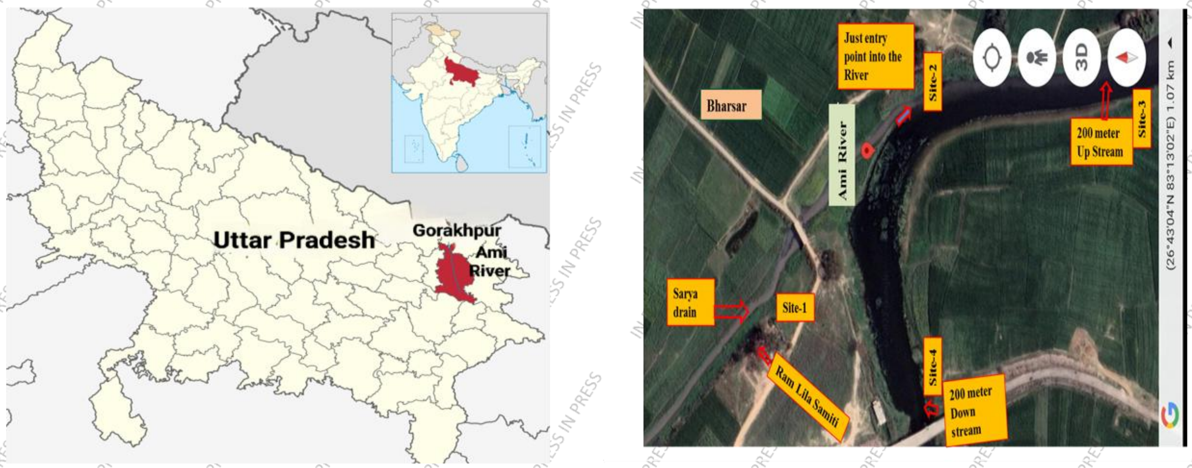

Figure 1. Location map and satellite image of Ami River

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Figure 2. Selected sampling sites of Sarya drain and Ami River

Figure 3. Diagrammatic representation of sampling location of Sarya drain and Ami River

2.3 Phytoplankton sampling and identification

The phytoplankton samples were collected by plankton net of standard bolting silk cloth no-25 (mesh size-0.03-0.04mm) by filtering 100 liters of water through it. This sieved residue, collected in the tube of 100 ml capacity attached at the end of the net, was transferred into a labeled glass bottle and transported to the lab under dark conditions and preserved 4% formaldehyde and 5% lugol solution. Phytoplankton were counted with the help of the Sedgwick Rafter Slide. The phytoplankton samples were observed under the electron microscope (Magnüs MXL plus). The Phytoplankton were identified by using books and literature (Bilgrami et al. 1991; Baird et al. 2017; Mahendra and Anand 2009).

2.4 Palmer's algal pollution

The present study rated the river water samples as high or low organically polluted, based on algae population by employing the Palmer pollution index (1969). Palmer developed a list of 20 algal genera and 20 algal species that are most tolerant to organic pollution with individual pollution index scores and formulated the pollution index scale as given below (Table 1). A score lower than 0-10 means a lack of organic pollution, 0-15 means that the river lacks moderate organic pollution, 15-19 indicates a high probability of organic pollution in the river, and 20 or more signifies high pollution in the river.

Table 1. Algal Genus Pollution Index (Palmer 1969)

Genus	*Index*	*Genus*	*Index*
Anacystis(Microystis)	**1**	***Micractinium***	**1**
Ankistrodesmus	**2**	***Navicula***	**3**
Chlamydomonas	**4**	***Nitzschia***	**3**
Chlorella	**3**	***Oscillatoria***	**5**
Closterium	**1**	***Pandorina***	**1**

Cyclotella	**1**	***Phacus***	**2**
Euglena	**5**	***Phormidium***	**1**
Gomphonema	**1**	***Scenedesmus***	**4**
Lepocinclis	**1**	***Stigeoclonium***	**2**
Melosira	**1**	***Syndra***	**2**

3. Result and Discussion

3.1 Phytoplankton Diversity

During the study period, 43 species of phytoplankton, belonging to 9 phyla, 9 classes, 21 orders, 30 families, and 2 sub-families were recorded. Forty-three species were identified of phytoplankton representing 5 groups namely Bacillariophyta, Chlorophyta, Cyanobacteria, Cyanophyta, Cyanobacteria, Dypnophyta, Myzozoa and. Euglenozoa. Bacillariophyceae includes 14 genera and species, Chlorophyceae 14 species, Cynophyceae 8 species, Dypnophyceae 4 species and Euglenophyceae 2 species, shown as (Plates, 1, 2, 3, and 4). The observation that algal diversity peaks in summer while declines during the rainy season is attributed to several factors, including changes in light availability, water temperature, and nutrient dynamics. During summer, increased sunlight and warmer temperatures likely create optimal conditions for phytoplankton growth. In contrast, heavy rain can lead to sedimentation and dilution of nutrients, creating unstable substrate conditions that adversely affect phytoplankton proliferation. From an ecological perspective, understanding these seasonal shifts is crucial as they influence food webs within aquatic ecosystems. A decline in phytoplankton diversity could lead to reduced food availability for higher trophic levels, potentially impacting fish populations and overall biodiversity. The dominance of Bacillariophyceae (diatoms) across various studies aligns with previous research indicating their resilience to pollution (Abdel-Hamid et al. 2019). Their ability to thrive in polluted waters

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suggests a level of adaptability that may allow them to outcompete other groups under certain environmental stress. However, this raises questions about the health of the ecosystem as a whole, while diatoms may flourish under polluted conditions. Such dominance could indicate an imbalance within the community structure (Panigrahi and Patra, 2013; Annalakhmi and Amsath 2012; Jahan and Singh 2022). The correlation between industrial effluents and decreased phytoplankton diversity noted in the Ami River serves as a critical ecosystem. The findings that forty-five species were reported by (Jahan and Singh 2022) alongside concerns over pollution emphasize the need for ongoing monitoring and management strategies aimed at reducing industrial runoff. The distribution of phytoplankton in the Ami River is shown in Table (2).

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Table 2. Distribution of phytoplankton at different sites during rainy winter and summer in Ami River at Gorakhpur.

Algal classes	Algal genera	Rainy				Winter				Summer			
		Site-1	Site-2	Site-3	Site-4	Site-1	Site-2	Site-3	Site-4	Site-1	Site-2	Site-3	Site-4
Bacillariophyceae	*Amphora*	+	+	+	+	+	+	+	+	+	+	+	+
	Cyclotella	-	+	+	+	-	-	-	-	-	-	-	-
	Diatoma	-	-	-	-	+	+	+	+	+	+	+	+
	Fragiliara	-	-	+	-	+	+	+	+	+	+	+	+
	Gainardia	-	-	-	-	-	-	-	-	+	+	+	+
	Gyrosigma	-	-	-	-	+	+	+	+	+	+	+	+
	Gamphonema	+	+	+	-	-	-	-	-	+	+	+	+
	Navicula	-	+	+	+	-	-	-	-	+	+	+	+
	Nitzschia	+	+	+	+	+	+	+	+	+	+	+	+
	Melosira	-	-	-	-	+	+	+	+	-	-	-	-
	Pleuroigma	-	-	-	+	-	-	-	-	+	+	+	+
	Pinnularia	+	+	+	+	+	+	+	+	+	+	+	+
	Synedra	+	+	+	+	+	+	+	+	+	+	+	+
	Suriella	-	-	-	+	-	-	-	-	-	-	-	-
Chlorophyceae	*Ankistrodesmus*	-	-	-	-	+	+	+	+	+	+	+	+
	Chlorella	-	-	-	-	+	+	+	+	+	+	+	+
	Chaetophora	-	-	-	-	-	-	-	-	+	+	+	+
	Cosmarium	+	+	+	+	+	+	+	+	+	+	+	+
	Chlorocccus	-	-	-	-	+	+	+	+	+	+	+	+
	Closterium	-	-	-	-	-	-	-	-	+	+	+	+
	Oedogonium	-	-	-	-	-	+	+	+	+	+	+	+
	Scenedesmus	-	-	-	-	+	+	+	+	-	-	-	-
	Spirogyra	+	+	+	+	+	+	+	+	+	+	+	+

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	Stigeodonium	-	-	-	-	-	-	-	-	+	+	+	+
	Ulothrix	-	-	-	-	+	+	+	+	+	+	+	+
	Volvox colony	+	+	+	+	-	-	-	-	+	+	+	+
	Zygnemagiganteume	+	+	+	+	+	+	+	+	+	+	+	+
	Zygnemaczurde	+	+	+	+	+	+	+	+	+	+	+	+
Cynophyceae	*Anabaena*	+	+	+	+	+	+	+	+	+	+	+	+
	Aphanizmenon	-	-	-	+	+	+	+	+	+	+	+	+
	Nostoc	+	+	+	+	+	+	+	+	+	+	+	+
	Microystis	+	+	+	+	+	+	+	+	+	+	+	+
	Merismopedia	-	-	-	-	+	+	+	+	-	-	-	-
	Oscillatoria	-	-	-	+	+	+	+	+	+	+	+	+
	Phormidium	+	+	+	+	-	-	-	-	+	+	+	+
	Spirulina	+	+	+	+	+	+	+	+	+	+	+	+
Dypnophyceae	*Ceratiumhirndinella*	-	-	-	-	+	+	+	+	+	+	+	+
	Dinophysis acuminate	-	-	-	-	-	-	-	-	+	+	+	+
	Gymnodonium	+	+	+	+	-	-	-	-	+	+	+	+
	Gonyaeslaxspinifera	-	-	-	-	+	+	+	+	-	-	-	-
Euglenophyceae	*Euglena species*	-	-	-	-	+	+	+	+	+	+	+	+
	Phacus species	-	-	-	-	-	-	-	-	+	+	+	+

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Note (+) = Present, (-) = Negative

BACILLARIOPHYCEAE (PLATE-1)

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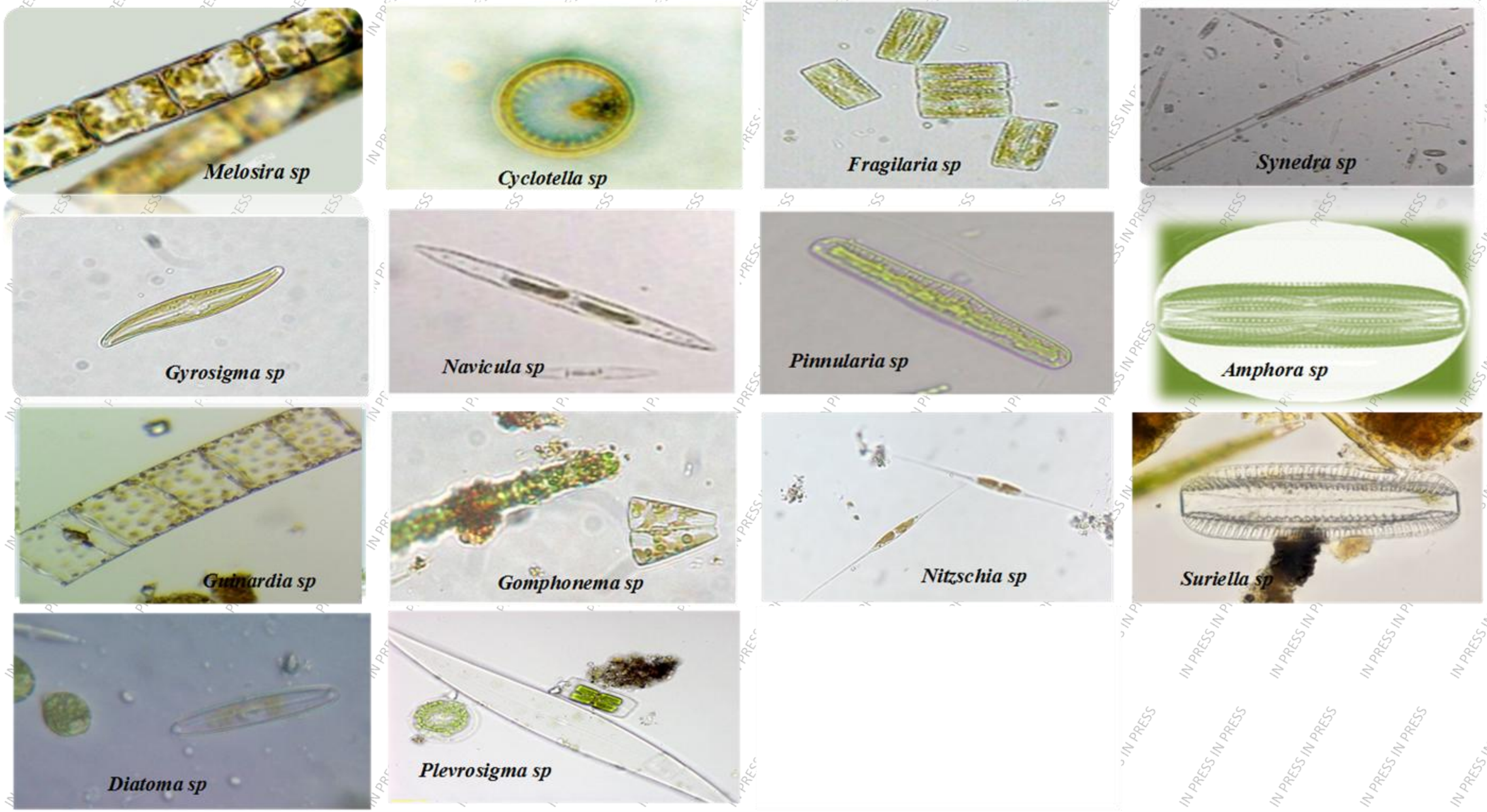

CHLOROPHYCEAE (PLATE-2)

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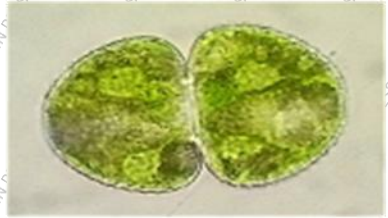
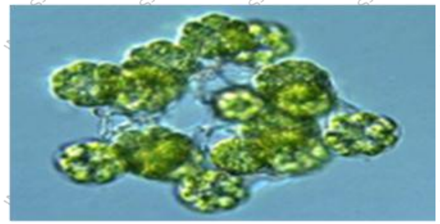
Ankistrodesmus sp

Spirogyra sp



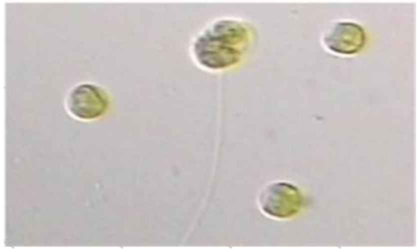
Cosmarium sp



Chaetophora sp

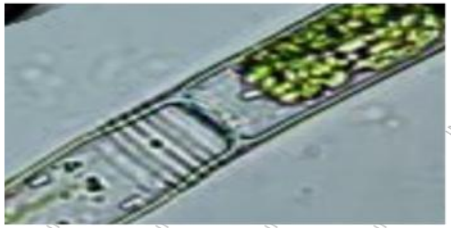
Volvox colony

Chroococcus sp

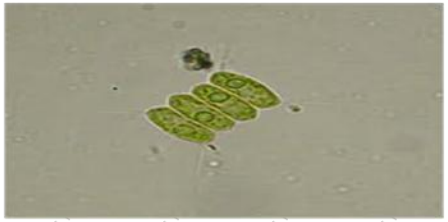


Chlorella sp

Closterium sp

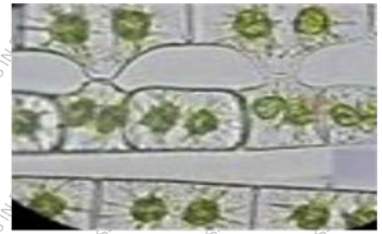


Oedogonium sp

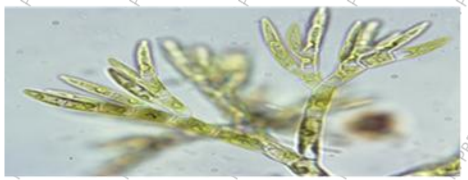


Scenedesmus sp

Ulothrix sp



Zygnema sp



Stigeodonium

CYNOPHYCEAE (PLATE-3)

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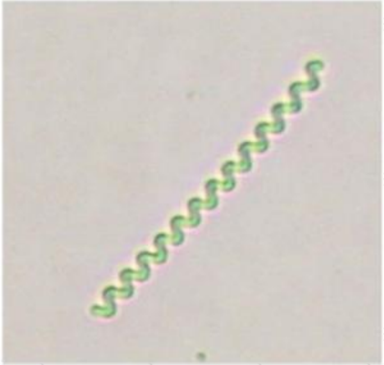
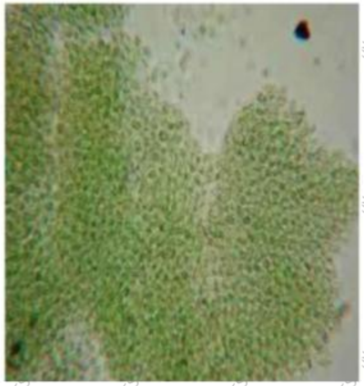
Oscillatoria sp



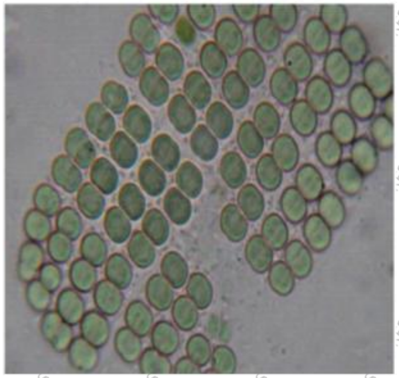
Spirulina sp

Phormidium sp

Nostoc sp



Microcystis sp



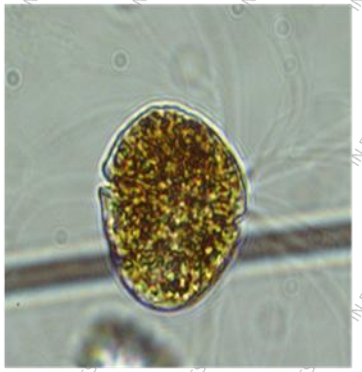
Merismopedia sp

Anabaena sp

DYPNOPHYCEAE AND EUGLENOPHYCEAE (PLATE-4)

Dinophysis

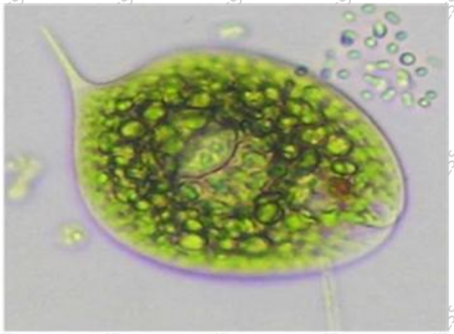
Gymnodonium



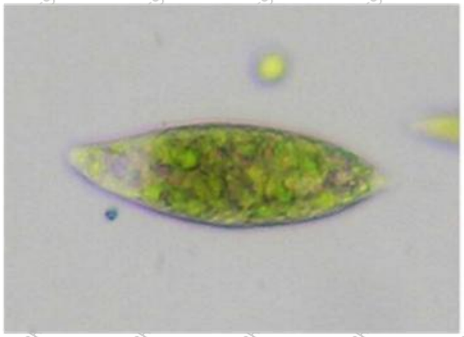
Gonyaulax

Ceratium

EUGLENOPHYCEAE



Phacus



Euglena

3.2 Level of Organic Pollution in the Ami River

The algae studied in genera and species, which can tolerate organic pollution, was reported by Palmer (1969). They prepared a list of 60 genera and 80 species, which can tolerate organic pollution. Algal species, reported in the present study, were recorded with the Palmer's index (Palmer 1969), along with the sign of occurrence. However, the highest score was recorded during summer, (32) at site 3 and winter, (25) at all the sites. The lowest score was recorded in rain (12) at site 2, and site 3, respectively as shown in (Table 3). The present investigation shows a high organic pollution load in summer and winter, and moderate organic pollution was recorded in the rainy season, during the study period in the Ami River.

A similar study, conducted by Jafari, and Gunale (2006), recorded site-1 (16), site-2 (36), and site-3 (41), in Mutha River, Pune. According to Palmer's index, all the ponds illustrate possible high levels of organic pollution. Pond-1(15), Pond-2 (19), Pond-3 (19), and Pond-4 (16), which showed moderate levels of pollution. The fourth pond showed the presence of *Microystis* indicating the deteriorated quality of water (Jose and Kumar 2011). The Palmer's score at stations A and B was 16 each. At stations C and D, the score was 24. These indicate moderate pollution load in A and B stations and confirm a high organic pollution at C and D stations in Pichhola Lake, Udaipur (Mishra et al. 2017). The pollution index at location D1-(15) shows moderate organic pollution, while locationsD2-(33) and D3-(25) respectively show evidence of high organic pollution The Deothan reservoir is highly polluted according to Palmer's index. So, it is urgent to avoid human interference in this natural reservoir (Wagh and Jondhale 2018). While total score pollution index at station (1) was 18, station (2) was 21, while station (3) was 17 recorded from Shatt Al-Arab River, Iraq. Station (1) indicated probable organic pollution and Stations 2 and 3 were greater than 20 indicating the confirmed high organic pollution (Al Kanani et al. 2018). Puttenahalli Lake is highly organically polluted and has reported the highest pollution index during pre-monsoon (28), monsoon (22), and during post-monsoon (23), recorded. The highest Palmer pollution index was recorded in the lake during all three seasons revealing the threatened condition of the lake (Veena, et al. 2022).

The study indicates that biological aspects with Physicochemical properties reveal a glossy polluted nature of the river having almost insignificant self-purification capacity to assimilate pollution in this stretch. The main sources of pollution in the river are industrial effluents, municipal water discharges, agricultural runoff, and human excreta. Thus, wastes discharged in Ami at Barshar (Gorakhpur) caused an adverse impact on the phytoplankton community structure and degraded the riverine habitat. Consequences of pollution are regarded as changes in qualitative and quantitative characteristics of the biological spectrum expressed as diversity (Pielou, 1969). Susceptible species are reduced and resistant species are favored as a result of pollution (Palmer 1963, Shevchenko et.al. 2020, Henson et.al. 2021, Yadava et. al. 1987). Physiological investigation at different sites of the Ami River suggests that algal pollution of the river is quite poor due to the continuous discharge of industrial wastes through the drain, containing different toxicants, and agricultural run-off with high oxygen-demanding wastes which probably acted synergistically leading to a very poor algal population despite of nutrient in the river water. The members of Bacillariophyceae appear to be best adapted in the polluted habitat as indicated by 14 species out of 41. The present investigation revealed that the effluents discharged from industries are very harmful to the phytoplankton as well as the aquatic ecosystem.

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Table 3. Palmer's pollution index during 2021-2022

Genus &Species	Palmer's Pollution Index (1969)	Rainy				Winter				Summer			
		Site-1	Site-2	Site-3	Site-4	Site-1	Site-2	Site-3	Site-4	Site-1	Site-2	Site-3	Site-4
Anacystis(Microystis)	1	1	1	1	1	1	1	1	1	1	1	1	1
Ankistrodesmus	2	-	-	-	-	2	2	2	2	2	2	2	2
Chlamydomonas	4	-	-	-	-	-	-	-	-	-	-	-	-
Chlorella	3	-	-	-	-	3	3	3	3	3	3	3	3
Closterium	1	-	-	-	-	-	-	-	-	1	1	1	1
Cyclotella	1	1	1	1	1	-	-	-	-	-	-	1	-
Euglena	5	-	-	-	-	5	5	5	5	5	5	5	5
Gomphonema	1	1	1	1	-	-	-	-	-	1	1	1	1
Lepocinclis	1	-	-	-	-	-	-	-	-	-	-	-	-
Melosira	1	-	-	-	-	1	1	1	1	-	-	-	-
Micractinium	1	-	-	-	-	-	-	-	-	-	-	-	-
Navicula	3	3	3	3	3	-	-	-	-	3	3	3	3
Nitzschia	3	3	3	3	3	3	3	3	3	3	3	3	3
Oscillatoria	5	-	-	-	5	5	5	5	5	5	5	5	5
Pandorina	1	-	-	-	-	-	-	-	-	-	-	-	-
Phacus	2	-	-	-	-	-	-	-	-	2	2	2	2
Phormidium	1	1	1	1	1	-	-	-	-	1	1	1	1
Scenedesmus	4	-	-	-	-	4	4	4	4	-	-	-	-
Stigeoclonium	2	-	-	-	-	-	-	-	-	2	2	2	2
Syndra	2	2	2	2	2	2	2	2	2	2	2	2	2
	Total	**12**	**12**	**12**	**17**	**26**	**26**	**26**	**26**	**31**	**31**	**32**	**31**

4. Conclusion

The Ami River has been significantly impacted by the discharges of industrial effluents from multiple sources, including the Bharsar layout and domestic and agricultural activities in the Adilapar area. This pollution has had detrimental effects on the river ecosystem, leading to a noticeable decrease in the diversity of phytoplankton and an alarming increase in the organic load, present in the water. The detrimental impact of industrial effluents and other pollutants has given rise to a pressing environmental concern that demands immediate attention and remedial action. Protective measures must be taken to address the pollution of the Ami River. This includes the implementation of stricter regulations governing the disposal of industrial waste and the adoption of sustainable practices in domestic and agricultural activities near the river. Additionally, there is a critical need for collaborative efforts that involve government authorities, industries, and local communities to devise and implement effective strategies to restore the ecological balance of the Ami River and safeguard the overall health of its ecosystem. By prioritizing the protection and restoration of the Ami River, we can work towards ensuring a sustainable and thriving environment for current and future generations. Concerted efforts must be made to mitigate the sources of pollution and promote responsible environmental stewardship to preserve the Ami River as valuable natural resources for years to come.

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