

The Relationship Between Water Quality and Phytoplankton Abundance at The Eastern Part of Segara Anakan Cilacap, Central Java

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Abstract

Phytoplankton is the primary producer whose existence depends not only on the nutrient. The eastern part of Segara Anakan waters experienced changes where the decline in quality which received input from organic and inorganic wastes. The area was also get the residu from residential, industrial and factory wastes of Holcim and Pertamina factories. The purpose of this research is to study the water quality and to study the relationship between water quality and abundance of phytoplankton at the eastern part of Segara Anakan. The result showed that Water quality in Segara Anakan waters in the east part of Cilacap consists of several parameters that beyond the quality standards according to the Keputusan Menteri Lingkungan Hidup No. 51 of 2004 such as pH, Nitrate, Ammonia, Phosphate, and TSS. Water temperature is a physical factor which has a strong negative correlation with the abundance of phytoplankton, followed by TSS as a physical factor which has a positive correlation. The chemical factor which has a positive correlation with abundance is TDS, Nitrite and pH, followed by Phosphate, Salinity, Ammonia, and Nitrate which has a negative correlation with the abundance of phytoplankton.

Key Words: *Environmental factor, phytoplankton, Segara Anakan, Spatial variation, temporal variation*

INTRODUCTION

The eastern part of Segara Anakan waters received the organic and inorganic waste from the domestic activities, factory, and industry, such as cement factory (Holcim) and oil industry (Pertamina). Several industrial event on the eastern of Segara Anakan which contains oil and the cement industry are predicted as producing wastes to the rivers, tend to cause environmental defilement and low quality in the aquatic area (Sulistiono, 2017).

The existence of phytoplankton can depict the rate of its productivity (Sachlan, 1980). If the abundance of phytoplankton in the water is at a high level, the water tends to have a high productivity level (Raymont, 1980). Phytoplankton has several functions, such as primary oxygen supplier for the aquatic organisms, synthesizing organic matters, as food sources of zooplankton and poisonous substances absorbance (NH_3 and H_2S). Phytoplankton also could be an indicator of environmental defilement, for example, *Skeletonema* sp. will be abundant in the water with high level of nutrient (Arinardi, 1997).

According to Djumanto *et al.* (2009), abundance and distribution of plankton influenced by physical conditions of waters such as light penetration, temperature, salinity and surface currents. The plankton abundance is fluctuating according to the season where the east/dry season (July) produces less phytoplankton compared to western seasons/rainy season (November). The

rainy season increase the water mass and upwelling bottom layer with higher salinity and rich nutrient content due to high rainfall. On the research of (Pratiwi, 2018), Donan River has reported that there are three classes of phytoplankton inhabit in the eastern of Segara Anakan. *Bacillariophyceae*, *Chlorophyceae*, and *Dinophyceae* have a significant correlation with the environmental and affected by some factors (light penetration, temperature, salinity, surface current, and content of nutrient). The lack of information about the spatial and temporal variation of phytoplankton in Segara Anakan, Cilacap, Central Java causes the need for doing research.

Based on the data above, the purpose of this research as follows as , 1) To study the water quality of the eastern part of Segara Anakan waters of Cilacap spatially and temporally; 2) To analyze the relationship between physical and chemical factors that affect the diversity and abundance of phytoplankton.

MATERIAL AND METHOD

Material

The object was the abundance and diversity of phytoplankton species. The tools were thermometer, depth sounder, Secchi disk, refractometer, pH meter, vacuum pump, Erlenmeyer, plankton net no. 25, sample bottles, dropper pipettes, buckets, GPS (Global Position System), Oven, Burette & Statif, Inverted Microscope, Sedgewick Rafter, Label paper, Stationery, and Boat.

The materials are Whatman No. 4,1 paper, Millipore paper, HCL, Sulfonamide, NED, ZnSO₄, NaOH, EDTA, Reagent Nessler, Millipore paper, Ammonium molybdate, Aquades, 4% Formalin, Lugol.

Sampling carried out in April, May, August, and September 2018 in the eastern part of Segara Anakan, Cilacap, Central Java. Measurement of physical, chemical and biological parameters will be carried out in Environmental Laboratory, Faculty of Biology, Jenderal Soedirman University.

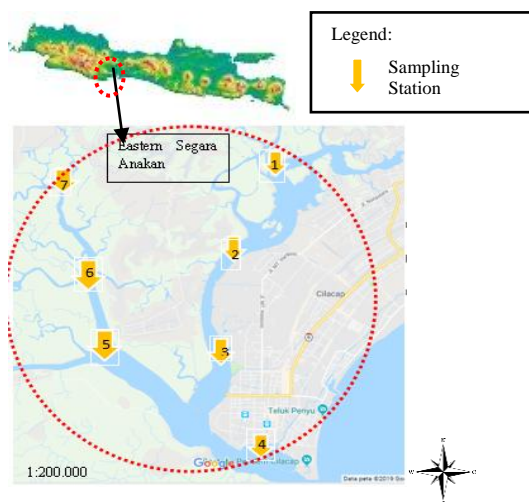


Figure 1. Research location of eastern Segara Anakan (Google,2019).

Table 1. Coordinate of Sampling Location at the Eastern Segara Anakan

Station	Area Name	Coordinate
1	Terith Kulon	07°39'41" S 108°59'07" E
2	Karangtalun	07°39'44" S 109°00'44" E
3	Donan River Mouth	07°43'52" S 108°59'07" E
4	Dermaga Holcim Quarry	07°44'57" S 108°59'59" E
5	Sapuragel River Mouth	07°43'12" S 108°58'14" E
6	Kutawaru	07°42'28" S 108°57'73" E
7	Babakan	07°40'5.5" S 108°57'8.3" E

Method

The research has been conducted by a survey method with purposive sampling technique in 7 locations (Figure 1) during the dry and rainy seasons. The sampling has been done in April, May, August, and September 2018.

The main parameters were the number of individuals per species and number of species of phytoplankton and water quality such as Salinity, Nitrate (NO₃), Nitrite (NO₂), Ammonia (NH₃), Fosfat (PO₄), pH, Temperature, TDS (Total Dissolved Solids) and TSS (Total Suspended Solid). The supporting parameters were the concentration of Salinity, Nitrate (NO₃), Nitrite (NO₂), Ammonia (NH₃), Fosfat (PO₄), pH, Temperature, TDS (Total Dissolved Solids) and TSS (Total Suspended Solid).

The dependent variables were water quality in the eastern part of Segara Anakan, Cilacap. The independent variables were abundance and diversity of phytoplankton. The planktons were identified with identification book of Planktonologi by Sachlan (1982), The Marine and Freshwater Plankton by Davis (1955).

The plankton samples at each Station were observed with 1 ml with a Sedgewick rafter. Each individual seen was recorded, then calculated by the formula:

Diversity Shannon-Wiener (Odum, 1993).

$$H' = - \sum_{i=1}^S p_i \ln p_i$$

Explanation :

H¹= Index diversity of types

P_i = The probability value of each species (n_i/N)

$$p_i = \frac{n_i}{N}$$

Explanation :

n_i= Number for individual kinds of -i (cell)

N= Total number of individuals (cell)

S= Number of species

Abundance (APHA *et al.* 1992)

Abundance per liter = F x N

$$F = \frac{Q_1}{Q_2} \times \frac{V_1}{V_2} \times \frac{1}{P} \times \frac{1}{W}$$

Explanation :

N= The average amount of plankter for each preparation,

Q₁= Glass cover area 18x18 (324 mm²)

Q₂= Field of view (1,11279 mm²)

V₁= Volume of water in a container bottle (1ml)

V₂= Volume of water under the cover glass (1ml)

P= The number of fields of view observed (20 times)

W= Volume of filtered water (100 liters)

The study of the relationship between water quality and abundance of phytoplankton spatially and temporally and the factors which influence the diversity and abundance the most were analyzed by using Bio-ENV with PRIMER software 5. According to Sugiyono (2010), the correlation coefficient is divided into several category, such as values between 0-0,19 categorized as very weak, 0,20- 0,39 categorized as weak, 0,40-0,59 categorized as moderate, 0,60-0,79 categorized as strong and values between 0,80-1 categorized as very strong.

RESULT AND DISCUSSION

Water Quality

The water quality in the eastern part of Segara Anakan represented by water temperature, pH, salinity, nitrite, nitrate, ammonia, phosphate, TSS and TDS. The parameter beyond the BMA (Water Quality Standard) was pH, Nitrate, Ammonia, Phosphate, and TSS. The result of the measurement was presented in (Table 2).

Table 2. The Measurement of Water Quality at the eastern part of Segara Anakan

Parameter	Unit	Station							BMA*
		1	2	3	4	5	6	7	
Water temperature	°C	28,60	29,00	30,50	28,70	28,10	28,60	28,50	28-32
pH		6,80	6,70	6,70	6,60	6,80	6,70	6,70	7-8,5
Salinity	ppt	27,50	30,00	30,50	30,30	29,30	29,80	27,80	<34
Nitrite	mg.l ⁻¹	0,01	0,02	0,02	0,02	0,02	0,02	0,02	-
Nitrate	mg.l⁻¹	5,20	4,70	4,10	4,20	3,40	3,30	5,30	>0,008
Ammonia	mg.l⁻¹	0,03	0,02	0,02	0,02	0,03	0,03	0,03	>0,3
Phosphate	mg.l⁻¹	0,20	0,10	0,20	0,20	0,20	0,20	0,20	>0,015
TSS	mg.l⁻¹	148,00	115,70	115,10	111,90	83,40	77,40	130,00	<80
TDS	mg.l ⁻¹	247,80	219,20	212,60	190,70	179,10	155,30	255,10	-

Explanation * = Kepmen LH Number 51 the Year 2004

The range of pH measurement in 7 observation sites were 6.6 – 6.8 and this was below the BMA, that the range should be 7.0 – 8.5. This condition might be influenced by residential and industrial activities surrounding. According to Susana (2009), one of the anthropogenic activities in the form of the use of many chemicals for the household and industrial purposes is the use of detergent, which causes a decrease in pH value and oxygen concentration in the river flow, so that the end result empties into the surrounding waters.

The nitrate measurement was at the range of 3.3 – 5.3 mg.l⁻¹. This range was beyond the BMA/ water quality standard. It should be below 0.008 mg.l⁻¹. According to Utami *et al.*(2016), that the flow of rivers around the upstream area can affect tidal waters where at low tide the flow of currents tends towards the sea and brings nitrates sourced from the river to the waters of the sea. It is proven in the Babakan area that it has the highest nitrogen concentration up to 5.3 mg.l⁻¹ which is an upstream part of the Sapuregel River and is still influenced by tide and recede conditions and surrounded by dense mangrove vegetation.

The ammonia measurement resulted tended to be below which ranged 0,02-0,03 mg.l⁻¹or not exceed the limits of Sea Water Quality Standards (0,3 mg.l⁻¹). According to Yulius *et al.* (2018) that ammonia levels exist in relatively small amounts if the oxygen content is high in the water. In conditions of high dissolved oxygen content, the ammonia present in relatively small amounts will increase with increasing depth.

Based on all sampling sites showed that the phosphate concentration was beyond the BMA, it should be below 0,015 mg.l⁻¹. The high concentration resulted from the location is an industrial area, settlement, and transportation of ships which are also downstream or estuary areas that have the highest depth. Putri *et al.* (2019) states that primary source of high phosphate originates from land, through weathering of rocks (allotons) that enter the waters through river transportation, and detergent as organic waste disposal.

The measurement of Total Suspended Solids (TSS) has beyond the specified Sea Water Quality Standard, which is equal to 80 mg.l⁻¹. TSS concentrations obtained ranged from 77.4 - 148.0 mg.l⁻¹. The high TSS concentration in Teritih Kulon is caused by the proximity of the location to agricultural areas, residential areas, and industries. The substrate which dominates in this area is mud. In accordance with Yulius *et al.*(2018), higher TSS concentrations occur due to the influence of more dominant land which consists of mud and microorganisms originating from soil erosion (soil erosion) which is carried from the land to water bodies.

Phytoplankton Abundance

Based on the results of identification of phytoplankton species spatially from seven observation stations in April, May, August, September 2018, was found that there were 43 species with a total abundance of 13460 species. Phytoplankton species found included 30 genera from 6 divisions namely: Bacillariophyceae, Chlorophyceae, Charophyceae, Cyanophyceae, Euglenophyceae, and Dinophyceae. Bacillariophyceae Division has 29 phytoplankton species identified, Chlorophyceae Division has five species, Charophyceae Division has three species, Cyanophyceae Division has four species, Euglenophyceae Division has one species and Dinophyceae Division has one species (Table 3).

The abundance of phytoplankton species spatially found ranged between 604-2931 ind.l⁻¹. The value of this abundance was in the medium level abundance group. According to Soegianto (1994), plankton grouping based on abundance is divided into three categories, namely abundance with a range of values <1,000 ind.l⁻¹ including low, abundance between 1,000-40,000 ind.l⁻¹ including moderate, and abundance > 40,000 ind.l⁻¹ including high.

The total abundance of each Station produced was 604 ind.l⁻¹ at Kutawaru Station (Station 6), 1143 ind.l⁻¹ at Karangtalun Station (Station2) then

Table 3. The Abundance of Phytoplankton at the Eastern part of Segara Anakan, Cilacap

No	Phytoplankton Species	Phytoplankton Abundance (ind.l ⁻¹)							Total
		1	2	3	4	5	6	7	
Division of Bacillariophyceae									
1	<i>Asterionella</i> sp.	-	44	291	102	36	15	109	597
2	<i>A. japonica</i>	-	51	-	429	124	22	-	626
3	<i>A. formosa</i>	165	-	284	66	58	36	66	675
4	<i>Rhizosolenia alata</i>	-	-	29	87	116	7	-	240
5	<i>Nitzschia longissima</i>	-	-	102	-	-	15	-	116
6	<i>N. sigma</i>	58	175	44	15	7	7	80	386
7	<i>N. gracilis</i>	10	-	-	-	44	-	-	53
8	<i>Melosira italica</i>	-	-	-	204	204	15	-	422
9	<i>Chaetoceros affinis</i>	58	15	58	531	662	29	-	1354
10	<i>C. socialis</i>	49	-	87	29	182	-	-	347
11	<i>C. senescence</i>	-	7	-	138	15	22	-	182
12	<i>C. dydymus</i>	-	-	-	-	95	66	-	160
13	<i>C. lauderi</i>	78	15	87	211	284	15	7	696
14	<i>C. weissflogii</i>	-	-	7	29	15	7	-	58
15	<i>C. diversus</i>	-	-	7	66	22	7	-	102
16	<i>Coscinodiscus marginatus</i>	39	160	95	22	22	7	58	403
17	<i>C. lineatus</i>	-	131	22	-	87	-	335	575
18	<i>Tabellaria</i> sp.	-	22	3	-	146	36	197	403
19	<i>Synedra acus</i>	10	29	36	167	87	58	22	410
20	<i>S. tabulata</i>	214	7	7	15	36	22	22	323
21	<i>Thalassiothrix nitzschioides</i>	-	7	87	36	7	22	22	182
22	<i>Pleurosigma intermedium</i>	58	7	22	66	22	22	7	204
23	<i>Gyrosigma balticum</i>	-	-	-	22	102	-	-	124
24	<i>G. strigilis</i>	-	-	29	15	-	-	-	44
25	<i>Grammatophora angulosa</i>	-	15	-	-	-	-	-	15
26	<i>Diatoma vulgare</i>	-	-	-	7	29	7	15	58
27	<i>Navicula</i> sp.	10	-	-	-	-	-	7	17
28	<i>N. placentula</i>	49	-	-	-	-	-	-	49
29	<i>Rhizosolenia longiseta</i>	97	-	-	-	-	-	-	97
Division of Chlorophyceae									
30	<i>Chlorella variegata</i>	-	15	15	7	36	-	15	87
31	<i>Eudorina elegans</i>	-	-	218	44	58	73	298	692
32	<i>Volvox aureus</i>	-	255	-	-	7	66	-	328
33	<i>Chodatella quadriseta</i>	49	-	-	-	7	7	-	63
34	<i>Chlorococcum humicola</i>	-	-	-	51	-	7	-	58
Division of Charophyceae									
35	<i>Zygnemopsis americana</i>	-	-	-	-	255	-	-	255
36	<i>Spirogyra azygospora</i>	-	-	-	167	-	-	-	167
37	<i>Hyalotheca mucosa</i>	-	-	44	-	-	-	7	51

Division of Cyanophyceae									
38	<i>Oscillatoria limosa</i>	1854	138	473	7	36	7	15	2531
39	<i>O. formosa</i>	126	36	-	-	-	-	-	163
40	<i>Chroococcus giganteus</i>	-	-	-	-	73	-	-	73
41	<i>Spirulina sp</i>	-	15	-	-	-	-	7	22
Division of Euglenophyceae									
42	<i>Phacus pleuronectes</i>	-	-	-	-	15	-	-	15
Division of Dinophyceae									
43	<i>Ceratium belone</i>	10	-	-	-	22	7	-	39
Total Abundance		2931	1143	2049	2533	2912	604	1288	13460
Total Spesies per stion		17	19	30	35	44	34	24	43

Explanation Sign (-) = Not found

1288 ind.l⁻¹ in Babakan area (Station 7), 2049 ind.l⁻¹ in Donan River Mouth (Station 3) has 2049 ind.l⁻¹ in, 2533 ind.l⁻¹ in the Dermaga Holcim Quarryarea (Station 4), 2912 ind.l⁻¹ in the Sapuregel River Estuary area (Station 5), and 2931 ind. l⁻¹ in the Teritih Kulon (Station 1). The total species per Station produced were 17 species in the Teritih Kulon (Station 1), 19 species in Karangtalun (Station 2), 24 species in Babakan (Station 7), 30 species in the Donan River Mouth (Station 3), 34 species in Kutawaru (Station 6), 35 species in the Holcim Pier Mine, and 44 species in the Sapuregel River Estuary (Station 5).

The most abundant phytoplankton was the *Oscillatoria limosa* species from the Cyanophyceae Division of 2531 ind.l⁻¹ which is almost found in all Stations. The Cyanobacteria /Cyanophyceae division was a division which commonly found in the lowest salinity, *Oscillatoria* is a cosmopolitan genus which can be found almost every waters condition such as freshwater, brackish and marine (Hoffman, 1996).

The abundance of this species is mostly found in the Teritih Kulon Station as many as 2781 ind.l⁻¹, this was because this area is the waters of the Donan

River which has the influence of waste disposal from PT Holcim's settlements and industries. In accordance Akrimi & Gatot (2002), the genus *Oscillatoria* was a genus of plankton which was commonly used as an indicator of water pollution because it has asexual reproduction in the form of spores and it has a high tolerance for polluted waters. While the lowest phytoplankton species with the lowest abundance were *Phacus pleuronectes* from the Euglenophyceae Division as much as 15 ind.l⁻¹ and *Grammatophora angulosa* as many as 15 ind.l⁻¹ in Karangtalun (Station 2) from the Bacillariophyceae division. Based on Weik (1967), *Phacus* was an euplanktonic (free-floating organism or open water plankton) found together with the genera Euglenophyta, *Phacus* was not a common species that live in a stagnant environment because these areas often do not have the right organic composition.

To find out more about the comparison of proximity between stations, cluster analysis was used to observe equations in species composition in the form of dendrograms through Figure 2.

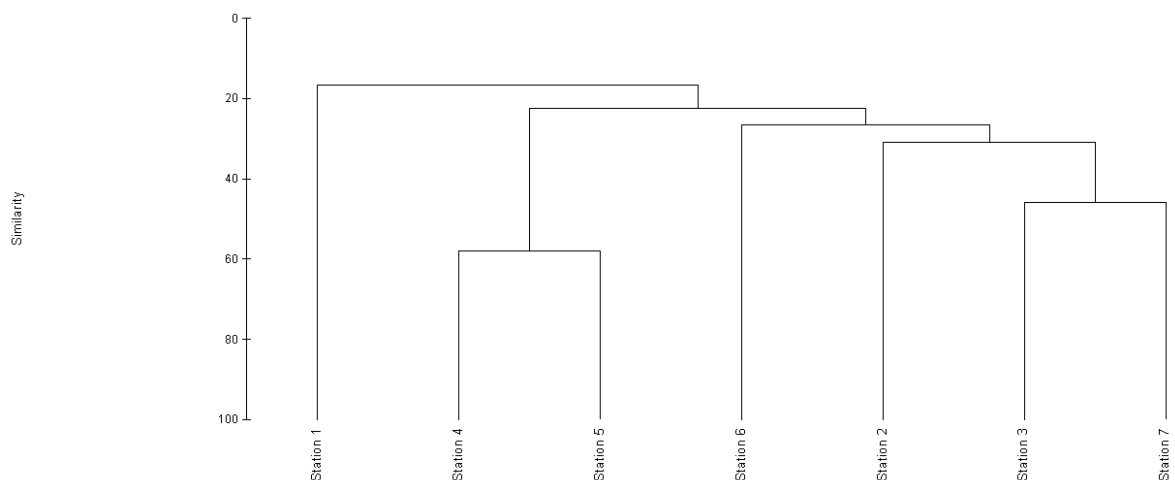


Figure 2. Dendrogram of Similarity of Phytoplankton Spatially

Karangtalun and Sapuregel River Mouth which is the area that meets the Kembang Kuning River with the same waters surrounded by dense mangrove vegetation which causes this species to have the smallest abundance. According to Siregar & Telaumbanua (2010), the weak currents in the area caused by mangrove vegetation which can reduce the speed of currents where the velocity of the plankton has a large influence and abundance, due to plankton is a microscopic organism that lives floating in water with very weak swimming ability, the movement is strongly influenced by the movement of water.

Dermaga Holcim Quarry (station 4) and Sapuregel River Estuary (station 5) have the largest or closest level of group similarity which indicates the same phytoplankton abundance level which is equal to 58.02% which dominated by the same species of *Melosira italica* (Bacillariophyceae) with species abundance as much as 204 ind.l⁻¹ at both stations also dominated with the same species of *Coscinodiscusmarginatus*(Bacillariophyceae) with species abundance as much as 22 ind.l⁻¹ , followed by the Donan River Mouth (station 3) and Babakan (station 7) which has a similarity of 45.77% which dominated by the same species of *Chlorella variegata*(Chlorophyceae) with species abundance as much as 15 ind.l⁻¹ at both stations.

Relationship Between Water Quality and Abundance of Phytoplankton

Analysis of the correlation of phytoplankton abundance with nine physical-number of variables environmental factors has been done with Bio-env analysis. The analysis has been done in software Primer 5 (appendix 5). The result of the analysis showed through Table 3.

Table 3. Correlation of Phytoplankton Abundance with Environmental Factors

Variable	Correlation	Category
TSS	0,184	weak (positive)
TDS	0,161	weak (positive)
Nitrite	0,056	weak (positive)
pH	0,030	weak (positive)
NitratE	-0,036	weak (negative)
Ammonia	-0,057	weak (negative)
Salinity	-0,110	weak (negative)
Phosfat	-0,125	weak (negative)
Water Temperature	-0,639	moderate (negative)

Based on analysis of Bioenv with Primer 5 applications resulted that water temperature as the physical factor which had -0,639 and categorized as strong, this correlation coefficient had opposite (negative) correlation, which means if the water

temperature were high it would be affected by the lowest abundant of phytoplankton. According to Sugiyono (2010), the correlation coefficient is divided into several category, such as values between 0-0,19 categorized as very weak, 0,20- 0,39 categorized as weak, 0,40-0,59 categorized as moderate, 0,60-0,79 categorized as strong and values between 0,80-1 categorized as very strong(negative). The other environmental factor followed with negative correlation is phosphate, salinity, ammonia, and nitrate (chemical factor). Meanwhile, TSS is the environmental factor which had a positive correlation on phytoplankton abundance and diversity with a correlation value of 0.184, which categorized as weak. This evidence is also supported by the abundance of 1854 ind.l⁻¹ species of *Oscillatoria limosa* at the Teritih Kulon (station 1). According to Effendi (2003), TSS is a suspended material that causes turbidity of water consisting of mud, fine sand and micro-organisms/biota in the form of plankton carried by water bodies. The other environmental factor followed with the positive correlation is TDS (physical factor), Nitrite and pH (chemical factor) which has low categorized.

CONCLUSIONS

Based on the results obtained, it can be concluded that water quality at the eastern part of Segara Anakan Cilacap consists of several parameters that beyond the quality standards according to the Keputusan Menteri Lingkungan Hidup No. 51 of 2004 such as pH, Nitrate, Ammonia, Phosphate, and TSS. Water temperature is a physical factor categorized as a strong negative correlation with the abundance of phytoplankton, followed by phosphate, salinity, ammonia, and nitrate (chemical factor) that has weak categorized. TSS is the physical factor categorized as weak which has a positive correlation with the abundance of phytoplankton, followed by TDS (physical factor), Nitrite and pH (chemical factor).

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