Omni-Akuatika Special Issue 3rd Kripik SCiFiMaS 2020: 14 - 20
ISSN: 1858-3873 print / 2476-9347 online

Research Article

journal homepage: http://ojs.omniakuatika.net

The Correlation Between Plankton Abundance and Water Quality in Donan River

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Received 20 November 2019; Accepted 1 October 2020; Available online 31 December 2020

ABSTRACT

Planktons have ability to live in aquatic ecosystem, including rivers ecosystem, estuary ecosystem, lake ecosystem and ocean ecosystem. The plankton abundance is estimated by correlation with water quality both of salinity, pH, temperature and others. This research aimed to analysis plankton abundance and to analysis correlation between plankton abundance and water quality. This research was conducted in Donan River using random sampling in 10 stations. The plankton are collected using plankton net no 25 and *Lackey Drop Mikrotranset Counting* (plankton analysis) and APHA (2005) to analysis water quality. The results showed that the plankton abundance ranged between 524 – 6,406 ind L^{-1} and best correlation with water salinity had index 0.975.

Keywords: plankton abundance, water quality, Donan river, water salinity, correlation

ABSTRAK

Plankton memiliki kemampuan untuk hidup di ekosistem perairan, termasuk ekosistem sungai, ekosistem muara, ekosistem danau dan ekosistem laut. Kelimpahan plankton diduga memiliki korelasi dengan kualitas air baik salinitas, pH, temperatur dan lainnya. Penelitian ini bertujuan untuk menganalisis kelimpahan plankton dan menganalisis hubungan antara kelimpahan plankton dengan kualitas air. Penelitian dilakukan di Sungai Donan ini dilakukan secara acak pada 10 stasiun. Pengumpulan plaknton dilakukan dengan menggunakan plankton net no 25 dan *Lackey Drop Mikrotranset Counting* (analisis plankton) dan APHA (2005) untuk menganalisis kualitas air. Hasil penelitian menunjukkan bahwa kelimpahan plankton berkisar antara 524 – 6.406 ind L^{-1} dan korelasi terbaik dengan salinitas air memiliki indeks kisaran 0,975.

Kata kunci: kelimpahan plankton, kualitas air, sungai Donan, salinitas air, korelasi

1. Introduction

Planktons are a micro and macroscopic organisms that plays an important role as the primary producer of an initial chain of food webs (Yan et al., 2012). Planktons are often used as an indicator of water fertility (Umar, 2003). Plankton consists of phytoplankton and zooplankton (Effendi et al., 2016; Su et al., 2015; Abdulwahab and Rabee, 2015) . Phytoplankton are water plants in waters ecosystem, while zooplankton are aquatic organisms characterized as animals (Gharib et al., 2011; Honggang et al., 2012; Khalifa et al., 2015; Pratiwi et al., 2016; Simanjuntak, 2009). Basically, plankton is food for other animals. The phytoplankton distribution is influenced by the light availability in waters especially in euphotic zone. The ability to create organic substances causing phytoplankton known as primary producers (Li et al., 2012; Masuda et al., 2017).

The Eastern Segara Anakan Lagoon is an aquatic ecosystem take supply of seawater from the Indonesian Ocean and freshwater supply from many rivers including the Donan River, Sapuregel River, Kembang Kuning River, and other rivers (Hilmi et al., 2015, 2019; Sari, 2016). Segara Anakan lagoon has several types

http://dx.doi.org/10.20884/1.oa.2020.16.3.844

of ecosystems including estuary and mangrove ecosystem that has a function as a habitat for plankton life.

Phytoplankton in Donan River are utilized by nektorn and fish as feed sources. If plankton is not abundant enough, then the growth rate of plankton will not be able to support fish life as handicap of fish growth which give impact for decreasing of fish abundance. Planktons are an organism's group to live in water surface and weak swimmer. The planktons abundance and diversity are influenced by the physical and chemical of water quality like as sedimentation, water level fluctuations, nutrients, heavy metals, temperature, pH, and oxygen content (Heriyanto, 2012; Nagelkerken et al., 2008; Siddiqui et al., 2008) . Whereas zooplanktons are animal organisms that life movements depend on water currents and as a life pillars of marine bio ecosystems because these plankton occupy the basic level of the aquatic food chain (Herbert, 2003; Nagelkerken et al., 2008). Most zooplankton are herbivores and as food for fish. The potential of zooplankton and phytoplankton can be used as an indicator of water fertility.

In general, the potential of plankton consisting of zooplankton and phytoplankton in Segara Anakan Timur is estimated has an abundance of between 500 - 6000 ind / L (Kristian, 2019). This research aimed to analysis plankton abundance and to analysis correlation between plankton abundance and water quality.

2. Materials and Methods

2.1. Study Area

This reseach was conducted in Donan River on 10 stations. The coordinates of site research can be seen on Figure 1.

2.2. Research Variables

Research variables are plankton abundance and biodiversity, temperature, water salinity, water pH, nitrate, phosphate, dissolve oxygen, and ammonia.

2.3. Sampling Technique

The sampling technique of this research using purposive sampling in Donan river. Purposive sampling using mangrove density as sampling indicator.

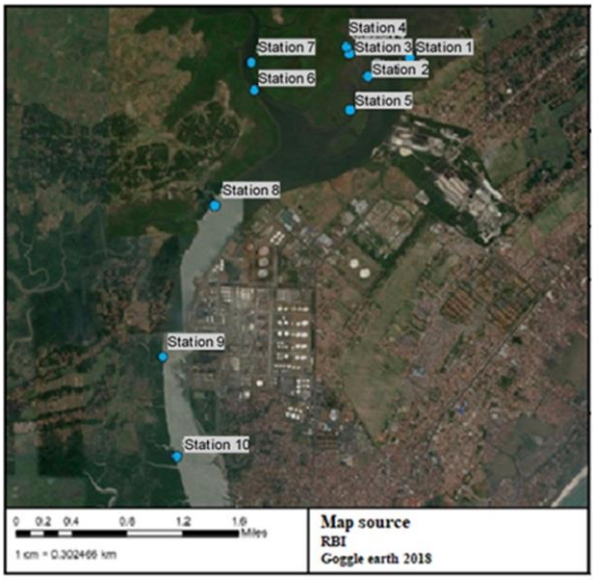
2.4. Water quality analysis

Water quality analysis in study area using APHA (2005) method will be shown on Table 1.

2.5. Plankton Analysis

Water Sampling of 100 liters on the water surface using a 10-liter bucket then filtered using No. plankton net. 25 with a mesh size of 60 µm. Water samples collected in the plankton net container are taken, and transferred into a 50 mL sample bottle. Then add 40% formalin solution to 4% using a dilution formula, and lugol solution as much as 2 drops, then labeled paper, cool in an ice box, then observed in the laboratory.

Dilution formula: $N_1 x\ V_1 = N_2 x\ V_2$



Station Coordinates

Station	Latitude (S)	Longitude (E)
1	07⁰ 40' 22,17"	109⁰ 0' 56,36"
2	07⁰ 40' 28,91"	109⁰ 0' 40,57"
3	07⁰ 40' 20,60"	109⁰ 0' 33,62"
4	07⁰ 40' 18,26"	109⁰ 0' 32,52"
5	07⁰ 40' 41,12"	109⁰ 0' 33,98"
6	07⁰ 40' 33,98"	108⁰ 59' 58,10"
7	07⁰ 40' 23,79"	108⁰ 59' 56,90"
8	07⁰ 41' 15,49"	108⁰ 59' 43,22"
9	07⁰ 42' 10,17"	108⁰ 59' 23,75"
10	07⁰ 42' 46,06"	108⁰ 59' 29,10"

Figure 1. Study Area in Eastern Segara Anakan Lagoon

Table 1. Water quality analysis

No	Variables	Unit	Tools/Methods	References
1	Temperature	°C	Thermometer	APHA (2005)
2	Salinity	Ppt	*Salt-Hand refractometer*	APHA (2005)
3	pH	-	pH meter	APHA (2005)
4	Water phosphate (PO_4)	Ppm	Spectrophotometric	APHA (2005)
5	Water nitrate (NO_3)	Ppm	Spectrophotometric	APHA (2005)
6	Dissolve oxygen (DO)	Ppm	Winkler	APHA (2005)
7.	Ammonia	Ppm	Spectrophotometric	APHA (2005)

where:
N1 = desired formaldehyde concentration (4%)
N2 = available formaldehyde concentration (40%)
V1 = water volume in the sample bottle (30 mL)
V2 = formalin volume in bottles needed (mL)

Then water sample was observed by a microscope with a magnification of 10×10 as many as 30 visual fields with 3 repetitions. Previously the sample bottle is homogenized and evenly distributed, after that is taken using a pipette. Then the plankton was identified by (Edmonson, 1966; Sachlan, 1982). Calculation of the number of phytoplankton are calculated using the modified formula from the *Lackey Drop Mikrotranset Counting* (APHA (American Public Health Association), 1989) that is potential of plankton (individuals L^{-1}) = N x F, where:

$$F = \frac{Q_1}{Q_2} \text{ x } \frac{V_1}{V_2} \times \frac{1}{p} \times \frac{1}{w}$$

where:
Q_1 = cover glass area (18 x 18 mm2)
Q_2 = field of view (1, 11279 mm2)
V_1 = volume of filtered water (30 mL)
V_2 = volume of one drop of water (0.05mL) under the cover glass
p = number of fields of view observed (30 times)
w = volume of filtered water (100 L)

The plankton diversity index is calculated using the Shanon Wiener equation. This calculation illustrates plankton abundance in a community (Krebs, 1989).

$$H' = -\sum_{i-1}^{s} \frac{ni}{N} \, ln \frac{ni}{N}$$

where:
H '= diversity index
S = number of species
Ni = number of individuals per species
N = total number of individuals of all species

2.6. Correlation Analysis

Data Analysis of Relations between Physical-Chemical Factors and Mangrove Density with Plankton Abundance in Donan river, Cilacap using Pearson correlation and regression.

3. Results and Discussion

3.1. Plankton abundance and diversity in the Donnan River

Plankton abundance in Donan river is 524 - 6,406 ind L^{-1} following the treatment and environmental conditions of water ecosystem. The highest abundance is station 9 with abundance 6,406 ind L^{-1}, while station 8 with the smallest abundance with value is 524 ind L^{-1}. Plankton abundance in Donan river is relatively low compared to Wiyarsih (2019) research which has abundance 29,888 ind L^{-1} (Table 2).

The results of the research showed that Donan river had 15 plankton genera divided into 10 genus of phytoplankton and 5 genera of zooplankton. Phytoplankton genus were Asterionella, Phormidium, Nitzschia, Anabaena, Oscillatoria, Brachionus, Gyrozigma, Surirella, Coelosphaerium, Bacteriastrum. Whereas zooplankton genus were Cyclops, Nauplius, Actinophyris, Brachionus, Diaptomus. This result is lower than the Wiyarsih et al., (2019) which found 22 genus with an abundance of 29,888 ind L^{-1}.

Wiyarsih et al., (2019) has argument that the condition of estuary is very influential for plankton abundance especially potential of nitrates and phosphates as main factor to support phytoplankton growth. Sihombing & Aryawati (2013) also notes potential of nutrients such as nitrates and phosphates in the waters have high correlation with abundance of phytoplankton and zooplankton.

3.2. Water Quality in Donan River

The physical of water quality were salinity, temperature, pH of water, and the chemical of

Table 2. Plankton Abundance in Donan River

Species	Stations									
	1	2	3	4	5	6	7	8	9	10
Phytoplankton										
Chrysophyta										
Asteroinella formosa	349	562	1824	1844	796	407	1824	155	1514	1534
Nitzschia vermicularis	20	504	796	738	504	0	214	0	874	0
Gyrozigma acuminatum	20	194	0	349	272	0	0	0	0	524
Surirella ovalis	0	38	0	0	194	0	0	0	0	0
Cyanophyta										
Coelosphaerium kuetzingianum	835	1960	1942	1786	1766	272	1204	98	1766	1223
Phormidium autumnale	0	38	0	0	0	0	0	0	0	0
Anabaena cycadae	0	77	0	718	0	0	0	0	0	0
Oscillatoria limosa	0	20	0	0	0	0	0	0	0	0
Chlorophyta										
Bacteriastrum delicatulum	20	0	0	0	98	0	0	0	0	0
Chaetoceros gracilis	38	0	562	0	0	20	0	0	834	252
Phytoplankton Abundance	1282	3393	5124	5435	3630	699	3242	253	4988	3533
Zooplankton										
Protozoa										
Actinophyris sol	20	0	58	0	0	0	0	0	0	0
Rotifera										
Brachionus plicatilis	0	20	0	130	78	0	0	0	0	0
Arthopoda										
Diaptomus castor	38	0	0	0	0	0	0	0	0	0
Nauplius	0	0	0	0	0	38	0	77	0	174
Cyclops abyssorum	38	314	758	776	252	136	931	194	1418	738
Zooplankton Abundance	96	334	816	906	330	174	931	271	1418	912
Number of Species	9	10	6	7	8	5	4	4	5	6
Plankton Abundance	1378	3727	5940	6341	3960	873	4173	524	6406	4445
H'	1.19	1.52	1.53	1.72	1.62	1.23	1.21	1.32	1.57	1.56

Note: Abundance (ind/L)

water quality were DO, water nitrate, aquatic orthophosphate, aquatic ammonia, and also dissolved oxygen can be shown on Table 3.

The first factor is water salinity as the total of ion concentration in water (Boyd, 1988). Brackish waters has water salinity between 0.5- 30 ppt (Effendi, 2003; Effendi et al., 2016) Salinity can affect oxygen levels in the waters, and has negative correlation with the dissolved oxygen (Karl & Church, 2017; Makmur & Fahrur, 2011; Tsuji & Montani, 2017). According to (Huang et al., 2003; Xiao et al., 2019) water salinity distribution is influenced by various factors such as the pattern of water circulation, evaporation, rainfall, and river flow. Salinity in Donan river has ranges 18-29 ppt and still available to support the plankton growth because plankton can grow on 10-30 ppt of water salinity (Yuliana, 2017). The second factor is the temperature, the temperature in Donan rivers had range between 26.33-30 °C. This range is in the

Tabel 3. Water quality in Donan River

Stations	Salinity (ppt)	Temperature (°C)	pH	Nitrate (mg L^{-1})	Ortophospate (mg L^{-1})	DO (mg L^{-1})	Amonnia (mg L^{-1})
1	25.33	27.33	6.9	0.34	0.12	5.4	0.015
2	25.67	27.67	6.9	0.28	0.13	5.5	0.008
3	27.00	26.33	6.67	0.41	0.16	5.67	0.013
4	26.00	26.67	6.7	0.42	0.12	5.3	0.01
5	28.00	27.33	7.07	0.19	0.1	5.63	0.018
6	27.33	28.67	6.83	0.33	0.13	5.7	0.021
7	18.00	28	6.76	0.27	0.19	5.21	0.009
8	27.67	30	6.83	0.29	0.18	5.8	0.012
9	28.67	28.33	6.7	0.28	0.16	5.53	0.015
10	29.00	26.67	7.07	0.31	0.17	5.51	0.022

Table 4. The correlation between water quality and plankton

Factors	Correlation	The Best Model	R^2
Salinity	0.975	$y = 755.88x^3 - 62367x^2 + 2*10^6xx - 2*10^7$	0.7238
Temperature	0.046	$y = 230.39x^3 - 15571x^2 + 334778x - 2*10^6$	0.7691
pH	0.314	$y = 146056x^3 - 3*10^6x^2 + 2*10^7x - 4*10^7$	0.7765
Nitrate	0.511	$y = 5*10^6x^3 - 4*10^6x^2 + 1*10^6x - 104738$	0.5697
Ortophospate	0.910	$y = -5*10^7x^3 + 2*10^7x^2 - 3*10^6x + 128526$	0.7058
Dissolved Oxygen	0.248	$y = -439669x^3 + 7*10^6x^2 - 4*10^7x + 7*10^7$	0.5891
Amonnia	0.532	$y = 9*10^9x^3 - 4*10^8x^2 + 6*10^6x - 21741$	0.1142

optimal range for plankton, because the optimal temperature to support plankton growth and life is 20˚C - 30˚C (Yuliana & Ahmad, 2017). The third factor is potential Hydrogen (pH), the water pH in Donan river has ranges between 6.67-7.07 which is optimum standard to support plankton life. Keputusan Menteri Lingkungan Hidup (MENLH), 2004) notes that water pH quality to support marine biota has ranges from 7-8.5. Lamury (1990) give categorizes the levels of water fertility are pH range 5.5-6.5 (unproductive water), pH 6.5-7.5 (productive water), and pH 7.5-8.5 (very productive). Makmur (2011) also notes that most aquatic biota has sensitive to pH changes and has normal ranges between 7-8.5 (Makmur & Fahrur, 2011).

The fourth factor is nitrate as the potential of nitrogen and the main nutrient to support the growth of plants and algae which has characteristic very soluble and stable. The potential of nitrogen in Donan river has ranges between 0.19 to 0.42 mg L^{-1}. The potential of nitrate is influenced by water current carrying nitrate and abundance of phytoplankton (Shiau et al., 2017; Simanjuntak, 2009). The potential of nitrate levels between 0.3-0.9 mg L^{-1} was sufficient for the organism's growth and potential of nitrate > 3.5 mg L^{-1} as critical factors of waters ecosystem. The fifth factor is Orthophosphate as an inorganic phosphate show potential of phosphorus (P) dissolved in water. Orthophosphate can be directly utilized by phytoplankton and aquatic plants (Patty, 2015). Phosphate levels in Donan river has ranges between 0.10 - 0.19 mg L^{-1}. Keputusan Menteri Lingkungan Hidup (MENLH), (2004) notes phosphate standard is 0.015 mg L^{-1}, then Patty, (2015) and Huang et al., (2003) note 0.087 mg L^{-1} as the upper limit of uncontaminated water.

The six factor is ammonia as the breakdown of organic nitrogen and inorganic nitrogen which comes from the decomposition of organic matter and biota feces by microbes and fungi. The potential of ammonia in Donan river has ranges between 0.022 to 0.01 mg.L^{-1}. The low concentration of ammonia in a water is good factor to support biota life. But, the concentration of ammonia can be shown as fertilize the waters with level less than 2 mg L^{-1} will (Makmur & Fahrur, 2011). The last factor is Dissolved oxygen (DO) as an important factor for the biota or the waters themselves. Dissolved oxygen comes from a process of diffusion from air and organism's photosynthesis in water ecosystem (Heriyanto, 2012). According to Patty, (2015) that the level of dissolved oxygen in a waters will decrease due to the process of decomposition of organic matter, respiration and inhabitation of reaeration. Dissolved oxygen levels in Donan river has ranges between 5.21-5.8 mg L^{-1}. Keputusan Menteri Lingkungan Hidup (MENLH), (2004) notes that DO is more than 5 mg L^{-1} (good standard) but less than 3 mg L^{-} will cause organism death (Hilmi et al., 2019; Kanwilyanti et al., 2013; Pan et al., 2017; Patty, 2015).

3.3. The correlation between plankton abundance and water quality

The correlation between water quality with plankton abundance can be seen in Table 4. The correlation showed that water salinity has the highest correlation with score 0.975 and temperature has lowest correlation with score 0.046. While the regression equation model for plankton abundance with water quality factors also can be shown on Table 4.

4. Conclussion

Plankton abundance and diversity in Donan River had range between 524 – 6,406 ind/L with 15 plankton genera divided into 10 genus of phytoplankton dan 5 genus of zooplankton. The genus of phytoplankton is Asterionella, Phormidium, Nitzschia, Anabaena, Oscillatoria, Brachionus, Gyrozigma, Surirella, Coelosphaerium, Bacteriastrum. Whereas

genus of zooplankton are Cyclops, Nauplius, Actinophyris, Brachionus, Diaptomus. The water quality factor has highest correlation with plankton abundance is water salinity with correlation score 0.975.

Acknowledgement

We thank for DIKTI Kemendiknas and UNSOED to support this research with Unsoed Grant (Increasing of competation grant 2019), Dr. Ir. Isdy Sulystio, DEA (Dean of Fisheries and Marine Science Faculty Unsoed) and Prof Dr Rifda Naufalin (head of LPPM Unsoed). We would also like to thank all reviewers and all researchers for their helpful and constructive comments which greatly helped us improve this manuscript.

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