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# Effectiveness of Depuration Method on the Elimination of Cadmium (Cd) and Lead (Pb) Heavy Metal Content in Rice Paddy Eel (*Monopterus albus*, Zuieuw 1793)

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## ABSTRACT

Eel is one of Indonesia's important commodities for local and export markets, with local market prices ranging from IDR 25,000 to IDR 50,000/kg and export market prices ranging from 6 to 10 US dollars/kg. Eel commodities in Indonesia are mostly obtained from nature, such as rice fields, but currently, rice fields are not free from pollution. This research aims to analyze the metal content of cadmium (Cd) and lead (Pb) in rice eels (*Monopterus albus* Zuieuw) after depuration experiments. Research on heavy metal depuration in eels has never been conducted in Indonesia. Rice eels (*Monopterus albus* Zuieuw) were taken directly from the rice fields of Sungai Batang Village and were then carried out depuration experiments in the laboratory. Depuration was carried out by immersion in controlled water for 3, 5 and 7 days. The results showed the cadmium (Cd) content ranged from 0.037 - 0.156mg/ kg and lead (Pb) ranged from 0.357- 2.230mg/ kg in paddy eels caught in Sungai Batang Village. The Friedman test results showed that depuration did not significantly affect the decrease in cadmium (Cd), while the repeated measure ANOVA test results showed that depuration significantly affected the decrease in lead (Pb) in paddy eels. The highest decrease in cadmium (Cd) and lead (Pb) occurred in the immersion treatment for 3 days.

## INTRODUCTION

Eel is an economically important commodity in Indonesia since it is in great demand by domestic and foreign communities, has a high protein content and is easily found in Indonesia **(Djajadiredja *et al.*, 1997)**. Export demand for eels from Indonesia comes from the United States, Australia, New Zealand, France, Italy, Spain, the Netherlands, the United Kingdom, Singapore, Hong Kong, Japan, and Korea. The price of eels in the export market ranges from 6 to 10 US dollars per kilogram, while in the local market it ranges from IDR 25,000 to IDR 50,000 per kilogram **(Mutiani, 2011)**. Eels have a habitat in freshwater, such as rivers, lakes, swamps, and rice fields, so they are easily found throughout Indonesia.

The eel commodity in Indonesia is mostly obtained from nature, such as rice fields. However, currently, the rice fields are not free from pollution **(Affandi *et al.*, 2003; Sultoni, 2020; Candra *et al.*, 2022)**, so that biota living in rice fields can also be exposed to pollutants. **Hilles and Mahmood (2019)** reported that heavy metals (Cu, Zn, and Ni) accumulated in the muscle tissue of *Monopterus albus*, while heavy metals viz. Cd, Pb, and Ni accumulated in the gills of eels caught from rice fields.

Heavy metals are not retained in the water but settle into the sediment because of its higher density compared to water. Heavy metals have properties that easily bind to organic matter, settle to the bottom of the waters, and unite with sediments, so that heavy metal levels in sediments are usually higher than in water **(Fitriyah, 2007**). Heavy metals can accumulate in the body of eels through two ways of accumulation, namely direct and indirect. Consumption of heavy metal-contaminated water and food through the digestive system is considered direct exposure, while indirect exposure is through permeable membranes such as skin and gills **(Akbar & Rahayu, 2023)**.

The depuration method can reduce and remove the heavy metal content that has accumulated in the eel's body. **Sriyono (2019)** conducted depuration on *Tilapia (Oreochromis niloticus)* with treatments of 3, 6, 9, and 12 days. The results of the depuration carried out showed that the metal concentration decreased since the third day of the depuration period with lead (Pb) concentration of 0.16mg/ kg and chromium (Cr) concentration of 0mg/ kg. The percentage decrease in lead (Pb) concentration after the first three days of the depuration process was 24% and the percentage decrease in chromium (Cr) concentration was 98%, so it can be said that the depuration process can reduce the concentration of metals contained in fish since the first three days of the depuration process.

Research on heavy metal depuration in eels is needed to reduce or eliminate the heavy metal content accumulated in the body of eels in order to meet consumption standards for the community. However, research on heavy metal depuration in eels has never been conducted in Indonesia. Therefore, this research needs to be conducted to determine the effectiveness of the depuration method in eliminating the content of heavy metals cadmium (Cd) and lead (Pb) in rice field eels (*Monopterus albus* Zuieuw) caught in Sungai Batang Village.

## MATERIALS AND METHODS

### 1.Research area

The research was conducted in January to measure the condition of the aquatic environment and the metal content of cadmium (Cd) and lead (Pb) in rice paddy eels caught in Sungai Batang Village, West Martapura, Banjar Regency, South Kalimantan. Sungai Batang Village is situated within the geographical coordinates of 3°21'17.2"S 114°49'06.4"E (Station 1), 3°21'08.7"S 114°49'03.9"E (Station 2) and 3°21'09.0"S 114°49'06.1"E (Station 3). The depuration method was carried out in March 2024 at Abdi Persada 2 Complex Banjarbaru with the sampling location of paddy eel from Sungai Batang Village, West Martapura, Banjar Regency, South Kalimantan. Data processing in the form of testing heavy metal content in eels was carried out at the Banjarbaru Standardization and Industrial Services Laboratory (BSPJI). Map of eel sampling locations in Sungai Batang Village, West Martapura, Banjar Regency, South Kalimantan can be seen in Fig. (1).

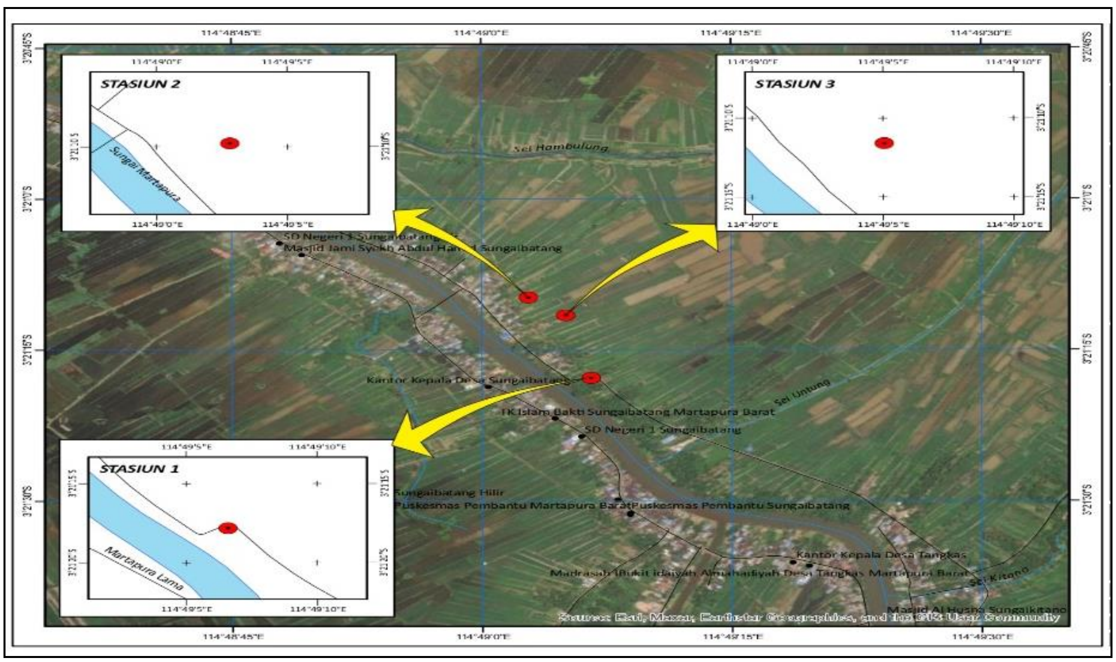


**Fig. 1.** Station location map in Sungai Batang Village

### 2.Research procedure

Depuration was carried out with 3, 5 and 7 days of immersion treatment without feeding and using controlled water to avoid recontamination of cadmium (Cd) and lead (Pb) in the Rice Paddy Eel. Water quality measurements during depuration included temperature, Dissolved Oxygen ((DO) and acidity (pH) at the beginning of the eel immersion and at the end of the depuration (at 3, 5 and 7 days, respectively). Temperature and DO measurements were evaluated using the lutron-5510 type. Acidity measurement was assessed using pH meter type HACH HQ40d. The procedure for measuring the heavy metal content of cadmium (Cd) and lead (Pb) in eel meat refers to SNI 2354.5: 2011 and measurement of heavy metal content of cadmium (Cd) and lead (Pb) in water refers to SNI 6989.84: 2019.

### 3.Experimental eels and depuration media

The method used in this research is experimentation on a laboratory scale. According to **Nazir (2014)**, experimental research is the research conducted by manipulating the object of research and the existence of controls (objects without treatment) as a comparison to research cause-and-effect relationships. Experimental research aims to investigate whether there is a causal relationship and how big the causal relationship is by giving certain treatments to several experimental groups and providing control objects. The experimental design used in this research is a completely randomized design (CRD) with an experimental approach. Experiments in the research were conducted with 3 periods of depuration treatment with different soaking mechanisms (3, 5 and 7 days) in 3 replications. The position of the basin of the experimental design can be seen in Fig. (2).

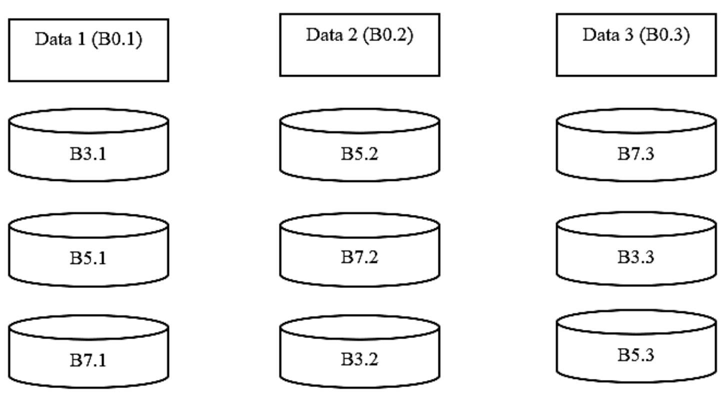


**Fig. 2.** Experimental design

There were 27 rice paddy eels taken to be used in the depuration treatment. Rice paddy eels were caught using (lukah) fishing gear. The eels taken were in the weight range of 150 - 250 grams to ensure that the samples taken were homogeneous. Eels with a weight range of 150 - 250 grams are the size of eels for the export market as well as the size at which eels have already mature gonads (**Chadijah, 2014; Afifah *et al.*, 2023**).

The water used as a living medium for the paddy eel (*Monopterus albus* Zuieuw) during the depuration treatment was well water from the Abdi Persada 2 Housing Complex in Banjarbaru, previously tested for heavy metal content of cadmium (Cd) and lead (Pb) using the *Atomic Absorption Spectrophotometry* method at the Banjarbaru Standardization and Industrial Services Laboratory (BSPJI). The basins used in the research amounted to 9 pieces with a diameter of 40cm and a height of 20cm. Water placed in the basin for depuration treatment was filled to a height of 15cm. Measurement of water quality during the depuration treatment included temperature, acidity (pH), and dissolved oxygen (DO). Water quality parameters were evaluated at the beginning of the treatment when the eels were placed in the water and at the end when the depuration treatment was completed (3, 5 and 7 days of treatment).

### 4.Hypothesis

$H_0$: The depuration treatment had no effect on the heavy metal content of cadmium (Cd) and lead (Pb) of rice paddy eel (*Monopterus albus* Zuieuw).
$H_1$: The depuration treatment affects the heavy metal content of cadmium (Cd) and lead (Pb) in rice paddy eel (*Monopterus albus* Zuieuw).

### 5.Data analysis

Data analysis was conducted by comparing the results of heavy metal content of cadmium (Cd) and lead (Pb) in eel meat with the quality standard (SNI 7387:2009) and continued with statistical tests. Statistical tests of depuration treatment on the content of heavy metals in (Sawah) eel were carried out using the repeated measure ANOVA test with an alternative Friedman test if the data were not normally distributed. The test used in the research is repeated measure ANOVA test (parametric) has a design model formula, namely (**Fig. 2)**:

$$\boxed{\text{Design model : } Y\,ij = \mu + \tau\,ij +}$$

Description :

- $Y\,ij$ the observation value for treatment $i$ and replication $j$
- $\mu$ is the common mean
- $\tau\,ij$ is the effect of treatment $i$ on replication $j$
- $\varepsilon\,ij$ is the random effect of treatment $i$ on replication $j$

## RESULTS

The content of cadmium (Cd) and lead (Pb) in well water in the Abdi Persada 2 Housing Complex Banjarbaru as a depuration treatment medium can be seen in Table (1).

**Table 1.** Cadmium (Cd) and lead (Pb) content in well water

| Parameter | Kandungan |
|---|---|
| **Cadmium** | <0,001 |
| **Lead** | <0,001 |

The content of cadmium (Cd) and lead (Pb) in the meat of rice paddy eel after depuration treatment can be seen in Figs. (3, 4).

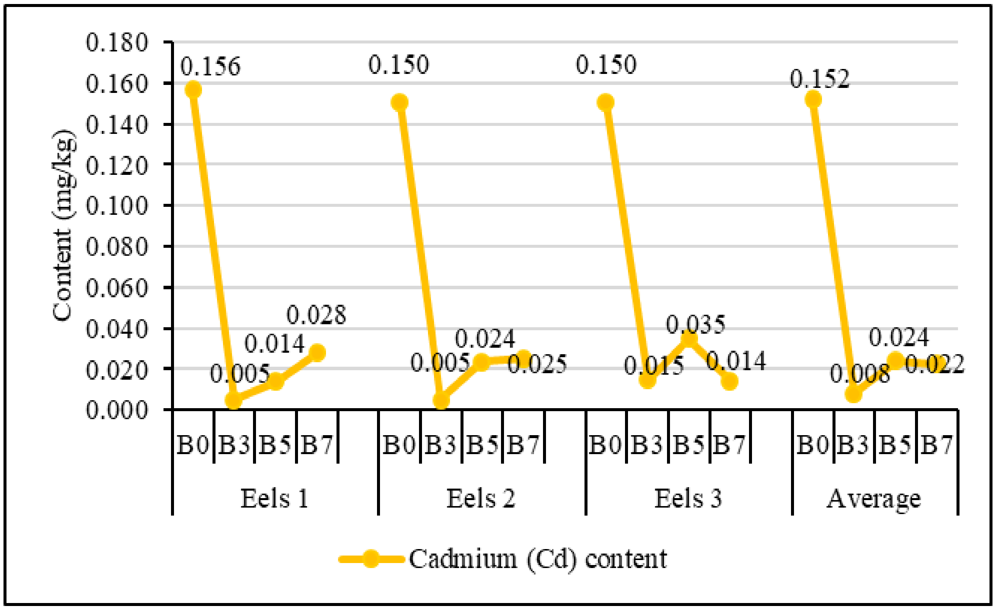


**Fig. 3.** Cadmium (Cd) content after depuration treatment

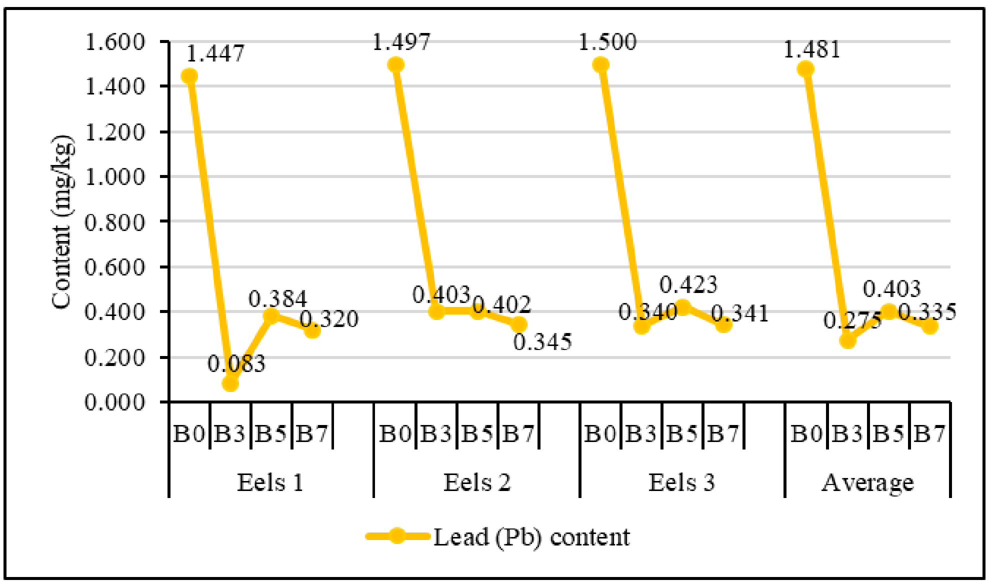


**Fig. 4.** Lead (Pb) content after depuration treatment

The measurement results of temperature, DO, pH during depuration treatment can be seen in Figs. (5, 6, 7).

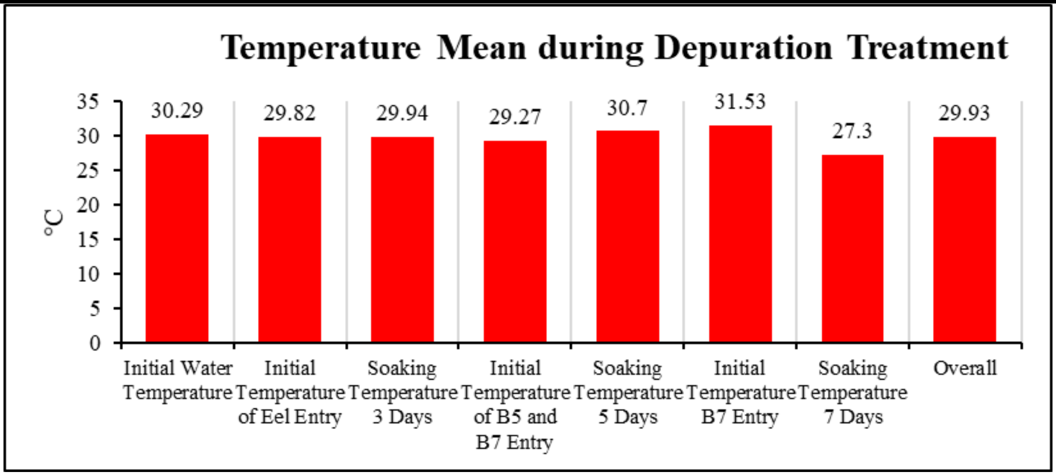


**Fig. 5.** Depuration temperature measurement

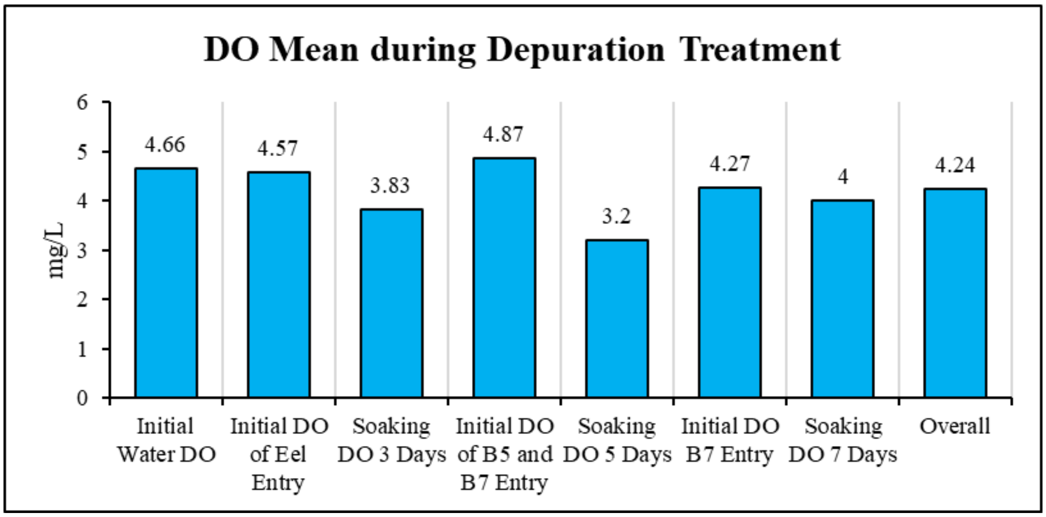


**Fig. 6.** Depuration DO measurement

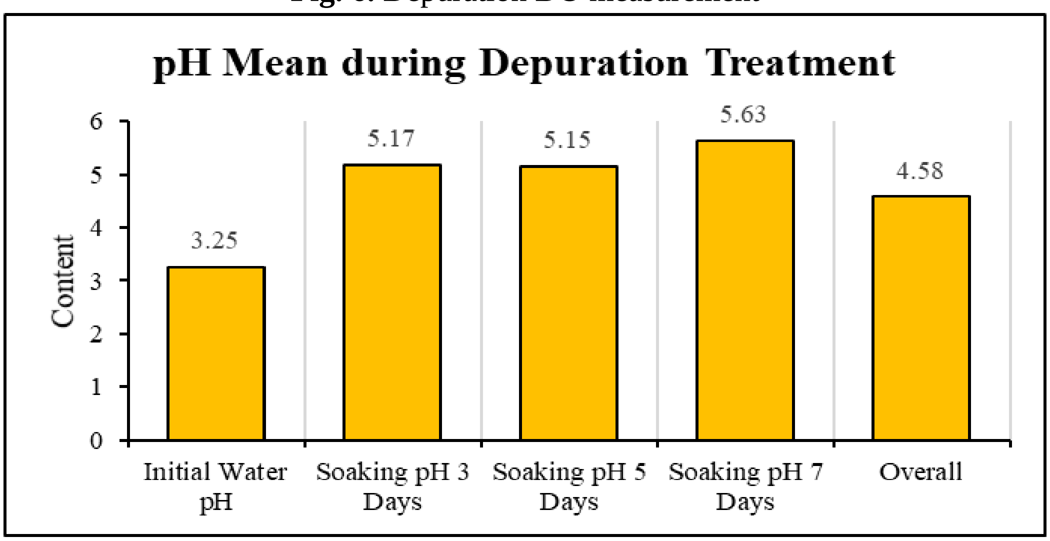


**Fig. 7.** Depuration pH measurement

The results of statistical tests during the depuration treatment can be seen in Tables (2, 3).

**Table 2.** Statistical test for cadmium

| | Code | Value/Significance | Assumption | Description |
|---|---|---|---|---|
| **Test of Normality Shapiro-Wilk** | Control | 0.000 ± 0.004 | > 0.05 | Not normally distributed |
| | B3 | 0.000 ± 0.006 | > 0.05 | Not normally distributed |
| | B5 | 0.948 ± 0.010 | > 0.05 | Normally distributed |
| | B7 | 0.391 ± 0.007 | > 0.05 | Normally distributed |
| ***Friedman Test Statistic*** | | | | |
| **Asymp. Sig.** | | 0.086 | < 0.05 | Not significantly different |
| **Chi-Square Table** | | 6.600 | 7.815 | Not significantly different |
| **Mean Rank** | Control | 4.00 | Lowest value | Rank 4 |
| | B3 | 1.33 | Lowest value | Rank 1* |
| | B5 | 2.33 | Lowest value | Rank 2/3 |
| | B7 | 2.33 | Lowest value | Rank 2/3 |

***Notes: * = most effective treatment***

**Table 3.** Statistical test for lead

| | Code | Value/Significance | Assumption | Description |
|---|---|---|---|---|
| **Test of Normality Shapiro-Wilk** | Control | 0.096 ± 0.029 | > 0.05 | Normally distributed |
| | B3 | 0.357 ± 0.169 | > 0.05 | Normally distributed |
| | B5 | 0.915 ± 0.019 | > 0.05 | Normally distributed |
| | B7 | 0.286 ± 0.014 | > 0.05 | Normally distributed |
| **Test of Homogeneity** | *Greenhouse-Geisser* | 0.006 | < 0.05 | Homogeneous, significant difference |
| ***Repeated Measure ANOVA*** | | | | |
| ***Descriptive Statistic (Mean)*** | Control | 1.481 | Lowest value | Rank 4 |
| | B3 | 0.275 | Lowest value | Rank 1* |
| | B5 | 0.403 | Lowest value | Rank 3 |
| | B7 | 0.335 | Lowest value | Rank 2 |
| ***Pairwise Comparisson (Object: Control)*** | B3 | 1.206 | Highest value | Rank 1* |
| | B5 | 1.078 | Highest value | Rank 3 |
| | B7 | 1.146 | Highest value | Rank 2 |

***Notes: * = most effective treatment***

## DISCUSSION

### 1. Cadmium (Cd) and lead (Pb) content in rice paddy eels and depuration treatment water quality

Depuration is a method to eliminate the content of heavy metals such as cadmium (Cd) and lead accumulated in the body of the (Sawah) eel by immersion in a controlled environment. The depuration treatment in this study was divided into 4 treatments, namely control treatment (B0), 3 days immersion (B3), 5 days immersion (B5), and 7 days immersion (B7).

The content of cadmium (Cd) and lead (Pb) in well water as a depuration treatment medium showed a result of <0.001, where the smaller the metal contained in the treatment medium, the less likely the eel is to be recontaminated through water. Water quality during depuration treatment needs to be observed and controlled regularly because it affects the life of the eel samples used as experiments. Water quality measured during the depuration treatment includes temperature, DO, and pH.

The cadmium (Cd) content in rice paddy eels after depuration is categorized as meeting quality standards. The graph displayed tends to have a similar pattern in each treatment code, where cadmium (Cd) drops dramatically in the B3 treatment, then rises in the B5 treatment and drops back in the B7 treatment, but in eel 1 there is an increase in treatment B5 to B7. Each individual eel has its own maximum limit in terms of cadmium (Cd) detoxification. Cadmium (Cd) will be detoxified by the liver, but if the exposure to cadmium (Cd) is excessive and the liver has reached the detoxification limit, the accumulation occurs in the muscles, the transition from the liver to the muscles through the blood vessels that spread throughout the body, so there will be an increase and decrease slowly. **Hilles and Mahmood (2019)** and **Soegianto *et al.* (2022)** stated that cadmium (Cd) accumulates in the gills, liver and muscles.

The lead (Pb) content in the rice paddy eels after depuration is categorized as not meeting the quality standards. The graph displayed tends to have a similar pattern in each treatment code, where lead (Pb) drops dramatically in the B3 treatment, then rises in the B5 treatment, and drops back in the B7 treatment. The drastic decrease in lead (Pb) in treatment B3 is thought to occur due to metabolism in the body of the eel that is not given food, so that the eel will use glycogen as its energy source. The distance between treatments B3 and B5 is thought to deplete energy reserves in glycogen so that the eel will break down fat reserves in its body as an energy source.

The pattern of lead (Pb) reduction in rice paddy eels is influenced by the lipophilic nature of lead (Pb) or being difficult to dissolve in water if it has been bound to fat **(Farida *et al.*, 2020)**. The process of fat breakdown throughout the body will potentially bind to lead (Pb), so that it will be distributed throughout the body. The source of energy in fat will decrease day by day as the metabolism and excretion system continue to run in the body of the (Sawah) eel, which explains what happened in treatment B7.

The temperature values observed during the depuration treatment were within the optimal range for fish survival, as reported by **Boyd and Lichkoppler (1986)** and **Fikri and Tancung (2007)**. The dissolved oxygen (DO) levels also met the suitability criteria for fish life according to **Boyd and Lichkoppler (1986)** and **Hukom (2012)**. However, the pH values did not fully meet the recommended range for fish survival stated by **Boyd and Lichkoppler (1986)**, who noted that the optimum pH for fish culture is between 6 and 9. The low pH levels were likely due to the use of well water stored in a reservoir, where precipitation processes occur and the water is directly exposed to sunlight. The initial drop in pH during the first treatment is attributed to the direct inflow of sediment-laden reservoir water into the experimental basin under hot weather conditions. In the subsequent treatments, the pH stabilized above 5, as aeration was applied to the reservoir water using a borehole pump before being directed into the basin.

### 2.Statistical test of depuration treatment

Data on cadmium (Cd) heavy metal content based on the Shapiro-Wilk test is not normally distributed, so the test performed is the Friedman test. Friedman test results with chi-square count < chi-square table (6.600 < 7.815) and Asymp. Sig. 0.086 > 0.05, which indicates that $H_0$ is accepted and $H_1$ is rejected, where the depuration treatment does not significantly affect the content of heavy metal cadmium (Cd) in paddy eel. Friedman test results showed the highest average decrease in cadmium (Cd) occurred in the depuration treatment for 3 days (B3) in the interpretation of ranks.

Data on heavy metal content of lead (Pb) based on shapiro-wilk test is normally distributed, then the test performed is the repeated measure ANOVA test. The repeated measure ANOVA test conducted using the correction of Greenhouse - Geisser shows the sig. value is 0.006 <0.05 where there is a real influence on the heavy metal content of lead (Pb) in the paddy eel (*Monopterus albus*, Zuieuw), H0 is rejected and H1 is accepted, $F\ (1.010,\ 2.019) = 171.503$, $P = 0.006$. Further interpretation of the repeated measure ANOVA test can be seen in the results of pairwise camparisons.

The results in the pairwise camparisons table show a comparison of the average decrease in lead content in each treatment, namely 1.206mg/ kg (B3), 1.078mg/ kg (B5) and 1.146mg/ kg (B7). The largest decrease in lead (Pb) content occurred in the 3-day depuration treatment.

## CONCLUSION

The results of this study indicate that the depuration method using immersion for 3, 5, and 7 days had no significant effect on reducing cadmium (Cd) content but showed a significant effect on reducing lead (Pb) content in the paddy eel. Based on the Friedman test, the highest average reduction in Cd concentration occurred in treatment B3, with comparable effectiveness observed in treatments B5 and B7. The greatest decrease in Pb concentration was also recorded in treatment B3, followed by B7 and B5, indicating that depuration for 3 days was the most effective in reducing lead (Pb) content.

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