Procedia
Environmental Science, Engineering and Management
http://www.procedia-esem.eu

Procedia Environmental Science, Engineering and Management **8** (2021) (2) 353-361

Environmental Innovations: Advances in Engineering, Technology and Management, EIAETM, 19th-23rd October, 2020

# WATER QUALITY ANALYSIS OF BENANGA RESERVOIR, IN SAMARINDA, EAST KALIMANTAN, INDONESIA*

**Vita Pramaningsih**, Deny Kurniawan, Syamsir, Mardiana**

*Universitas Muhammadiyah Kalimantan Timur, Samarinda, Kalimantan Timur, Indonesia*

## Abstract

Benanga reservoir has functions as a flood controller in Samarinda. It also for used water treatment intake. Surface condition of the reservoir is currently covered by aquatic plants and sedimentation occurs. Many people live on the edge of the reservoir and dispose of their household waste in the reservoir and use reservoir to fish cages. Purpose this study was to measure water quality of the reservoir and compared with the standard of district regulation, East Kalimantan Regional Regulation No. 02 / 2011 concerning management of water quality and water pollution control. Sampling point were 5 locations by purposive sampling. The location is crowded with aquatic plants (1), near cages (2), locations where there were no aquatic plants and cages (3), reservoir outlets (4) and water treatment intake (5). Sampling is done by composite. Samples were analyzed in the laboratory and compared to the standard. Result of the study obtained an average of pH 5.3; temperature of 28°C; DO 3.23 mg/L; BOD 18.43 mg/L; COD 26.27 mg/L; TSS 13.28 mg/L; Nitrite 0.0042 mg/L; Nitrate 0.2 mg/L; Ammonia 0.3214 mg/L; Phosphate 0.0105 mg/L and Fecal Coliform 392 MPN/100mL. Parameters of pH, DO, BOD, COD, Fecal Coliform exceeding the standard and temperature, TSS, Nitrite, Nitrate, Ammonia, Phosphate meet the standard.

*Keywords:* analysis, reservoir, water quality

## 1. Introduction

Benanga Reservoir is located in Lempake Village, North Samarinda District East Kalimantan. Function of the reservoir is used as a flood control in Samarinda and as a water treatment intake. Inlet reservoir comes from tributaries in the area of Kutai Kartanegara and Samarinda. Water Quality in Benanga Reservoir is influenced by community activities around the reservoir. Many people live on the edge of the reservoir, dispose of their

* Selection and peer-review under responsibility of the EIAETM
** Corresponding author: email: vp799@umkt.ac.id

household waste in the reservoir and there is Intake of Water Treatment Plant for drinking (Fig. 1). It is needed monitoring for physical, chemical and microbiological parameters to measure water quality in the reservoir. Water test for physical, chemical and microbiological parameters are very important before used for drinking, domestic, agriculture or industrial purpose (Bhateria and Jain, 2016). The outlet of reservoirs flow into the Karang Mumus River and end to the Mahakam River. Then Mahakam River water is used as raw water for water treatment to serve the entire community of Samarinda.

Current condition of the Benanga Reservoir shows that the surface water cover by aquatic plants in a large area (Fig. 2). Its impact to sedimentation process in the reservoir because of decomposition process in the waters. Total sedimentation in Benanga Reservoir is estimated to reach 1.87 million cubic meters which will be carried out by River Area Agency (Badan Wilayah Sungai /BWS in Indonesia) (Tribun Kaltim Newspaper, March 9, 2018 accessed December 6, 2018). It causes the reservoir storage capacity to decrease and reservoir becomes shallow. Eutrophication levels and water quality status were worse in wet season than in dry season (Wang et al., 2019). But it is difference in shallow lakes eutrophication can enhance at low water level (Sharip et al., 2019). Benanga reservoir is shallow lake because a lots of sedimentation occur and a lots of aquatic plant in the surface as eutrophication.

**Fig. 1.** Settlements around the Benanga Reservoir and Intake Water Treatment


**Fig. 2.** Water Plant Growth on the Surface of the Benanga Reservoir

Base on these problems, a study was conducted on monitoring water quality of Benanga Reservoir. Water quality analysis compared with the regulation standard of East Kalimantan Regional Regulation No. 02 / 2011 concerning management of water quality and water pollution control. Water quality and trophic status varied during drought season and low water levels condition are difference between lakes (Sharip et al., 2019).

The main objective of this study is to analyze the water quality of Benanga Reservoir in Samarinda. The parameter was measure are physics, chemical and biology. The result will compare with regulation standard.

This work is divided in three main parts:

- selection of water sampling location spot in Benanga Reservoir are 5 spot as crowded with aquatic plants (1), near cages (2), locations where there were no aquatic plants and cages (3), reservoir outlets (4) and Water Treatment intake (5).
- each water samples measure and analyze in the Region Health Laboratory of Samarinda Province.
- evaluation and analyze the laboratory result as drawing conclusion and compare with standards.

## 2. Material and methods

### *2.1. Location of Measurement*

Location of this research is at the Benanga Reservoir located in Lempake Village, Samarinda, East Kalimantan. Land use around Benanga Reservoir is agriculture, fields and settlement. There are settlement on the edge of the reservoir and use reservoir to fish cages. Sampling point were 5 locations by purposive sampling. It is crowded with aquatic plants (1), near cages (2), locations where there were no aquatic plants and cages (3), reservoir outlets (4) and Water Treatment Intake (5). Determination of sampling location was done by purposive sampling with consideration of location accessibility and potential sources of pollutants. Sampling is done by composite to represent the sample homogeneously and it is done in dry season.

### *2.2. Main List of Parameters*

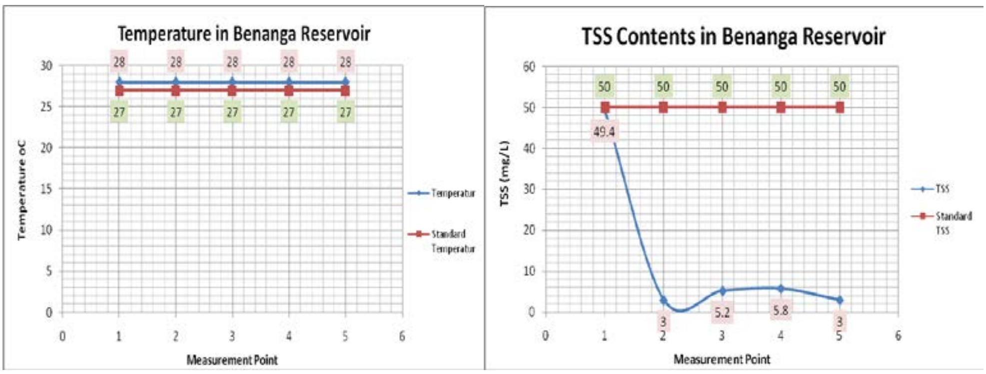
Important parameters for identify water quality are physical, chemical and biological. The main list of the parameters was measure are physical include temperature, Total Suspended Solid (TSS) ; chemical include pH, Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrite, Nitrate, Ammonia, Phosphate and biology is Fecal Coliform. The laboratory result will compare with regulation standard East Kalimantan Regional Regulation No. 02 / 2011. Water Quality consider physical, chemical and biological parameters for describing the quality of water and its protection (Bhateria and Jain, 2016).

## 3. Results and discussion

### *3.1. Physical Parameters*

Physical parameters are include temperature and TSS. The measurements result are shown in Fig. 3. Results of temperature measurements in Benanga Reservoir show the same results at all measurement points, 28ºC. Time of measurement was done at 08.00 WITA (in Indonesia) with hot weather. The temperature still meets the standard according to East Kalimantan Regional Regulation No. 02 / 2011 for Class I. Temperature of the reservoir still support the ecosystem life in the reservoir. Range temperatures around 24.8ºC – 28.7ºC still in optimum range for phytoplankton growth (Herawati et al., 2019). Temperature affect to the chemical and biological process in the water. When temperature increase BOD and COD high, DO (Dissolved Oxygen) in the water will be decrease (Bhateria and Jain, 2016). Its happen because of domestic waste, organic matter and photosynthesis process in aquatic organism. The temperature in Benanga Reservoir supports the growth of ecosystems in the waters.

Result of TSS in Benanga Reservoir show a significant difference content especially in point 1 (aquatic plants). Highest TSS contents in point 1 (aquatic plants) is 49.4 mg/L. This point is shallow depth and has low level water in dry season as measurement done. In the shallow lake occur mix water that effect to organic matter distributed vertically (Komala et al., 2019). It is effect a high TSS and has an impact on high sedimentation. Lowest TSS contents are at point 2 (near cages) and 5 (water treatment intake) which are 3 mg/L. Average TSS content in Benanga Reservoir is 13.28 mg/L. TSS standard according to East Kalimantan Regional Regulation No. 02 / 2011 for Class I is 50 mg/L. TSS contents still meets the standard except at point 1 approaches standard. TSS contents in point 1 is high because a lots of deposit, solids and decaying aquatic plants. Suspended solid include silt, vertical mixed bottom sediment, decaying plant matter and sewage (Bhateria and Jain, 2016). This point also near the settlement that a lot of sewage enters the reservoir. TSS contents at others measurement point show low result. This study was conducted in summer season, there was no runoff that brought solids into reservoir. High TSS contents in the waters have an impact on the amount of sediment. It causes sedimentation in the reservoir that the reservoir capacity decrease. Function of the reservoir as water reservoir does not function optimally.

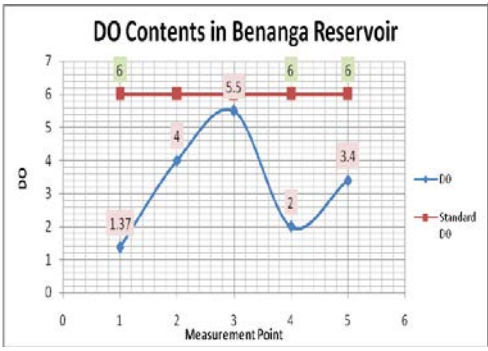



a) b)

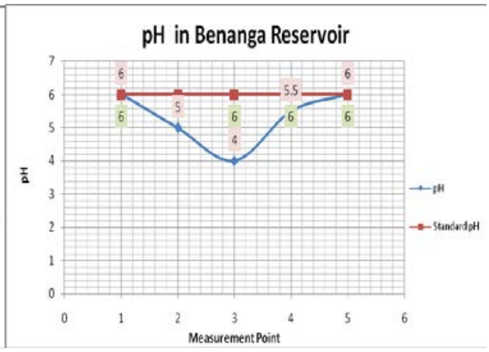
**Fig. 3.** Water Quality Result of Physical Parameters: a) Temperature and b) TSS

## *3.2. Chemical Parameter*

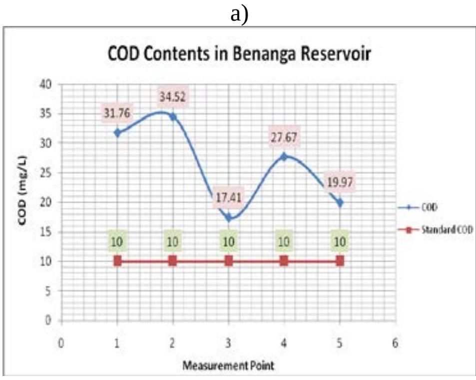
Chemical parameters are include pH, DO, BOD, COD, Nitrite, Nitrate, Ammonia, and Phosphate. The measurements result are shown in Fig. 4. Result of pH measurements in Benanga Reservoir show significant differences in result at each measurement point. The average pH value in the Benanga Reservoir is 5.3 which classified as acidic. Standard pH according to East Kalimantan Regional Regulation No. 02 / 2011 for Class I is 6-9. Point 2 (fish cages) and point 4 (outlet reservoir) have pH 5 and 5.5. Lowest pH show in point 3 (location where there are no plants and cages) which is 4. Finally pH in point 1 and point 5 have pH 6. Point 5 (intake water treatment) have pH 6 that meets standard, even though it is close to the residential area lives on the edge of the reservoir. Point 3 (location there are no plants and cages) has lowest pH 4. Average pH value in Benanga Reservoir is 5.3 classified acidic. Water quality in Benanga Reservoir is influenced by community activities in the upstream area that enter to the reservoir.



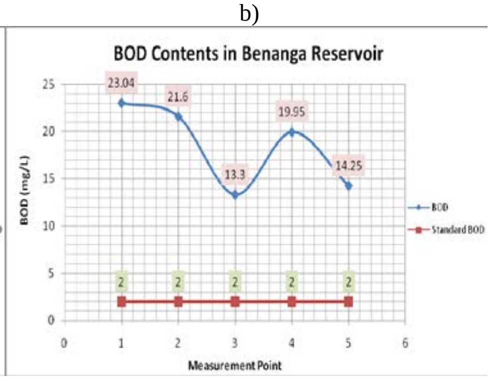

a)



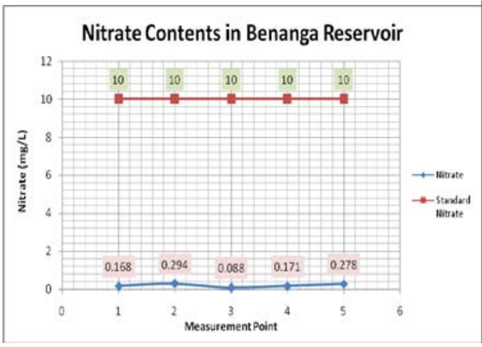

b)



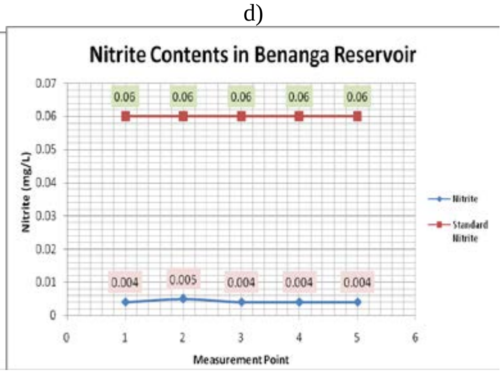

c)|



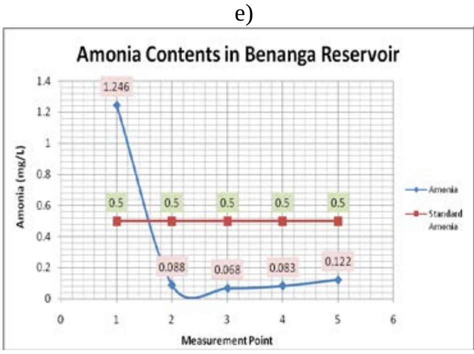

d)



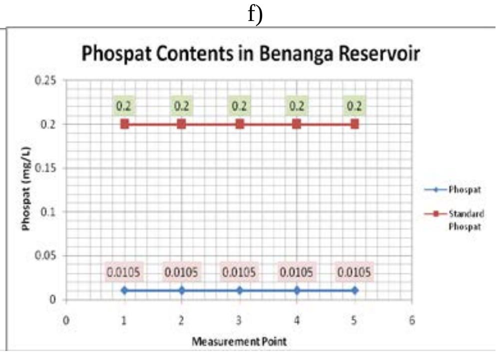

e)




f)




g)




h)

**Fig. 4.** Water Quality Result of Chemical Parameters:
a) pH; b) DO; c) BOD; d) COD; e) Nitrite; f) Nitrate; g) Ammonia; and h) Phosphate

Many settlements on the edge of Benanga Reservoir and surface water of the reservoir covered by water plants give affect water quality especially pH. Dead water plants will settle in the bottom of reservoir and decompose along with organic and an organic compound. Decomposition process runs fast supported by DO (Dissolved Oxygen). During dry season, probably high photosynthetic impact DO and pH increase (Sharip et al., 2019).

Results of DO measurements in Benanga Reservoir show significant differences in result at each measurement point. Highest DO content was at point 3 (location where there are no plants and cages) which was 5.5 mg/L. The lowest DO content is in point 1 (water plant) which is 1.37 mg/L. Average DO content in Benanga Reservoir is 3.23 mg/L exceed the standard. Standard DO according to East Kalimantan Regional Regulation No. 02 / 2011 for Class I is 6 mg/L. DO content in the water is very important for survival of the aquatic ecosystems in reservoir, its similar with (El Zokm et al., 2018). DO contents are closely related to the contents of BOD and COD. Water bodies that have high DO will have low BOD and COD. It happens because oxygen availability is sufficient for needs of microorganisms decompose biologically organic matter and for oxidation of organic matter chemically. Lowest DO content in point 1 (aquatic plants) because many aquatic plants die and decomposition occurs at the bottom of reservoir. Decomposition process by microorganisms in the waters requires DO (Dissolved Oxygen). It affect DO decrease because it is not balanced by Photosynthesis in the waters. Photosynthesis process is hampered because the surface of the Benanga Reservoir is covered by aquatic plants which inhibits the penetration of sunlight into the waters.

Result of BOD measurement in Benanga Reservoir show a significant difference in value at each measurement point. Highest BOD content is in point 1 (aquatic plants) which is 23.04 mg/L. Lowest BOD contents at point 3 (location where there are no plants and cages) is 13.3 mg/L. BOD average contents in Benanga Reservoir is 18.43 mg/L. BOD standard according to East Kalimantan Regional Regulation No. 02 / 2011 for Class I is 2 mg/L. BOD contents is high in point 1 because of process decomposition organic matter from aquatic plants die and settle at the bottom of reservoir by microorganism. Activities of the community around the reservoir such as domestic waste, agriculture and field affect the content on BOD, COD and DO. Human activities around the lake, especially fish cage has highest contribution to organic matter contents (Komala et al., 2019). Allocation of sectoral pollution load capacity of BOD and COD in Karang Mumus River originated from domestic activities (Pramaningsih et al., 2020). Benanga Reservoir upstream of the Karang Mumus River, that the water quality of the reservoir affects the water quality of river downstream.

COD measurement results have a pattern similar to BOD. Highest COD content is in point 2 (near cages) which is 34.52 mg/L. Lowest COD contents at point 3 (location where there are no plants and cages) is 34.54 mg/L. Average BOD contents in Benanga Reservoir is 26.27 mg/L. Standard COD according to East Kalimantan Regional Regulation No. 02 / 2011 for Class I is 10 mg/L. COD contents exceeds the standard, it is becomes an indicator of polluted waters. Highest COD in point 2 (near cages) is 34.52 mg/L then high COD in point 1 (aquatic plants) is 31.76 mg/L. Similar with BOD and DO, it is affected by degradation or organic and an organic materials in the water from cages and aquatic plants. BOD and COD content relate to organic matter in the water that degradable by microorganism or by chemical process (Goher et al., 2017). Sewage treatment plants and livestock farm are the major pollution source to increase the contents of TP (Total Phosphor), TN (Total Nitrogen), BOD, COD, TSS and CE (Electrical Conductivity) in the Headwater (Mamun et al., 2018). Major sources of water pollution come from domestic waste, human activities. The role of government, entrepreneurs and the community is very needed in efforts to control water pollution.

Result of Nitrite in Benanga Reservoir show almost same contents at all measurement point. Nitrite contents at all measurement points are 0.004 mg/L except point 2 (near cages) is 0.005 mg/L. Nitrite standard according Perda Kaltim No. 02 / 2011 for Class I is 0.06 mg/L and nitrite content in Benanga Reservoir still meets the standard. Highest Nitrate content at point 2 (near cages) is 0.294 mg/L. Lowest Nitrate content at point 3 (location where there are no plants and cages) is 0.088 mg/L. Average Nitrate content in Benanga Reservoir is 0.2 mg/L. Nitrate standard according is 10 mg/L and nitrate content in Benanga Reservoir still meets the standard. Nitrite content in Benanga Reservoir is smaller than phosphate content. Flushing during summer season and high nutrient content (Nitrogen and Phosphorous) in the waters have an impact on algae growth (Mamun et al., 2018). During dry season and low water level in the lake, probably high photosynthetic then DO and pH increase and total nitrogen is decrease (Sharip et al., 2019). Eutrophication levels in Lake Idku increase due to the huge input of terrigenous and anthropogenic nutrients are mainly coming from drainage, agricultural, and sewage discharges heavy nutrients load, especially nitrogen and phosphorous (Ali and Khairy, 2016).

Results of Ammonia measurements in Benanga Reservoir show a significant difference contents especially in point 1 (aquatic plants). Highest Ammonia content in point (aquatic plants) is 1.246 mg/L. Lowest Ammonia content was at point 3 (location where there were no plants and cages) which was 0.068 mg/L. Average Ammonia content in Benanga Reservoir is 0.3214 mg/L. Ammonia standard according Perda Kaltim No. 02 / 2011 for Class I is 0.5 mg/L. Ammonia at Benanga Reservoir still meets the standard except for point 1 (aquatic plants). Highest Ammonia contents content is in point 1 because the location overgrown with aquatic plants and close to settlements and agriculture. This location is quite shallow because a lot of sediment, comes from degraded aquatic plants at the bottom of the reservoir. Degradation of the organic matter in the sediment need oxygen. Because of that DO content in this point is low, its affect the ammonia increase. This is in accordance with the statement of (Bhateria and Jain, 2016) that ammonia will increase during vertical mixing event in shallow lakes, at low DO nitrification of ammonia reduced then ammonia will be increased caused sediments.

Result of Phosphate measurement in Benanga Reservoir shows all measurement poin have same result was 0.0105 mg/L. Phosphate standards according to Perda Kaltim No. 02 / 2011 for Class I is 0.2 mg/L. Phosphate contents at Benanga Reservoir is low and still meets the standards. Nitrite, Nitrate and phosphorous in the two lakes, showed fluctuating changes with notable increase overtime (Goher et al., 2017). Nitrogen and phosphorous ratio explain that phosphorous limited factor for phytoplankton growth in Burullus Lake (Elsayed et al., 2019). But its difference with (El Zokm et al., 2018) that their result describe the nitrogen is limiting factor for phytoplankton growth in Mariot Lake. Nitrogen content in Nitrite, Nitrate Ammonia specific and phosphorus content in Benanga reservoir are very low below the standard, except Ammonia in point 1 (aquatic plants).

### *3.3. Biological Parameter*

Biological Parameter measurement is Fecal Coliform contents. Result of Fecal Coliform measurement in Benanga Reservoir looks a significant difference contents especially in point 1 (aquatic plants) as shown in Fig. 5. Highest Fecal Coliform contents in point 1 (aquatic plants) is 1.100 MPN/100mL. Lowest Fecal Coliform contents at point 4 (reservoir outlet) is 130 MPN/100mL. Average Fecal Coliform contents in Benanga Reservoir is 392 MPN/100mL. Fecal Coliform standard according Perda Kaltim No. 02 / 2011 for Class I is 100 MPN/100mL. Fecal Coliform in Benanga Reservoir exceed the standard. Source of Fecal Coliform pollution comes from liquid waste such as septictank and runoff in urban areas. Waste Water Treatment Plan (WWTP) can reduce Fecal Coliform pollution but there are several factors that influence such as discharge, rainfall and weather (Bhat and Danek, 2012).

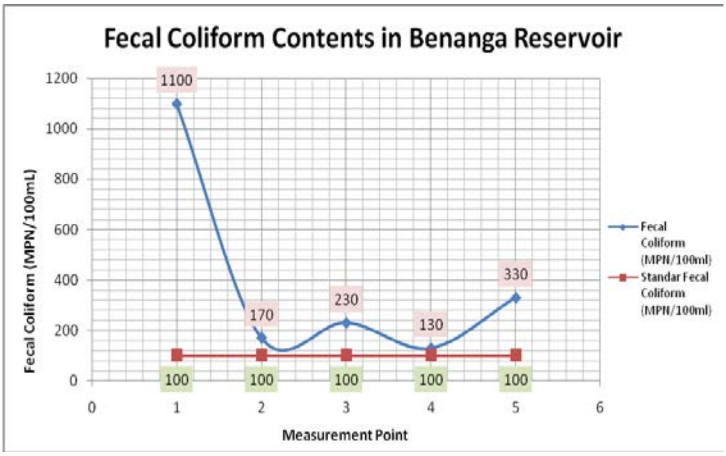



**Fig. 5.** Water Quality Result of Biological Parameter is Fecal Coliform

## 4. Conclusions

Water quality for parameters of pH, DO, BOD, COD, Fecal Coliform exceeding the standard and temperature, TSS, Nitrite, Nitrate, Ammonia, Phosphate meet the standard. The rapid growth of aquatic plants in the Benanga Reservoir has no effect on the content of nitrites, nitrate, ammonia and phosphate in dry season. Ammonia contents is comparable to Fecal Coliform content. High DO content in the water can reduce BOD and COD content. High BOD and COD are indicators of water pollution, its similar with (El Zokm et al., 2018).

## Acknowledgements

The author would like to thank Lembaga Penelitian dan Pengabdian Masyarakat, Universitas Muhammadiyah Kalimantan Timur (LPPM UMKT) for provided funding in this study through Penelitian Kompetitif (PEKOM) grant. Thanks to Hana, Jodi and Verly for helping on field data collection.

## References

Ali E.M., Khairy H.M., (2016), Environmental assessment of drainage water impacts on water quality and eutrophication level of Lake Idku, Egypt, Environmental Pollution, Elsevier Ltd. DOI: 10.1016/j.envpol.2016.05.064.

Bhat S., Danek L.J., (2012), Comparison of fecal coliform before and after wastewater treatment facility: a case study near a coastal town in the Southeastern USA, *Water Air Soil Pollut*, 1923-1930. DOI: 10.1007/s11270-011-0991-6.

Bhateria R., Jain D., (2016), Water quality assessment of lake water: a review, *Sustainable Water Resources Management*, **2**, 161-173. DOI: 10.1007/s40899-015-0014-7.

El Zokm G.M., Tadros H.R.Z., Okbah M.A., Ibrahim G.H., (2018), Eutrophication assessment using TRIX and Carlson's Indices in Lake Mariout water, Egypt, *Egyptian Journal of Aquatic Biology and Fisheries*, **22**, 321-339. DOI: 10.21608/ejabf.2018.23918.

Elsayed F.A., Okbah M.A., Elsyed S.M., Eissa M.A., Goher M.E., (2019), Nutrient salts and eutrophication assessment in Northern Delta Lakes: case study Burullus Lake, Egypt, *Egyptian Journal of Aquatic Biology and Fisheries*, **23**, 145-163.

Goher M.E., Mohamed E.M.M., Abdo M.H., El Dars F.M., Korium M.A., Elsherif A.A., (2017), Water quality status and pollution indices of Wadi El-Rayan, *Sustainable Water Resources Management*, Springer International Publishing. DOI: 10.1007/s40899-017-0162-z.

Herawati H., Nurruhwati I., Dhahiyat Y., (2019), The structure of phytoplankton community to estimated trophic level in Jatigede reservoirs, *International Journal of Fisheries and Aquatic Research*, **4**, 33-37.

Komala P.S., Nur A., Nazhifa I., (2019), Distribution of organic contamination based on depth stratification in Maninjau Lake, Indonesia, *IOP Conference Series: Materials Science and Engineering*, **602**, 9-16. DOI: 10.1088/1757-899X/602/1/012057.

Mamun M., Lee S.J., An K.G., (2018), Temporal and spatial variation of nutrients, suspended solids, and chlorophyll in Yeongsan Watershed, *Journal of Asia-Pacific Biodiversity*, **11**, 206-216. DOI: 10.1016/j.japb.2018.02.006.

Pramaningsih V., Suprayogi S., Loyola I., Purnama S., (2020), Pollution load capacity analysis of BOD, COD, and TSS in Karang Mumus River, Samarinda, Indones, *Journal of Chemistry*, **20**, 626-637. DOI: 10.22146/ijc.44296.

Sharip Z., Yusoff F.M., Jamin A., (2019), Seasonal water quality and trophic status of shallow lentic waters and their association with water levels, *International Journal of Environmental Science and Technology*, **16**, 4851-4862. DOI: 10.1007/s13762-018-2172-2.

Wang J., Fu Z., Qiao H., Liu F., (2019), Assessment of eutrophication and water quality in the Estuarine Area of Lake Wuli, Lake Taihu, China, *Science of the Total Environment*, **650**, 1392-1402. DOI: 10.1016/j.scitotenv.2018.09.137.