Water quality assesment of Pengambang River, Pekanbaru City, Riau Province, Indonesia using pollution index (PI)

Yuliati Yuliati[1*], *Eni* Sumiarsih[1], *Adriman* Adriman[1], *Efawani* Efawani[1] and *Daniel* Poima Saputra Napitupulu[1]

[1]Lecturer in Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, Universitas Riau, Pekanbaru, Indonesia
[2] Student in the Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, Universitas Riau, Pekanbaru, Indonesia

Abstract. River water quality monitoring must be carried out because rivers are a source of fresh water for the community. Tributaries in the city of Pekanbaru receive waste from domestic activities, industry, livestock, and agricultural runoff, reducing river water quality. The pollution index is one of the most effective tools for informing river water quality conditions. This research was conducted in one of the tributaries in Pekanbaru City, Indonesia, with a quantitative approach to assess the water quality status of a river using a pollution index. For this research, water samples were collected from three locations upstream, an outlet dam site, and downstream from May to July 2023. The collected samples were analyzed for eight water quality indicators: TSS, pH, DO, BOD, COD, Nitrate, Total Phosphate and Total Coliform. The Pollution Index (PI) method is used to assess the water quality of Pengambang Rivers according to the Indonesian Minister of Environment Decree number 27 of 2021. Guidelines for water quality indicators use class III water quality standards (PPRI 22/2021) for cultivating freshwater fish, livestock, Water for irrigated plants. The water quality of the Pengambang River still meets quality standards (Class III) for the parameters TSS, DO, COD, pH, nitrate, and phosphate, except BOD and total coliform.The PI results show that Pengambang Rivers are categorized as lightly polluted to moderately Polluted with a value of 1.61 to 8.17. The contamination of the Pengambang River was caused by the BOD and Total Coliform values exceeding the water quality standards (BOD = 8.78-17.5 mg/l and T.Coliform ranging from 2600-24,000 MPN/100 ml). The findings indicated that these water bodies were subjected to anthropogenic activities and untreated sewage inflow. Due to the poor quality of the water, these water bodies must be appropriately managed and conservation efforts made.

* Corresponding author: yuliati@lecturer.unri.ac.id

1 Introduction

River water pollution is a common problem in almost all developing countries, including Indonesia. In general, more than 50% of Indonesian rivers experience pollution [1]. Considering that surface water is one of the essential sources of drinking water for the population, maintaining the quality of surface water is very important for the daily needs of every household [2].

River water can be affected by human and natural activities, According to [3], the rivers that flow in urban areas experience degradation due to anthropogenic activities such as household activities, agricultural, livestock, and deforestation, which would result in changes in river water quality. Furthermore, urbanization and rapid populationgrowth have put the greatest pressure on aquatic ecosystems and environments. The decline in river water quality is also caused by the wastewater industry and emissions that produce pollutants [4].

Pekanbaru City has 13 tributaries, one of which is the Pengambang River. This river is used for fishing recreation and as a water source for an artificial lake in Pekanbaru. The Pengambang River basin is increasingly developing into a residential area for livestock activities, oil palm plantations, and ecotourism. Anthropogenic activities make the Pengambang River vulnerable to pollution, which can change the fragile river ecosystem. Furthermore, land use patterns in river areas will influence river water quality. Land clearing, livestock, and agricultural activities in river areas can channel nutrients, sediment, organic matter, pathogens, and heavy metals through runoff or irrigation [5-6]. In addition, land use in river basins also influences the physical and chemical parameters of water quality [3].

In recent years, many studies have been conducted to evaluate river water pollution, including the index method. The pollution index is a simple and easy method for evaluating the level of river pollution [7]. Several Indonesian researchers have used the pollution index method to assess the rivers flowing in urban areas [8-9]. Until now information on the water quality of the Pengambang River is very limited, while this area is being developed for various activities that can threaten the quality of the river water. Some research on the Pengambang River is only on fish diversity [10]. and the potential of the river as ecotourism [11]. Meanwhile, river water quality data is needed as basic information and reference in managing and controlling pollution. Thus, research related to the water quality of the Pengambang River with the pollution index needs to be carried out.

2 Material and methods

2.1 Sampling and data sources

The study was conducted in the Pengambang River which empties into the Siak River, Rumbai Pesisir District, Pekanbaru City, Riau Province. The study site is located at 0°33'36.6"N 101°29'28.3"E and 106º21'30"– 0°33' 38.7"N 101°29'21.3"E. Sampling was carried out three times from May to July 2023. Methods for water quality measurement are introduced in Table 1. There are three observation station points. Station one (Sta. 1) in the upstream part of the river is a swamp area. This location adjacent to a horse farm. Furthermore, Station two (Sta.2), the middle part of the river. This location there are residential areas, outlets dam site, and location of tourism activities. Moreover, station three (Sta. 3), is the lower reaches of the Pengambang River which empties into the Siak River. Water sample measurements were carried out directly in the field and in the laboratory. Water samples were taken using a water sampler and then stored in 500 ml plastic bottles. Next, the sample bottle is put in a cool box at a temperature of 4 C to be taken and analyzed in the laboratory.

Table 1. Parameters and methods of water quality analysis of the Pengambang River.

Parameters	Unit	Methods
Temperature	°C	Potensiometrik
Total Suspended Solids (TSS)	mg/L	Gravimetrix
pH	-	Colorimetrix
Disollved Oxygen (DO)	mg/L	Winkler
Biological Oxygen Demand (BOD)	mg/L	SNI 6989.72:2009
Chemical Oxygen Demand (COD)	mg/L	SNI 06-6989.15-2004
Nitrate	mg/L	SNI 06-6989.15-2004
Total Phosphate	mg/L	SNI 06-6989.31-2005
Total Coliform	MPN/100 ml	MPN (Most Probable Number)

2.2 Analysis data

The pollution level of the Pengambang River is used in the Pollution Index [12]. Government Regulation of the Republic of Indonesia number 22/2021 classifies surface water in Indonesia into four classes. In this study, the water quality parameters were determined class III, namely water intended for acceptable use for freshwater agriculture, animal husbandry, and other uses with similar requirements Pollution Index can be determined by selecting parameters and standards for each sampling point, average, and maximum values are determined by the following formula:

$$. \mathrm{Pl_j} = \sqrt{\frac{\left(\frac{C_i}{L_{ij}}\right)_M^2 + \left(\frac{C_i}{L_{ij}}\right)_R^2}{2}} \qquad (1)$$

Where: PIj = pollution index (j); Lij = the permissible values for parameter i determined for water use j; and Ci = measured concentration of parameter (Ci /Lij); R = Ci /Lij average value; Ci /Lij) M = Ci /Lij maximum value. Category of Pollution Index can be seen in Table 2.

Table 2 Category of water quality status based on Pollution Index (PI).

Value	Category
0 ≤ PIj 1.0	Not Polluted
1.0 ≤ PIj ≤ 5.0	Lightly Polluted
5.0 ≤ PIj ≤ 10.0	Moderately Polluted
PIj ≤ 10.0	Highly Polluted

3 Results and discusion

3.1 Water quality of Pengambang River

The physicochemical and biological analyses of Pengambang Rivers for the nine parameters are presented in Figures 1 to 9. The Pengambang River temperature fluctuated with a minimum value of 27 at Sta.2 (Sampling 1) and a maximum of 30 at Sta.1 (sampling 2) (Figure 1). The different temperature periods of this study are due to the difference in the measurement time. The highest temperature was recorded during the afternoon measurement when the intensity of sunlight was increased, while the lowest temperature was in the morning. In general, the largest source of surface water warming comes from solar radiation 13]. According to [14], minimum seasonal temperature fluctuations occur during winter or summer in shallow waters.

TSS in the Pengambang River is presented in Figure 2. The TSS concentration fluctuated during the study, with the highest value at Sta.1 during the third sampling at 129 mg/l. This high value is due to the sample carried out after rain. Rainwater runoff carries several particles from land into rivers. According to [15], rainwater runoff, agricultural runoff, road erosion, soil contamination, and soil leaching are the primary sources of TSS. The lowest concentration of TSS was found in Sta 2, namely 3 mg/l, during the 3 rd sampling. The low TSS was because the station was shallow water, and the current speed was very weak, so no stirring occurred.

The pH value of the water during the study was almost uniform, ranging from 5 to 6 (Figure 3). The water of Pengambang River was found to be acidic due to the influence of peat swamps. Pengambang river basin to become oil palm plantations has affected the leaching of organic carbon into the river, affecting the pH value. According to [16], washing peat swamps is a source of organic material in the waters of the Siak River. These organic materials will be broken down by microorganisms, and have an impact on increasing carbon dioxide in the waters and ultimately lowering the pH. This pH value is not much different from the pH of other Siak tributaries in Pekanbaru City, which is around 5-6 [18-19].

The Dissolved Oxygen ranges in Pengambang River varied from 2.5 to 5.8 mg/l (Figure 4). During the research sampling, the highest dissolved oxygen concentration was measured at Sta.1, located upstream, while the lowest was at Sta.3, at the mouth of the river confluence with the Siak River. Oxygen levels from upstream to downstream tend to decrease. The Pengambang watershed downstream is a peatland; most has changed into oil palm plantations. According to [20]. the conversion of land to plantations and the recent degradation of peatlands significantly affect the flux of dissolved organic carbon, water quality, and dissolved oxygen. Furthermore, carbon is leached from peat soils, rich in organic matter, and subsequent decomposition is a further process leading to low oxygen conditions [16]. The DO of the Pengambang River did not meet the quality standards (minimum 3 mg/l) (PPRI 22/2021), except in the river's upper reaches upstream. Dissolved oxygen in water is essential for all living organisms. Oxygen levels in waters below 2 mg/l disrupt the function of biological life and impact fish mortality [14].

The COD value in this observation fluctuated, but in the lower reaches of the river (Sta.3), it tended to be higher. The highest COD was found in the third sampling at Sta.3 (48 mg/l) (Figure 5). The high COD value is suspected from the Siak River because Sta.3 is located at the mouth of the river, so when the Siak River tides, water enters the Pengambang River. According to [21]. the COD concentrastion in the Siak River is relatively high, ranging from 51.76 to 80.62 mg/L. In addition, the source of COD also comes from domestic waste along the river. In general, COD at the study sites still met the standards (PPRI 22/2023, class III (50 mg/l). COD is often used as a measure of vulnerability oxidation of inorganic and organic elements available in water bodies [14].

The highest BOD value of Pengambang River is 14.4 mg/l at Sta.1 and the lowest is 8.75 mg/l at Sta.2 recorded in the second sampling (Figure 6). BOD at all observation stations has exceeded the established quality standard, which is 6 mg/l according to PPRI No.22/2023. This value indicates that the Pengambang River has been polluted by organic matter. Organic wastes directly raise the biological and chemical oxygen requirements in receiving waters. The outcomes are localized areas of oxygen depletion and the release of several trace elements due to the reduction of iron and manganese. Such effluents are frequently highly harmful to aquatic organisms. The presence of BOD in the waters of the Pengambang River comes from domestic waste, livestock waste and residential areas around the river.

Total phosphate (TP) concentration showed significant variation between sampling times. TP in Pengambang Rivers at all observation stations is lower than 1.00 mg/l, the recommended limit according to PPRI (2021) class III. A high maximum TP concentration was recorded at Sta.1 (0.3 mg/l), and a minimum concentration of TP at Sta. 3 (0.006 mg/l) (Figure 7). The highest TP at Sta. 1 is due to the influence of livestock waste at the observation site. Livestock manure disposal has a significant effect on the nutrient content of TP in runoff water [22]. In additional, high phosphate concentrations in waters indicate the presence of contaminants and cause eutrophication [14]. Eutrophication causes excessive growth of algae and aquatic plants. The overgrowth of aquatic plants that results from high concentrations of phosphate ions in shallow waterbodies gives rise to algal blooms. As a result, the water loses a lot of its dissolved oxygen. The amount of dissolved oxygen in the water body drastically decreases, which causes aquatic plants and animals to suffocate and die. The rotting of dead plants and animals lowers the quality of the water.

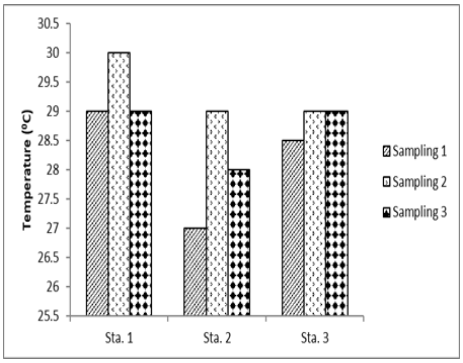

Fig. 1. Temperature

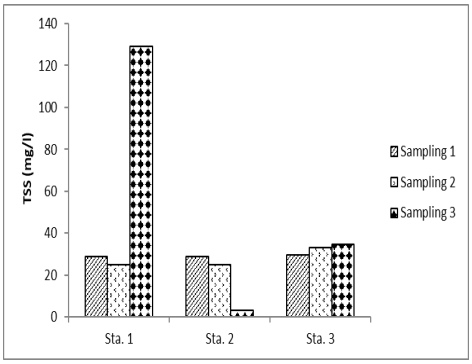

Fig. 2. TSS

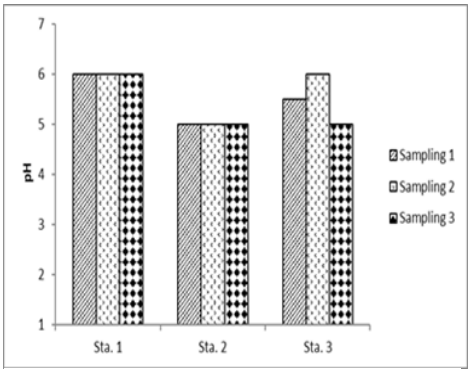

Fig. 3. pH

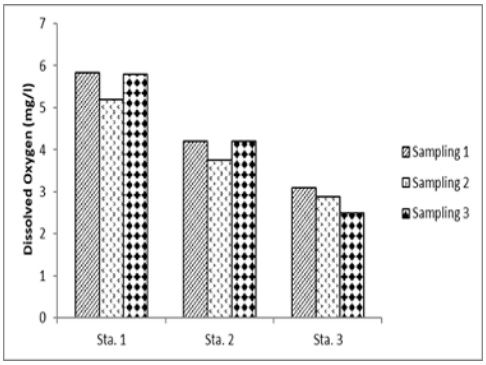

Fig. 4. Dissolved Oxygen

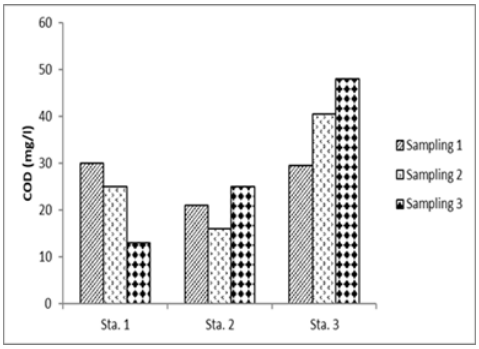

Fig. 5. COD

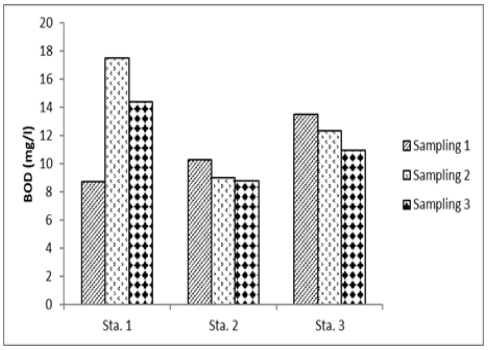

Fig. 6. BOD

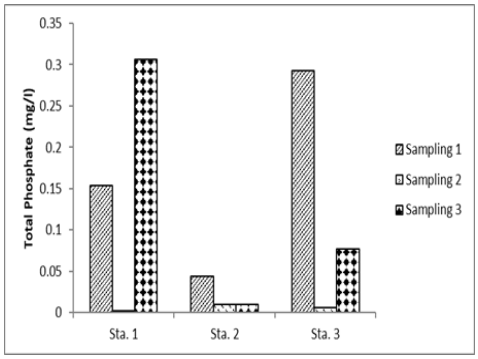

Fig. 7. Total Phosphate

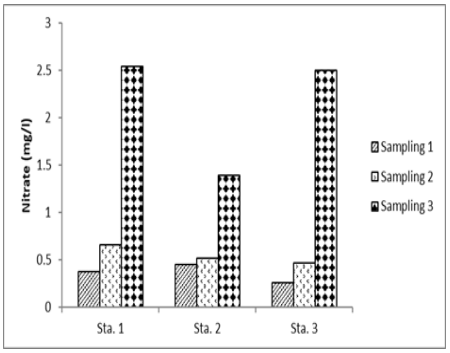

Fig. 8. Nitrate

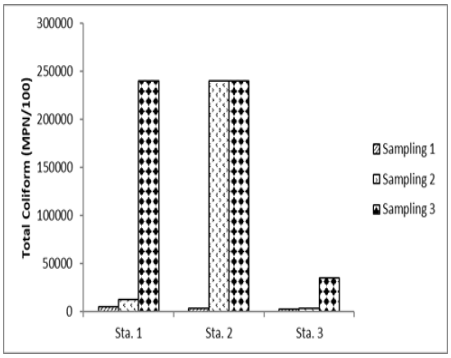

Fig. 9. Total Coliform

Figure 8 shows the nitrate values during the study at the Pengambang River. Nitrate fluctuated based on sampling, with the highest values recorded at Sta.1 and 3, 0.3 mg/l and 0.2 mg/l, respectively, during the third sampling. Nitrate values were higher in the third sampling at all research stations. The high value is due to the selection carried out after the rain so that the nitrate is carried along with the rainwater runoff. Nitrate concentration in the Pengambang River meets the quality standard according to PPRI (2023), which is 20 mg/l. Total coliform is a pathogen that is often found in river water in urban areas. The total number of coliforms during the study is presented in Figure 9. In all station points, the total coliforms in the Pengambang River fluctuated wildly, ranging from 2600 MPN/100 to 24,000 MPN/100 (Figure 9). The Total Coliform (TC) value no longer meets quality standards (PPRI 2023). Total Coliforms in river water are high in Sta.1 and Sta. 2, in residential and livestock areas. Therefore, this value shows that the Pengambang River has been polluted by total coliform bacteria originating from feces. An increase in TC may result in waterborne diseases and may affect water quality in the future [27]. Pathogens, including bacteria, parasites or viruses, can come from animals and humans. These microbes can enter water bodies from waste of animal and human agricultural and recreational activities [2]. Moreover, pathogens are difficult to identify their origins and routes of entry because they come from various sources. These sources include sanitary sewers, livestock, processing factory wastewater and agricultural activities. Pathogens can enter rivers from a variety of sources, but it is difficult to identify their routes and origins [16].

3.2 Pollution index (PI)

Table 3 shows the Pollution Index values in the Pengambang River. The results of the analysis of the water quality of the Pengambang River using the Pollution Index (PI) show that the Pengambangan River is categorized as lightly to moderately polluted, with a PI value ranging from 1.61 to 8.17. In the first sampling, the PI values were lower at all station points compared to the second and third sampling. The increase in PI values in the second and third sampling was due to the higher concentrations of BOD, nitrate, and Total Coliform in river water. The PI value is more elevated at Sta 1 on all sampling. This shows that the station is more polluted. The pollution originates from activities around the river, horse breeding, and human settlements. Overall, pathogenic organisms are present in all ecosystems, however, microbiological contamination, namely fecal bacteria originating from anthropogenic activities, is considered a crucial problem in rivers. Escherichia coli and fecal coliforms are monitored in the standard, and these parameters are expressed as fecal pollution indicators [2]. Coliform bacteria were found in lower numbers in the Puncang River (Indonesia) ranging from 0.014-920 MPN/100 ml. These bacteria come from domestic wastewater from residential areas, and agricultural and industrial activities. This value is below the PPRI 22/2021 guidelines. River water containing coliforms can threaten human health if the water is drunk without proper processing [24]. The results of the pollution index analysis reveal that Pengambang River water can not be used for cultivating freshwater fish, animal husbandry, and irrigating crops. Pengambang River is required to be adequately managed and conservation measures taken.

Table 3. Pollution index value in Pengambang River

Station Point	**Pollution Index (PI)**					
	Sampling 1	**Category**	**Sampling 2**	**Category**	**Sampling 3**	**Category**
Sta.1	2.14	Lighly Polluted	8.09	Moderately Polluted	8.17	Moderately Polluted
Sta.2	1.61	Lighly Polluted	2.67	Lighly Polluted	8.16	Moderately Polluted
Sta.3	1.70	Lighly Polluted	1.67	Lighly Polluted	5.10	Moderately Polluted

4 Conclusion

The water quality of the Pengambang River still meets the quality standards according to PPRI number 22 of 2023 class II, except for the BOD and Total Coliform parameters. The quality statute of Pengambang Rivers is classified as lightly polluted to moderately polluted with a pollution index value of 1.67 to 8.16. Pollution of the Pengambang River originates from domestic and livestock waste. Controlling pollution in the Pengambang River is done by managing domestic and livestock waste before it enters the river.

References

1. H. Effendi. The 2nd International Symposium on LAPAN-IPB Satellite for Food Security and Environmental Monitoring 2015, LISAT-FSEM. Procedia Environmental Sciences **3**, 562-567 (2016)
2. WHO (2016). https://www.who.int/water_sanitation_health/publications/pswh-160830.pdf
3. N.T. Anh, L.D. Can, N.T. Nhan, B. Schmalz, T. Le Luu. Case Studies in Chemical and Environ. Engineering, **8**
4. Y. Chen, K. Yu, M. Hassan, C. Xu, B. Zhang, K.Y.-H. Gin, Y. He.Ecotoxicol. Environ. Saf **166,** 320-327 (2018)
5. E. D. Gerónimo, V.C. Aparicio, S. Bárbaro, R. Portocarrero, S. Jaime, J.L. Costa. Chemosphere, **107** (2014), pp. 423-431
6. M. Camara, N.R. Jamil, A.F.B. Abdullah. Ecol. Process. **8,** 10 (2019)
7. A. Suriadikusumah, M. Oviyanti, S. Rija, S.T. Emma, M.R.H. Muhammad, M. Asep. Acta Ecologica Sinica, 1-6 (2020)
8. I.P. Santikayasa, M.S. Babel, S. Shrestha, D. Jourdain, R.S. International Journal of Sustainable Development and World Ecology, **21**, 2 (2014)
9. D. Marganingrum, D. Roosmini, P. Pradono, A. Sabar, Diferensiasi Sumber Pencemar Sungai Menggunakan Pendekatan Metode Indeks Pencemaran
10. S. Al'ayubi, C. P. Pulungan, Windarti. Jurnal Online Mahasiswa. http://jom.unri.ac.id.(2014).
11. Muthia Anggrainia, Virgo Trisep Harisb , Alfian Salehc. Mattawang: Jurnal Pengabdian Masyarakat. 4(1) (2023)
12. PPRI. Peraturan Pemerintah Republik Indonesia Number 22, (2021)
13. F.H Hauer, Hill, WR. 2007. *Temperature, Light and Oxygen*. Di dalam: Hauer F.C dan Lamberti GA, Editors. *Methods in Stream Ecology.* China. 103-108.
14. D. Chapman, V. Kimstach. 1996. Selection of Water Quality Variables. Di dalam: Chapman D, Editor. Water Quality Assessments - A Guide to Use of Biota, Sediments and Water in Environmental Monitoring. London (IO): WHO. Ed ke-2.
15. P.K. Pandey, P.H. Kass, M.L. Soupir, S. Biswas, V.P. Singh. Amb. Express, 4 (2014), p. 51T.
16. T. Rixen, A. Baum, H. Sepryani, T. Polhmann, C. Jose, J. Samiaji. Journal of Environmental management*,* **91**, 1730-1737.
17. Y. Yuliati, E.Sumiarsih, Efawani, EnviroScienteaea. **8**,1 (2022).
18. Y. Yuliati, E.Sumiarsih, Efawani, I. Mulyani Depik. **12**, 2 (2023)
19. C. Jennerjahn, A. Baum, A. Damar, M.Flitner, J.Heyde, I. Jänen , M.C. Lukas, M.Luk man, M.S Nugrahadi, T. Rixen, J.Samiaji, F.Schroeder. SPICE 45-82. (2022)
20. Yuliati. Y., E. Riani, B.P.N. Pramudya, A. Fahrudin. Akuatika, 13(1):66-772017.
21. A. Singh, J. R. Bicudo, S.R. Workman. **99**, 18, (2008)
22. Y. Chen, K. Yu, M,Hassan, C.Xu, B. Zhang, K.Y.H. Gin, Y. He. Ecotoxicol. Environ. Saf., **166**, 320-327 (2018)
23. A. E. Rivera, A. D. Fonseca, S. T. Mora, W.A. G Suastegui, E. C. Bravo, R. C. Vega, J.L.M. Perales, A. H. Silva. Sustainability, **14**, 667 (2022)
24. P.K. Pandey, P.H. Kass, M.L. Soupir, S. Biswas, V.P. Singh. Amb. Express, **4**, 51 (2014),

25. Keputusan Menteri Negara lingkungan Hidup Nomor 27 Tahun 2021 tentang Pedoman Penentuan Status Mutu Air.
26. D. Vinueza, V. Ochoa
Herrera, L. Maurice, E. Tamayo, L. Mejía, E. Tejera, A. Machado. Sci. Rep., **11** (2021)
27. P. Whitehead, G. Bussi, M. A. Hossain, M. Dolk, P. Das, S. Comber, R Peters, K.J. Charles, R. Hope, S. Hossain. Science of the Total Environ, **631-632** (2018)