

ANALYSIS OF WATER QUALITY AND CAPACITY OF THE PEGIRIAN RIVER, SURABAYA USING THE QUAL2KW METHOD

Verina Himmatuha Fissuroyya¹, Rr Diah Nugraheni Setyowati¹, Sulistiya Nengse¹, Abdul Hakim¹

¹Department of Environmental Engineering, Faculty of Science and Technology, Sunan Ampel State Islamic University, Surabaya, Indonesia

*Corresponding author
himmaverina@gmail.com

Abstract

Pegirian River is a tributary of the Kalimas River from Undaan street which empties into the Tambak Wedi sluice gate. The results of the BLH Surabaya laboratory analysis in 2015 showed that the BOD concentration in the Pegirian River throughout the year did not meet quality standards. This study intends to evaluate water quality based on physical, chemical and biological parameters applying the Qual2Kw model; to assess water quality status by applying data from STORET; and to determine the capacity of the Pegirian River. Samples were taken from four locations in the morning and evening with the parameters tested being temperature, TSS, pH, BOD, COD, DO, PO₄, NH₃, and E coli. Based on modeling with Qual2Kw, the quality of the Pegirian River in simulation 1 (existing) shows that the BOD, phosphate, amonia and E coli parameters have exceeded class IV river quality standards, thus indicating that the quality of the Pegirian River is polluted. For simulation 2 (prediction for 2029) only the BOD parameter exceeds class IV river quality standards. Simulations 3 (self purification) and 4 (capacity capacity) are still in line with class IV river quality standards for all parameters. The water quality status of the Pegirian River according to the STORET method obtained a total score of -47.75 which indicates a heavily polluted status. Pegirian River has a capacity for TSS, BOD, COD, phosphate, amonia and E coli parameters.

Keywords: Water Quality, Model, Qual2Kw, STORET, Load Capacity



This work is licensed under a [Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License](https://creativecommons.org/licenses/by-nc-sa/4.0/)

1. INTRODUCTION

Every daily human activity produces waste, both in small and large quantities. One of the common environmental issues is the discharge of large amounts of liquid waste, both from domestic and industrial activities. Poor management of liquid waste can have a negative impact on the quality of the surrounding waters [1]. Pegirian River is a branch of the Kalimas River which starts from Undaan street and empties into the Tambak Wedi sluice gate. with a length of about 8 km. Surabaya City Environmental Agency (2015) explains that the Pegirian River is a river that is included in the Class IV river category and is intended as irrigation water. This means that the results of laboratory analysis show that the Pegirian River has BOD levels that exceed water quality standards throughout the year. The cause is because it is contaminated by various pollutant sources, including housing, small and medium businesses, public buildings, health facilities, educational institutions, livestock and workplaces. If this waste is not managed properly before being discharged into the river, it can cause high levels of pollution and potentially affect the water quality in the Pegirian River.

Based on the problems that have been mentioned, steps are needed to reuse the Pegirian River water so that it fits its function as irrigation water. The STORET method [2] can be used to investigate the impact of

domestic waste pollution on water quality. Water quality is also determined by the river's capacity to receive input pollution loads without causing pollution to the water. Based on Minister of the Environment Regulation No.1 of 2010 it is recommended to use the Qual2Kw.5.1 version of the software which was upgraded by the United States Environmental Protection Agency (USEPA) [3].

This explanation provides interest for researchers to study the use of the Qual2Kw model on the Pegirian River using the following parameters: temperature, acidity level (pH), Total Suspended Solid (TSS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), phosphate, ammonia, and E coli bacteria. The selection of these parameters is based on the main pollutants that affect the Pegirian River, namely domestic waste, hospital waste, market waste and livestock waste.

2. METHOD

This study is a quantitative study. This study was carried out from February to June 2024. The location of this research was the Pegirian River, Surabaya City. The water sampling points are divided into 4 sampling points starting from Genteng District, Simokerto District, Semampir District, and Bulak Banteng District. River water quality testing was carried out at two locations, namely at the insitu study location (pH, temperature, and DO) and testing at the Bangil Fish and Environmental Health Laboratory UPT, Pasuruan (TSS, BOD, COD, phosphate, ammonia, and E bacteria coli). This study was carried out taking samples twice, namely in the morning and evening with one repetition using the instantaneous sampling method (grab sample). The following is the segmentation determination for the Pegirian River:

Table 1. Research Segmentation

Location	Point	Distance	Segmentation	Length (km)	Coordinat
Undaan bridge	upstream	8.02	S1(upstream-T1)	3.47	-7.255467 ⁰ LS 112.743430 ⁰ BT
Ampel bridge	T1	4.55	S2(T1-T2)	2.08	-7.227534 ⁰ LS 112.745882 ⁰ BT
Ujung 13 state elementary school bridge	T2	2.47	S3(T2-T3)	2.47	-7.213654 ⁰ LS 112.751663 ⁰ BT
Tambak Wedi sluice gate	T3	0			-7.206279 ⁰ LS 112.771851 ⁰ BT

Source: Observation Results, 2024

The data contained in the Qual2Kw program worksheet are: hydraulic data, data on discharge and quality of the Pegirian River, climatology data, data on waste water from diffuse sources of pollution. After data input, the calibration process is carried out by trial and error with the aim of obtaining model validation. The validation model used is RMSE (Root Mean Square Error). The formula for RMSE is [4]:

$$RMSE = \left(\frac{\sum (y_i - \hat{y}_i)^2}{n} \right)^{\frac{1}{2}} \dots \dots \dots 1)$$

Information:

y_i : Observation value

$\hat{y}_i$: Model value

n : Number of samples

Simulations are carried out after the model is calibrated and validated. The following are some of the simulations applied in this study:

Table 2. Simulation

Simulation	Water Conditions Upstream	Pollutant Sources	River Water Conditions
1	existing	existing	Model
2	existing	Estimated year 2029	Model
3	Class IV Water Quality Standards	Initial Conditions	Model

Simulation	Water Conditions Upstream	Pollutant Sources	River Water Conditions
4	Class IV Water Quality Standards	Trial and Error	Class IV Water Quality Standards

Source: [5]

The assessment of the capacity of the Pegirian River to bear the maximum amount of waste that can be discharged into it is carried out through an evaluation of the pollution load. This evaluation is based on simulation results to determine the capacity. The formula used to calculate capacity is [6]:

Pollution load capacity= Full Pollutant Load (according to quality standards) – initial condition load.....2)

3. RESULTS AND DISCUSSION

3.1. Qual2Kw Modeling

The impact estimation parameters using the Qual2Kw program are as follows:

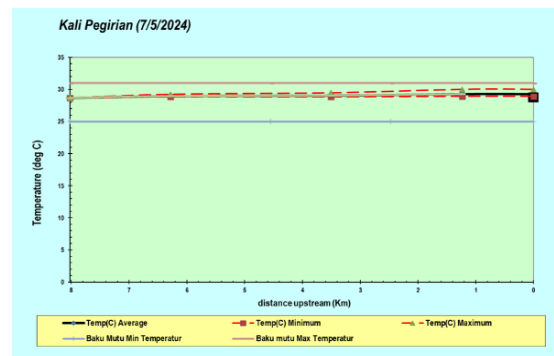


Figure 1. Temperature Profile
Source: Qual2Kw, 2024

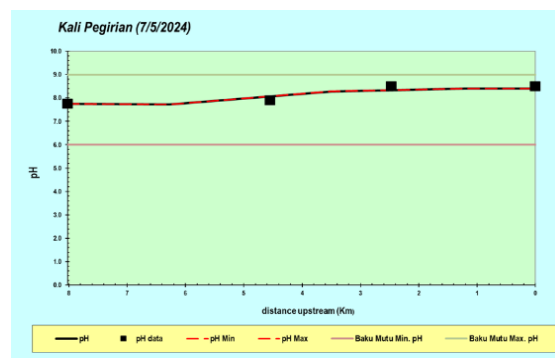


Figure 2. pH Profile
Source: Qual2Kw, 2024

The black line represents the average model data for the Pegirian River, the black box depicts the existing data for the Pegirian River, and the dotted red line shows the maximum and minimum model data for the Pegirian River. Figure 1 shows that the temperature parameter is in the value range 28.7 to 29.3. However, the temperature value is almost close to the maximum water temperature limit, namely at deviation 3 with values of 25⁰C and 31⁰C. This happened because sample testing was carried out during the summer. Changes in water temperature can be influenced by human activities and climate factors [7]. Water temperature is a supporting factor for bacterial life because it is related to their metabolic processes. Good temperature values can promote bacterial growth [8]. Figure 2 modeling results depict pH values ranging from 7.72 to 8.4. This data illustrates the stability of the pH value which meets class IV quality standards. Aquatic organisms are very susceptible to

changes in pH, as well as inappropriate pH conditions [9]. In addition, there is a significant relationship between temperature and pH because increasing temperature can increase the rate of chemical reactions in water, including acid-base reactions. As a result, the pH of the water will increase with increasing temperature [10].

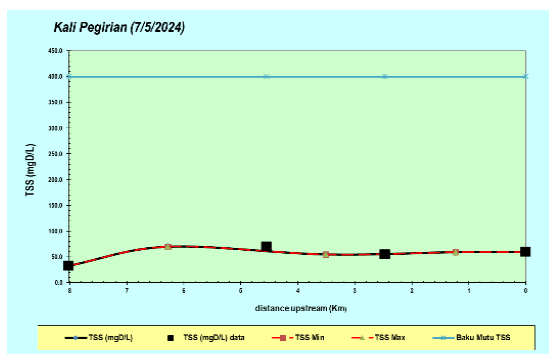


Figure 3. TSS Profile
Source: Qual2Kw, 2024

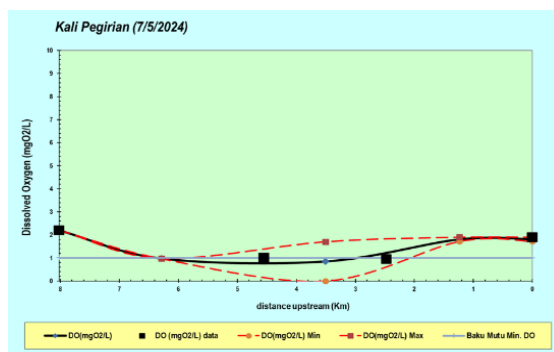


Figure 4. DO profile
Source: Qual2Kw, 2024

Figure 3 shows the TSS value model in the range of 33–59.49 mg/L which can be categorized as class III water quality standards. According to field observations, a lot of waste is released into water bodies. Apart from that, domestic waste also influences changes in water quality. However, the low TSS value shows that Pegirian River water can carry out a good self-purification process which reduces pollutants on a regular basis. Low TSS concentrations indicate a high abundance of phytoplankton. TSS concentration affects the number of phytoplankton because increasing TSS can block the penetration of sunlight into waters [11]. Figure 4 depicts the DO value at the Pegirian River. The DO value shows the closeness of the model to existing data. At the headwater point which is 8.02 km away with a DO value of 2.2, segment 1 at a distance of 6.29 km with a DO value of 0.98, segment 2 at a distance of 3.51 km with a DO value of 0.85, and segment 3 at a distance of 1.24 km with a DO value of 1.81. When the DO value is low, it indicates that there is pollution in the water which can inhibit the growth of aquatic biota. On the other hand, a high DO value indicates sufficient total oxygen in the water body, which indicates good water quality to support the growth of aquatic biota [12].

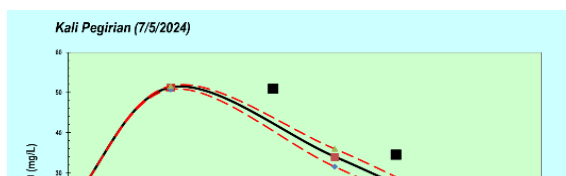


Figure 5. BOD Profile
Source: Qual2Kw, 2024

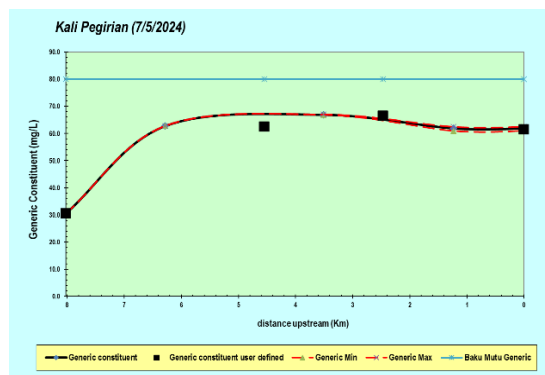


Figure 6. COD profile
Source: Qual2Kw, 2024

Figure 5 shows the simulated BOD value ranging from 19.85–51.35 mg/L. In segment 1, the BOD value increased due to the presence of domestic waste which had been mixed with market waste, hospital waste and slaughterhouse waste. Most organic waste is the result of oxidation by microorganisms, so that when this waste is discharged into waters, the BOD increases, which causes a reduction in the availability of dissolved oxygen in the water. This illustrates the high level of organic pollution in the Pegirian River. Figure 6 COD trend line (model) has approached existing data and still meets class IV quality standards. The simulated values are in the range 30.5–66.92 mg/L. In segment 2, the COD value increases because many settlements living on riverbanks dispose of their waste directly into water bodies, thereby affecting changes in the water quality of the Pegirian River. The relationship between COD and BOD parameters is that the higher the BOD value, the higher the COD value produced. This is because COD represents the total oxygen needed to decompose all types of organic materials, both those that are easy and difficult to decompose [13].

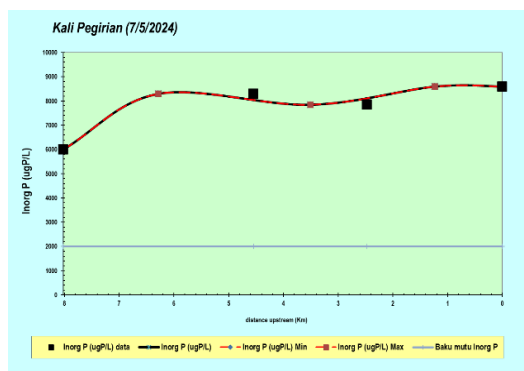


Figure 7. PO₄ Profile

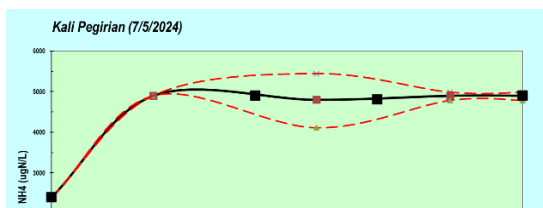


Figure 8. NH₃ profile
Source: Qual2Kw, 2024

Figure 7 simulated phosphate values are in the range of 6-8.6 mg/L. This value has exceeded the specified quality standards. In segment 1, the phosphate concentration shows a high value due to domestic activities, hospitals, livestock and other activities that contain phosphate. The highest phosphate value is found in segment 3 because the phosphate content contains detergent which is discharged directly into the river and the presence of the Tambak Wedi pump house which makes the river produce large amounts of foam. River water polluted by waste from three tributaries is sucked in by a high-pressure pump at a pumping station, then discharged, resulting in the appearance of foam on the surface of the river [14]. Figure 8 illustrates that the ammonia value is in the range of 4.8-4.9 mg/L. The simulation results of the ammonia value have exceeded the specified quality standards. The results of the model simulation illustrate that there is a significant increase in ammonia concentration in segment 1. This shows that there is disposal of feces and urine waste in animals and humans originating from livestock waste and domestic waste. Excessive amounts of ammonia can cause physiological and respiratory disorders, which in turn inhibit the photosynthesis process [15]. In waters that have not been properly degraded, increasing ammonia levels result in a nitrification process by bacteria which reduces oxygen levels, thereby damaging river ecosystems [16].

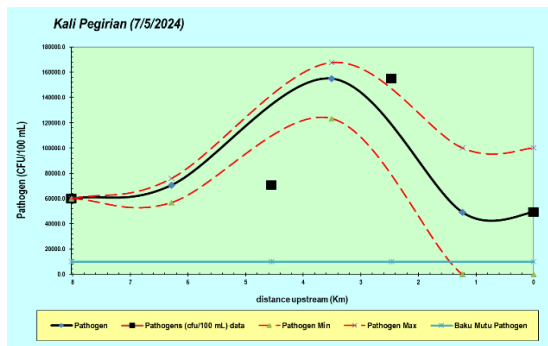


Figure 9. E coli Profile
Source: Qual2Kw, 2024

Figure 9 depicts a 1 parameter simulation of E coli. The simulation results are in the value range of 60000 to 155001 CFU/100 mL. The simulation results have exceeded the specified quality standards. Segment 1 shows an increase in E coli values due to domestic hospital waste containing pathogenic bacteria, namely bacteria that spread disease. In segment 2, the model experienced a significant increase due to the presence of domestic waste from residential areas around the river. This bacteria comes from the human digestive tract, so its presence in waters shows that human activities on land do not pay attention to environmental sustainability, which results in waste entering rivers [17].

3.2. STORET method

Based on the assessment using the STORET method, the scoring system can determine the water quality status of the Pegirian River. The following is a pollutant classification table presented in Table 3 below:

Table 3. Water Quality Status Results of the STORET Method

Calculation	Results,	Sampling point	Score	Category	2024	Source:
		1	-45	heavily polluted		
		2	-45	heavily polluted		
		3	-55	heavily polluted		
		4	-46	heavily polluted		
		Average Score	-47.75	heavily polluted		

Based on Table 3, it shows that the average score obtained heavily polluted status. The main factors that play a role in water pollution in the Pegirian River are the parameters of temperature, pH, BOD, DO, phosphate, ammonia and E coli. The STORET method relies heavily on biological parameters because the highest scores are found on biological parameters [18].

3.3. Pollution Load Capacity

The calculation of the water pollution storage capacity of the Pegirian River takes into account the differences in results between simulation 4, which shows the maximum pollution load, and simulation 3, which shows the load without pollutants. Pollution storage capacity is calculated by multiplying the water discharge by the pollutant concentration recorded in the source summary for each simulation. The following is the calculation of the capacity of the Pegirian River which is presented in Table 4 below:

Table 4. Capacity Calculation Results

Reach Label	TSS (kg/day)	BOD (kg/day)	COD (kg/day)	PO ₄ (kg/day)	NH ₃ (kg/day)	E coli (kg/day)
Segment 1	4.713	0.200	2.173	0.020	0.003	239.832
Segment 2	2.020	0.086	0.931	0.009	0.001	102.785
Segment 3	4.377	0.186	2.018	0.019	0.003	222.701

Source: Calculation Results, 2024

According to data from Table 4, the pollution storage capacity of the Pegirian River shows a positive value. This is caused by the river's self-purification process, which involves reaeration to reduce the concentration of pollutants in the water. As a result, oxygen can dissolve into the water more quickly. The maximum capacity is in segment 1 and the minimum capacity is in segment 2.

4. CONCLUSION

In simulation 1 (current), temperature, pH, TSS, DO, and COD still comply with water quality standards for class IV rivers, but BOD, phosphate, ammonia, and E. coli have exceeded standard limits, indicating the level of pollution in the Pegirian River. In simulation 2 (prediction for 2029), only the BOD parameter exceeds the standard limit for class IV rivers. Simulations 3 (self purification) and 4 (for capacity) still meet class IV river quality standards for all parameters. The water quality status of the Pegirian River according to the STORET method obtained a total score of -47.75 which indicates a heavily polluted status. Pegirian River has a capacity for TSS, BOD, COD, phosphate, ammonia and E coli parameters. The maximum capacity is in segment 1 and the minimum capacity is in segment 2.

REFERENCES

- [1] F. Y. Monica, "Identifikasi Daya Tampung Beban Pencemar Dan Kualitas Air Sungai Lesti Sebelum Pembangunan Hotel Gold Miami Di Desa Ngaglik Kota Batu, Jawa Timur," Skripsi Program Studi Teknik Lingkungan Jurusan Keteknikan Pertanian Fakultas Teknologi Pertanian Universitas Brawijaya, pp. 1-90, 2019.
- [2] KepMenLH115 Tahun 2003, Keputusan Menteri Negara Lingkungan Hidup Nomor: 115 Tahun 2003 Tentang Pedoman Penentuan Status Mutu Air. Jakarta: Menteri Lingkungan Hidup.
- [3] N. Hendrasarie and I. D. A. Swandika, "Resistance of Loading Loads in Surabaya River and Its Branch with Qual2KW Model," *J. Phys. Conf. Ser.*, vol. 1569, no. 4, p. 042096, Jul. 2020, doi: 10.1088/1742-6596/1569/4/042096.
- [4] M. L. Ashari and M. Sadikin, "PREDIKSI DATA TRANSAKSI PENJUALAN TIME SERIES MENGGUNAKAN REGRESI LSTM," *J. Nas. Pendidik. Tek. Inform. JANAPATI*, vol. 9, no. 1, p. 1, Apr. 2020, doi: 10.23887/janapati.v9i1.19140.
- [5] L. Maghfiroh, "Penentuan Daya Tampung Beban Pencemaran Sungai Kalimas Surabaya (Segmen Taman Prestasi-Jembatan Petekan) Dengan Pemodelan Qual2Kw," Tugas Akhir Jurusan Teknik Lingkungan Fakultas Teknik Sipil Dan Perencanaan Institut Teknologi Sepuluh Nopember, pp. 1-177, 2016.

- [6] N. A. Febriyana, "Identifikasi Daya Tampung Beban Pencemaran Air Kali Surabaya Segmen Tambangan Cangkir – Bendungan Gunungsari Dengan Pemodelan Qual2kw," Tugas Akhir Jurusan Teknik Lingkungan Fakultas Teknik Sipil Dan Perencanaan Institut Teknologi Sepuluh Nopember, pp. 1-97, 2016.
- [7] D. Chen, M. Hu, Y. Guo, and R. A. Dahlgren, "Changes in river water temperature between 1980 and 2012 in Yongan watershed, eastern China: Magnitude, drivers and models," *J. Hydrol.*, vol. 533, pp. 191–199, Feb. 2016, doi: 10.1016/j.jhydrol.2015.12.005.
- [8] N. A. Lubis, S. Nedi, and I. Effendi, "Level of Water Pollution Based on Organic Material Parameters and Number of Bacteria Escherechia coli in Dumai River Estuary, Dumai City," vol. 2.
- [9] H. Irawati, E. Weliyadi, and D. Maulianawati, "Analysis of Water Quality Status in Sesayap River of Malinau Regency Using Storet Method," vol. 5, no. 1.
- [10] Y. Yolanda, "Analisa Pengaruh Suhu, Salinitas dan pH Terhadap Kualitas Air di Muara Perairan Belawan," *J. Teknol. Lingkung. Lahan Basah*, vol. 11, no. 2, p. 329, Jul. 2023, doi: 10.26418/jtllb.v11i2.64874.
- [11] A. R. M. D. Oliveira, A. C. Borges, A. T. Matos, and M. Nascimento, "Estimation On The Concentration Of Suspended Solids From Turbidity In The Water Of Two Sub-Basins In The Doce River Basin," *Eng. Agric.*, vol. 38, no. 5, pp. 751–759, Sep. 2018, doi: 10.1590/1809-4430-eng.agric.v38n5p751-759/2018.
- [12] V. R. A. Katili, K. Koroy, and M. Lukman, "Water Quality Based on Chemical Physics Parameters in Daruba Morotai Island Regency," *Agrikan J. Agribisnis Perikan.*, vol. 13, no. 2, pp. 413–418, Dec. 2020, doi: 10.29239/j.agrikan.13.2.413-418.
- [13] E. Nuraini, T. Fauziah, and F. Lestari, "Penentuan Nilai Bod Dan Cod Limbah Cair Inlet Laboratorium Pengujian Fisis Politeknik Atk Yogyakarta," *Integrated Lab Journal*, vol. 7, no. 2, pp. 10-15, Oct. 2019, doi: 10.5281/ZENODO.3490306.
- [14] S. R. Febriani, "Analisis Kebijakan Penanganan Pencemaran Limbah Cair di Sungai Kalisari Damen Kota Surabaya," Jun. 2023, doi: 10.5281/ZENODO.8024474.
- [15] S. D. Ramadhani and M.R.T. Laksani, "Analisis Uji Kualitas Air di Sungai Kalidami, Kota Surabaya," *Environ. Pollut. J.*, vol. 4, no. 1, pp. 883–894, Apr. 2024, doi: 10.58954/epj.v4i1.170.
- [16] E. N. Aprillina, S. W. D. Kusumawardani, and I. W. Abida, "SEBARAN KANDUNGAN AMONIA (NH₃) DI ALIRAN SUNGAI DESA PEJAGAN, KABUPATEN BANGKALAN," Seminar Ilmiah Nasional Fakultas Perikanan dan Ilmu Kelautan Universitas Muslim Indonesia, vol. 3, pp. 68-76, 2023.
- [17] N. F. Afianti, "Kondisi Pencemaran Lingkungan Berdasarkan Parameter Mikrobiologis di Sekitar Muara Sungai Cilandiri, Teluk Pelabuhan Ratu, Jawa Barat," vol. 37, no. 3, 2020.
- [18] M. F. Aminullah, " Perbandingan Status Mutu Air Dengan Menggunakan Metode Indeks Pencemaran, Storet, Ccmewqi, Dan Bcwqi Di Kali Surabaya Segmen Karang Pilang," *Tugas Akhir Program Studi Teknik Lingkungan Fakultas Sains Dan Teknologi Universitas Islam Negeri Sunan Ampel Surabaya*, pp. 1-122, 2022.