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Water quality assessment of river based on phytoplankton biological integrity index in rural areas of the upstream Citarum River, West Java, Indonesia

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Abstract. *Pratiwi D, Oktavia D, Sumiarsa D, Sunardi S. 2024. Water quality assessment of river based on phytoplankton biological integrity index in rural areas of the upstream Citarum River, West Java, Indonesia. Biodiversitas 25: 881-889.* The deterioration of water quality in the upstream Citarum River is one of the consequences of agricultural practices characterized by fertilizer and pesticide runoff that disrupts the ecological balance of aquatic ecosystems. The research area was on agricultural land use in the Cihawuk segment, Kertasari, Bandung District. The present study attempts to community structure and assess the water quality using the biological indexes of rural areas in upstream Citarum River through phytoplankton studies. A purposive sampling technique was used to collect data on physico-chemical parameters and phytoplankton community structure from stations selected on the basis of agricultural land use. Furthermore, biological indexes such as pollution levels based on the Shannon Wienner diversity index (H'), Palmer algae index, and Diatomeae index are examined using the data community structure of phytoplankton. The findings show that the abundance of phytoplankton in rural areas is 4,105 cells/L. The community structure of phytoplankton was dominated by *Coelastrum* sp. and *Trachellomonas* sp. The Palmer algae index ranges from 23-26, indicating that the water was a highly organic pollutant. The pollution level of upstream Citarum River based on the diversity index shows moderately polluted water. Meanwhile, the diatomeae index showed less than 0.2, which sites water bodies were mesotrophic. Phytoplankton and their indexes serve as valuable tools for evaluating the quality of the water environment.

Keywords: Agriculture, diatomeae index, organic pollution, palmer alga index, Shannon Wiener index

INTRODUCTION

Water quality assessment is critical in comprehending the intricate dynamics of ecological health within aquatic systems, especially in regions heavily influenced by human activities (Li et al. 2022). The upstream Citarum River serves as a poignant case study, grappling with the adverse effects of pollution originating from agricultural waste. The Citarum River, a vital water source for numerous communities, faces a formidable challenge due to the runoff of agricultural pollutants, such as fertilizers and pesticides, into its waters. These anthropogenic inputs can disrupt the ecological balance, impacting aquatic organisms' health and the riverine ecosystem's overall integrity (Bashir et al. 2020; Sudarso et al. 2021; Lin et al. 2022). In this context, the use of biological indexes emerges as a necessary tool to provide insight into the state of the ecosystem as a whole.

Phytoplankton are microscopic organisms that can produce energy through photosynthesis (Utami et al. 2021). Phytoplankton play a critical role in their ecosystem as primary producers, forming the base of the aquatic food chain (Djoru et al. 2020). Algal groups are extremely sensitive to even minor changes in water quality (Omar 2010). Environmental factors such as sunlight, carbon dioxide, and nutrient availability significantly influence the composition and abundance of phytoplankton (Valenzuela-Sanchez et al. 2021; Indrayani et al. 2023). The detection of algae is a strength for evaluating the resources and biodiversity of the water body (Stevenson 2014; Valenzuela-Sanchez et al. 2021). Therefore, due to their high sensitivity to changes in environmental conditions, assessing the presence and distribution of phytoplankton supports clarifying environmental characteristics and the impact of water quality changes (Trang et al. 2018; Firsova et al. 2023). In previous research, many studies have been conducted on the structure of phytoplankton communities in the upstream Citarum River. However, previous research only focused on phytoplankton morphology, community structure, and correlation with physicochemical parameters (Ibrahim and Sjarmidi 2017; Sunardi et al. 2017; Alhafidzoh et al. 2021; Salsabila et al. 2021; Samosir et al. 2021). Research on assessing water quality based on the biological and diversity indexes has yet to be carried out.

The biological indexes, particularly the Palmer Index and Diatomeae Index derived from phytoplankton communities, play a critical role in unraveling the intricate ecological dynamics of water systems in assessing water quality (Trang et al. 2018). This is most evident in the upstream Citarum River, where agricultural waste runoff poses a significant challenge to the aquatic ecosystem. The Palmer Index, a widely utilized indicator, offers a nuanced understanding of water quality by evaluating the tolerance levels of various phytoplankton species to pollution (Trang et al. 2018; Yilmaz et al. 2021). Moreover, the diatomeae index, focusing specifically on diatoms within the phytoplankton community, provides a more targeted assessment (Trang et al. 2018). Complementing these indexes, an exploration of the diversity index of phytoplankton in the upstream Citarum River provides a broader perspective on the overall health and resilience of the aquatic ecosystem. A higher diversity index indicates a more robust and adaptable community, while a decline may signify the onset of ecological stress (Landi et al. 2018). Understanding the diversity of phytoplankton in this context becomes crucial for unraveling the ecological consequences (Borics et al. 2021) of agricultural pollution and aids in developing strategies for sustainable river management. Incorporating these biological indexes into water quality assessments for the upstream Citarum River is paramount for deciphering the intricate interplay between anthropogenic activities and ecological health. This research analyzes water quality using biological and diversity indexes of phytoplankton. Thus, research was conducted on the physicochemical of water and the pattern and community of phytoplankton to provide information for assessing water quality in rural areas of upstream Citarum River. This research is important for examining the structure and function of aquatic ecosystems as indicators of environmental health, water resource management, and land use practices.

MATERIALS AND METHODS

Study area

The sampling locations for this study were situated in the upstream Citarum River, West Java, Indonesia, in August 2022 (Figure 1). The research plot was in Cihawuk segment. Cihawuk was a rural area with >50% horticulture and agriculture practices without soil and water conservation. Sampling sites were determined using the purposive sampling method; sites were selected based on representative rural areas in the upstream Citarum River. Three sample sites were selected for each segment. Sample rural area sites in Cihawuk segment were located at coordinates 750,000 m (UTM Easting), 7,953,014 m (UTM Northing) (C1), 750,006 m (UTM Easting), 7,952,935 m (UTM Northing) (C2), and 750,012 m (UTM Easting), 7,952,846 m (UTM Northing) (C3).

Sampling procedure

During the dry season in August 2022, water samples were collected. Water samples are used to measure physicochemical parameters. Water samples were collected using the grab sampling technique. Temperature, pH, turbidity, dissolved oxygen (DO), total organic carbon (TOC), and total organic matter (TOM) were the physicochemical parameters used. Temperature, dissolved oxygen (DO), and pH were assessed on-site using a portable DO meter and pH meter from the Lutron series (Lutron, Taiwan). Turbidity was measured with a nephelometer (pH-207, Lutron, Taiwan). The methods for sampling, preserving, and analyzing samples for measuring TOC and TOM followed SNI (Standar Nasional Indonesia) and APHA (American Protection Health Agency).

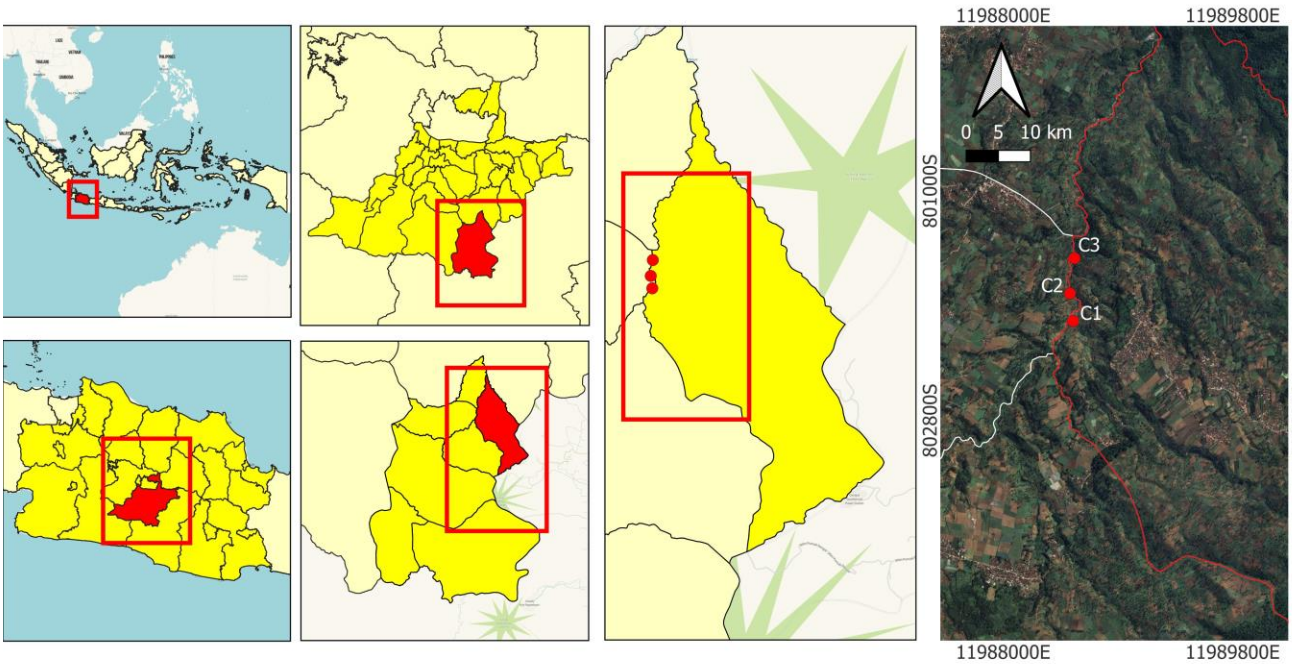

Figure 1. Sampling sites in segment Cihawuk of upstream Citarum River, Cihawuk, Kertasari, Bandung, West Java, Indonesia

Plankton samples were collected using the filtration method. Water samples were filtered with plankton net number 25. 10 L of river water was filtered with a plankton net, and 50 mL of the filtrate was collected in a plankton bottle and preserved with Lugol (APHA 2017). The abundance of each type of phytoplankton in the water sample was calculated. Plankton species were identified using the books Freshwater Algae of North America and Planktonology. Phytoplankton abundance is determined using the Sedgewick Rafter counting chamber, a specialized device with precise grid markings, under a light microscope. This method allows researchers to accurately quantify the density of phytoplankton cells suspended in a water sample. The identification of plankton and benthos is conducted at the Center of Environmental and Sustainability Science (CESS) at Universitas Padjadjaran, Sumedang, Indonesia.

Data analysis

The ecological index was used to analyze the community structure of phytoplankton by calculating the Shannon-Wiener index (H') (Odum 1993). We analyzed the biological indexes to determine and identify water quality in the rural area of upstream Citarum River. We used biological indexes such as Palmer, Shannon Wiener, and diatomeae indexes. Based on the criteria of Wilhm (1975), the diversity index was used to determine water pollution levels. A Shannon Wiener index score of 3-4 was considered to be slightly polluted, 2-3 was lightly polluted, 1-2 was moderately polluted, and <1 was to be heavily polluted. The Palmer Index assesses the abundance of algal genera with different levels of tolerance to organic pollution in water bodies. The Palmer Index assigns scores from 1 to 5 based on the presence of algal genera, with higher scores indicating higher pollution levels, while less tolerant genera receive lower scores. High organic contamination was indicated by a Pollution Index score ≥20. The diatomeae index is based on species of diatoms tolerant of organic pollution. Diatoms have a high tolerance to organic pollution due to their ability to efficiently adapt to and metabolize various organic compounds present in polluted aquatic environments. We compared the presence of species of Centrales (C) and Pennales (P) in water bodies (Nguyen 2003). Scores <0.02 indicated that the bodies of water are eutrophic or highly organic.

RESULTS AND DISCUSSION

Physicochemical water

The following physicochemical parameters were measured: temperature, pH, turbidity, DO, TOC, and TOM. The physicochemical characteristic in rural areas is shown in Table 1. The water temperature in the research location is 25°C, considered standard and good for aquatic organisms; the DO concentration in rural areas is 5.7 mg/L, following national class 2 quality standards. The rural area in upstream Citarum is located at 1,294 masl, a high elevation. High elevation is associated with lower atmospheric pressure and low temperature. Lower atmospheric pressure can affect the solubility of oxygen in water and push down the water, making it easier for oxygen to dissolve. Furthermore, cooler temperatures can promote high dissolved oxygen levels. In addition, in topography with high slopes and mountainous regions, water bodies may experience rapid flow as they descend from high elevation. Fast-flowing water can increase turbulence, facilitating oxygen exchange from the atmosphere to water.

Organic matter and organic carbon in rural areas were 13.94 mg/L and 13.93 mg/L, respectively. The organic matter category is quite high despite no quality standard set. This can be caused by crop residues in water bodies. Agriculture practices without soil and water conservation can impact runoff, increasing nutrient loading and turbidity (Atwell and Bouldin 2022; Rey-Romero et al. 2022). Turbidity values showed above-standard normal turbidity (79.57 ntu). High turbidity in agricultural areas is often associated with agricultural practices, including the disposal of waste, soil erosion, and sediment runoff, which significantly influence water turbidity through various mechanisms (Rad et al. 2022). Turbidity is the degree of cloudiness or haziness in a liquid due to the presence of suspended particles, which can affect water clarity and quality. High turbidity can diminish sunlight penetrating the water column, negatively impacting the aquatic ecosystem. Thus, changes in water clarity and habitat degradation due to turbidity can disrupt aquatic organisms' distribution and abundance (Lunt and Smee 2020). Some species may be more sensitive to changes in water quality, potentially leading to shifts in species composition (Lind et al. 2022). In high organic input, the decomposition process influences microbial activity. It can lead to oxygen depletion (Pratiwi et al. 2023), eutrophication (Han et al. 2022), stimulate the growth of bloom algae (Han et al. 2022), and sedimentation (Frates et al. 2023). These impacts can disrupt the balance of the ecosystem and cause a decline in water quality.

Phytoplankton community

The phytoplankton community structure was analyzed in Cihawuk segment of the upstream Citarum River (Table 2). Phytoplankton abundance was presented as the number of individuals of a species per cubic liter (ind/L). The total abundance of phytoplankton was 4,105 cells/ L. A total of species is 46 species and 10 classes of phytoplankton were identified, including 20 species of Ochrophyta, 15 species of Chlorophyta, 4 species of Euglenozoa, 2 species of Cyanobacteria, 3 species of Charophyta, 1 species of Myzozoa, and 1 species of Rhodophyta.

Table 1. Physicochemical properties of water in segment Cihawuk of upstream Citarum River, West Java, Indonesia

Parameters	Units	Cihawuk segment			Mean±STD
		C1	C2	C3	
Temperature	°C	24	25	26	25±0.82
pH		8.06	8.03	7.78	7.96±0.15
Turbidity	NTU	80.85	79.45	78.4	79.57±1.23
DO	mg/L	5.7	5.7	5.7	5.7±0
TOC	mg/L	14	12.2	14.4	13.53±1.17
TOM	mg/L	13.46	13.76	14.6	13.94±0.60

Notes: DO: dissolved oxygen; TOC: total organic carbon; TOM: total organic matter; C1/C2/C3: station of Cihawuk segment

Chlorophyta and Ochrophyta were most abundant in the rural areas (Figure 2), and high species diversity occurred in those habitats. In rural regions, *Coelastrum* sp. dominated with an abundance of 63.20%, followed by *Trachellomonas* sp. at 13.40% and *Pediatrum* sp. at 3.70%. Chlorophytes demonstrated a prevalence towards a specific type of catchment area, a group of microalgae, which tend to be more commonly found in agricultural areas. In rural areas, typical agricultural areas support chlorophyta adapted to nutrient-rich and high-organic conditions. *Coelastrum* sp. is more found in rural areas, which may be due to nutrient and water conditions. Nutrient content and nitrogen to phosphorus ratio on the growth of *Coelastrum* sp. suggest that higher nutrient content with higher nitrogen to phosphorus is better for its growth (Figler et al. 2021). These findings imply that the nutrient-rich environment associated with agricultural activities may favor the growth of *Coelastrum* sp. Agriculture runoff, which may contain fertilizers and nutrients from farming activities, can contribute to elevated nutrient levels in water bodies.

Furthermore, the warmer temperature can promote the growth and reproduction of *Coelastrum* sp. (Figler et al. 2021). In rural areas, elevated temperature is due to sunlight exposure and shallow water. Rhodophyta is rare and found in rural areas due to their natural habitat preferences. The abundance of *Lemanea* sp. was only 4 cells/L, which is less abundant; freshwater algae typically grows in running water and shallow lakes. The agricultural area is characterized by the specific habitats that favor the growth of *Lemanea* sp., which have high turbulence. Meanwhile, other algae species in the research location can affect the growth and distribution of *Lemanea* sp. Some species can form dense blooms, which may outcome *Lemanea* for nutrient and habitat space (Celewicz et al. 2022).

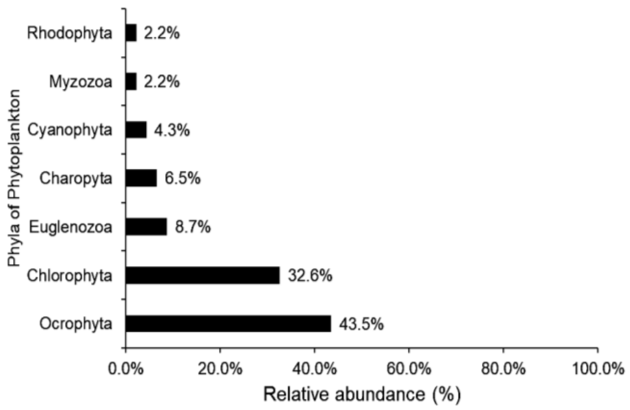

Figure 2. Dominant distribution phylum of phytoplankton in the Cihawuk segment of upstream Citarum River, West Java, Indonesia

Table 2. Phytoplankton distribution in Cihawuk segment of upstream Citarum River, West Java, Indonesia

Taxa	Species	Cihawuk		
		C1	C2	C3
Phylum: Ochrophyta				
Class: Bacillariophyceae	*Amphora* sp.	4	4	9
	Cocconeis sp.	0	0	1
	Cyclotella sp.	6	16	15
	Cymbella sp.	4	8	9
	Diatoma sp.	4	4	2
	Epithemia sp.	0	1	0
	Fragilaria sp.	39	35	27
	Gomphonema sp.	1	2	4
	Gyrosigma sp.	3	6	11
	Melosira sp.	5	26	17
	Navicula sp.	21	22	34
	Neidium sp.	0	1	0
	Nitzschia sp.	2	22	2
	Nitzschia sp 1	2	22	0
	Pinnularia sp.	10	8	9
	Stauroneis sp.	0	2	1
	Stenopterobia sp.	5	2	4
	Surirella sp.	7	10	4
	Synedra sp.	15	25	27
Class: Xanthophyceae	*Tribonema* sp.	5	66	33
Phylum: Chlorophyta				
Class: Chlorophyceae	*Ankistrodesmus* sp.	0	2	3
	Coelastrum sp.	840	1117	636
	Pediastrum sp.	23	73	56
	Pediastrum boryanum	1	4	7
	Pediastrum simplex	5	13	4
	Pleodorina sp.	0	1	0
	Scenedesmus sp.	3	1	2
	Scenedesmus acuminatus	2	1	2
	Scenedesmus armatus	0	1	0
	Scenedesmus obtusus	1	2	2
	Scenedesmus opoliensis	7	17	6
	Scenedesmus quadricauda	3	6	13
Class: Trebouxiophyceae	*Actinastrum* sp.	0	6	4
	Crucigenia sp.	2	2	0
Class: Ulvophyceae	*Ulothrix* sp.	2	00	4
Phylum: Myzozoa				
Class: Dinophyceae	*Peridinium* sp.	1	10	0
Phylum: Euglenozoa				
Class: Euglenidea	*Euglena* sp.	4	0	3
	Euglena acus	0	4	2
	Phacus sp.	2	1	0
	Trachellomonas sp.	109	300	139
Phylum: Rhodophyta				
Class: Florideophyceae	*Lemanea* sp.	4	0	0
Phylum: Charophyta				
Class: Zygnematophyceae	*Closterium* sp.	2	1	0
	Cosmarium sp.	4	0	2
	Sphaerozosma sp.	1	0	1
Phylum: Cyanobacteria				
Class: Cyanophyceae	*Anabaena* sp.	0	0	1
	Phormidium sp.	3	1	12

Bioindex of phytoplankton to assess water quality

Diversity level could serve as an indicator for assessing the pollution level. Figure 3 shows the Shannon-Wiener diversity index at each station, along with the corresponding pollution levels. The analysis of the results could determine both the level of diversity of the phytoplankton in each station and the level of pollution. Good availability and sustainability of life-sustaining resources are indicated by a high diversity of aquatic organisms (Protasov et al. 2019). Pollution can have a detrimental effect on the natural function of the water as a support system for phytoplankton, as only certain species can survive in polluted water (Aida et al. 2022). The diversity index value was 1.29-1.82, indicating moderate diversity. According to Shannon-Wiener, diversity index values between 1 and 3 are considered moderate. A moderate phytoplankton diversity index in rural areas indicates a reasonable level of species richness and evenness within the phytoplankton community. This means the community is neither overly dominated by a few species nor overly diverse but has a well-balanced and reasonably rich species diversity (Roswell et al. 2021). The phytoplankton diversity index indicated moderate pollution. A moderate pollution level in water indicates the presence of contaminants or impurities but does not reach critical levels (Syeed et al. 2023). While not severe, it requires careful monitoring and management to prevent further water quality degradation and keep the aquatic ecosystem healthy.

A bioindicator is a biological process that periodically indicates the state of the environment and its changes. A community characteristic can indicate environmental stability through the diversity value associated with population equilibrium (Downing et al. 2014). Planktons are ideal indicators for monitoring water system changes due to their acute sensitivity to environmental fluctuations and anthropogenic input of nutrients and toxic substances (Sharma and Singh 2022). In addition, their dynamic nature, coupled with their foundational role in aquatic food webs, provides valuable insights into ecosystem health and enables effective monitoring of diverse water environments. A relation between the intensity of pollution and the organisms living in it. Palmer (1969) were among the initial researchers who endeavored to identify and compile genera that exhibit resistance to organic pollution. In the present study, an assessment of the organic matter of the upstream Citarum River was attempted using Palmer's algal genus index. Palmer's algal index calculated at different stations of rural areas in upstream Citarum River is shown in Table 3. In the present study, the phytoplankton was classified as species tolerant of organic pollutants by Chlorophyceae, Cyanobacteria, Euglenidea, and Bacillariohyceae. Tolerant genera of phytoplanktons were found in rural areas, such as *Phormidium, Scenedesmus, Ankistrodesmus, Coelastrum, Cyclotella, Melosira, Gomphonema, Navicula, Nitzchia, Synedra, Euglena,* and *Phacus* appeared on all six occasions (Figure 4). The existence of these genera in larger numbers indicates the potential organic pollution in the sampling locations (Shams and Karimian 2017; Le et al. 2018).

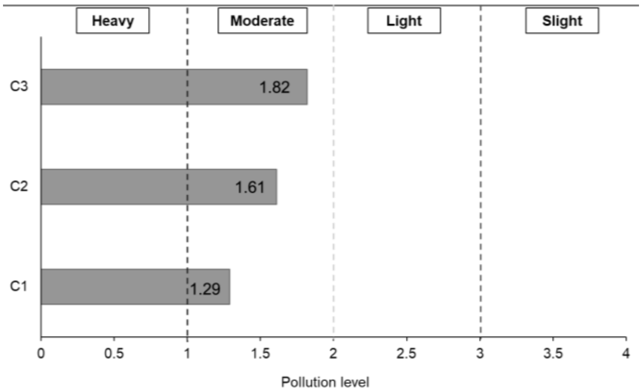

Figure 3. Water pollution level from conversion Shannon-Wiener Index (H') of phytoplankton

Table 3. Palmer's algae pollution index value in segment Cihawuk of upstream Citarum River, West Java, Indonesia

Alga genera	Index value	C1	C2	C3
Anacystis	1	-	-	-
Oscillatoria	4	-	-	-
Phormidium	1	1	1	1
Chlamydomonas	4	-	-	-
Pandorina	1	-	-	-
Scenedesmus	4	4	4	4
Micratinium	1	-	-	-
Ankistrodesmus	2	-	2	2
Chlorella	3	-	-	-
Closterium	1	1	1	-
Stigeoclonium	2	-	-	-
Cyclotella	1	1	1	1
Melosira	1	1	1	1
Gomphonema	1	1	1	1
Navicula	3	3	3	3
Nitzchia	3	3	3	3
Synedra	2	2	2	2
Euglena	5	5	5	5
Phacus	2	2	2	-
Lepocinclis	1	-	-	-
Total Palmer Index		24	26	23

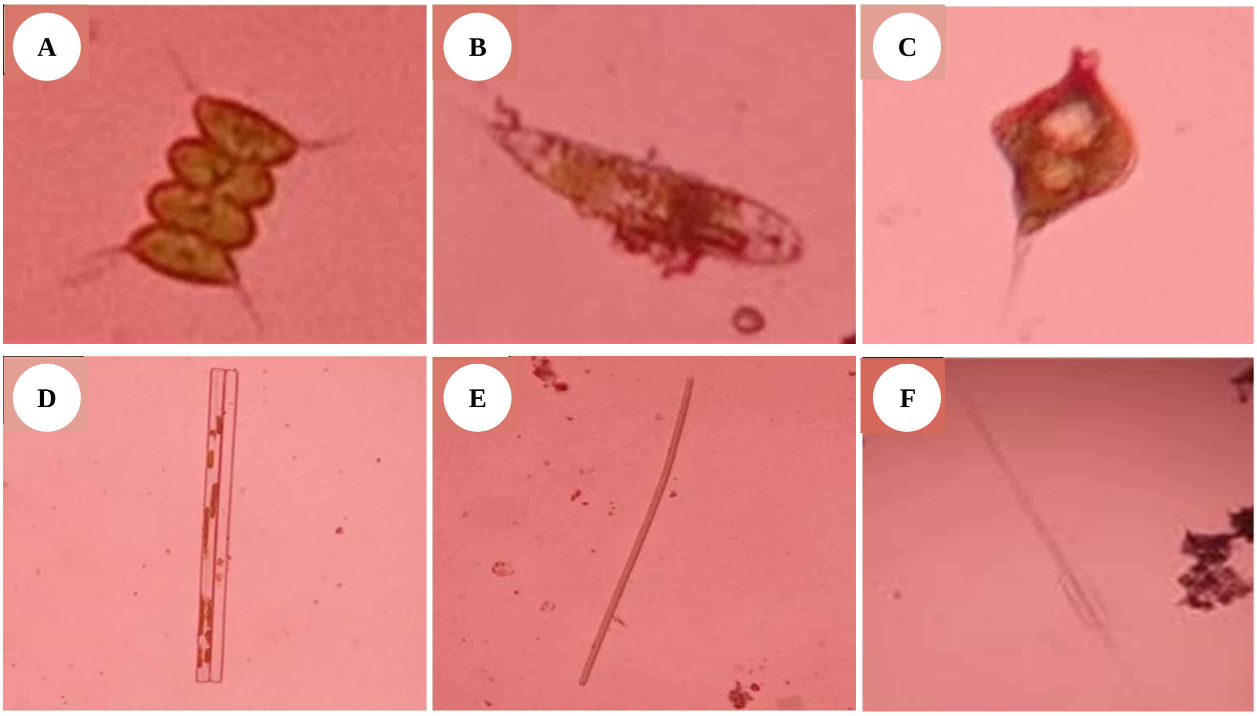

Figure 4. Some widespread pollutant genera of phytoplankton in rural areas of upstream Citarum River, West Java, Indonesia. A. *Scenedesmus quadricauda*, B. *Euglena* sp., C. *Phacus* sp., D. *Synedra* sp., E. *Phormidium* sp., F. *Nitzchia* sp

Scenedesmus is Cyanophyceae found in all stations of study. The genus *Scenedesmus* is found in all ponds, and its presence in polluted water, particularly eutrophic water, has been established by (Bala et al. 2022). *Scenedesmus*, a green algae genus, exhibits adaptive features that enable it to tolerate and adapt to organic pollution in aquatic ecosystems (Jimenez-Veuthey et al. 2018). Its rapid growth rate allows for efficient nutrient utilization, including organic compounds, giving *Scenedesmus* a competitive edge in environments containing elevated organic pollution. Primarily autotrophic, *Scenedesmus* relies on photosynthesis, reducing energy dependence on external organic matter (Kamalanathan et al. 2017). The algae's versatility in nitrogen uptake and ability to form resting stages during adverse conditions further contribute to its resilience in polluted waters (Kamalanathan et al. 2017). Additionally, *Scenedesmus* possesses biochemical adaptations that facilitate the breakdown and utilization of organic compounds, enhancing its ability to thrive in environments influenced by organic pollution (Bala et al. 2022; Abdelfattah et al. 2023). These combined features underscore the adaptability and robustness of *Scenedesmus* coping with challenging environmental conditions.

The Bacilariophyceae like *Ankistrodesmus* sp., *Gomphonema* sp. *Navicula* sp., *Nitzchia* sp., and *Surirela* sp. were well found and distributed in upstream Citarum River stations. Diatom phytoplankton species such as *Navicula* and *Nitzchia* were used as assessment indicators because their presence and abundance provide valuable insight into water quality. *Navicula* and *Nitzschia* are recognized as microalgae whose presence can signify the impact of anthropogenic pollution on their aquatic habitats (Apriansyah et al. 2021). These algae indicate unnatural pollution from human activities or interventions in water sources (Sawaiker and Rodrigues 2017). Their tolerance and sensitivity to nutrient levels and organic pollution changes make them useful for monitoring and evaluating aquatic ecosystem health. Therefore, *Navicula* and *Nitzschia*, belonging to the diatom group, exhibit adaptive strategies enabling them to tolerate organic pollution in aquatic environments (Zelnik et al. 2023). These microscopic algae possess biochemical mechanisms that allow efficient metabolism and assimilation of organic matter, contributing to their ability to thrive in environments with increased pollutant levels (Ding et al. 2019; Mohsenpour et al. 2021; Abdelfattah et al. 2023). The unique silica-based cell wall of diatoms, including *Navicula* and *Nitzschia*, protects against potential adverse effects. At the same time, their rapid life cycle, adaptability to changing conditions, and competitive advantage contribute to *Navicula* and *Nitzschia* being recognized as microalgae whose presence can significantly impact anthropogenic pollution on their aquatic habitats and their resilience in the presence of organic pollutants (Sardo et al. 2021). As bioindicators, changes in the abundance and composition of *Navicula* and *Nitzschia* populations can offer valuable insights into the impact of organic pollution on aquatic ecosystems and help assess and manage water quality.

Moreover, we found two species of *Euglena* in each sampling point. Genus are much more tolerant of organic pollution than others (Palmer 1969). *Euglena*, a versatile genus of single-celled flagellates, exhibits adaptive strategies that enable it to tolerate and adapt to organic pollution in aquatic environments (Li et al. 2014; Khan and Tisha 2020). Their mixotrophic nutrition allows *Euglena* to utilize diverse carbon sources, combining photosynthesis and heterotrophic feeding, including organic compounds in polluted waters (Inwongwan et al. 2019; Ilham et al. 2020). The organism's motility, facilitated by a flagellum, enables active movement, allowing *Euglena* to navigate from areas with high pollutant concentrations (Häder and Hemmersbach 2022). Additionally, *Euglena* can form protective cysts during unfavorable conditions, contributing to its resilience (Roy et al. 2014). Biochemical adaptations for the breakdown and assimilation of organic compounds and rapid reproduction further enhance *Euglena's* ability to thrive in environments affected by organic pollution (Hasan et al. 2019). These adaptive features collectively position *Euglena* as a resilient and adaptable organism in the changing environmental conditions associated with organic pollutants.

Moreover, at the three stations, 13 of the 20 genera in the Palmer's list of algal indexes were present in the upstream Citarum River (Table 3). The value of the Palmer Index during the rural monitoring was relatively high, ranging from 23 to 26, indicating organic water pollution (Palmer 1969). The highest Palmer index was recorded in the upstream Citarum River, revealing the river's threatened condition. Algae genera such as *Navicula*, *Nitzchia*, *Scenedesmus*, *Euglena*, *Phacus*, and *Synedra* predominated in the studied river, and these algae species are the most prominent indicators on the Palmer pollution index list. The phytoplankton scenario of the rural area in the upstream Citarum River depicts the river's high organic condition as a result of high human interferences such as agricultural practices such as runoff sediment, pesticides, fertilizers, and plant residue. Organisms with high tolerance levels will persist, reproduce, and spread in polluted environments until the pollution exceeds their tolerance threshold. The continued presence of a species or genus in a given location indicates favorable conditions for its survival, although its absence does not necessarily indicate unfavorable environmental conditions (Hillebrand et al. 2018).

Diatoms were dominant in species number in rural areas in upstream Citarum River. We can analyze water tropic status based on species of diatoms. Table 4 shows the Diatomeae index values from this study. Throughout the study period, the majority of stations had diatom index values below 0.2, indicating that rural water quality is mesotrophic. This result indicated tropic status or fertility in rural areas is moderate or high organic matter that does not correlate with the Palmer index. Indicating measure of tropic group use species of diatom need more collected from diatom phytobenthos from sand, sediment, mud, natural rock, stones, leaves, or man-made surfaces such as concrete, brick, etc., or epiphyte diatom assemblages on aquatic plants and macroscopic algae (Zelnik et al. 2023).

Table 4. Diatomeae index of phytoplankton in segment Cihawuk of upstream Citarum River, West Java, Indonesia

Species diatom	Cihawuk		
	C1	C2	C3
Amphora sp.	P	P	P
Cocconeis sp.	-	-	P
Cyclotella sp.	C	C	C
Cymbella sp.	P	P	P
Diatoma sp.	P	P	P
Epithemia sp.	-	P	-
Fragilaria sp.	P	P	P
Frustulia sp.	-	-	-
Gomphonema sp.	P	P	P
Gyrosigma sp.	P	P	P
Melosira sp.	C	C	C
Mastogloia sp.	-	-	-
Navicula sp.	P	P	P
Neidium sp.	-	P	-
Nitzschia sp.	P	P	P
Nitzschia sp 1	P	P	-
Pinnularia sp.	P	P	P
Stauroneis sp.	-	P	P
Stenopterobia sp.	P	P	P
Surirella sp.	P	P	P
Synedra sp.	P	P	P
Diatomeae index	0.154	0.125	0.154

Notes: Abbreviations are defined as follows: P: Pennnales; C: Centrales

In conclusion, phytoplankton can be a bioindicator for assessing the health of aquatic ecosystems with biological index. Pattern distribution of phytoplankton in rural areas of upstream Citarum River by Chlorophyceae (69.60%), Euglenidea (13.75%), and Baccilariohyceae (12.68%), relatively. The Cihawuk segment has been polluted by agricultural waste, leading to organic load and disturbing aquatic organisms. Upstream Citarum River classified moderate pollution level and mesotrophic trophic status based on the diversity index of phytoplankton and diatomeae index. Furthermore, these water bodies have organic pollution found *Euglena, Navicula, Nitzchia,* and *Scenedesmus* in the study location. We suppose this study is expected to provide a fundamental basis for the management of the water bodies and agricultural land use, which serves as a management and protective ecosystem service in upstream Citarum River West Java, Indonesia.

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