Jurnal Presipitasi
Media Komunikasi dan Pengembangan Teknik Lingkungan
e-ISSN: 2550-0023

Vol 19, No 2, 2022, 208-221
Article available at homepage presipitasi

Regional Case Study

The Use of Qual2KW to Analyze the Concentration of pH, Nitrate, Phosphate, and Fecal Coliform on Water Quality: A Case Study of the Klampok River, Semarang Regency

Winardi Dwi Nugraha[1,2], Sudharto Prawata Hadi[1], Setia Budi Sasongko[1,3], Adranandini Noor Anisa[4], Mochamad Arief Budihardjo[2*]
[1]Doctoral Program of Environmental Sciences, Universitas Diponegoro, Indonesia
[2]Department of Environmental Engineering, Universitas Diponegoro, Semarang, Indonesia
[3]Departement of Chemical Engineering, Universitas Diponegoro, Indonesia
[4]Master Program of Environmental Engineering, Universitas Diponegoro, Semarang, Indonesia
* Corresponding author: E-mail: m.budihardjo@ft.undip.ac.id

Abstract
Usually, the main source of water is a river, which makes it essential to ensure that the water from that source is not polluted and in accordance with the water quality standards. Water quality can deteriorate as a result of domestic and industrial waste. This quality is measured based on several parameters, such as the concentration of pH, nitrate, phosphate, and fecal coliform in the water. QUAL2KW can be used to analyze river water quality in order to solve several water quality-related problems. The main river water source in Semarang Regency is the Klampok River, whose water is used to support agriculture, livestock, and other activities. This study aims to determine the concentration of the above-mentioned parameters in the samples from the Klampok River using QUAL2KW. The water samples are obtained from different six points on the Klampok River, and the chi-square test is used for validation. From the laboratory test results for the river-quality parameters, after being simulated using QUAL2KW and validated using the chi-square method, it can be concluded that the quality of the Klampok River belongs to class II. These results can be used as a reference by the Semarang Regency government in managing river water quality.

Keywords: Parameters; Qual2KW; river; water quality

1. Introduction

Water is one of the sources for the sustenance of human life (Paul, 2017), and rivers are one of the main sources of our need for clean water. Thus, the quality of the river water must be in accordance with the applicable quality standards. Human activities affect the quality of water. Activities such as industrial activities, which produce industrial waste, and household activities, which produce domestic and various other wastes, can cause water quality degradation (Egbueri, 2018). Although human activities have a positive impact on the economy (Liu et al., 2020). they can deteriorate the quality of river water. Thus, the greater the level of human activity, the greater the possibility of water pollution.

Water quality parameters generally represent the pollution level due to organic matter in river water, namely Biochemical Oxygen Demand (BOD) (Chen et al., 2012). High concentrations of organic substances in waters can result in a decrease in Dissolved Oxygen (DO). Low DO levels in waters disrupt aquatic ecosystems because there is no oxygen to survive living things in the seas. Rainwater runoff causes the existing sediment to be eroded (Loi et al., 2022). Domestic wastewater originating from household waste and livestock waste is the primary source of high organic pollutants and nutrients (Malaj et al., 2014). Thus, monitoring water quality regular is very important for controlling pollution in rivers. Monitoring will provide location and time data to identify areas where pollution or water quality has decreased (Loi et al., 2022). Liquid waste made from chemicals from industry is also dangerous if it enters the waters (Bisimwa et al., 2022). A total of 350,000 known chemicals and 70,00 unknown chemicals have been produced and are commonly used, according to research by Wang et al., (2020). Chemicals that enter the aquatic environment, such as solid waste, liquid waste, and gas emissions, are hazardous pollutants.

In Semarang Regency, the main source of clean water is the Klampok River. This river flows from Sidomukti Village, Bandungan District to Pringapus Village, Pringapus District. The Klampok River is part of the Jragung watershed. Communities around the river use the water for irrigation, drinking, bathing, and cleaning purposes. Considering these activities, the possibility of rivers being polluted is also very high. Therefore, there should be a water-monitoring station that is in charge of assessing how the transportation of pollutants into the river water (Wang et al., 2019). There are several types of river water pollutants, such as industrial, agricultural, domestic, and tourist wastes (Lee et al., 2021; Leng et al., 2021; Mokarram et al., 2020).

These types of pollutants can affect the river water quality, which can impact river classification. The classification of water quality standards for each concentration of river water is divided into class I, class II, class III, and class IV (Anonymous, 2021). With the development of technology, many models and software have been proposed for managing water quality. One of these innovations is the QUAL2KW software developed by the United States Environment Protection Agency (USEPA).

Antunes et al. (2018) used QUAL2K to calculate water quality standard violations in the application of social rules. Allam et al. (2016), on the other hand, utilized QUAL2KW to analyze water quality for reusing agricultural drainage water. Some of the reasons for choosing this software is its ability to consider the effect of point and non-point pollutant loads in water bodies and to simulate the transformation and migration of various parameters such as pH, nitrate, phosphate, and fecal coliform.

However, there is still no study in the literature that discusses the use of the QUAL2KW software for high concentration of fecal coliform in the Klampok River is an indicator of the need to build proper sanitation facilities Thus, this study aims to identify the correlation between pollutant load and human activities around the Klampok River by analyzing water samples collected from six different river points for parameters such as pH, nitrate, phosphate, and fecal coliform and assessing the results using QUAL2KW. The study results will show the relationship between parameter concentrations in the Klampok River.

2. Methods

2.1 Study Area

The Klampok River is located in Semarang Regency, Central Java, at 110°20'45,528" – 110°33'24,882" East Longitude and 7°11'12,513" – 7°8'27,491" South Latitude. The river passes through four sub-districts and 22 villages. It covers an area of 3,669.92 Ha, with the main river length being 16 km and the average depth being 0.275 m.The Klampok River is used as the main source of water to meet the requirements for local community activities such as drinking water, bathing, laundry, and irrigation.

The maximum elevation of the Klampok River is 1010 m, while the minimum is 359 m. The surrounding conditions of the upstream river are agricultural settlements with quite steep slopes. While in the downstream part, the lands are residential, agricultural, industrial, and tourism with gentle slopes.

Water sampling was conducted at six different stations that were divided based on the division of the watershed sub, land use, topography, physical conditions of the river, and administrative boundaries. The average rainfall and rainy days in the Semarang Regency area in 2020 were 2,587 and 127 days, respectively. The potential points of pollution in the Klampok River were located at stations 1, 2, 5, and 6, with each station having a different use. For example, station 1 is mostly used for agriculture. Meanwhile, at station 2, some of the lands are used for residential purposes, resulting in domestic waste. While at stations 5 and 6, pollution is caused by textile waste.

Table 1. Sample station condition

Station	Initial elevation(m)	Final elevation (m)	Length between points (m)	River width (A) (m)	Cross-sectional area (m^2)	Flow speed (m/s)	Flow (m^3/s)
1	1010	932	605.49	2.4	0.144	0.1	0.0144
2	932	774	1332.97	6.84	4,241	0.1	0.4241
3	774	609	2897.01	5.1	1,632	0.6	0.9792
4	609	513	3848.66	6.4	3,551	0.3	107.535
5	513	426	3768.78	7.02	16,943	0.2	1,268
6	426	359	3612.72	12.25	3,717	0.4	1,487

The effluents from this textile waste usually have high organic content, intense color, and high toxicity (Xue et al., 2019). At station 5, there are seven textile industries, while at station 6, four out of five industries are textile industries. Textile waste releases various kinds of chemicals as a result of production processes, including high pH, turbidity, complex composition, and other factors (Watari et al., 2021). Mathew et al. (2019) explained that green-fiber, known as a natural synthetic polymer composite material, can be used as a modification of filtration and adsorption in wastewater treatment in the textile industry. Another study conducted by Sandoval et al. (2020) showed the reprocessing of wastewater from the agricultural industry as an adsorbent for heavy metals in water bodies. Meanwhile, nanoparticles are being increasingly used as an adsorbent in industrial wastewater treatment (Kumari et al., 2019).

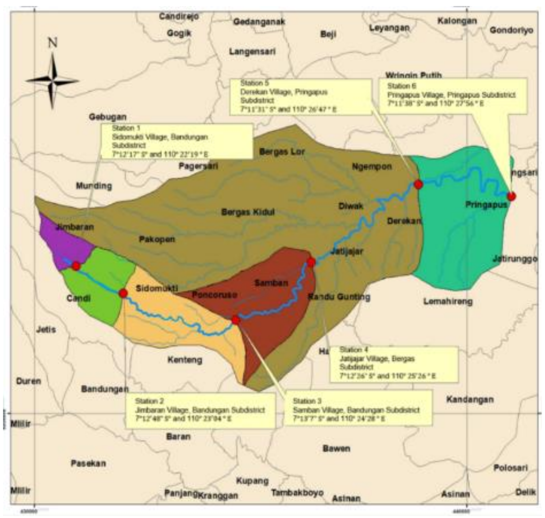

Figure 1. Sampling station map

2.2 Field Data and Historical Water Quality

The sample will be taken from six points, namely Sidomukti Village, Samban Village, Jatijajar Village, Derekan Village, and Pringapus Village. The points in the rivers with the potential for pollution are stations 1, 2, 5, and 6. Land use for agriculture and animal husbandry accounts for 83% of the activities at station 1. Station 2 is predominantly occupied by settlements. Pollution occurring in residential areas is caused by fecal coliform bacteria that enter waterways through rainwater runoff and sewage overflows (Zhang et al., 2021). While at stations 5 and 6, the source of river water pollution is liquid waste generated by the textile industry around the stations. The following is the data in Table 2, which shows the land use around the Klampok River. Station 4 is ranked first with a high residential area, and the main industry there is the garment industry.

Table 2. Land use around Klampok River

Station	Agriculture	Urban	Forest/Garden	Industry	Others	Information
Station 1	83%	17%	-	-	0,01%	
Station 2	15%	77%	8%	-	-	Hotel Area
Station 3	53%	21%	26%	-	-	Hotel Area
Station 4	49%	22%	29%	-	-	Garment Majority
Station 5	58%	20%	22%	-	0,43%	Majority of Textiles
Station 6	24%	16%	60%	-	0,05%	Majority of Textiles

Water sampling of six station points along the river, from upstream to downstream, was carried out on December 16, 2019, at the beginning of the rainy season with sunny cloudy weather conditions. With the said state, the water sample obtained from the day alone should be sufficient for this research since the data will be representative enough for both possible Indonesian weather conditions. The research parameters are pH, nitrate, phosphate, and fecal coliform, which would then be processed using the QUAL2KW software. According to Wang et al. (2005) pH in waters often varies due to various processes or environmental conditions. Likewise, in rivers, pH can change due to the presence of certain pollutant sources or chemicals. The results of field data from water sampling at the six different points are outlined in Table 3. The data comes from water sampling at 6 stations on the Klampok River, Semarang Regency. The water samples were then tested in the laboratory to determine the concentration of the parameters pH, Phosphate, Nitrate, and Fecal Coliform in the waters of the Klampok River.

Table 3. Water sampling result

No	Parameter	Unit	Station						Class II water quality standard
			1	2	3	4	5	6	
1	pH	-	7.88	7.74	8.2	8.18	8.13	7.97	6-9
2	Fosfat	mg/L	0.06	1.72	0.11	0.12	0.61	0.66	0,2
3	Nitrate	mg/L	1.74	2.62	1.65	0.93	1.03	1.17	10
4	Fecal Coliform	mg/L	24,000	24,000	11,000	4,600	24,000	11,000	1,000

2.2 Using QUAL2KW

With the development of technology, several software and models have been provided to ensure easy and smooth data processing and analysis. One of these innovations is the QUAL2KW software that is used for river water quality modelling. This software was developed by the USEPA Water Quality Modeling Center in collaboration with the Department of Civil Engineering at Tufts University and the Athens-Greece Environmental Research Laboratory.This software is used to determine that the quality of the water flow along the river is in stable flow conditions (Kannel et al., 2007) in order to perform water quality analysis. Thus, our report can be used as reference material for related industries located along the river in managing their activities. For example, the industries can be more aware of disposing of their waste based on the information pertaining to the magnitude of the pollutant load in the contaminated water.

After the sampling, the concentration of the parameters such as pH, nitrate, phosphate, and fecal coliform is determined by analyzing the river water samples. The results of this sample test will be used to create a graphic model using the QUAL2KW software for further calculation of the pollution load capacity. Some of the data needed for processing in QUAL2KW pertain to water quality and river hydraulics. Later, the software will be used for calibration using a genetic algorithm system on the kinetic rate parameters automatically (Kannel et al., 2007) so that the results obtained can adjust the model predictions according to the field data. Calibration is usually done by trial and error to obtain the closest model to the actual condition. This automatic calibration feature will relieve the one manually conducting model calibration through trial and error. This QUAL2KW validation uses the chi-square method, which is a statistical method used to test the relationship between class values and variables (Peker & Kubat, 2021).

The method used in the chi-square test is the x^2 test statistic (chi-squared) where there is a difference between the modelling results (WQ Output) and the measurement results (WQ Data) that meet the test criteria, It means that the QUAL2KW model is feasible for use. The equation used for the chi-square test is:

$$X^2 = \sum \frac{(0i - Ei)^2}{Ei}$$

Where, oi = observation data (Model Data)
Ei = expected data (Field Data)

The calculation results obtained will be compared with those in the chi-square table (Table 4). Therefore, if the value of x^2 is greater than the value in the table, then the modelling results will be rejected; otherwise, the modelling can be used. In this study, the value used is 0.05 and k (amount of data) is 6. As seen in Supplementary Table 1, Chi-square has an x^2 value of 1.6354. The chi-square method was first used for validation, comparison, evaluation, and comparison of asset pricing models under the assumption that the knowledge of the interactions can help identify opinion profiles about the relationship of a spouse as a family structure.(Gospodinov, Kan, & Robotti, 2013; Rodríguez-Sabiote et al.,, 2021).

3. Result and Discussion

3.1 Current Conditions of the Klampok River

From the sample testing conducted at five stations at the Central Java Province Health Laboratory and Medical Device Testing Center in 2020, it was found that the Klampok River belongs to a class II unit. This is mainly used for water recreation facilities or infrastructure, freshwater fish cultivation, animal husbandry, crops irrigation, and others that require a similar high water quality.

Based on Table 4 pertaining to the upstream part of the Klampok river identified at stations 1 and 2, the content of a few parameters exceeds the quality standard, for instance, the phosphate content at station 2. On the other hand, stations 3 and 4 are known to have a high fecal coliform content exceeding the quality standard value for class II. In the downstream river part, stations 5 and 6 have high concentrations of phosphate and fecal coliform parameters.

Table 4. River class clasification

Water Class	Appropriation and Use
Class I	for drinking water, and or other uses that otherwise require water quality equal to usability:
Class II	Infrastructure/facilities water recreation, freshwater fish cultivation, animal husbandry, water to irrigate crops
Class III	freshwater fish cultivation, animal husbandry, water to irrigate the crop
Class IV	irrigate crops

The high concentrations of phosphate at stations 2, 5, and 6 were caused by several factors such as the agricultural, industrial, and household water use activities carried out around the river. Meanwhile, there were activities around the river that caused various intensities and impacts, such as self-purification. The decrease in phosphate at stations 3 and 4 was caused by self-purification along the river flow assisted by plants around the river body and turbulent water flow as a result of rocky river morphology, which then introduced additional DO to the river water (Silva et al., 2020).

Fecal coliform is a pollutant in water bodies that comes from Escherichia coli bacteria, which come from feces (Stachler et al., 2017). Based on Table 3, contamination of fecal coliform occurred in all segments of the river, with concentrations reaching CFU per 100 ml. This figure exceeds the water quality standard for class II. Fecal coliform contamination can be caused by livestock, fisheries, and household activities such as bathing and washing clothes that occur around the river body. The decrease in values at stations 3 and 4 was caused by self-purification in the Klampok River and access to proper sanitation for 96.2% of the population in Bawen sub-district (the majority of the population at station 4) according to the Health Agency of Semarang Regency. At stations 3 to 6, most of the activities are related to animal husbandry and fisheries, and both of these types of activities have the potential to increase the parameter values of fecal coliform in the river bodies as a result of feces runoff. For example, there is a chicken farm located on the edge of a water body at station 6; it directly dumps its waste into the river.

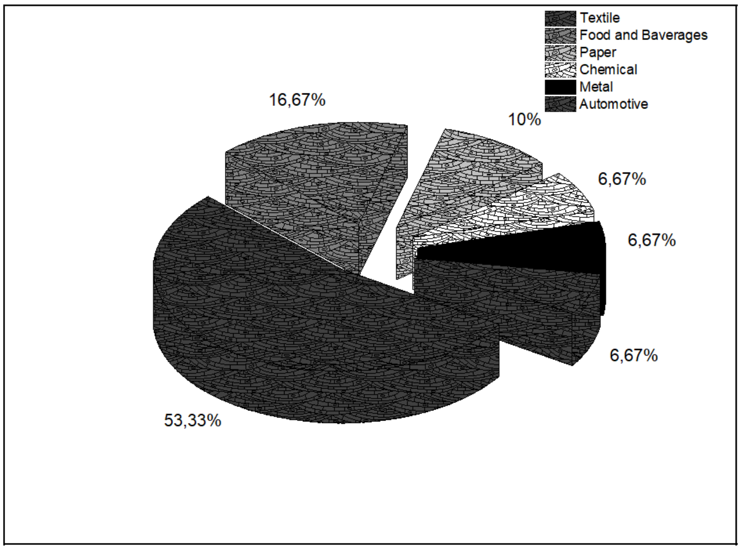

Figure 2. Represents an industry percentage chart (Environmental Agency of Semarang Regency)

From the results of field samples and data processing using QUAL2KW, it is known that the most polluted stations are stations 2, 5, and 6. This is because, at these stations, there are two parameters, in particular, that violate the quality standards, namely, fecal coliform and phosphate. The highest pollution, compared to the other two stations, is at station 2, caused by phosphate of 1.72 mg/L and fecal coliform of 24000 CFU per 100 ml. Meanwhile, station 5 has the same fecal coliform content as station 2 (24000 CFU per 100 ml) and a phosphate concentration of 0.61 mg/L. Finally, station 6 has a phosphate concentration of 0.66 mg/L, against a class II quality standard of 0.2 mg/L, and a fecal coliform concentration of 11000 CFU per 100 ml, which is higher than the class II quality standard of 1000 CFU of fecal coliform per 100 ml. The lowest quality standard is in class IV, a concentration of 2000 CFU fecal coliform per 100 ml. The concentrations of fecal coliform at all stations exceed the class II quality standards. Meanwhile, other parameters such as pH, nitrate, and phosphate are classified into the class II river classification. However, the high fecal coliforms in the Klampok river flow mean that the river water should not be consumed and cannot be used for daily activities.

Several factors such as weather patterns and rainfall can affect water quality. The resulting sewage overflows and rainwater runoff in urban and residential areas cause fecal coliforms to flow into the river (Chen et al., 2020; Jennings et al., 2018) As shown in the research by Shehane et al., (2005) rain can be a transportation medium for the introduction of bacteria into natural waters. Similarly, the high fecal coliform in the Klampok River can cause a decrease in water quality. Furthermore, the water samples used for the study were taken during the rainy season, which might have also affected the results of the content of fecal coliforms in the test samples.

Based on the pie chart in Figure 2, the type of industry around the Klampok River is predominantly the textile industry. This industry produces wastes of materials used in the various stages of the textile production process. In this production process, several types of tasks are carried out, namely yarn spinning, dyeing, and weaving, all of which produce wastewater. As many as 48% of the environmental conditions at stations 4, 5, and 6 are related to textile industries, which are precisely located in Pringapus District, Bawen District, and Bergas District. Considering that the largest number of textile industries are located at station 5, with 24 industries out of the total 33 industries that exist along the Klampok river body, this pollutant source is also referred to as a point pollution source. This is because the pollutant load, which comes out or is at one point and can be easily measured, is local, spatial, and has uniform characteristics.

3.2 Model Performance Evaluation

The QUAL2KW software is used to obtain simulations from data after sampling and laboratory tests, which help in determining the conditions along the river. The results provide the industries operating around the river with an understanding of how much pollutant load can be discharged into the river.

The first step in using the QUAL2KW software is to perform hydraulic calibration by filling in several worksheets available in the modeling. The first worksheet (QUAL2KW worksheet and headwater worksheet) in the software is completed based on the data pertaining to the conditions and water quality at the sampling point in the upstream part of the river. Furthermore, the data will be inputted into the reach worksheet, which inquires about the physical conditions of the river at each station. The physical data in question are the distance between sampling points, elevation, slope, depth, etc. The last step is hydraulic calibration, which is performed by filling in the hydraulic data worksheet on flow, discharge, velocity, and width of the river.

The modeling is carried out by running VBA, which is then performed in the water quality determination stage using several worksheets. In the first stage, it is used to determine river water quality by using a point source worksheet in which data related to river water quality from a specific source such as hotels, industry, etc. are required to be inputted. Furthermore, data processing will be carried out through the diffuse source worksheet; for instance, as the pollutant source data cannot be determined precisely, the worksheet needs to be filled in with the parameter coefficients, and finally, the water parameter values (pH, phosphate, nitrate, and fecal coliform) from the results of the water sample test need to be entered. This model is then executed by running VBA again. In both stages, a trial and error model will be implemented with the aim to approach the situation in the field. The last stage will entail the use of the chi-square method to validate the model developed from QUAL2KW.

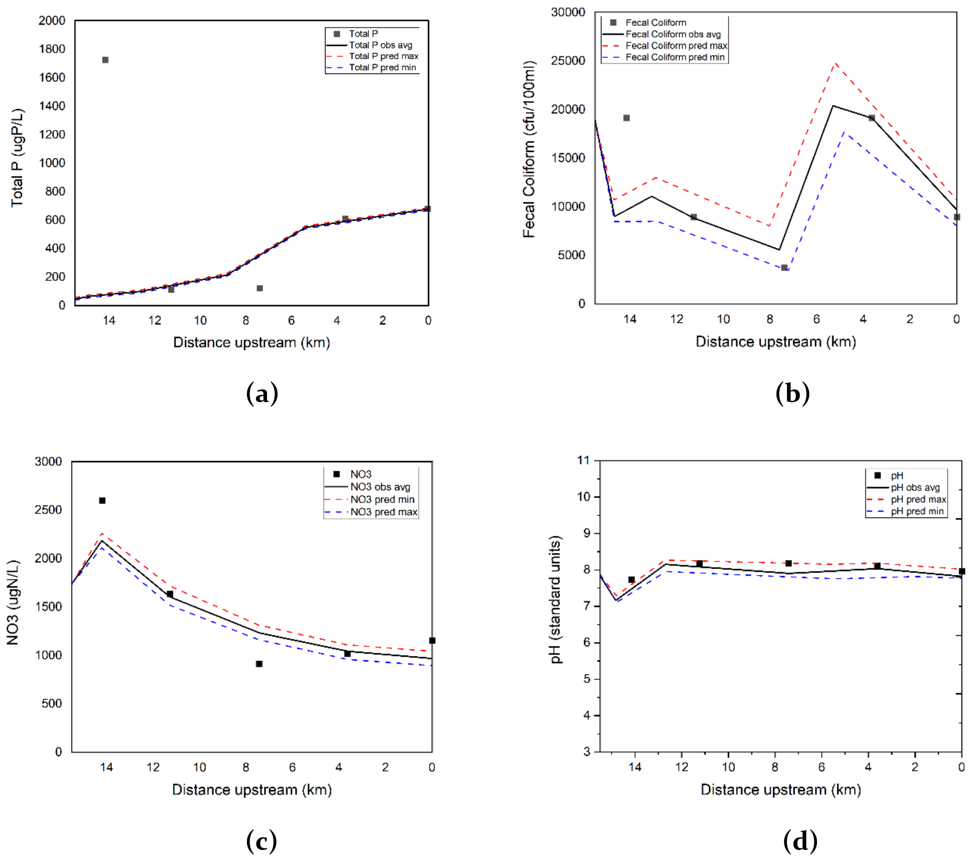

Figure 3. Qual2KW result (a) Phosphate; (b) Fecal Coliform; (c) Nitrate; (d) pH

Figure 3 shows the modeling results of QUAL2KW with respect to various parameters such as fecal coliform, phosphate, nitrate, and pH. The graph in Figure 3(b) shows that there are six stations; station 5 has the maximum fecal coliform concentration, while stations 1 and 6 have a concentration equal to the predicted average fecal coliform concentration. Further, the fecal coliform at stations 2 and 4 is above the maximum predicted concentration, while, at station 3, this concentration is below the minimum prediction.

As perceived from Figure 3(a), the phosphate parameter when running produces good data. This is because the resulting graph between the maximum prediction of phosphate parameter concentration, minimum prediction, and average prediction is divided into three lines that are close to one another. The comparison of the sample test results with the model test at station 2 is higher than the results from the QUAL2KW model simulation. On the other hand, at station 4, the results are lower than the simulation model results for the concentration of nitrate parameters. Meanwhile, stations 1, 3, 5, and 6 are close to or equal to the phosphate parameter concentration model.

The comparison of the sample test results and the simulated nitrate concentration model in Figure 3(c) shows that the model results related to nitrate concentrations at stations 1, 3, and 5 are under normal conditions. Meanwhile, for station 2, it can be seen that the nitrate content is close to the maximum predicted nitrate concentration. The concentration at station 4 according to the test results is closer to the minimum prediction on the QUAL2KW model. However, according to Figure 3(d), the pH parameter at all stations is close to the predicted maximum concentrate, minimum concentrate, and average concentrate. Almost all stations, except station 1, which had a pH concentration below the concentrate, had an average concentration.

After deriving the results using QUAL2KW, these results will be validated with the help of the chi-square method using Equation 1. Validation with the chi-square method is used to examine the similarity between QUAL2KW simulation and the sample test in the laboratory. The result will be compared with the chi-square table; if the x^2 score is higher than the table, then the score will be rejected. The results of the chi-square test are presented in Table 5.

Table 5. Chi-square calculation

Parameter	Station	x^2	x^2 chi-square
Fecal Coliform	1	0,4167	
	2	0,4713	
	3	0,087	
	4	0,301	
	5	0,4845	
pH	1	0,0435	1,6354
	2	0,0003	
	3	0,0096	
	4	0,0011	
	5	0,0028	
Phosphate	1	1,6253	
	2	0,0168	
	3	0,0033	
	4	0,2558	
	5	0,0183	
Nitrate	1	0,3971	
	2	0,1748	
	3	0,4827	
	4	0,0002	
	5	0,0345	

From Table 5, it can be seen that the result of x2 is not more than 1.6354. Therefore, it can be concluded that the water quality modeling using QUAL2KW is valid. The value of x2 on all the parameters (pH, fecal coliform, nitrate, and phosphate) is not more than x2. This leads to the conclusion that QUAL2KW agrees with the parameters of the Klampok River, which fulfill the criterion of α = 95%.

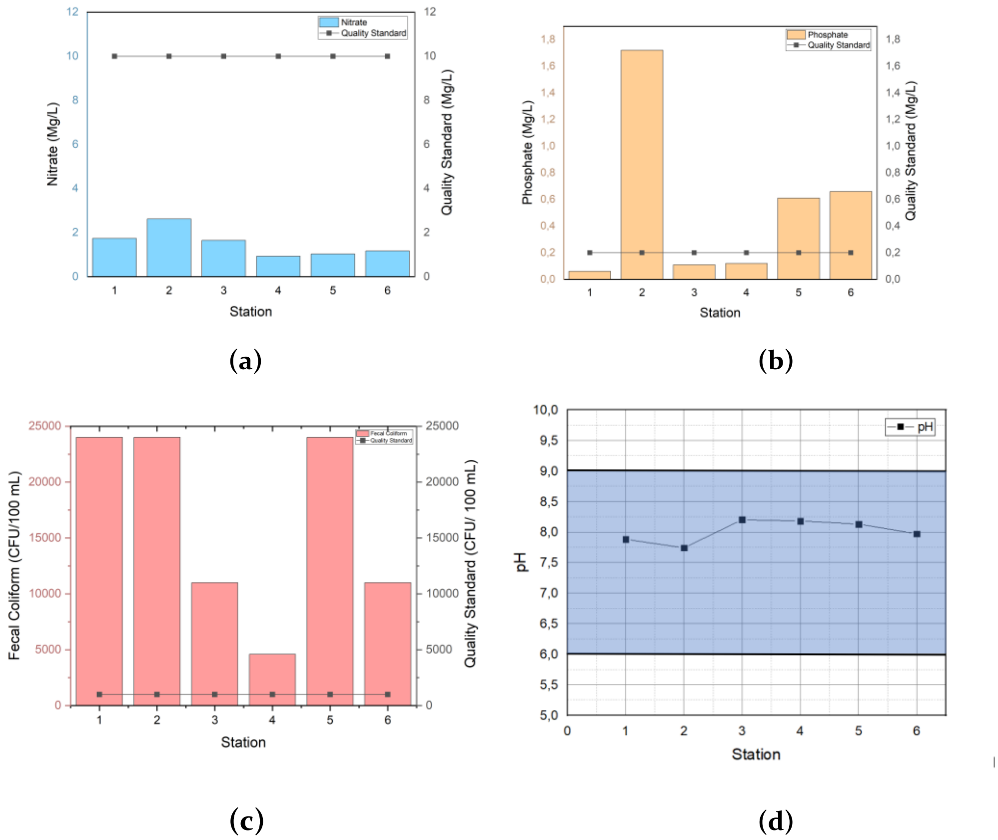

Figure 4. Comparison of sampling results with quality standard

3.3 Parameter in the Research

From testing the parameters, it was found that the phosphate emission on the water is responsible for eutrophication in the water body. Eutrophication can be the cause of plankton reproduction and algae that cannot be controlled on the water body (Li et al., 2019). Nitrate is a contaminant that is always available in the water body. The nitrate pollutant usually comes from farming, nitrogen fertilizer, and feces (Jones et al., 2016). Nitrogen content in nitrate can cause damage to human health and that of other organisms. If consumed, it can hinder the transportation of blood oxygen to the body cell (Moeini & Azhdarpoor, 2021). Escherichia coli (E. coli) is a pathogen zoonosis in food that can negatively affect human health (Xu et al., 2021).

Fecal coliform is usually used as an indicator of the feces contaminant and E. coli in the environment (Zhou et al., 2019). A high concentration of fecal coliform can be an indicator of the level of domestic waste pollution in rivers caused by rapid population growth, which is not balanced by the development of adequate sanitation infrastructure. The high pollutant load in the Klampok River is also influenced by effluents from point source outlets such as industries and hotels around the river.

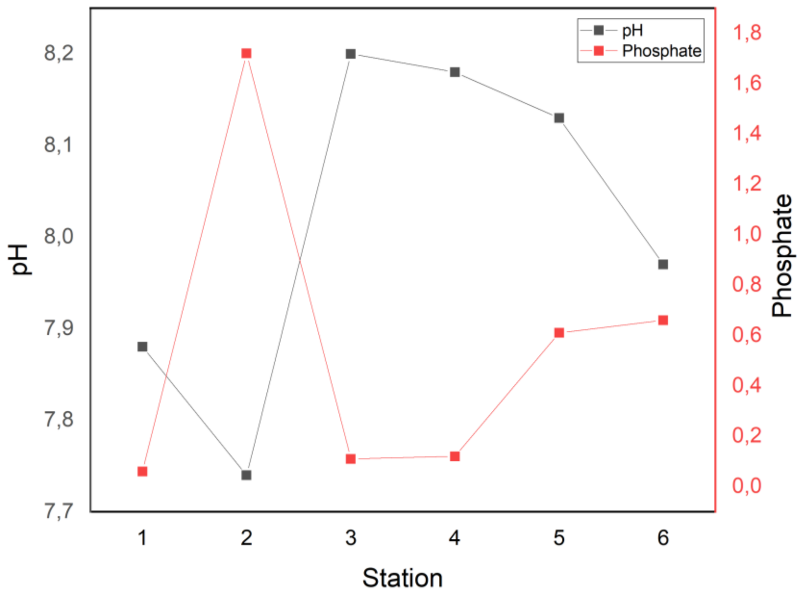

Figure 5. Relationship between pH and Phosphate

Based on Figure 5, the increase and decrease in the concentration of pH and phosphate are inversely related. According to Cerozi & Fitzsimmons (2016) the pH content of the aquaponic nutrient solution increases with the decrease in phosphorus content. Their study also showed that, in the solution, phosphorus binds to some of the cations present in it, leaving slightly more free phosphate ions that can be absorbed by plants. The high pH value can affect the formation of phosphate (Cerozi & Fitzsimmons, 2016). Thus, it indicates that the decrease in pH concentration in the Klampok River is highly dependent on the formation of phosphate in the water body. Plants around the river also affect the phosphate concentration, as plants can bind some of the phosphate ions present in water bodies.

Weather conditions greatly affect the pollutant load of the Klampok River, as the intensity and volume of rainfall affect the sewage. The frequency of rainfalls is also one of the contributors to pollutant discharge into water bodies. The high pollutant discharge is sourced from the sediment of the industrial wastewater channel around the Klampok River. Thus, it can be understood that the source of the pollutant contributes to the ups and downs of water quality in the Klampok River. Awareness and involvement from both stakeholders and surrounding community are essential to prevent further contamination in Klampok River. The Environmental Agency of Semarang Regency is already paying attention to conserve Klampok River and has an advantage of being supported by Indonesian River Conservation Organization Semarang Regency, a non-governmental organization formed to dedicate itself for preserving Klampok River. Further collaboration from both organizations are expected alongside with other stakeholders such as industries, economic facilities, and heads of subdistricts under several meetings or focused group discussions (FGDs) to gain insights on aspirations regarding the future of Klampok River. Some recommended initial steps to take for Klampok River protection can include Klampok River policymaking and construction of wastewater treatment plants (WWTPs) for industries and other economic facilities, as well as communal WWTPs to support better sanitation for community surrounding Klampok River. Collaborations from every stakeholder and the community are expected to yield satisfactory results.

4. Conclusions

The parameters tested in this study for the Klampok river were the concentration of nitrate, pH, phosphate, and fecal coliform. The most polluted point in this study was station 2 located in Jimbaran Village, Bandungan District, Semarang Regency, which has the highest fecal coliform and phosphate concentrations (that exceed water quality standards) of 24000 CFU/100mL and 1.74 mg/L, respectively. These high values of phosphate and fecal coliform concentrations are a result of the high settlements in the watershed at station 2 and the large number of scattered industries, which increase the point source pollutant in the Klampok River. From the laboratory test results for the river-quality parameters, after being simulated using QUAL2KW and validated using the chi-square method, it can be concluded that the quality of the Klampok River belongs to class II, which indicates that the water can be used for water recreation facilities/infrastructure, freshwater fish cultivation, water husbandry, irrigation of plantations, and other uses requiring the same water quality standards. The high concentration of fecal coliform in the Klampok River is an indicator of the need to build proper sanitation facilities in the community along the Klampok River, while the high phosphate concentrations provide the basis for the construction of WWTPs for domestic waste, including the management of detergent water that causes high phosphate concentrations.

References

Allam, A., Tawfik, A., Yoshimura, C., & Fleifle, A. 2016. Simulation-based optimization framework for reuse of agricultural drainage water in irrigation. Journal of Environmental Management, 172, 82-96.

Antunes, I. M. H. R., Albuquerque, M. T. D., Oliveira, S. F., & Sánz, G. 2018. Predictive scenarios for surface water quality simulation - A watershed case study. CATENA, 170, 283-289.

Bisimwa, A.M., Amisi, F. M., Bamawa, C.M., Muhaya, B. B., & Kankonda, A, B. 2022. Water quality assessment and pollution source analysis in Bukavu urban rivers of the Lake Kivu basin (Eastern Democratic Republic of Congo). Environmental and Sustainability Indicators, 100183.

Cerozi, B. D. S., & Fitzsimmons, K. 2016. The effect of pH on phosphorus availability and speciation in an aquaponics nutrient solution. Bioresource Technology, 219, 778-781.

Chen, C. H., Lung, W. S., Li, S. W., & Lin, C. F. 2012. Technical challenges with BOD/DO modeling of rivers in Taiwan. Journal of Hydro-environment Research, 6(1), 3-8.

Chen, Li., Xu, Yufan., Ogata, Hiroaki., Shimada, Atsushi., Yamada, M. 2020. Do different instructional styles affect students' learning on summer assignments? Paper presented at the 2020 IEEE 20th International Conference on Advanced Learning Technologies (ICALT).

Egbueri, J. C. 2018. Assessment of the quality of groundwaters proximal to dumpsites in Awka and Nnewi metropolises: a comparative approach. International journal of energy and water resources, 2(1-4), 33-48.

Gospodinov, N., Kan, R., & Robotti, C. 2013. Chi-squared tests for evaluation and comparison of asset pricing models. Journal of Econometrics, 173(1), 108-125.

Goverment Regulation of The Republic of Indonesia Number 22 Year 2021 2021.

Jennings, W. C., Chern, E. C., Donohue, D. O., Kellogg, M. G., & Boehm, A. B. 2018. Frequent detection of a human fecal indicator in the urban ocean: environmental drivers and covariation with enterococci. Environmental Science: Processes & Impacts, 20(3), 480-492.

Jones, R. R., Weyer, P. J., Valle, C. T. D., Choi, M. I., Anderson, K. E., Cantor, K. P., Krasner, S., Robien,K., Freeman, L. E. B., et al. 2016. Nitrate from Drinking Water and Diet and Bladder Cancer Among Postmenopausal Women in Iowa. Environmental Health Perspectives, 124(11), 1751-1758.

Kannel, P. R., Lee, S., Lee, S., kanel, S. R., & Pelletier, G. J. 2007. Application of automated QUAL2Kw for water quality modeling and management in the Bagmati River, Nepal. Ecological Modelling, 202(3), 503-517.

Kumari, P., Alam, M., & Siddiqi, W. A. 2019. Usage of nanoparticles as adsorbents for waste water treatment: An emerging trend. Sustainable Materials and Technologies, 22, e00128.

Landin-Sandoval, Castillo, D. I. M., Petriciolet, A. B., Villareal, I. A. A., Avila, H. E. R., Ponce, H. A. G. 2020. Valorization of agri-food industry wastes to prepare adsorbents for heavy metal removal from water. Journal of Environmental Chemical Engineering, 8(5), 104067.

Lee, L.-C., Wang, Y., & Zuo, J. 2021. The nexus of water-energy-food in China's tourism industry. Resources, Conservation and Recycling, 164, 105157.

Leng, P., Zhang, Q., Li, Fadong., Kulmatov, R., Wang, Guoqin, Qiao, Y., Wang, J., Peng, Yu., Tian, C., et al. 2021. Agricultural impacts drive longitudinal variations of riverine water quality of the Aral Sea basin (Amu Darya and Syr Darya Rivers), Central Asia. Environmental Pollution, 284, 117405.

Li, Bing., Udugama, I. A., Mansouri, S. S., Yu, W., Baroutin, S., Gernaey, K. V., & Young, B. R. 2019. An exploration of barriers for commercializing phosphorus recovery technologies. Journal of Cleaner Production, 229, 1342-1354.

Liu, Y., Yang, L., & Jiang, W. 2020. Coupling coordination and spatiotemporal dynamic evolution between social economy and water environmental quality – A case study from Nansi Lake catchment, China. Ecological Indicators, 119, 106870.

Loi, J. X., Chua, A. S. M., Rabuni, M. F., Tan, C. K., lai, S. H., Takemura, Y., & Syutboso, K. 2022. Water quality assessment and pollution threat to safe water supply for three river basins in Malaysia. Science of The Total Environment, 832, 155067.

Malaj, E., Ohe, P. C. V. D., Schafer, R. B. 2014. Organic chemicals jeopardize the health of freshwater ecosystems on the continental scale. Proceedings of the National Academy of Sciences, 111(26), 9549-9554.

Mathew, M. L., Gopalakrishnan, Aravindarkumar C. T., Aravin, U. K. 2019. Low – cost multilayered green fiber for the treatment of textile industry waste water. Journal of Hazardous Materials, 365, 297-305.

Moeini, Z., & Azhdarpoor, A. 2021. Health risk assessment of nitrate in drinking water in Shiraz using probabilistic and deterministic approaches and impact of water supply. Environmental Challenges, 5, 100326.

Mokarram, M., Saber, A., & Sheykhi, V. 2020. Effects of heavy metal contamination on river water quality due to release of industrial effluents. Journal of Cleaner Production, 277, 123380.

Paul, D. 2017. Research on heavy metal pollution of river Ganga: A review. Annals of Agrarian Science, 15(2), 278-286.

Peker, N., & Kubat, C. 2021. Application of Chi-square discretization algorithms to ensemble classification methods. Expert Systems with Applications, 185, 115540.

Rodríguez-Sabiote, et al., 2021. Using chi-squared automatic interaction detection modelling to identify student opinion profiles regarding same-sex couples as a family structure. Heliyon, 7(3), e06469.

Shehane, et al., 2005. The influence of rainfall on the incidence of microbial faecal indicators and the dominant sources of faecal pollution in a Florida river. Journal of Applied Microbiology, 98(5), 1127-1136.

Silva, D. C. V., Queiroz, L. G., Marassi, R. J., Araijo, C. V. M., Bazzan, T., Silva, S. C., Silva, G. C., Muller, M., Silva, F. T. et al., 2020. Predicting zebrafish spatial avoidance triggered by discharges of dairy wastewater: An experimental approach based on self-purification in a model river. Environmental Pollution, 266, 115325.

Stachler, E., Ketty, C., Sivaganesan, M., Li, X.., Bibby, K., Shanks, O. C. 2017. Quantitative CrAssphage PCR Assays for Human Fecal Pollution Measurement. Environmental Science & Technology, 51(16), 9146-9154.

Wang, P., Yaou, J., Wang,G., Hao, F., Shrestha, S., Xue, B., Xie, G., & Peng, Y. 2019. Exploring the application of artificial intelligence technology for identification of water pollution characteristics and tracing the source of water quality pollutants. Science of The Total Environment, 693, 133440.

Wang, S., Jin, X., Pang, Y., Zhao, H., & Zhao, X. 2005. The study of the effect of pH on phosphate sorption by different trophic lake sediments. Journal of Colloid and Interface Science, 285(2), 448-457.

Wang, Z., Walker, G. W., Muir, D. C. G., Yoshida, K. N. 2020. Toward a global understanding of chemical pollution: a first comprehensive analysis of national and regional chemical inventories. Environmental Science & Technology, 54(5), 2575-2584.

Watari, T., Hata, Y., Hirakata, Y., Nguyet, P, N., Nguyen, T. H., Maki, S., Hatamoto, M., Sutani, D., Setia, T., et al., 2021. Performance evaluation of down-flow hanging sponge reactor for direct treatment of actual textile wastewater; Effect of effluent recirculation to performance and microbial community. Journal of Water Process Engineering, 39, 101724.

Xu, G., Wang, T., Wei, Y., Zhang, Y., & Chen, J. 2021. Fecal coliform distribution and health risk assessment in surface water in an urban-intensive catchment. Journal of Hydrology, 127204.

Xue, F., Tang, B., Bin, L., Ye, J., Huang, S., Fu, F., Li, P., Cui, J.. 2019. Residual micro organic pollutants and their biotoxicity of the effluent from the typical textile wastewater treatment plants at Pearl River Delta. Science of The Total Environment, 657, 696-703.

Zhang, X., Chen, L., & Shen, Z. 2021. Impacts of rapid urbanization on characteristics, sources and variation of fecal coliform at watershed scale. Journal of Environmental Management, 286, 112195.

Zhou, S., Yang, D., Xu, Q., Yang, Z., Jin, M., Yin, J., Wang, H., Zhou, K., Wang, L. 2019. Presence of bacteroidales as a predicator of human enteric viruses in Haihe River of Tianjin City, China. Environmental Science and Pollution Research, 26(8), 8169-8181.