

Characteristics of Aquatic Insects as Bioindicators of Water Pollution in the Kokoq Babak River, Kebon Kongok Landfill

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Abstract. Water pollution is a critical environmental concern, especially near landfills. Landfill waste management generates leachate containing hazardous substances that can degrade water quality and alter aquatic habitat structure. This study assesses the condition of the Kokoq Babak River, impacted by the Kebon Kongok landfill, by using water striders (Gerridae) as bioindicators of environmental quality. The research employs a descriptive quantitative method with a correlational approach to explore the relationship between the Diversity Index (H') and Family Biotic Index (FBI) of Gerridae species and the water's physicochemical parameters. Analytical results demonstrate that the physicochemical parameters of the Kokoq Babak River generally comply with the quality standards stipulated in the Government Regulation of the Republic of Indonesia No. 22 of 2021, including temperature (28.6–28.9°C), Total Dissolved Solids (TDS) (141–250 ppm), Dissolved Oxygen (DO) (12.9–13.7 mg/l), and pH (7–8). Species distribution identification revealed three primary species: *Aquarius najas*, *Gerris lacustris*, and *Aquarius paludum*. The average diversity index (H') across the three observation points was 0.78, placing it in the "Low" diversity category. Conversely, the FBI value of 5 indicates that the water quality remains in the "Good" category, with pollution levels within tolerable limits.

Keywords: Bioindicators; Gerridae; Water quality; Water striders.

I. INTRODUCTION

Environmental pollution is one of society's most common problems, with water pollution the most dominant issue. This is because water is essential for the survival of all living things and is used for basic needs such as bathing, washing, cooking, and drinking. When unwanted substances enter water bodies, their quality declines significantly, potentially threatening public health (Toyoda et al., 2022).

This problem is evident in the Kokoq Babak River in West Lombok, which has a high pollution risk because it is close to the Kebon Kongok Final Processing Site (TPA) (Hemachandra & Sewwandi, 2023). This proximity makes the river vulnerable to leachate contamination generated

during the landfill's waste management process. Leachate is classified as a hazardous pollutant because it contains contaminants such as organic residues, heavy metals, and pathogenic bacteria and microorganisms. The accumulation of these substances in water not only pollutes the environment but also seriously impacts ecosystems and human health (Talalaj & Hajduk, 2024).

Leachate has been shown to pollute the Kokoq Babak River flow from the Kebon Kongok Landfill, with the highest pollution load in Total Coliform, BOD, and the heavy metal Cadmium in 2023 (Nuzuliana et al., 2023). This finding is supported by research by Athifah et al. (2019), which stated that, based on water quality analysis using Mollusca as a bioindicator, it showed H' between 1.3 and 1.5, which falls into the criteria of 'Moderate Pollution', in line with the increasing reports of cases of

diseases such as diarrhea, skin disorders, and acute respiratory infections among residents. This is reinforced by Meiliyadi et al., (2024), who identified significant pollution of several water parameters in the Kokoq Babak River as a direct result of landfill activities. These changes affect aquatic organisms, including macroinvertebrates such as water striders (Gerridae), which are sensitive to fluctuations in aquatic-environment quality.

Water striders, better known as *anggang-anggang*, are aquatic insects in the Gerridae family commonly found in various types of water, such as ponds, lakes, swamps, rivers, and even the sea surface (coast). Water striders have special adaptations that let them move freely on the water surface without sinking, using long, smooth, evenly distributed legs. Although generally slender and long, species vary in size and color. Sexual dimorphism, where males are typically smaller than females, is a characteristic feature of the Gerridae family. The family's approximately 56 genera and 450 species reflect broad adaptation to aquatic environments worldwide (Fadilah et al., 2017).

Water striders are classified as facultative benthos, a type of benthos that tolerates environmental pressures fairly well. This is supported by Fachrul (2007) and Setiawan et al. (2018), who stated that facultative benthos is a type of benthos with a fairly good tolerance to environmental changes compared to the other two types, causing this type to live in unpolluted to moderately polluted waters and still live in heavily polluted waters. This tolerance does not reduce water striders' sensitivity to changes in water quality, so this insect is often used as a bioindicator of water pollution. Water striders respond quickly to pollution, and their population abundance decreases significantly as an early signal of ecosystem disturbance. Highly toxic chemicals, such as those found in domestic or industrial waste, and reduced dissolved oxygen needed for survival can trigger this decline (Juliantara & Sutrisna, 2017). Gutiérrez (2018) supports this, showing that water striders respond to changes in water quality, such as pH levels, turbidity, organic matter content, and heavy metals.

In this study, water striders' ability to accumulate pollutants makes them well-suited as bioindicators for evaluating water quality in the Kokoq Babak River at the Kebon Kongok Landfill. In the analysis stage, the Diversity Index (H') and Family Biotic Index (FBI) formulas are used as important tools in evaluating freshwater quality. The (H') analysis can provide a deeper understanding of the relative distribution of dominant species in the study area (Alwi et al., 2020). Meanwhile, the FBI analysis provides a tolerance value based on how well water strider species can survive in an environment exposed to organic pollutants. The FBI value ranges from 1 to 10, where a higher tolerance value indicates lower

water quality. This means that a higher FBI value indicates more polluted waters (Illahi & Basyaiban 2022). Therefore, this study was conducted to analyze water quality based on the Diversity Index (H') and Family Biotic Index (FBI) analysis of aquatic species, along with physical and chemical water parameters, in the Kokoq Babak River, Kebon Kongok Landfill. This research is expected to help manage the environmental consequences of leachate and other human activities around the Kokoq Babak River, Kebon Kongok Landfill.

II. METHODS

This research was conducted on May 22, 2025. The research was carried out at the Kokoq Babak River, Suka Makmur Village, Gerung District, West Lombok Regency. Figure 1 shows the research location map.

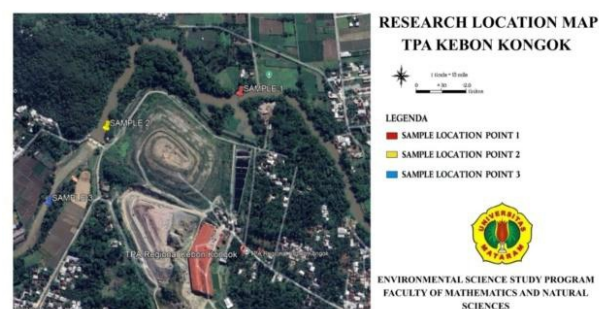


Figure 1. Map of the Kokoq Babak River Research Location, Kebon Kongok Landfill, Suka Makmur Village, Gerung District, West Lombok Regency.

The tools and materials used in this study support data and sample collection. The tools used in this study are stationery, sample bottles, Water Quality Meter, thermometer, pH meter, fishing net, cellphone camera, label paper, plastic bags, and reference books or journals on identification guides for water strider species (Gerridae) based on Hilsenhoff (1988) and Juliantara & Sutrisna (2017). Meanwhile, the materials used are water strider samples and water samples from the Kokoq Babak River.

This type of research is quantitative descriptive with a correlational approach, which focuses on exploring and presenting the relationship between water quality based on analysis (H') and FBI of aquatic species and the physical and chemical parameters of water in the Kokoq Babak River. *Anggang-anggang* samples will be collected using the direct capture method (hand picking) with a fish net, while river water samples will be collected using the hand-grab sampling method.

The work procedures in this research include several steps, including:

1. Determination of Sampling Points.

The sampling points were determined using purposive sampling, as shown in Figure 1. Point 1 (inlet) is assumed to be where river water is contaminated by leachate. Point 2 (middle) marks the boundary between water suspected of leachate exposure and water intended for use by the surrounding community.

Point 3 (outlet) is assumed to have good water quality and be suitable for use by the surrounding community. We selected sampling points at strategic locations that represent water-flow conditions: before, during, and after passing through the landfill site. This aims to observe how variations in environmental conditions affect sample collection (Lestari et al., 2020).

2. Sampling

We collected anggang-anggang samples using a fishing net. We placed captured samples in sample bottles, labeled them with the location, collection time, and number of individuals, and photographed them. After collection, we took the samples to a laboratory for identification.

River water sampling follows the Indonesian National Standard (SNI) 6989.57:2008 for Water and Wastewater. We collected samples using a 500 mL sample bottle. We inserted the sample bottle into the water with the mouth facing the flow, filled it to the brim, and then closed it.

Next, the laboratory analyzes the samples. We record each sample measurement result, along with the sampling point location, sampling time, and weather conditions. We compare the physical and chemical parameters with the water quality standards stipulated in Government Regulation of the Republic of Indonesia Number 22 of 2021 to determine river water quality (Table 1).

Table 1.

Water quality standards stipulated in Government Regulation

Parameter	Quality standards	Symbol
<i>Physical</i>		
1. Color	-	-
2. Turbidity	-	-
3. Smell	-	-
4. Temperature	Deviation of ±3°C	°C
5. TDS	2.000	ppm
<i>Chemical</i>		
1. DO	0	mg/L
2. pH	6 – 9	-

Source: Government Regulation of the Republic of Indonesia Number 22 of 2021.

The identified water strider species were then analyzed using the Shannon-Wiener Diversity Index (H'), which uses a formula with reference to research conducted by Batubara et al. 2024), which is stated as follows:

$$H' = -\sum (P_i \ln P_i)$$

Where (P_i) is the relative abundance of the i -th species, (P_i) = (n_i/N_t), (n_i) is the number of individuals of the i -th species, and (N_t) is the total number of individuals of all recorded species. The species diversity index value is an important tool in evaluating the health of aquatic ecosystems (Safnowandi, 2021). This diversity value shows not only the richness of an aquatic ecosystem, but also the importance of water striders in the food chain and the ecological balance of their habitat (Meliawati et al., 2024).

The FBI approach calculates the water quality index using a formula based on water strider species' tolerance values to environmental changes. The formula used is:

$$FBI = \frac{(x_i \times t_i)}{n}$$

Where (x_i) is the number of individuals found in each family, (t_i) is the tolerance value of the family, and (n) is the total number of organisms found at each sampling point (Hettige et al., 2020). The reference tolerance value (t_i) used to calculate the FBI value follows the standards established in the study (Mandaville, 2022).

The tolerance value ranges from 0 (very intolerant to organic waste) to 10 (very tolerant to organic waste); the higher an organism's tolerance value, the lower the water quality. Water quality categories will vary according to the FBI value obtained, ranging from "Possible Slight Organic Pollution" to "Severe Organic Pollution". Table 2 presents the division of river water quality categories based on FBI values, referring to research (Hilsenhoff, 1988).

III. RESULTS AND DISCUSSION

Based on the results of the research that has been carried out, the analysis of physical and chemical parameter measurements at 3 (three) sampling points at the research location, namely the Kokoq Babak River, Kebon Kongok Landfill, is presented in Table 3. The results of the biological parameter analysis, calculated using the FBI value and the level of diversity of water sedge species (H') at three points, can be seen in Table 6 and Table 7.

The physical condition of the water at three observation points around the river, namely point 1 (inlet), point 2 (middle), and point 3 (outlet), is classified as "somewhat turbid" for the turbidity section. All three observation points show high turbidity. This is mainly due to waste

around riverbanks, waste-processing activities that produce leachate, and the river's physical characteristics that affect the distribution of suspended particles. Water turbidity is an important parameter that affects light transmission, which in turn impacts aquatic life. Sidik et al. (2017) explained that suspended particles influence water turbidity. Based on observations, the depth at point

2 exceeds that of the other two points. Suteja & Purwiyanto (2018) reported a positive correlation between water depth and turbidity, although it was not significant. Based on field observations, the midstream location near the riverbank causes sedimentation on the waterbed, which affects the turbidity classification at point 2.

Table 2.
Water quality based on the range of Biotic Family Index (FBI) values

Biotic Index	Water Quality	Organic Pollution Level
0.00-3.50	Superior	Possibility of Organic Contamination is slight.
3.51-4.50	Very good	Some organic pollution.
4.51-5.50	Good	Some organic pollution.
5.51-6.50	Balanced	Organic pollution is quite significant
6.51-7.50	Quite Poor	Major organic pollution.
7.51-8.50	Poor	Organic pollution is very significant.
8.51-10.0	Very Poor	Severe organic pollution.

Table 3.
Results of Analysis of the Quality of Physical-Chemical Parameters of the Kokoq Babak River Water at the Kebon Kongok Landfill

Point	Color	Turbidity	Smell	Temperature (°C)	TDS (ppm)	DO (mg/l)	pH
1 (Inlet)	Yellowish	A bit cloudy	Odorless	28.8	245	12.9	7.74
2 (Middle)	Yellowish	A bit cloudy	Odorless	28.6	141	13.7	7.90
3 (Outlet)	Yellowish	A bit cloudy	Odorless	28.9	250	13.3	8.70

Source: Primary data

At the three sampling points, the river water was clear and yellowish. The color at points 1 and 3 is influenced by high Total Dissolved Solids (TDS) or suspended particles. Meanwhile, at point 2, the yellowish color is influenced by greater depth than at the other two observation points (Rahadi et al., 2020). The yellowish color of the water may also indicate organic contaminants or dissolved metals. Sunarsih et al. (2023) support this, noting that changes in water color can result from organic and inorganic materials, plankton, humus, metal ions (such as iron and manganese), and other substances. This color not only indicates the presence of pollutants but also reflects light interactions in the water, which can disrupt photosynthesis in aquatic organisms and result in ecosystem imbalance. For water striders, cloudy water color indicates changes in aquatic environment quality. This change is often accompanied by hazardous materials that can reduce water strider populations.

Based on the observation results, the odor parameters at the three observation points were relatively odorless. This indicates that other chemical and physical parameters do not significantly affect river water quality. Water

temperatures at all points ranged from 28.6 to 28.9°C, within $\pm 3^\circ\text{C}$ of the air temperature above the water surface, indicating that the water temperature still meets quality standards. TDS at all points ranged from 141 to 250 ppm, well below the 1,000 ppm maximum limit, indicating good water quality in terms of dissolved solids content. However, if TDS increases too high, it can disrupt the osmotic pressure of the water strider's body, making it harder to absorb water or leading to dehydration. This stress can reduce the body's resistance and ultimately lead to population decline. Therefore, as TDS increases, water strider populations tend to decrease because only species tolerant of osmotic stress can survive. Sholiha's research (2022) supports this, stating that high TDS can negatively impact the ecosystem and disrupt water balance. Dissolved oxygen (DO) is also above the minimum limit set, with values between 12.9 and 13.7 mg/l, which indicates very good water quality to support aquatic life, and the pH value at all points is in the range of 7 to 8, according to the permitted limit of 6 to 9, indicating that the water is not excessively acidic or alkaline. Water quality analysis in the Kokoq River Babak TPA Kebon Kongok shows that all

main physical and chemical parameters meet the permitted limits for class II quality standards under Government Regulation of the Republic of Indonesia Number 22 of 2021 concerning the Implementation of Environmental Protection and Management.

Table 4.
Identification of water strider species

Individual images	Species Name
	<i>Gerris lacustris</i>
	<i>Aquarius najas</i>
	<i>Aquarius paludum</i>

Human activities, such as agriculture, livestock farming, disposing of waste into rivers, and using detergents for washing, can cause eutrophication (Nazma et al., 2025). This eutrophication increases algae and phytoplankton that compete for light and oxygen, while increasing carbon dioxide (CO₂) levels and reducing water quality. Sonarghare et al. (2020) and Zhang et al. (2023) support this, defining eutrophication as excessive plant and algal growth caused by increased availability of growth-limiting factors (sunlight, carbon dioxide, and nutrient fertilizers) needed for photosynthesis. If this continues, river water quality can decline (Lin et al., 2016). The data show that at Point 1 (inlet), all parameters remain within permitted limits, although several piles of rubbish line the riverbank. At Point 2 (middle), all parameters were also within permissible limits; however, the higher TDS value indicated increased dissolved solids from leachate waste, a main source of eutrophication. Research by Nazma et al., (2025) showed that high water mass movement can increase DO concentrations due to oxygen diffusion from the air. Temperature, salinity, and water mass movement influence oxygen transfer from the air. At Point 3 (outlet), all parameters were within permissible limits, indicating that water conditions around the settlement remain good.

According to Kesuma et al., (2022), Gerridae, often called water striders, are insects typically found in still waters. This species spends its entire life cycle in intermittent, still water currents. Therefore, if the watercourse dries up, the water striders will seek out or create small holes to hide and shelter until the water refills. This species is often found in large numbers and forms small groups. This grouping behavior helps them avoid predators and find prey. According to Ulfazillah (2021), water striders occur in a variety of environments, from shallow ponds to deeper rivers, because they adapt well to changing conditions.

Observations at three sampling points showed that *Gerris lacustris* and *Aquarius najas* were the most dominant species at all locations, with values varying by location. Point 1 has a calm current and is influenced by several garbage piles. At this location, researchers found three individuals of *Gerris lacustris* and four individuals of *Aquarius najas*, for a total of seven individuals. Meanwhile, at point 2, which has a strong current with eutrophicated water conditions, four individuals of *Aquarius najas*, 11 individuals of *Gerris lacustris*, and five individuals of *Aquarius paludum* were found, for a total of 20 individuals. The strong current and sandy substrate provide an ideal habitat for these species, giving them a competitive advantage in resource access and a safe place to breed. Morphological and behavioral adaptations to strong currents, including the ability to use rocks and sand as anchor points, are evident in the species' dominance at this point.

Table 5.
Types and Number of Water Striders Found at Three Sampling Points

Point	Species Name	Number of Individuals
1	<i>Gerris lacustris</i>	3
	<i>Aquarius najas</i>	4
2	<i>Aquarius najas</i>	4
	<i>Gerris lacustris</i>	11
	<i>Aquarius paludum</i>	5
3	<i>Aquarius najas</i>	2
Total		29

At point 3, with a calm current approaching low tide, we found only two *Aquarius* individuals. This suggests that despite its ability to survive in nutrient-rich environments with changing water quality, this species' population tends to be small. Waste does not significantly affect the species' distribution, but waste containing hazardous chemicals can contaminate food sources. This pollution can reduce food quality and availability for these species. Nevertheless, these three species still adapt well to these environmental conditions. Shrinking river water volume and eutrophication from leachate seeping through

the soil are driving the decline in individual numbers. As shown by Widjaja and Gunawan (2022), eutrophication results from chemical waste from agricultural activities, livestock, garbage disposal, and household waste,

including detergents. This condition triggers nutrient enrichment, which excessively increases algae and phytoplankton populations.

Table 6.
Shannon-Wiener Diversity Index (H') for the Kokoq Babak River Water at the Kebon Kongok Landfill

Point	Family	Species	Number of individuals	Pi × in × Pi	H'
1	Gerridae	<i>Gerris lacustris</i>	3	- 0.3431	
		<i>Aquarius najas</i>	4		
2	Gerridae	<i>Aquarius najas</i>	4	- 0.2564	
		<i>Gerris lacustris</i>	11		
		<i>Aquarius paludum</i>	5		
3	Gerridae	<i>Aquarius najas</i>	2	- 0, 1846	
Total			29		0.78

Source: Primary data

Table 7.
Family Biotic Index (FBI) Analysis Values of the Kokoq Babak River Water at the Kebon Kongok Landfill

Point	Family	Species	Number of individuals	xi × ti	FBI
1	Gerridae	<i>Gerris lacustris</i>	3	35	
		<i>Aquarius najas</i>	4		
2	Gerridae	<i>Aquarius najas</i>	4	100	
		<i>Gerris lacustris</i>	11		
		<i>Aquarius paludum</i>	5		
3	Gerridae	<i>Aquarius najas</i>	2	10	
Total			29	145	5

Source: Primary data

This increase increases competition for light for photosynthesis and for oxygen, leading to mass deaths of aquatic organisms. Excessive respiration raises CO₂ levels, degrading water quality and causing mass die-offs of aquatic fauna. This explains the discovery of only two *Aquarius najas* individuals at point 3, with no other species present. Eutrophication hampers population stability, allowing only highly adaptable species like *Aquarius najas* to survive. As a result, the habitat at point 3 does not support a stable population, so *Aquarius najas* is the only species found in very limited numbers.

Analysis using the *Shannon-Wiener diversity index* yielded a value (*H'*) of 0.78. Based on the index classification, this value falls into the 'Low' diversity category. This suggests that the aquatic ecosystem at the research location tends to be unstable, with only one or two species dominating. A value (*H'*) of less than 1 indicates that the waters in the Kokoq Babak River, Kebon Kongok TPA, are in a severely polluted condition. The limited species presence and uneven individual distribution reflect

strong environmental pressure from pollution, likely originating from landfill leachate seepage.

We measured water quality in the Kokoq Babak River at the Kebon Kongok Landfill using bioindicators of freshwater algae commonly found in large rivers. We calculated the FBI value. The FBI value ranges from 1 to 10, based on Hilsenhoff (1988). On this scale, a higher tolerance value indicates lower water quality; in other words, a higher FBI value means more polluted water (Illahi & Basyaiban, 2022).

Based on the calculations above, the water strider bioindicator's FBI value was 5. This value indicates that the water quality in the Kokoq Babak River at the Kebon Kongok Landfill falls into the 'Good' classification according to Table 1, but still meets the criteria for organic material contamination. Field conditions support this finding and indicate community activities such as washing, settlements, and waste processing at the Kebon Kongok Landfill. These activities directly affect water quality through leachate overflowing, seeping into the ground, and

mixing with river water. Waste processing activities that produce leachate are the largest contributor to pollution affecting water strider species, as well as the diversity index and FBI values obtained. The lack of analysis of how environmental parameters influence water strider diversity is a research gap that can be studied further. This includes a more in-depth study of how abiotic factors around the sampling location affect diversity and the samples' adaptability to surrounding environmental conditions. Therefore, this phenomenon can serve as a basis for more comprehensive future research.

IV. CONCLUSION

The water quality in the Kokoq River Babak TPA Kebon Kongok still meets the quality standards stipulated in Government Regulation Number 22 of 2021 for several field parameters. This is evident from the water's physical and chemical parameters, such as color, odor, temperature, TDS, DO, and pH, which fall within normal ranges. However, the identification results show that species diversity is limited to three main species: *Aquarius najas*, *Gerris lacustris*, and *Aquarius paludum*. Environmental conditions at several observation points do not support species diversity because shrinking water volume and eutrophication reduce it.

This is indicated by the diversity index value (H'), which is included in the 'Low' category. Meanwhile, the FBI value indicates that water quality is in the 'Good' category, with a tolerable level of pollution. However, human activities such as using detergents for washing and waste processing that produces leachate still contribute to the decline in water quality. Overall, the water strider species showed good adaptation to environmental conditions in the Kokoq Babak River, Kebon Kongok Landfill, with varying tolerance values and diversity influenced by physical and chemical characteristics at each observation point

CONFLICT OF INTEREST

The authors have no conflict of interest regarding this publication

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