Water Quality Changes Due to Effect of Arowana Aquaculture Activities at Bukit Merah

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ABSTRACT

A study on water quality at Bukit Merah was conducted in order to investigate the changes of water quality from the inflow towards the outflow discharge of Arowana farm due to the presence of Arowana aquaculture activities. Water samples at the inflow (Bukit Merah reservoir, Terusan Besar and intake structure) with the discharge (outlet vault, drainage canal and Sungai Kurau) from the Arowana farm were collected on a weekly basis from 10th July to 2nd October 2011 and being compared. The calculated water quality index (WQI) shows that the mean for all WQI for inflow and discharge were within the Interim National Water Quality Index (INWQS) Class II. A decreasing WQI values occur as the water was discharge from the Arowana farm. However, the reduction does not affect the water quality since the WQI was still within the INWQS Class II. It is concluded that the presence of aquaculture farm at the Bukit Merah does have an immediate deterioration effects towards the water quality but, as the water were released, the pollutant mix and become diluted. This natural attenuation process improves the water quality and eventually the water meets the standard and the water quality fell in INWQS Class II.

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INTRODUCTION

In Malaysia, the Arowana are well known to breed successfully at Bukit Merah. The source of water is solely from the Bukit Merah reservoir. Bukit Merah reservoir is a modified homogeneous earthfill embankment located upstream of the confluence of Sungai Kurau and Sungai Merah in the State of Perak. The reservoir provides irrigation water for double cropping to 24,000 Ha of paddy land under the Krian-Sungai Manik Project. In addition to the irrigation supply, it also provides some 5.6 m^3/s of water to meet the domestic and industrial demands for the Krian District. Water in the reservoir is also a source of income for the local fishermen[1]. The main purpose of this study is to observe the water quality changes that occur at the Sungai Kurau (outflow discharge) due to the presence of Arowana aquaculture activities.

Arowana is one of the most valuable species in the Asian ornamental trade[2]. Basically there are three main varieties colour of this species which are Golden Arowana, Red Arowana and Green Arowana[3]. Among these three varieties, the best quality is the Malaysian Golden Arowana which can only breed successfully at Bukit Merah Lake in the state of Perak, Malaysia. The breeding seasons for Arowana normally occur from August to October every year [4]. Since it can only breed at Bukit Merah, the government had gazetted 186 Ha of land for the Arowana Breeding Zone [5]. Impacts of aquaculture activities had been a growing concern recently.

Aquaculture wastes were produced by fish activity, feeding techniques, and the presence of heterotrophic organisms (bacteria and fungi) in the aquaculture system [6]. Environmental activists and scientists have expressed their concern towards the impacts on the environment and natural resource causes by aquaculture activities. Among the most serious concerns are the conversion of agricultural land to ponds, water pollution resulting from pond effluents, excessive use of drugs, antibiotics, and other chemicals for aquatic animal disease control, excessive use of ground water and other freshwater supplies for filling ponds and conflicts with other resource country and disruption of nearby communities [7]. Due to those concerns, the water pollution by pond...
Effluents had become the most common complaints and had rise the official attention in most nations [8,9,10]. Usually wastes discharged from aquaculture consist of uneaten feed, feces and bacteria. The feed contain protein, carbohydrate, fat, minerals and water. As the fish eat the feed, 25% of amount nitrogen is assimilated from the feed for the biomass production whereas the rest is released as ammoniacal nitrogen (NH$_3$-N), dissolved organic nitrogen or feces [11]. These wastes will further cause environmental changes such as deoxygenated and it will leads to considerable eutrophication and an increase in the frequency of toxic algae blooms [6]. An estimation of 85% phosphorus, 80 to 88% of carbon, 60% of mass feed input and 52 to 95% of nitrogen in aquaculture will end up as dissolved chemicals, particulate matter or gases. Due to that, the discharge of aquaculture wastewater to the natural bodies needs to followed the guidelines provided by adopting more environmentally friendlier methods [12].

**Methodology:**
In this study, water samples at the inflow which involves Bukit Merah reservoir, Terusan Besar and intake structure with the discharge which involves outlet vault, drainage canal and Sungai Kurau were collected on a weekly basis from 10th July to 2nd October 2011. Fig. 1 shows the location plan of study area at Krian irrigation scheme while Fig. 2 shows the respective sampling points. Table 1 shows the details of each sampling points.

**Table 1:** Sampling points and the coordinate.

<table>
<thead>
<tr>
<th>Point</th>
<th>Inflow</th>
<th>Coordinate</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>Bukit Merah reservoir</td>
<td>N05°01’04.5” E 100°39’07.0”</td>
</tr>
<tr>
<td>S2</td>
<td>Terusan besar</td>
<td>N05°01’00.9” E 100°38’36.5”</td>
</tr>
<tr>
<td>S3</td>
<td>Intake structure</td>
<td>N05°00’58.8” E 100°37’16.9”</td>
</tr>
<tr>
<td>S4</td>
<td>Outlet vault</td>
<td>N05°01’00.5” E 100°37’16.7”</td>
</tr>
<tr>
<td>S5</td>
<td>Drainage canal</td>
<td>N05°01’00.3” E 100°37’16.8”</td>
</tr>
<tr>
<td>S6</td>
<td>Sungai Kurau</td>
<td>N05°00’53.6” E 100°36’47.5”</td>
</tr>
</tbody>
</table>

Six water quality parameters involved which are dissolved oxygen (DO), biochemical oxygen demand (BOD$_5$), chemical oxygen demand (COD), total suspended solids (TSS), ammoniacal nitrogen (NH$_3$-N) and pH were used in the calculation of DOE Water Quality Index (DOE-WQI) in order to determine the classes of water. In general, water quality indices integrate data from various water quality parameters into mathematical equation that rates the health of a stream with a single number. It consists of water quality variables where each of the parameter had specific impacts to uses [15]. The sampling involves in- situ and ex- situ parameter. The in-
situ parameter measured are DO and pH. The parameters were measured directly at each sampling points using YSI multiparameter ORP meter. On the other hand, for ex-situ parameter the surface water was collected from each point in 600ml sampling bottle for laboratory analysis to measure the NH$_3$-N, TSS, BOD$_5$ and COD. All the samples collected from the site were kept in cold room at a temperature below 4 °C to reduce all the activities and metabolism of the organisms in the water. The BOD$_5$, COD, TSS and NH$_3$-N were measured in accordance with the standard method procedure. NH$_3$-N, TSS and COD were determined by using a spectrophotometer Model HACH DR 2500 at a specified wavelength [17]. BOD$_5$ was sampled using dark BOD bottle 300 ml.

Water qualities from inflow (Bukit Merah reservoir, Terusan Besar and intake structure) were compared with the discharge (outlet vault, drainage canal and Sungai Kurau). The comparison was made based on the WQI values for each sampling points. The t-test analysis was conducted in order to identify whether the Sungai Kurau water quality had been affected by the presence of the aquaculture farm. The t-test assesses whether the means of two groups are statistically different from each other. The t-test analysis was conducted for the water parameter at intake structure with the water parameter at the Sungai Kurau.

RESULTS AND DISCUSSIONS

The calculated Malaysian Water Quality Index (DOE-WQI) from Fig.3 shows that the mean for all WQI were within the INWQS Class II. This shows that the water is suitable for water supply and conventional treatments are required. It is also suitable for fishery of sensitive aquatic species. A decreasing WQI values occur as the water was discharge from the Arowana farm. However, the reduction does not affect the water quality since the WQI was still within the INWQS Class II. Despite the reduction at the outlet vault, the WQI eventually raised as it flows 50 meter from the outlet vault towards the drainage canal and Sungai Kurau. This signifies in general that the Arowana aquaculture activities at Bukit Merah do not deteriorate the water quality that flow through Sungai Kurau.

Table 3: Independent samples t-test for NH$_3$-N at intake structure with Sungai Kurau.

<table>
<thead>
<tr>
<th>NH$_3$-N</th>
<th>Levene's Test for Equality of Variances</th>
<th>t-test for Equality of Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>Sig.</td>
</tr>
<tr>
<td>Equal variances assumed</td>
<td>1.133</td>
<td>.296</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>25.97</td>
<td>4</td>
</tr>
</tbody>
</table>

From the t-test analysis, NH$_3$-N was the only parameter that had a statistical significant value from intake structure toward the Sungai Kurau. The p-value for the Levene's test for equality of variance is 0.296. Since the p-value is more than 0.05, equality of variances can be assumed. Therefore, for the test of equality of means, the statistics in the first row in the Table 3 will be used. The mean different is -0.17467, the standardized different, t
=-3.460 and df = 28. The 2-tailed p-value of the test is 0.002 which is less than 0.05. The 95% CI for mean difference is [-0.27807, -0.07126], which does not contain 0. Thus, it can be concluded that there is a different in mean between NH$_3$-N at intake structure with the Sungai Kurau.

![Diagram of NH$_3$-N at inflow and discharge](image)

**Fig. 4: NH$_3$-N at inflow and discharge.**

Fig. 4 shows the parameter NH$_3$-N at inflow towards the discharge. The mean for NH$_3$-N for both inflow and discharge comply with the INWQS Class II despite the high raised of NH$_3$-N as it is being discharged to the outlet vault. Immediate raised of NH$_3$-N at the outlet vault was due to the actively managed of Arowana ponds with feeding of live food and fertilizer. However, the NH$_3$-N value shows a decreasing trend as it flows towards the drainage canal and Sungai Kurau. The decreasing trend of NH$_3$-N was due to the effects of dilution which eventually restore back the NH$_3$-N to the acceptable limit.

**Conclusions:**

In this study, WQI at inflow and discharge were compared and from the result in can be concluded that the presence of aquaculture farm at the Bukit Merah does have an immediate deterioration effects towards the water quality at the discharge especially at the outlet vault. NH$_3$-N was one of the parameter that contributes to the deterioration process. However, as the water were released 50 meters from the outlet vault, the pollutant mix and become diluted. This natural attenuation process improves the water quality and eventually the water meets the standard and the water quality fell in INWQS Class II.

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