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Assimilation Capacity Of BOD, Fecal Coliform, and MBAS in Kampar River Water, Riau Province

Daya Asimilasi BOD, Koliform Fekal, dan MBAS pada Air Sungai Kampar, Provinsi Riau

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ABSTRAK

Sungai Kampar berasal dari Sumatra Barat dan bermuara di Teluk Meranti, Kabupaten Pelalawan, melewati permukiman masyarakat. Air sungai dimanfaatkan untuk kebutuhan domestik, penangkapan ikan, serta kegiatan budidaya ikan dalam keramba jaring apung. Perkembangan sektor industri pertanian dan perkebunan, serta kegiatan penambangan pasir dan kerikil (sirtu) yang berada di daerah aliran Sungai (DAS) Kampar pada umumnya belum memenuhi kriteria keberlanjutan lingkungan. Kondisi ini menimbulkan ketidakseimbangan antara upaya pemanfaatan dan upaya pelestarian di DAS Kampar yang kemudian memicu permasalahan ekosistem lingkungan. Tujuan penelitian ini adalah menghitung daya tampung beban pencemaran dan kapasitas asimilasi (AC) BOD, Fecal Coliform, dan Metilen Biru Aktif Substansi (MBAS) pada lokasi Pemantauan Kualitas Air (WQM) di Desa Danau Bingkuang, Sungai Kampar. Metode survei dilakukan dengan mengumpulkan data dari populasi representatif (sampel). Hasil perhitungan menunjukkan bahwa beban pencemaran terukur (PL) untuk BOD, Fecal Coliform, dan MBAS berada di bawah nilai maksimum daya tampung beban pencemaran (MPLC) untuk parameter BOD, Fecal Coliform, dan MBAS. Kapasitas asimilasi (AC) pada titik pemantauan TPP-12 Desa Danau Bingkuang tahun 2020 adalah: BOD sebesar 1,54 Kg/hari, Fecal Coliform sebesar 1,06 Kg/hari, dan MBAS sebesar 0,03 Kg/hari.

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ABSTRACT

The Kampar River originates in West Sumatra and flows into Teluk Meranti, Pelalawan Regency, passing through community settlements. The water is utilized for domestic purposes, fishing, and fish farming activities in floating cage systems. The development of the agricultural and plantation industry sectors, as well as sand and gravel (sirtu) mining located in the Kampar watershed, has generally not met environmental sustainability criteria and has resulted in an imbalance between utilization efforts and conservation efforts in the Kampar watershed, causing environmental ecosystem problems. The purpose of this study was to calculate the pollution load capacity and assimilation capacity (AC) of BOD, Fecal Coliform, and Methylene Blue Active Substances (MBAS) at the Water Quality Monitoring (WQM) location in Danau Bingkuang Village, Kampar River. The survey method was conducted by collecting data from a representative population (sample). The calculation results showed that the measured pollution load (PL) for BOD, Fecal Coliform, and MBAS was below the maximum pollution load capacity (MPLC) for BOD, Fecal Coliform, and MBAS. The AC at monitoring point TPP-12 Danau Bingkuang Village in 2020 was: BOD = 1.54 Kg/day, Fecal Coliform = 1.06 Kg/day, and MBAS = 0.03 Kg/day.

1. INTRODUCTION

1.1 Background

The development of science and technology, along with the rapid growth of industry today, creates both positive and negative impacts. The positive impacts naturally include improved quality and better living standards. However, the negative impacts of technological development, such as environmental degradation resulting from excessive exploitation, must be approached with greater caution to prevent more severe disruptions to existing environmental elements, both living and non-living. In its development, environmental and social order must always be maintained to avoid bringing various types of disasters. Therefore, the responsibility of all elements of society is necessary for maintaining environmental and social order, thereby creating a better environmental perspective (Effendi et al., 2018).

Pollution can occur anywhere, including in water. Water pollution as an impact of development activities can also occur in water sources. In this regard, river pollution as one of the primary sources of water pollution, can occur in rivers, especially those passing through major cities. Pollution can occur anywhere, including in water. Water pollution as an impact of development activities can also occur in primary sources. In this regard, river pollution, as one of the water sources, can occur in rivers, especially those passing through major cities. Settlement activities contribute organic materials to rivers. Likewise, other activities, such as industrial operations that discharge their waste into rivers (Djoharam et al., 2018).

Water is one of the essential sources of life for living beings, however, until now, water resources in watershed (DAS) areas have been in conditions unsuitable for use as raw water sources, and this has become a priority issue in developing countries. The decline in surface water quality is caused by high levels of pollutants entering the waters and the lack of optimal efforts to control and utilize wastewater treatment installations. Monitoring efforts on several water quality parameters can be used to evaluate and assess the status of river water quality (IKA method) (Novita et al., 2020).

Rivers and receiving waters possess a finite assimilative capacity for organic load (commonly measured as BOD), microbial contaminants (fecal coliform/E. coli), and anionic surfactants (MBAS); when loading from domestic, industrial, or greywater sources exceeds that capacity the system's self-purification and public-health protection are compromised, producing persistent oxygen depletion, elevated pathogen risk, and surfactant-driven ecological impacts such as foaming and altered microbial processes (Lubis, 2022; Nugraha et al., 2022; Jena et al., 2023).

Field assessments and modeling studies demonstrate that BOD may sometimes remain within regulatory limits in less-impacted segments while fecal coliform and MBAS spike near point and diffuse discharges, highlighting that biological oxygen demand alone is an insufficient indicator of overall sanitary and chemical stress (Matolisi et al., 2024; Basuki et al., 2024). Recent reviews and monitoring work further emphasize that MBAS (an easily measured proxy for anionic surfactants) can persist at concentrations that impair microbial communities and reduce natural attenuation rates, thereby lowering the effective assimilative capacity for organic and microbial pollutants (Badmus et al., 2021; Jena et al., 2023).

Emerging sensor and remediation studies (e.g., MBAS sensors and novel adsorbents) offer improved detection and targeted removal options that can help managers better quantify loads and expand engineered pre-treatment solutions where natural assimilation is insufficient (Simonetti et al., 2025; Kharabsheh et al., 2025). Overall, integrated monitoring (BOD + fecal indicator bacteria + MBAS), calibrated hydraulic/water-quality modeling, and upstream source control (sanitation upgrades, greywater treatment, and surfactant reduction) are essential to safeguard assimilative capacity and public-health outcomes in tropical and developing catchments.

Community settlements are located along the Kampar River, which flows through West Sumatra and empties into Teluk Meranti. Water from the Kampar River is used for drinking, fishing, and floating cages for fish farming. The use of water resources in the Kampar Watershed (DAS) continues to increase, while on the other hand, the quantity and quality of water received will change due to damage to the catchment area. If no efforts are made to improve the condition of water sources through catchment area conservation, this condition will worsen (Yunus & Haryanto, 2019).

These environmental ecosystem problems are caused by the development of industry, agriculture, and plantation sectors, such as palm oil processing and plantation industries, as well as sand and gravel (sirtu) mining in the Kampar watershed, which are generally carried out by communities that do not meet environmentally friendly criteria. River pollution is a problem that requires the collaboration of multiple parties. This is caused by various sources of pollutants that enter and accumulate in the river. Pollution sources include settlements and activities occurring within the river water body itself, as well as productive and non-productive activities in the upland areas. The habits of communities living around the river also contribute to the increase in pollution entering the river waters. Communities around the river typically discharge household waste both liquid and solid, directly into the river waters (Yulhadis et al., 2018).

The use of water quality index can provide general overview of water quality assessment, utilizing selected parameters that indicate improving quality conditions with increasing index can values (Pratiwi et al., 2020). Water Quality Monitoring (WQM) using the Pollution Index (PI) and Storet methods in the downstream segment of the Kampar River by the Riau Province Environmental and Forestry Agency. WQM at Danau Bingkuang Village. Tambang District, from 2017 to 2020, met the moderate pollution quality standards using the PI method, but was heavily polluted using the Storet method. Around the WQM site in Danau Bingkuang Village, a traditional market and densely populated residential area exist, which can be a source the pollution contributing to the Kampar River.

The quality and quantity challenges faced by water resources include the inability to meet continuously increasing water demands and meet quality standards, especially for domestic purposes, Industrial, Domestic, and other activities tend to reduce the quality and quantity of water resources (Effendi, 2018). Knowing water quality can be done quantitatively and descriptively by comparing several water quality parameters with the quality standards of Government Regulation No. 22 of 2021, according to the water class and designation.

1.2 Research Objectives

The purpose of this research is to determine the assimilation capacity of BOD, Fecal Coliform, and MBAS parameters at the WQM location in Danau Bingkuang Village, Kampar River, Kampar Regency.

2. METHOD

2.1 Tools and Materials

The tools used in the research included a vertical-type water sampler, GPS, pH meter, thermometer, DO meter, conductivity meter, TDS meter, sample bottles, and a cool box. The primary material used was water from the Kampar River, which passed through Rantau Berangin Village, Air Tiris, and Danau Bingkuang Village, as presented in Table 1 and Figure 1.

2.2 Research Procedure

Water sample collection using the grab sampling method in August and October 2020 is presented in Table 2. (Source: Directorate of Pollution and Environmental Damage Control. Ministry of Environment and Forestry).

Table 1. Water sampling locations in 2020

No	Name/PKA	Coordinate		Location	District
		Longitude	Latitude		
1	TPP-2	100054’50.200”E	0018’5.100”N	Rantau Berangin Village	West Bangkinang
2	TPP-11	10006’6.400”E	0021’27.700”N	Air Tiris Marke	Kampar
3	TPP-12	100014’1.800”E	0021’30.300”N	Danau Bingkuang Village	Tambang

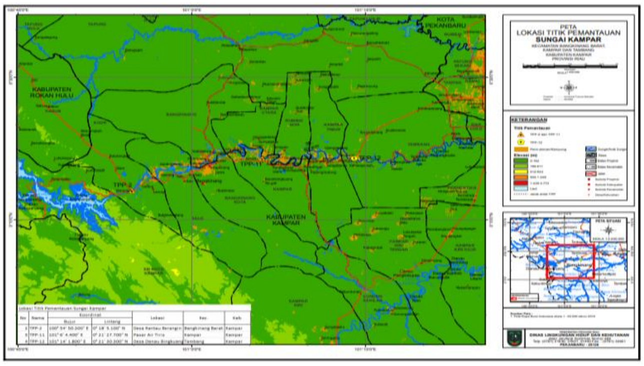

Figure 1. Map of Kampar River WQM. Locations WQM-2, WQM-11, and WQM-12 (Riau Province Environmental and Forestry Agency, 2020)

The materials used in this research were water samples collected at WQM locations TPP-2, TPP-11, and TPP-12 of the Kampar River using standard test methods as presented in Table 2. The water sampling locations are also water sources for the surrounding communities’ needs. The water sampling procedure refers to the Indonesian National Standard (SNI) 6987.57:2008 concerning surface water sampling methods

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Table 2. Water quality parameters and their testing methods

No.	Parameter	Unit	Method	*Water Class per Government Regulation No. 22 of 2021
1.	Water discharge	m^3/dtk	Velocity cured	
2.	Temperature	0C	SNI 06-6989.23-2005	
3.	pH	-	SNI 06-6989.11-2004	6 - 9
4.	DHL	Mmhos/cm	SNI 06-6989.1-2004	
5.	BOD5	mg/L	SNI 06-6989.72-2009	3
6.	COD	Mg/L	SNI 06-6989.2-2009	25
7.	Fecal Coliform	MPN/100 ml	APHA9221 F EDISI 222012	1000
8.	MBAS	µg/L	APHA9221 F EDISI 222012	0.2

The calculation of pollution load is based on the multiplication of river water discharge measurement and waste concentration in the river, referring to Appendix II of the Minister of Environment Regulation number 1 of 2010 concerning Procedures for Water Pollution Control, with the following equation:

BPs = Qs x Cs(j) x f ………………………………………...…(1)

Where:
BPs = River pollution load (kg/day)
Qs = River water discharge (m^3/second)
Cs(j) = Concentration of pollutant element j (mg/L)
f = Unit conversion factor (kg/day)

The Pollution Load Carrying Capacity (Allocation) (DTBP) is calculated from the difference between the Quality Standard Pollution Load (BPBM) minus the measured Carrying Capacity (BPs), equation (2).

DTBP = BPBM - BPs ………………………………………….(2)

The Assimilation Capacity (AC) of Danau Bingkuang Village (WQM-12) is determined using a linear regression model of the relationship between water quality at Danau Bingkuang Village (WQM-12) and the pollution load at Air Tiris Market (WQM 11), equation (3).

Y = a + bX ………………………………………………………..(3)

Where:
a = Coefficient representing the value of Y at the intersection between the linear line and the vertical axis.
X = Value of the independent variable, namely the pollution load at WQM Air Tiris Market (TPP-11)
b = Slope related to variable X.
Y = Dependent variable, namely the concentration of parameters tested at WQM Danau Bingkuang Village x(TPP-12).

3. RESULTS AND DISCUSSION

3.1 Kampar River Water Quality

The Kampar watershed area is more than 2.500 hectares, where the Kampar watershed area in Riau Province is more than 2.247 ha or 89.67%, while the West Sumatra Province area is more than 250 ha or 10.33%. Unsustainable clearing practices have led to a decline in water quality in the Kampar watershed. Population growth, climate change, urbanization, erosion, sedimentation, flooding, landslides, forest fires, water supply, and other problems, such as land use changes in the Kampar basin. Land use changes are driven by shifts in social life and the fulfillment of financial needs in rural watershed populations. The Kampar watershed spans 2 provinces, namely Riau Province (Pelalawan Regency, Kuantan Singingi Regency, Kampar Regency, Indragiri Hilir Regency, Indragiri Hulu Regency, Rokan Hulu Regency, Siak Regency, and Pekanbaru City), and West Sumatra Province (Lima Puluh Koto Regency and Sijunjung) (Tofani et al., 2021).

A watershed is an area topographically bound for the collection, storage, and management of water in tributaries and main rivers flowing to the sea, including aquifers (Erliza et al., 2019). The location and distribution of pollutants in water bodies (watersheds) can be identified from topographic maps, as well as land management and use. The type and amount of pollution sources can be obtained from information provided by the Department of Industry, Trade, Agriculture, Energy, and Mineral Resources, as well as Health. Statistics Agency, and others (Kurniawan et al., 2017). Besides being a source of freshwater, rivers are also utilized for various purposes, including settlements, agriculture, fisheries, tourism, hydroelectric power generation, and industrial waste disposal. Populations living along rivers and various activities/businesses have increased water consumption needs, which can impact river water pollution (Novianti et al., 2022). Water Quality Monitoring (WQM) of the Kampar River at TPP-2, TPP-11, and TPP-12 is presented in Table 3.

Table 3. Water quality of Kampar River WQM at Rantau Beringin Village (TPP-2), Air Tiris Market (TPP-11), Danau Bingkuang Village (TPP-12) in 2020

Parameter	Unit	Location			*Water Class per Government Regulation No. 22 of 2021
		TPP-2	TPP-11	TPP-12	
Water discharge	m^3/second	229.16	279.10	256.40	
Temperature	^0C	28	29.91	29.44	
pH	-	6.91	7.43	7.18	6–9
DHL	Mmhos/cm	51.16	49.16	43.89	
BOD	mg/L	2.13	2.41	2.36	3
COD	Mg/L	15.84	16.31	2.36	25
FeColiform	MPN/100 ml	1.25	2.07	16.7	1000
MBAS	µg/L	12.93	15.54	13.84	0.2

**Note : Class II*

Water quality at each WQM location, as described in terms of BOD and COD parameters, is outlined in Appendix VI of Government Regulation No. 22 of 2021. Class II quality standards can be applied to infrastructure/facilities, aquatic tourism, freshwater fish farming, livestock, agricultural water sources and other designations that require water quality equivalent to their designation. MBAS at each WQM location exceeds the class II quality standard in Appendix VI of Government Regulation No. 22 of 2021.

According to BPS (Statistics Indonesia) information in 2012, the estimated population of Indonesia in 2035 is projected to increase from 240.7 million in 2010 to 304.9 million. The continuously increasing population will be directly proportional to the increase in activities and businesses in various sectors, which will subsequently lead to an increase in the production of solid and liquid waste in the environment. Waste discharged into waters, especially liquid waste, will impact the decline in river water quality (Muhamad & Sigis, 2015).

The results of a socio-economic survey of communities regarding the utilization of the Left Kampar River for fishing provide a positive impact on increasing community income. Types of fish cultivated include catfish, baung fish, tapah fish, and tilapia, which are commodities with fairly good market share in Riau, Padang, Jambi, and North Sumatra provinces. Besides the positive impacts of pond use along riverbanks, it can also cause negative impacts in the form of declining river water quality due to feed provision. The increase in BOD parameter pollution load originating from liquid waste from households, industries, and other public places typically contains materials or substances that can endanger human health and disturb the environment (Erliza et al., 2019).

Kampar Regency has great potential in the plantation and inland fisheries sectors, with a significant portion of the population employed in fisheries. Plantations, and forestry sectors, including Palm oil and rubber plantations, are among the sources of income for local communities, as well as fishermen, and fish farmers, who have developed both community-owned and privately-owned fish farms along the Kampar River. Other pollutants affecting river water quality come from illegal gold mining (PETI) and community-owned sirtu mineral mining in several river sections, which increase TSS pollutant load concentrations and cause river water turbidity and oxygen deficiency in the water, which in turn reduces water quality and the aesthetics of the Left Kampar River (Hidayatuddin et al., 2017). Water quality can be expressed through water quality parameters. These parameters include physical. chemical. and microbiological parameters. River water quality data serves to determine water quality. Water quality decline occurs due to uncontrolled waste discharge from activities along the river which exceeds the river's carrying capacity (Wifarulah & Marlina., 2021).

Water quality assessment is crucial and should be conducted to ensure that water quality remains in good condition. Good water quality conditions are necessary to meet certain purposes according to need. This index is a mathematical instrument that can simply state the overall water quality at a specific location and time, based on several selected water quality parameters, into a single value indicating the level of water quality. The use of the Water Quality Index (WQI) can facilitate water quality assessment, providing early indications of water body health and identifying trend changes. Water quality information over time or from one location to another. However, this cannot provide all detailed information about water quality because not all water quality parameters are considered in the WQI index, which is compiled based on several important parameters that can provide simple water quality indicators (Ratna et al., 2020).

3.2 Quality Standard Pollution Load Carrying Capacity (DTBP) for BOD, Fecal Coliform, and MBAS Parameters

BPBM (Quality Standard Pollution Load) is determined by multiplying water discharge and quality standard parameter concentrations, while measured PL (Pollution Load) is obtained by multiplying measured discharge and concentration data from Kampar River WQM parameters in 2020. The main parameters used in calculations and analysis are BOD, Fecal Coliform, and MBAS parameters. The selection of these parameters is based on their relevance to various activities within the Kampar watershed, including industries that utilize main plant-based materials, residential settlements, agriculture, fisheries, and other sectors. Figures (2), (3), and (4) present the Quality Standard Pollution Load (BPBM) and measured Pollution Load (BPs) for BOD, Fecal Coliform, and MBAS at WQM locations in Rantau Berangin Village (TPP-2), Air Tiris Market (TPP-11), and Danau Bingkuang Village (TPP-12).

In Tables 4, 5, and 6, Figures 2, 3, and 4, the measured BPs for BOD. Fecal Coliform and MBAS per day are below the BPBM for BOD, Fecal Coliform, and MBAS. Water discharge at each WQM location fluctuates, affecting the pollutant load value. The BOD and Fecal Coliform parameter concentrations at each location increase but remain below the Class II quality standard in Appendix VI of Government Regulation No. 22 of 2021. The increase and fluctuation of measured BPs for BOD, Fecal Coliform and MBAS from WQM location TPP-2 to TPP-11 and TPP-12 are analogous to the increase in water discharge. The Kampar River water discharge at the WQM location is presented in Figure 5.

Table 4. DTBP BOD TPP-2, TPP-11, and TPP-12 Kampar River WQM (Kg/day)

Description	Monitoring		
	TPP-2	TPP-11	TPP-12
BPBM	59.398	72.343	66.459
BPs	4.62	23.82	4.62
DTBP	59.394	72.319	66.454

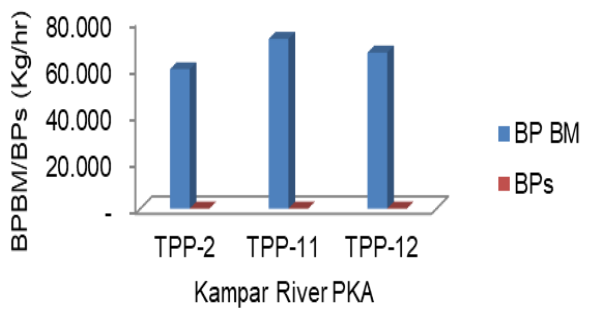

Figure 2. Quality Standard Pollution Load (BPBM) and Measured Pollution Load (BPs) for BOD at WQM locations in Rantau Berangin Village (TPP-2), Air Tiris Market (TPP-11), and Danau Bingkuang Village (TPP-12) in 2020

The observed phenomenon is assumed to be due to improvement in Kampar River water quality influenced by the ability to reduce organic pollutants based on fairly good reoxygenation values. The reoxygenation rate in the Kampar River segments TPP-2, TPP-11, and TPP-12 is greater than the deoxygenation value, indicating a fairly good organic matter reduction capability. River flow and water discharge play important roles in diluting COD values (Table 3) and degrading easily decomposable organic matter. This decrease in oxygen levels is caused by the activity of microorganisms that decompose organic waste in the presence of oxygen (Situmorang, 2017).

Coliform bacteria are used as bioindicators of water quality decline. The determination of Coliforms as a pollution indicator is done by observing the number of bacterial colonies, which are positively correlated with the presence of pathogenic bacteria. Coliform analysis is faster and cheaper compared to the analysis of other bacterial types. The low presence of Coliform bacteria in waters indicates increasingly better water quality (Saputri & Efendy, 2020). Table 5 presents the Fecal Coliform Pollution Load Carrying Capacity at TPP-2, TPP-11, and TPP-12 Kampar River WQM (Kg/day).

Table 5. DTBP Fecal Coliform TPP-2, TPP-11, and TPP-12 Kampar River WQM (Kg/day)

Description	Monitoring		
	TPP-2	TPP-11	TPP-12
BPBM	1.98×10^{14}	2.4 x 1014	2.22×10^{14}
BPs	14.37	14.69	15.23
DTBP	1.98×10^{14}	2.40 x 1014	2.22×10^{14}

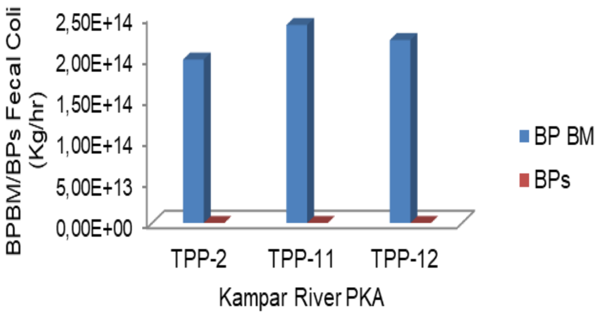

Figure 3. Quality Standard Pollution Load (BPBM) and Measured Pollution Load (BPs) for Fecal Coliform at WQM locations in Rantau Berangin Village (TPP-2), Air Tiris Market (TPP-11), and Danau Bingkuang Village (TPP-12) in 2020

With the increasing population and development of hamlets and villages around the Kampar River, community patterns of directly disposing of domestic waste or waste carried by rainwater onto the river surface have emerged. Waste from community activities entering the Kampar River varies, including runoff from residential housing, sanitation facilities (MCK), market waste, livestock manure, and garbage piles, which serve as habitats for Fecal Coliform. If not controlled, this can reduce the river's water quality. The Fecal Coliform Quality Standard in Government Regulation No. 22 of 2021 Class 2 (Table 3) is 1000 MPN/100 ml. In Table 5 and Figure 2, the BPs for Fecal Coliform are below BPBM, Temperature at WQM locations TPP-2, TPP-11, and TPP-12 ranges from 28°C to 30°C (Table 3), weather factors during water sampling, and conditions conducive to microorganism growth, especially Coliform, supported by pH 7, Temperature, and pH significantly influence the growth, and development of Coliform bacteria (Pratiwi et al., 2020). .

Microbes frequently found in polluted water bodies are Coliform bacteria. Coliform in waters originates from domestic waste (pollutants) carried by water from land and entering the waters (Hasibuan et al., 2022). Microorganisms in water consist of bacteria, fungi, and algae. Fungi and bacteria act as decoomposers that break down complex compounds into simpler ones, serving as essential components in food chains whitin environmental ecoosystems. River water quality can also be determined by microbiological factors, such as the presence of parasites, viruses, or bacteria in the water. Bacteria that can serve as indicators of water quality are Coliform bacteria (Effendi, 2018; Anisafitri et al., 2020).

Table 6. DTBP MBAS TPP-2, TPP-11, and TPP-12 Kampar River WQM (Kg/day)

Description	Monitoring		
	TPP-2	TPP-11	TPP-12
BPBM	3.96	4.80	4.43
BPs	2.41	2.57	2.59
DTBP	1.55	2.22	1.84

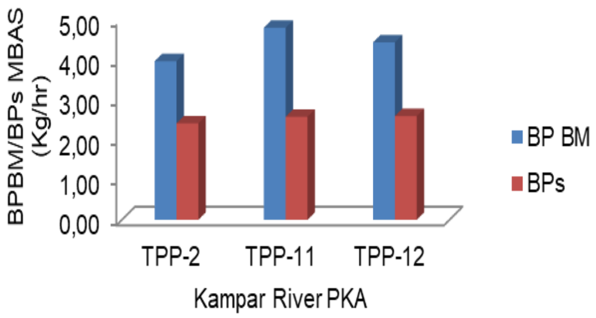

Figure 4. Quality Standard Pollution Load (BPBM) and Measured Pollution Load (BPs) for MBAS at WQM locations in Rantau Berangin Village (TPP-2), Air Tiris Market (TPP-11), and Danau Bingkuang Village (TPP-12) in 2020

Detergent in river waters originates from waste or discharge from household and industrial activities as a cleaning agent. Foam from cleaning liquids on the water surface blocks oxygen from entering the water and disrupts the life of organisms in the water. Currently, the use of detergents has become very widespread and can almost replace the use of soap in household needs because synthetic detergent has good cleaning properties and are soluble in water. Synthetic detergent contains an active ingredient called surfactant, which functions to reduce water tension. The most widely used surfactant material is alkyl benzene sulfonate (ABS) compound, which is a benzene derivative, ABS containing surface-active substances is difficult to decompose by microorganisms and remains in water bodies (Situmorang, 2017). River waters are characterized by unidirectional water flow, flowing from upstream to downstream toward the estuary. Rivers play an important role for inside the river and around it. Rivers serve as habitats for aquatic life, but they are often used as sites for disposing of household waste (Pratiwi et al., 2020).

The allocation of pollutant loads in waters can also be determined from the assimilation capacity of monitoring locations in those waters. The ability of water in aquatic environments to absorb waste, energy, and microorganisms entering the river by human actions or naturally. Researchers use models to explain the role of parameters in improving and deteriorating water quality (Muhamad & Sigis, 2015). Many rivers in Indonesia have not yet had their pollution load carrying capacity calculated, while, on the other hand, activities along rivers and their banks continue to increase following population growth and economic needs. Water discharge at Kampar River WQM locations is presented in Table 7 and Figure 5; in August and October 2020. sunny weather and dry season. Water discharge has a significant impact on the movement of pollutants from upstream to downstream segments.

Table 7. Water Discharge at WQM TPP-2, TPP-11, and TPP-12 Kampar River WQM (Kg/day)

Description	Monitoring		
	TPP-2	TPP-11	TPP-12
BPBM	3.96	4.80	4.43
BPs	2.41	2.57	2.59
DTBP	1.55	2.22	1.84

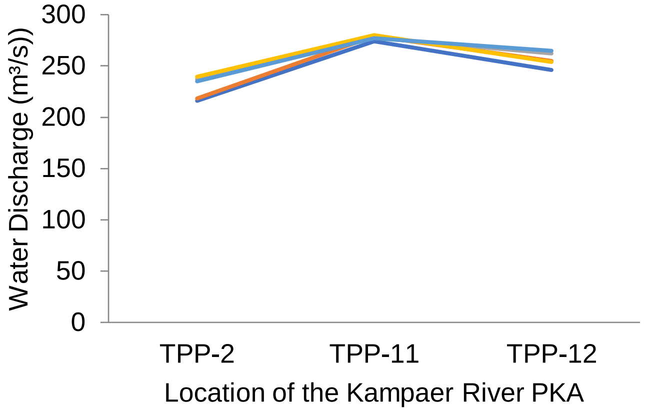

Figure 5. Water Discharge at Kampar River WQM Locations

In Table 7 and Figure 5, water discharge at WQM locations TPP-2, TPP-11, and TPP-12 fluctuates with each water sample collection. Flow discharge is the volume of water flowing per second, expressed in cubic meters per second (m^3/s). Water discharge is strongly influenced by local climate, temperature, tides, and water flow (Asdak, 2007). Water discharge flowing affects river water quality. During the dry season, low water flow velocity can reduce water quality. High water discharge from upstream and dilution processes can improve water quality in middle and downstream segments (Rezagama et al., 2019).

To obtain actual discharge data during sampling, two measurements are conducted: river cross-sectional area and river velocity. To obtain river cross-sectional area data, the average width and depth of the river are measured at the water sampling location. Discharge data is random and stochastic, related to the dynamics of population activities and climate or weather occurring at the research location. Therefore, statistical approaches can be used to determine the sensitivity or trend of river discharge data in a region, according to the amount of data and applicable regulations (Marganingrum et al., 2018).

3.3 Assimilation Capacity (AC) of BOD, Fecal Coliform, and MBAS Parameters

Assimilation Capacity (AC) refers to the allocation of pollutant load entering a river that can be cleaned through natural physical, chemical, and biological processes. The calculation of Assimilation Capacity value at WQM location TPP-11, which is approximately ± 43 kilometers from WQM TPP-12 on the Kampar River, uses a regression graph correlating the concentration of BOD, Fecal Coliform, and MBAS parameters measured at WQM location Danau Bingkuang Village (TPP-12) with the pollution load at WQM Air Tiris Market (TPP-11) as a data series. The AC values for BOD, Fecal Coliform, and MBAS parameters at WQM location Danau Bingkuang Village (TPP-12) on the Kampar River are presented in Figures (6), (7), and (8).

In Figure 6, the linear regression equation for BOD AC at WQM TPP-12 is Y = 1.9534X. R^2 = 0.977. The Assimilation Capacity value for BOD Pollution Load is 1.54 Kg/day, at a Quality Standard concentration of 3 mg/L in Appendix VI of Government Regulation No. 22 of 2021, class II. The value of 1.54 Kg/day represents the maximum capacity to receive pollution load from the BOD parameter.

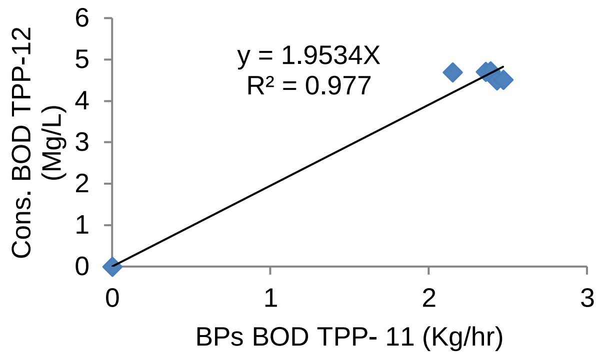

Figure 6. Linear Regression Equation for BOD AC Value at WQM TPP-12

The correlation coefficient value R^2 = 0.977 illustrates a very strong relationship between the BOD concentration variable at TPP-12 and the BOD PL variable at WQM TPP-11. The coefficient of determination (R^2) value indicates that BOD concentration at TPP-12 is influenced by BOD PL at TPP-11 by 97.7%, while the remaining 2.3% is influenced by other factors.

BOD is the reduction in oxygen concentration in water consumed by living organisms over a five-day period in dark conditions. This oxygen reduction is caused by the activity of organisms (bacteria) consuming or degrading organic compounds and other nutrients present in water that require oxygen. Oxygen depletion at the bottom of the water is mainly caused by the decomposition process of organic matter, which requires dissolved oxygen (aerobic) (Effendi, 2018). The BOD parameter describes the oxygen requirement needed by microorganisms in water to decompose organic compounds present in water into carbon dioxide and water. The higher the BOD, the more oxygen is required for biological processes (Nugroho, 2020).

Most of the BOD pollutant load tends to originate from domestic waste and the habits of communities living around rivers. Rivers serve as facilities for bathing, washing, and sanitation (MCK), as well as disposal sites for solid or liquid waste from households, restaurants, and leftover feed from fish cages and other livestock. Through chemical and biological reactions. BOD concentration can increase (Hidayatuddin et al., 2017). In Figure 7, the linear regression equation for AC at WQM TPP-12 is Y = 939.06X; R^2 = 0.087. The Assimilation Capacity value for Fecal Coliform Pollution Load is 1.06 Kg/day, at a Quality Standard concentration of 1000 mg/L in Appendix VI of Government Regulation No. 22 of 2021, class II. The value of 1.06 Kg/day represents the maximum capacity to receive pollution load from the Fecal Coliform parameter.

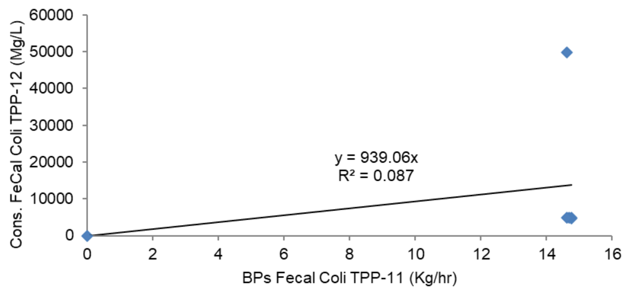

Figure 7. Linear Regression Equation for Fecal Coliform AC Value at WQM TPP-12

The correlation coefficient value R^2 = 0.08108 indicates that there is no relationship between the Fecal Coliform concentration variable at TPP-12 and the Fecal Coliform PL variable at WQM TPP-11. The coefficient of determination (R^2) value indicates that Fecal Coliform concentration at TPP-12 is not influenced by Fecal Coliform PL at TPP-11, but rather is influenced by other factors, amounting to 91.3% that are located around the TPP-12 location.

The entry of pollutants impacts the decline in river water quality, which can be determined by comparing measured parameters to quality standards; treatment is necessary, or the water should not be used directly. it can cause health problems (Tanjung et al., 2018). The potential of settlements as pollution sources is quite high, as they represent a significant source of organic waste. One parameter commonly used to identify domestic waste contamination in an area is biological characteristics in the form of the presence of coliform bacteria (Anisafitri et al., 2020).

The biological characteristics of Coliform bacteria presence are microbes most frequently found in polluted water bodies. The abundance of Coliform in waters due to domestic waste (pollutant) contamination can be determined by calculating the density of Coliform entering the waters (Hasibuan et al., 2022). Surface water flow and discharge fluctuations play roles in diluting and decomposing organic waste. Organic waste becomes suspended matter in water, becoming cellulose, fats, and proteins that float in the water. Surface water flow also carries microorganisms, such as bacteria and algae. Besides originating from natural sources, these organic materials also come from human activities, especially households. Additionally, waste from agricultural, livestock, and industrial sectors releases organic matter (Rahayu et al., 2018). Pollutants in water bodies undergo processes of diffusion, chemical decomposition (oxidation-reduction), biological (biodegradation), and physical (adsorption) processes (Effendi, 2018).

Monitoring results of the Siak River recorded an average of 5.859 coliform and 1.112 for E. Coliform, which are considered very high and not suitable for drinking. Nevertheless, there was no significant difference in microbiological parameters prior to the COVID-19 pandemic in 2020. These microbiological parameters can occur because household activities did not change during lockdown (Hasibuan et al., 2022). In Figure 8, the linear regression equation for AC at WQM TPP-12 is Y = 6.8295X. R^2 = 0.9847.

The assimilation capacity value for MBAS Pollution Load is 0.03 Kg/day, at a Quality Standard concentration of 0.2 mg/L in Appendix VI of Government Regulation No. 22 of 2021, class II. The value of 0.03 Kg/day represents the maximum capacity to receive pollution load from the MBAS parameter.

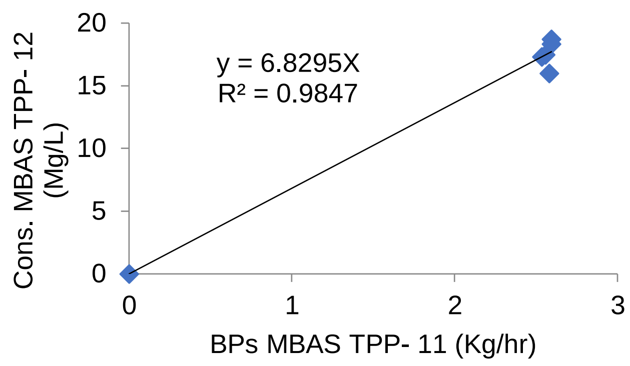

Figure 8. Linear Regression Equation for MBAS AC Value at WQM TPP-12

The correlation coefficient value R^2 = 0.9847 indicates a strong relationship between the MBAS concentration variable at WQM TPP-12 and the MBAS PL variable at WQM TPP-11. The coefficient of determination (R^2) value indicates that MBAS concentration at TPP-12 is influenced by BOD PL at TPP-11 by 98.47%, while the remaining 1.53% is influenced by other factors.

Detergent dissolved in water can form a foam that blocks light penetration, thereby inhibiting photosynthesis and killing microalgae, as well as blocking oxygen diffusion from the air, thereby reducing the oxygen supply to the water body. Phosphate compounds in detergents can also cause eutrophication, resulting in the population explosion (blooming) of aquatic plants and phytoplankton (Sari & Haeruddin, 2016).

Water is an important component for humans and other living beings as a source of life. One water source can come from surface water, which can be defined as water found above the ground surface, either stationary or flowing, such as rivers. The availability of surface water in the form of rivers in Indonesia has a very large volume. Rivers are very often utilized for drinking water supply, rice field irrigation, fisheries cultivation, tourism, and transportation. River protection efforts are actions taken to protect changes in river quality due to incoming pollution. Meanwhile, river mitigation efforts involve actions to prevent changes in river water quality, as designated. River protection and mitigation efforts can be carried out through multi-sector collaboration. First, from community groups, understanding and awareness are needed from communities living in river areas, not to dispose of waste, garbage, and other domestic activities into river bodies. Second, industrial initiator groups must be responsible for all processes in the industry, including existing waste disposal. Industrial initiators are required to have environmental permit documents in proper form, or an environmental management system as a benchmark for environmental prevention and control. The third group is the government, which is responsible for sanctioning industrial initiators if violations occur regarding river water pollution due to their production processes. The government is also responsible for facilitating communities in building communal or integrated Waste Water Treatment Plants (WWTP) if a community group does not yet have a WWTP (Firmansyah et al., 2021).

4. CONCLUSION

Based on the calculation results, the DTBP for BOD, COD, Fecal Coliform, and MBAS are below the BPBM for BOD, COD, Fecal Coliform, and MBAS at WQM locations TPP-2, TPP-11, and TPP-12 on the Kampar River. The Assimilation Capacity at WQM Location TPP-12 Danau Bingkuang Village, Kampar River in 2020, for BOD parameter: 1.54 kg/day, Fecal Coliform: 1.06 Kg/day, and MBAS: 0.03 Kg/day.

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