Monitoring of ecotoxicological parameters in the floating net cage area in Buluhcina Village, Kampar District, Riau Province, Indonesia

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Abstract. Net cages culture activities produced organic pollutant that are distributed in the surrounding area and thus affects the water's ecotoxicological parameters. This research was conducted along the Kampar River in the village of Buluhcina during the period of May to July 2023. Water samples were collected three times and the parameters measure were TSS, DO, COD, pH, Nitrite and Total P. Results indicate that in general, the water quality of the Kampar River's was less contaminated (Pollution Index 1.19). The most polluted area was in Station 1 (PI 1.35) as indicated by high TSS and nitrite content that were more than the standard level. Relatively high nitrate content was also found in Station 3 (0.08 mg/l). In Station 2, however, the water quality was relatively good (PI 0.87), and the COD level was slightly above the standard value (0.5 mg/l). Based on data collected, it can be concluded that the water quality in the study site can be categorized as good and it may be used to conduct aquaculture activities.

1 Introduction

The Buluhcina village is one of administrative regions in the Siak Hulu District, Kampar Regency. This village is located in the Kampar River Basin and it has high potential of Mystus nemerus and Wallago leeri catfish resources [1]. High demand of this fishes, however, increased the catching activities that may lead to reduced hose fish populations. During the rainy season, juveniles of M. nemurus and W. leeri are commonly present in the river. The villagers used to capture and rear these fishes in Floating Net Cages (FNC) that are placed in the river. Even though the FNC activities provided advantages in economical terms, but it may negatively affect the surrounding environment.

The development of FNC in the Buluhcina Village this decade is not only having socio-economic and cultural impacts, but also has environmental consequences, particularly on water quality. According to Beveridge [2], FNC operations potential to alter water quality as...
organic pollutant input originated from fish feed and metabolic waste of the fish. The present of these organic materials may reduce the water quality in general [3]. Decomposition of these organic materials will produce nitrogen (N) and phosphorus (P). This process unfortunately consuming O\textsubscript{2} and producing CO\textsubscript{2} that reduced the water quality. As a consequence, this condition may disturb the life of aquatic organisms living in that area.

The present of N and P in the water may support the live of phytoplankton that serve as a basis for foodchain in that area[4]. In natural waters, phytoplankton plays as primary producers that facilitated food resources for the higher trophic level organisms[5]. The present of N and P in certain concentration may improve the fertility of the water, but high concentration of these chemicals may reduced the water quality as well as reducing the carrying capacity of the water.

Environmental carrying capacity is the upper limit of population growth that a population can no longer be sustained by the available resources, means, and the environment [6]. The opportunity for significant profits from Floating Net Cage (FNC) aquaculture has led many individuals to engage in FNC cultivation in water bodies that exceed their environmental carrying capacity. The negative impact of this is the potential for mass mortality of cultured and wild fish in the water [7]. This can occur when the conditions of the river, as the cultivation medium, are already polluted. To minimize these negative impacts, knowledge of FNC cultivation in Buluhcina Village is essential and should be adjusted by calculating the environmental pollution index of the Kampar River to ensure sustainability.

The dynamic nature of water quality implies that it is subject to fluctuations and can evolve over time. An assessment of water quality within the Buluhcina region was previously conducted in 2017. Given that a span of 6 years has elapsed since that assessment, it is reasonable to anticipate that various alterations and developments may have transpired in the area. Consequently, it is pertinent and intriguing to reevaluate and monitor the current state of water quality therein.

2 Research Method

This investigation was undertaken within the confines of Buluhcina Village, situated in the Siak Hulu District of Kampar Regency, with the primary objective of evaluating the pollution levels of the Kampar River within this specific ecological context. The research spanned a period encompassing May through July of the year 2023. The assessment of physical and chemical parameters was executed through a combination of in situ measurements conducted directly within the field and ex situ analyses performed at the Ecology and Environmental Management Laboratory, affiliated with the Faculty of Fisheries and Marine Sciences at Universitas Riau.

This study constitutes a quantitative investigation employing a survey methodology. The study involved the acquisition of morphometric data related to the river, encompassing dimensions such as its length, width, and depth, along with temperature assessments and coordinate registrations. These measurements were conducted using an Echo Sounder device, specifically the Garmin GPSmap 585 series. Furthermore, the study documented the quantity and spatial arrangement of Floating Net Cages (FNC). Sampling activities were carried out at 10 AM during weather conditions characterized by clear skies. Three distinct sampling stations were established: Station 1, situated upstream of the FNC area; Station 2, positioned within the FNC zone; and Station 3, located downstream of the FNC area. The research stations were designated based on the coordinate points of the stations observed in the previous study conducted in 2017. Sampling events occurred only once at each designated station. The parameters under scrutiny encompassed variables such as water temperature, water flow velocity, light penetration, total nitrogen concentrations, nitrate and nitrite levels, total phosphorus content, orthophosphate concentrations, total suspended solids (TSS),
dissolved oxygen levels (DO), chemical oxygen demand (COD), pH levels, Nitrite levels, and Total P. All samples designated for ex situ analyses were promptly placed in a cooling container on the same day of collection and subsequently transported to the laboratory for further analytical procedures.

The acquired data were subsequently subjected to analysis employing the Pollution Index (PI) methodology [8], which is grounded in the water quality classification denoted as Class II, as stipulated by the Government Regulation of the Republic of Indonesia No. 82 of 2001 [4]. The formula utilized for calculating the PI is as follows:

\[ IP_j = \sqrt{\frac{\left(\frac{C_i}{L_{ij}}\right)^2 + \left(\frac{C_i}{L_{ij}}\right)^2}{2}} \]  

In the provided context, \( IP_j \) represents the Pollution Index allocated to category \( j \). The variable \( C_i \) denotes the concentration of water quality parameter \( i \), which corresponds to the field measurement outcomes and is expressed in milligrams per liter (mg/l). \( L_{ij} \) represents the concentration of water quality parameter \( i \) specified within the standard for water category \( j \), also measured in milligrams per liter (mg/l). Here, \( M \) signifies the maximum value, and \( R \) denotes the average value.

The Pollution Index (IP) comprises four distinct classes, each associated with specific value ranges. A value within the range of 0 to 1.0 indicates compliance with water quality standards, representing a "good" quality designation. When the IP falls within the range of 1.0 to 5.0, it signifies slight pollution. A range of 5.0 to 10.0 indicates moderate pollution, while an IP exceeding 10.0 implies a highly polluted status for the water under consideration.

3 Result and Discussion

3.1 Research Area Conditions

The village of Buluhcina is geographically partitioned into four distinct hamlets, specifically identified as Hamlet I, Hamlet II, Hamlet III, and Hamlet IV. Hamlets I and II are positioned along the eastern bank of the Kampar River, while Hamlets III and IV are situated on the western bank of the same river. Presently, there exists no bridge infrastructure facilitating direct connectivity between Hamlets I and II on one hand and Hamlets III and IV on the other. Consequently, the crossing of the river between these hamlets necessitates the utilization of watercraft, such as boats or motorized vessels.

Buluhcina constitutes a region that has taken shape due to the outflow of water from the Koto Panjang hydroelectric power dam. The primary investigative scope of this study is centered within the confines of Buluhcina Village and encompasses an approximate length of 1,400 meters along the course of the river. In comparison to research conducted in 2017, it becomes evident that there has been an augmentation in the quantity of fish cages within the Buluhcina area. In the previous study, encompassing the described research zone, there were 105 fish cages distributed collectively, with 700 meters of riverbank allocated for their placement on the right side. Presently, this number has surged to 125 cages. Similarly, on the left bank of the river, there were initially 213 fish cages spanning a stretch of 1,100 meters, and this count has now escalated to 242 cages. When aggregating the total number of enclosures, the cumulative figure stands at 368 units, representing an increment of 49 units from the previous count of 318 units.
Fig 1. Echo Sounder Processing Data Results and Location of Observation Station in Kampar River, Buluhcina Village[1]

3.2 Pollution Index (PI)

The outcomes derived from the Pollution Index (PI) computations conducted within the vicinity of the Kampar River, specifically within the Buluhcina Village region, reveal that the water quality at three designated monitoring stations falls short of the established water quality standards denoted as Class II. Nevertheless, there exists a variability in the values associated with distinct parameters, thereby influencing the computed PI values. The findings stemming from the PI measurements have been compiled and are presented in Table 1.

In general, the water quality remained consistent across all monitoring stations, despite a marginal elevation in the PI value recorded at stations 2 and 3. This is believed to have transpired as a consequence of the amplified presence of cage units utilized for cultivation purposes at station 2, subsequently influencing station 3 as it serves as a rinsing area for the cultivation activities. The difference in PI values can be seen from Tables 1 and 2.

Table 1. The outcomes of the physical-chemical analysis of the Kampar River water parameters in Buluhcina Village and the associated Pollution Index values in 2017[1].

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sampel (mg/l)</th>
<th>Standards class 2 (mg/l)</th>
<th>Exceed the conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>St 1</td>
<td>St 2</td>
<td>St 3</td>
</tr>
<tr>
<td>TSS</td>
<td>74</td>
<td>21</td>
<td>49</td>
</tr>
<tr>
<td>DO</td>
<td>7</td>
<td>5.5</td>
<td>7.6</td>
</tr>
<tr>
<td>COD</td>
<td>6.4</td>
<td>25.6</td>
<td>12.8</td>
</tr>
<tr>
<td>pH</td>
<td>6.8</td>
<td>6.6</td>
<td>6.6</td>
</tr>
<tr>
<td>Nitrite</td>
<td>0.08</td>
<td>0.06</td>
<td>0.08</td>
</tr>
<tr>
<td>Total P</td>
<td>0.0699</td>
<td>0.0359</td>
<td>0.0712</td>
</tr>
<tr>
<td>IP</td>
<td>1.35</td>
<td>0.86</td>
<td>1.29</td>
</tr>
</tbody>
</table>
Table 2. The outcomes of the physical-chemical analysis of the Kampar River water parameters in Buluhcina Village and the associated Pollution Index values in 2023.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sampel (mg/l)</th>
<th>Standards class 2 (mg/l)</th>
<th>Exceed the conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>St 3</td>
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<tr>
<td>TSS</td>
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<td>19</td>
<td>49</td>
</tr>
<tr>
<td>DO</td>
<td>7,1</td>
<td>5,5</td>
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<tr>
<td>COD</td>
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<tr>
<td>pH</td>
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<td>6,7</td>
<td>6,5</td>
</tr>
<tr>
<td>Nitrite</td>
<td>0,09</td>
<td>0,06</td>
<td>0,09</td>
</tr>
<tr>
<td>Total P</td>
<td>0,0789</td>
<td>0,039</td>
<td>0,0841</td>
</tr>
<tr>
<td>IP</td>
<td>1,35</td>
<td>0,90</td>
<td>1,32</td>
</tr>
</tbody>
</table>

Information : = Parameters that exceed the quality standards

A notable contrast is observed in the Total Suspended Solids (TSS) value recorded for station 1. This divergence is presumed to be a result of station 1’s proximity to the river meander. It is conceivable that the water samples collected in this vicinity were impacted by sediment deposition on the inner side of the meander and the erosional effects occurring on the outer side of the meander. Odum [9] posited that the flow patterns can significantly affect the presence of particulate matter in water, primarily due to the agitating actions brought about by currents. Furthermore, the mixing process can elevate the presence of particles within the river sediment, facilitating their transportation by the water's current.

These PI values collectively indicate that, on the whole, the condition of the Kampar River's water quality can be categorized as marginally polluted, with a calculated PI value reaching 1.19. The most pronounced pollution is discerned at Station 1, where the PI value
stands at 1.35, particularly within the upstream fish cage vicinity. This circumstance arises primarily due to the fact that two parameters exceed the defined threshold levels, specifically Total Suspended Solids (TSS) and nitrite. The elevated TSS levels noted at Station 1 are attributed to the mixing effects induced by water flow [10]. Notably, nitrite levels surpassing the prescribed quality standard (0.06 mg/l) are observed at Stations 1 and 3, registering values as high as 0.09 mg/l. Conversely, at Station 2, denoted by a PI value of 0.87, the nitrite level is at the threshold specified within the quality standard, resting at 0.06 mg/l. The amplified nitrite concentrations at Stations 1 and 3 are ascribed to contributions conveyed by the flow of water. At Station 2, which encompasses fish cages, the singular parameter exceeding the established quality standard is Chemical Oxygen Demand (COD), albeit by a slight margin, hovering around 0.5 mg/l. Given the adherence to quality standards by other parameters, the overarching evaluation based on the PI values categorizes this area as compliant with quality standards, signifying a "good" water quality status and rendering it good for aquaculture.

4 Conclusion and recommendation

4.1 Conclusion

Overall, the state of the Kampar River's water quality, especially within the confines of Buluhcina Village, falls within the classification of being minimally contaminated. The portion of the river deemed suitable for fish cage cultivation is precisely situated at Station 2. Meanwhile, the water conditions at both Station 1 (upstream) and Station 3 (downstream) also align with the classification of being slightly polluted. In contrast, Station 2, which corresponds to the fish cage area, maintains a water quality that does not exhibit any signs of pollution.

4.2 Recommendation

Conduct further studies to identify potential sources of pollution that may affect Station 1 (upstream) and Station 3 (downstream). This may involve a more detailed analysis of the types and origins of pollution, as well as mitigation measures that can be taken. Carry out research on the management of fish cultivation at Station 2 (fish cage area) to ensure the sustainability of these practices. This includes continuous monitoring of relevant water parameters and the implementation of sustainable practices.

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