Analysis of Sedimentary Organic Carbon Content in Lake Sentani, Papua

Ervina Indrayani[1], Suwarno Hadisusanto[2], Rustadi[3], Dirk Y. P. Runtuboi [4], John Dominggus Kalor[5], Lisiard Dimara[6]

[1] Department of Marine Science and Fisheries, Faculty of Mathematics and Natural Sciences, Cenderawasih University, Indonesia

[2]Department of Biology, Faculty of Biology, Gadjah Mada University, Yogyakarta, Indonesia

[3]Department of Fisheries, Gadjah Mada University, Yogyakarta, Indonesia

[4]Department of Biology, Faculty of Mathematics and Natural Sciences, Cenderawasih University, Jayapura, Papua, Indonesia

[5]Department of Marine Science and Fisheries, Faculty of Mathematics and Natural Sciences, Cenderawasih University, Indonesia

[6]Department of Marine Science and Fisheries, Faculty of Mathematics and Natural Sciences, Cenderawasih University, Indonesia

Email: ervina_indrayani@yahoo.com, suwarnohs@ugm.ac.id, rustadi@ugm.ac.id, dirk.runtuboi@fmipa.uncen.ac.id, john_pela@yahoo.com, dimaralisiard@gmail.com

*Correspondence author: ervina_indrayani@yahoo.com

ABSTRACT

The study about sedimentary organic carbon content in Lake Sentani Papua is very important because it has en effects in the carbon content in waters. The carbon in sediment is one of the macro nutrients for organism. Carbon, Nitrogen and Phospor has an important role in the formation of biomass. This research using survey method in sediment sampling purposively. Sampling site consists of the location of the inlet, floating net cages, the middle of the lake and outlet. The results are sedimentary organic carbon concentration in Lake Sentani respectively was at the net cages location of 22,437 mg/kg, followed by the inlet about 20,81 mg/kg, in the outlet area is about 18,3 mg/kg and in the middle area of the lake is about 1,99 mg/kg.

Keywords: Organis Carbon, sediment, Lake Sentani.

INTRODUCTION

Lakes are stagnant waters which are generally experienced stratification due to differences in light intensity and temperature differences water column that occurs vertically and has unique characteristics (Horn and Goldman, 1994; Effendi, 1997).

The function of the lake is to store water habitat for living things and an important part in the balance of land use, water use and components ir use (Kamiso, 2003; Khiatuddin, 2003). Lake has multiple benefits which include ecological and economic function, controlling floods and irrigation, supplier of water needs for public and industrial consumption, fisheries, tourism, transportation, power generation, water reservoirs, and

habitat for living things.

Lake Sentani is the largest lake in Papua Province by area 9.248 ha (Indrayani, et.al., 2015). The lake has potential in the fisheriea, tourism and industrial sectors. Lake Sentani supports inland fisheries in Papua (Anonymous, 2008). So far, this potential has not been utilized optimally because it only relies on catches and cultivation are still low about 437,3 tons/year of potential sustainable fisheries about 1.647 – 1.816 tons/year. Fisheries potential in Lake Sentani not only for consumption but also endemic and rare fishes. Today, the utilization for cultivation fisheries in this lake is just about 1,6% of all targeted.

The concentration of nutrients in the lake will affect the availability of natural foods for fish and the number of fish population. The concentration od N and P in the water affect the biomass of phytoplankton, phytoplankton community, benthic algal biomass, composition and biomass macrophyte organism, water transparency,oxygen, fish mortality, fish yield, and aesthetic value of water bodies (Krebs, 2009). Janse (1997) explained that the supply of nitrogen in water bodies is 10 times higher than supply of phosphorus. Sedimentation comes from watershed and land erosion, and has a positive correlation with discharge capacity of the water (Rimmer, et al., 2006; Putra, et al., 2003).

Hoss, et al. (2010) also explained that aquatic sediments are odten contaminated from chemicals introduced into the waters. Sediment is an important component in environmental quality because is the habitat of benthis organism that play a role in the cycle of carbon, nitrogen, and phosphorus. The influence of sediment by human activities is actually low because it is more influenced by littoral vegetatiom and organic matter supply from the watershed. In addition to nitrogen and phophorus, organis carbon content enters together with other organic compounds also affect the condition of the waters, especially aquacukture (Sabar and Widiyanto, 1998; Widiyanto, et al., 1998). Hadisusanto (2006) states that organic carbon content shows the levels of dissolved carbon in waters associated with the movement of organic matter in bottom waters, with range of 1 – 30 mg/L in natural waters. The sedimentary carbon content is closely related to dissolved particles, nitrate concentration and phosphorus concentration in the waters (Indrayani and Hadisusanto, 2009). The carbon concentration can increase the population of pathogenic organism, plankton population explosion and the level of secondary metabolites in the aquaculture area (Widiyanto, et al., 1998). The C:N:P ratio affects food webs in the waters, so the value different in plants, bacteria, zooplankton and fish (Krebs, 2009).

Research on the sedimentary carbon content is necessary. It contributes to integrated the inlet area, floating net cages area, middle area of the lake and the outlet area of the lake. The informatiom is very important for the sustainability of the lake.

MATERIALS AND METHODS

Research Location

The research was conducted from Maret 2012 to January 2013 in Lake Sentani, Papua. It began with planning, preparation, data collection and analysis, then ended with reporting. Sampling locations are determined based on stations I (the inlet area of the lake), K (the floating net cage area), T (in the midle area of the lake) and O (the outlet area of the lake), with three repetitions for each station at Lake Sentani (Figure 1).

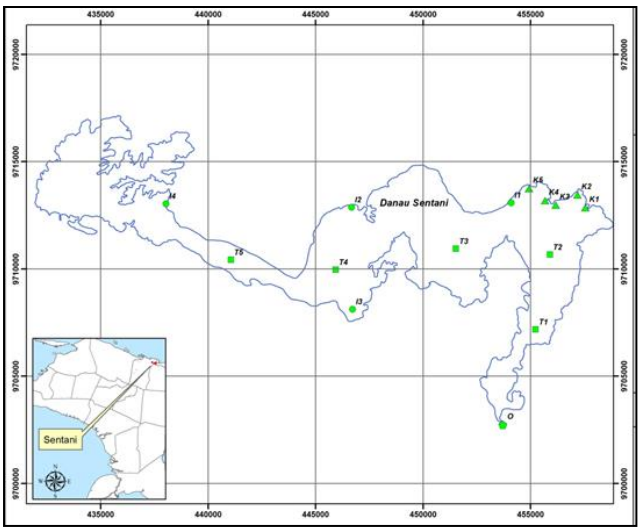

Figure 1. Position the sampling plot at each observation station

Research Material

The material used in this study consists of research tools and materials. Tools used during the study included boat engine to around the lake, secchi disks and scale sticks to measure the water's brightness and depth. Mercury thermometers are used to measure water temperature. pH-meter is used to measure the pH of water. DO meters are used to measure dissolved oxygen in the water. Eckman dredge with capacity of 5 kg to take sediment sample from the bottom of the lake. O-Haus analytical balance (P/N 490203) to measure the sediment weight.

Research Methods

The research methods used are field survey methods and comparative methods. The survey method is one of the research methods by collecting data derived from samples that will produce relative relationships (Bolbakov et al. 2020).

Sampling Techniques

Sampling is carried out by purposive sampling method. According to Campbell et al. (2020), purposive sampling is a sampling method that is specifically selected based on the purpose of the study. The sampling location is determined after a site survey. Sampling was conducted at stations I, K, T and O at Lake Sentani, where three repetition in each station. At a predetermined location, measurements of several physical parameters (tranasparency and temperature) are made. The chemical parameters measured in situ are pH and dissolved oxygen.

Measurement of Aquatic Physical Parameters

Transparency Measurement

Water transparency measurements were carried out using secchi disks (Umasugi et al. 2021). The water transparency measurement was carried out three times. Secchi Disk is a simple disc-shaped plate, on the surface of which there are black and white colours in the form of shading with four parts. The formula can measure the transparency of water: $K = \frac{d1}{d2}$

K = Brightness
d1 = Secchi depth of disk when not visible
d2 = Secchi disk depth when it starts to appear again

Temperature Measurement

The water temperature is measured using a rod thermometer inserted into the water for 2 minutes, and then a temperature value reading is taken while the thermometer is still in the water. The temperature measurement time was carried out three times each station.

Measurement of Chemical Parameters

The chemical parameters observed in this study were the pH and dissolved oxygen of the waters. Measurements of the pH of the water is measured using a pH meter (Garini et al. 2021). The dissolved oxygen measurements with DO-meter. The measurement was carried out three times each station.

Sedimentary Organic Carbon Measurement

Measurement of organic carbon content using Non-Dispersive Infra Red – Supercritical Water Oxidation (NIDR-SCWO) (Anonymous, 2005).

Data Analysis

This research uses ArcGIS 10.1 software with IDW particular analysis interpolation. The IDW method directly implements the assumption that something close to each other will be more similar than something that is far from each other. To estimate a value at any location that is not measured, IDW will use the measure values surrounding the location to be estimated. According to the distance to the estimator data, the weight will change linearly as a distance function (Yang and Xing, 2021). This weight is not affected by the position or location of the estimator data with other estimator data (Mott, 2018).

RESULTS AND DISCUSSION

Sedimentary Organic Carbon Content

The results of sampling at four stations for sedimentary organic carbon showed that the sedimentary organic carbon concentration in Lake Sentani were 22.437 mg/kg at the net floating cage area, following by inlet area were 20.81 mg/kg, an outlet area were 18.3 mg/kg, and in the middle area of the lake were 1.99 mg/kg. This condition is thought to be due to higher nutrient runoff from the watershed into the water of Lake Sentani, which is related to high human activity around the river basin. In addition, when the concentration or organic carbon reaches a saturation value it will be carried towards the middle of the lake and most of it will accumulate in the outlet (Figure 2).

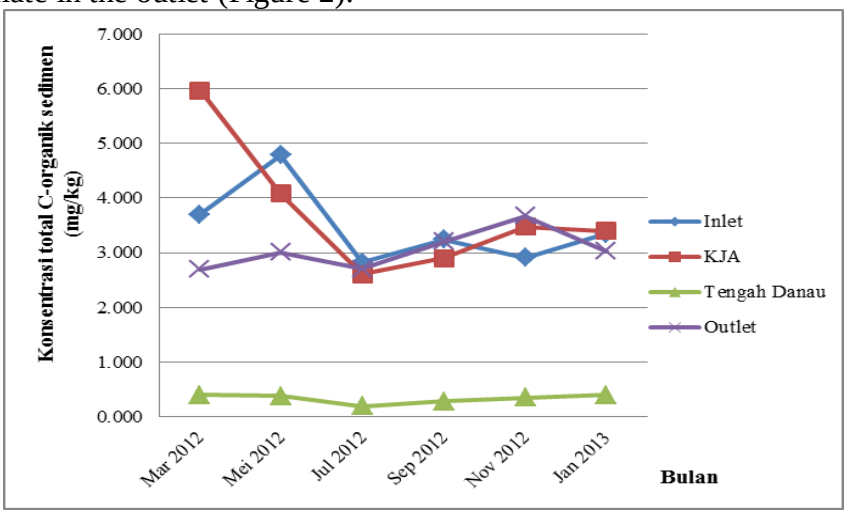

Figure 2. Total Sediment Organic Carbon Graph

Analysis of variance showed that the concentration of total organic carbon was significantly different ($P < 0.05$) between the net floating cage area and the outlet area, and very significantly different from the middle area. Significant differences were also seen between the outlet area and the middle of the lake area (Figure 3).

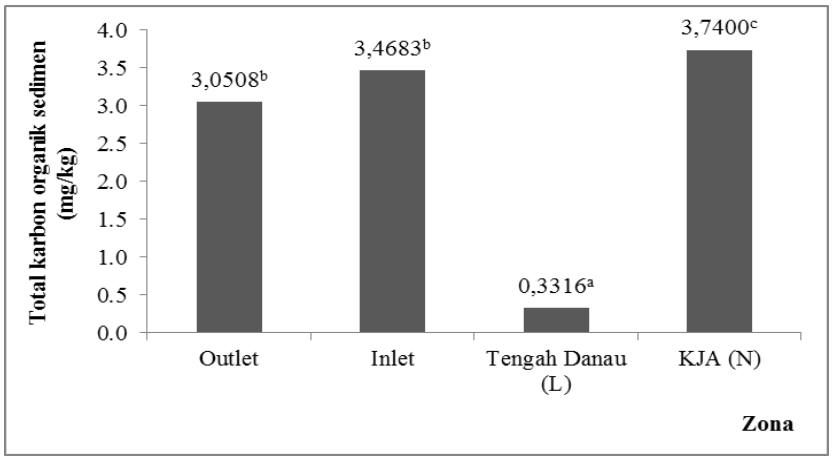

Figure 3. Average concentration of total sediment organic carbon at each station.

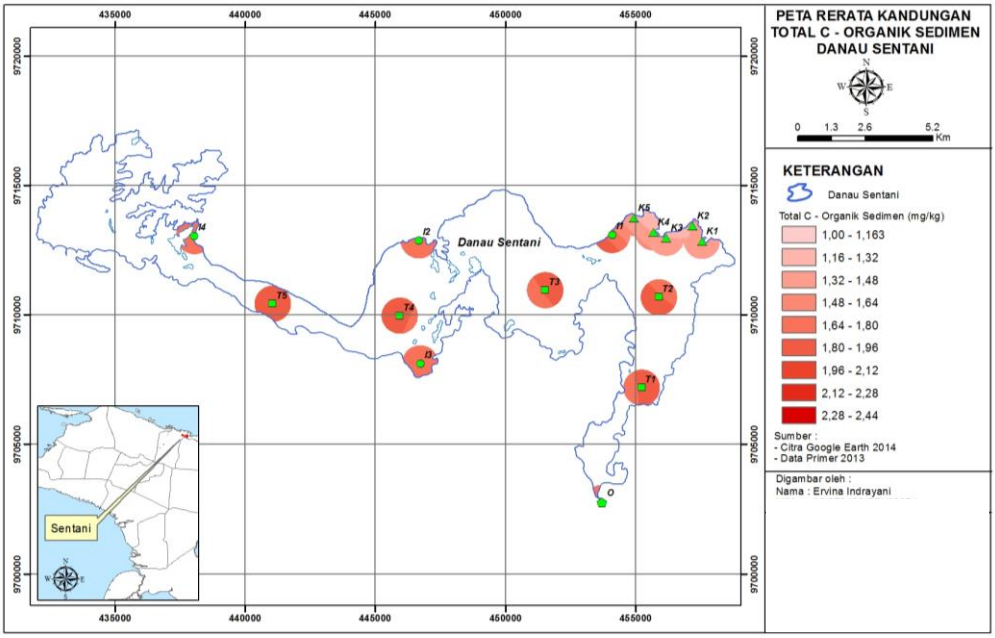

Figure 4. Distribution of total sediment organic carbon at each station

Hadisusanto (2006) states that the organic carbon content of sediments indicates the dissolved organic carbon content in the water. Carbon is also on of the constituent elements of nutrients in sediment which plays a role in the formation of biomass of aquatic organism (Hartoto, et al., 1998). Sedimentary organic carbon fluctuations indicate the movement of organic matter at the bottom of the waters. Sedimentary organic carbon concentration plays a role in nitrogen and carbon assimilation. The high content of sediment organic carbon will increase nitrogen assimilation, then nitrogen will affect the concentration of phosphate in the water column.

The cause of water pollution is the result of high concentration of nitrogen and phosphorus, however, it must be understood more deeply that the presence of sediment organic carbon is very closely related to the assimillation of nitrogen and utilization of phosphorus as an energy source. The summary is the concentration of organic carbon in

sediments directly affects the concentration of aquatic carbon produced and affect the concentration of nitrogen and phophorus in the waters.

Water Quality Parameters

Water Temperature

The mean of water temperature from the highest were in the inlet area (31.47 ± 2.73), in the middle area of the lake (31.23 ± 0.88), the floating net cage area (30.9 ± 1.16) and the outlet area (30.28 ± 0.83). The standars deviation of temperature indicates a value that is still within the limits of the aquatic environment quality standard. Based on location, the highest average temperature was in the inlet (31.47ºC), followed the middle area (31.2ºC), the net floating cage area (30.88ºC) and the outlet (30.28ºC) (Figure 5).

Alabaster and Llyod (1982) state that normal water temperatures range from 20 – 29ºC. The summary is the water temperature range in Lake Sentani exceeds this value. This condition is thought to be due to release of heat during the day from the bottom of the waters, thereby increasing the surface temperature. Temperature is also an indicator of bacterial activity (Omnes, et al., 1996) so that it affects the concentration of water nutrients.

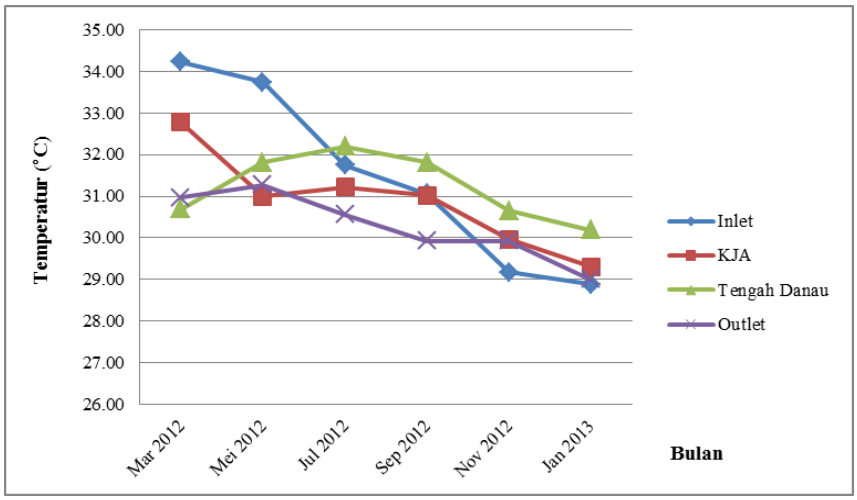

Figure 5. Average water temperature in each station

Water pH

The pH range in Lake Sentani is 5.34 – 7.68 mg/L. This value is still included in the optimal growth range of cultured fish. In general, the PH is still in the range of environmental quality standard. The pH range that still meets these requirements is in the middle area (6.31 – 7.0 mg/L) and the inlet area (6.16 – 7.13 mg/L), while the pH range in the floating net cage and outlet area is slightly higher, were 5.34 – 6.93 mg/L and 7.45 – 7.83 mg/L (Figure 6).

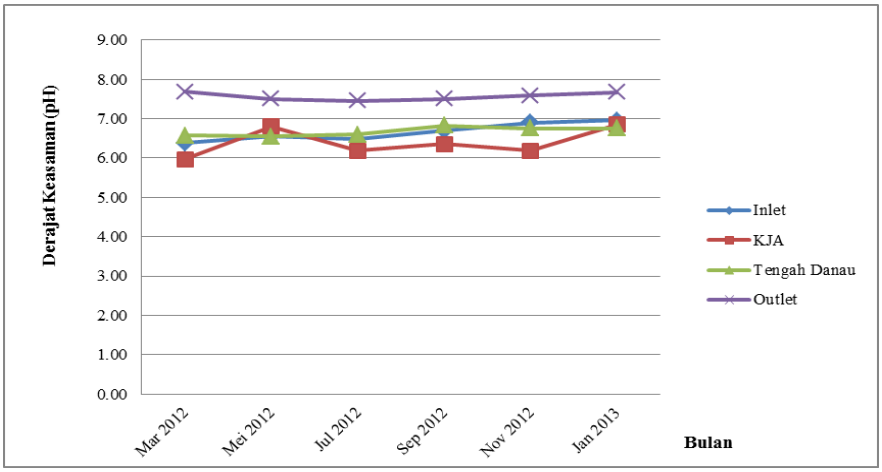

Figure 6. Average water pH in each station

Water Dissolved Oxygen (DO)

The highest mean of DO was in the inlet area (8.01 mg/L/month), followed by the outlet area (7.66 mg/L/month), the middle area (7.26 mg/L/month) and the floating net cage area (6.64 mg/L/month) (Figure 7). High water temperatures will reduce DO in the waters, thereby affecting the presence of communities in the water bodies. This condition is inversely proportional to what occurred during the study, temperature and dissolved oxygen simultaneously tended to be high. Salmin (2005) explained that dissolved oxygen content can indicate the quality of waters due to organic pollution, namely lightly polluted (> 5 mg/L), moderately polluted (2 – 5 mg/L) and heavily polluted (0 – 2 mg/L). The oxygen content in Lake Sentani were > 5 mg/L, it is categorized as lighly polluted. This condition meets the criteria for environmental quality standards for Class II water category, where the minimum DO concentration is 4 mg/L.

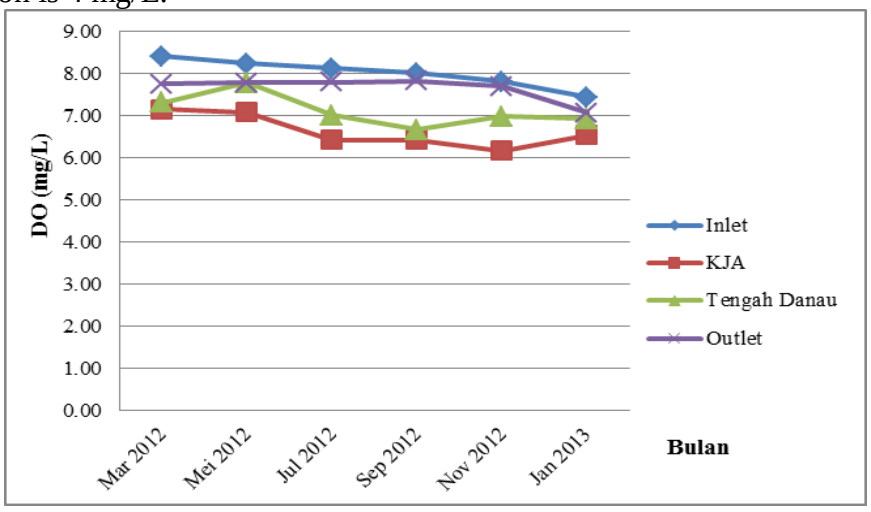

Figure 7. Average water dissolved oxygen (DO) in each station

Water Transparency

The highest water transparency is in the floating net cage area were 2.79 m/month, followed the middle area were 2.34 m/month, he inlet area were 1.64 m/month and the outlet were 1.63 m/month. The brighteness in the floating net cage area and the middle area of the lake differed significantly from the brightness in the inlet and outlet area (Figure 8).

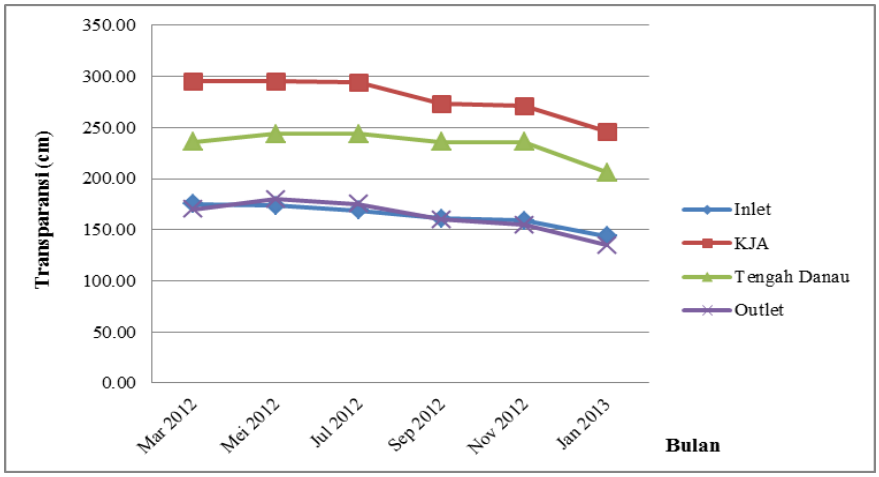

Figure 8. Average water transparency in each station

Transparency is a supporting factor for aquatic metabolism (Hadisusanto, 2006). The high transparency of water indicates good light penetration, because it shows the ability of light to penetrate the depth of water to supports the process of photosynthesis in water. The transparency of the water in Lake Sentani ranges from 162.5 – 279 cm. the value is very significant in suppoting the process of photosynthesis and increase dissolved oxygen levels. The high transparency of the water will trigger the phytoplankton move towards the surface to carry out photosynthesis and increase the oxygen concentration.

ACKNOWLEDGEMENTS

The author would like to convey much grateful to ANCORA Foundation in Jakarta, Indonesia and PT. Sakura Indah Lestari in Jayapura, Papua, Indonesia.

REFERENCES

Alabaster, J.S. and Liyod. 1982. *Water Quality Criteria for Freshwater Fishes.* University Press of Cambridge. Great Britain.

Anonymous, 2005. *Analisis Kimia Tanah, Tanaman, Air, dan Pupuk*. Edisi Pertama. Balai Penelitian Tanah. Bogor.

_____. 2008. *Potensi Perikanan dan Kelautan Kabupaten Jayapura*. Dinas Perikanan dan Kelautan Provinsi Papua. PEMDA PAPUA. Jayapura.

Bolbakov RG, Sinitsyn AV, Tsvetkov VY, 2020. Methods of comparative analysis. Journal of Physics: Conference Series. 1679 (2020). DOI:10.1088/1742-6596/1679/5/052047.

Campbell S, Greenwood M, Prior S, Shearer T, Walkem K, Young S, Bywaters D, Walker K, 2020. Purposive sampling: complex or simple? Research case examples. Journal of Research in Nursing. 25 (8): 652-661.

Effendie, M.I. 1997. *Biologi Perikanan*. Yayasan Pustaka Nusatama. Yogyakarta.

Garini BN, Suprijanto J, Pratikto I. 2021. Chlorophyll-a content and abundance in Kendal waters, Central of Java. Journal of Marine Research, 10(1): 102-108. DOI: https://doi.org/10.14710/jmr.v10i1.28655.

Hadisusanto, S. 2006. *Distribusi dan Kemelimpahan Larva Bentonik Chironomidae (Diptera) : Hubungannya dengan Jeluk dan Nutrien di Waduk Sempor, Kebumen, Jawa Tengah*. Disertasi.Universitas Gadjah Mada. Yogyakarta.

Hartoto, D.I, S. Sunanisari, M.S. Syawal, Yustiawati, I. Ridwansyah dan S. Nomosatryo. 1998. Alternatif Tata Guna Danau Teluk Berdasar Sifat Limnologis. *Hasil-Hasil Penelitian PUSLITBANG Limnologi, LIPI*. Cibinong.

Horne, A.J. and C.R. Goldman. 1994. *Limnology*. Second Edition. McGraw-Hill Inc.New York.

Hoss, S., W. Ahlf, C. Fahnenstich, D. Gilberg, H. Hollert, K. Melbye, M. Miller, M. Hammers-Wirtz, P. Heininger, H. Neumann-Hensel, R. Ottermanns, H.-T. Ratte. T.-B. Seiler, D. SPira, J. Weber, and U. Feiler. 2010. Variability of sediment-contact test in freshwater sediments with low-level anthropogenic contamination – determination of toxicity thresholds. *Environmental Pollution*: 2999-3010.

Indrayani, E., S. Hadisusanto, Rustadi, and Kamiso, H.N. 2012. Diversity of freshwater fishes: Aquaculture for community welfare at Lake Sentani, Papua. *Proceeding of The 2nd Society for Indonesian Biodiversity International Conference* Vol. 2: 115-119.

Janse, J.H. 1997. A model of nutrient dynamics in shallow lakes in relation to multiple stable stats. *Hydrobiologia* 342/343: 1-8.

Kamiso, H.N. 2003. Manajemen Danau di Indonesia. *Prosiding Seminar Nasional Limnologi PBI*. 8 Februari 2003. Yogyakarta.

Khiatuddin, M. 2003. *Melestarikan Smber Daya Air dengan Teknologi Rawa Buatan*. Gadjah Mada University Press. Yogyakarta.

Krebs, C.J. 2009. *Ecology: The Experimental Analysis of Distribution and Abundance*. 2nd Ed. Pearson Education, Inc. USA.

Mott RL, Vavrek EM, Wang J, 2018. Machine Elements In Mechanical Design Sixth Edition. Pearson Education.

Omnes, P., G. Slawyek, N. Garcia and P. Bonik. 1996. Evidence of denitrification and nitrate ammonification in the RiverRhone plume. *Marine Ecology Progress Series* Volume 141: 275-281.

Putra, S.S., C. Hassan, Djudi, and H. Suryatmojo. 2013. Reservoir saboworks solutions in Limboto Lake sedimentations, Northern Sulawesi, Indonesia. *Procedia Environmental Sciences* 17: 230-239.

Rimmer, A., M. Boger, Y. Aota, and M. Kumagai. 2006. A lake as a natural integrator of linear processes: application to lake Kinneret (Israel) and Lake Biwa (Japan). *Journal of Hydrology* 319: 163-175.

Sabar, F. dan T. Widiyanto. 1998. Profil Senyawa Organik pada Sistem Perairan Tambak Udang. *Hasil-Hasil Penelitian Puslitbang Limnologi tahun 1997/1998* : 429-432. LIPI – Cibinong.

Salmin. 2005. Oksigen Terlarut (DO) dan Kebutuhan Oksigen Biologi (BOD) sebagai salah satu Indikator untuk menentukan Kualitas Perairan. *Ocean*, Volume XXX, No.3 : 21-26.

Umasugi S, Ismail I, Irsan I. 2021. Kualitas Perairan Laut Desa Jikumerasa Kabupaten Buru Berdasarkan Parameter Fisik, Kimia Dan Biologi. Biopendix: Jurnal Biologi, Pendidikan dan Terapan, 8(1): 29-35.

Yang R, Xing B, 2021. A Comparison of the Performance of Different Interpolation Methods in Replicating Rainfall Magnitudes under Different Climatic Conditions in Chongqing Province (China). Atmosphere. 12(10):1-24. DOI: 10.3390/atmos12101318.