Reduction of River Pollutants with Raffia-Cord in Sail River Pekanbaru Indonesia

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Abstract. The Sail River has been polluted by various types of pollutants in Pekanbaru. Raffia-cord is shaped like a feather duster, made of raffia rope that has been smoothed and then woven like a feather duster. This research was conducted as an effort to reduce the river pollutants (nitrate, phosphate, ammonia, Pb, Cr, COD, and BOD) in the river in March – April 2019 using the Completely Randomized Design (CRD) method with density variations: low density (P1), medium density (P2), and high density (P3). The average results showed that the decrease for nitrate was 0.075-0.117 mg/L (35-44%) from 0.136-0.347 mg/L; phosphate 0.205-0.267 mg/L (29-40%) from 0.339-0.381 mg/L; ammonia 0.027-0.076 mg/L (28-58%) from 0.093-0.108 mg/L. The decreasing effectiveness of P1, P2, and P3 for Pb were 67.146%, 70.465% and 67.242%; for Cr were 81.346%, 83.335% and 81.893%. The average COD reduction effectiveness were 38.7%; 46.9%; 42.5% while BOD were 71.4%, 74.1% and 69.5%. It was concluded that raffia-cord could be used to reducing nitrate, phosphate, and ammonia levels, raffia-cord was able to reduce the concentration of Pb and Cr but raffia-cord had no significant effect on decreasing COD and BOD.

1. Introductions
The Sail River is located in an area where there are various activities from upstream to downstream. The accumulated waste comes from residential areas, restaurants, small industries, and various other sources. Waste from various sources is directly channeled and dumped into the river without any prior processing [1]. In the Sail River area there are also local community activities looking for natural food for fish, as mentioned in previous studies [2] the Sail River area is used to find and collect worms as natural food. Various activities made Sail River become polluted. The Sail River needs management in reducing water pollution.

Water pollution can be reduced in various ways, such as Bio-Cord. Bio-Cord is used for management in reducing water pollution using microbial activity applied in rivers, lakes, and swamps. The Bio-Cord is formed with a simple cord covered with yarn. The fiber contained in the Bio-Cord is a good and supportive place for microorganisms [3]. Bio-Cord technique from Japan by JICA which has been widely used in Indonesia [4] as a bio-filter. Some use wire, known as bio-yarn [5]. Bio-filter using plastic fiber [6]. Bio-cord is widely used in Jakarta and needs to be developed as an alternative installation in river areas [4].

Bio-Cord is formed with yarn. In this study it was substituted using plastic rope. The plastic rope is then smoothed and shaped like a feather duster which is then known as Raffia-Cord. Substitution with
raffia rope because it is a good place as a medium for attaching microorganisms and easy to find. Raffia-Cord was used to reduce the river pollutants (nitrate, phosphate, ammonia, Pb, Cr, COD, and BOD$_5$ in the Sail River Pekanbaru.

2. Materials and Methods

2.1. Study area
The study was conducted in downstream of the Sail River, Bambu Kuning Village, Tenayan Raya District, Pekanbaru, Riau Province (Figure 1).

![Figure 1. Study area](image)

2.2. Procedures
This research was conducted in March – April 2019 using a single factor Completely Randomized Design (CRD). The raffia-cord was divided into 9 replications and 3 different treatments based on the number of nodes. The water is sourced from downstream of the Sail River. The artificial trench is made of wood like blocks with a length of 325 cm, a width of 30 cm, and a height of 50 cm. For the Raffia-cord, the raffia rope is formed with a height of 50 cm and a width of 15 cm like a feather duster, which will be used as a place for attaching aquatic organisms. The feather duster was formed with different densities (Figure 2): low (50 knots), medium (75 knots), and high (100 knots) then hung in the middle in an artificial trench. The raffia-cord is placed in the middle of an artificial ditch, where the artificial ditch is shaped like a river. An artificial ditch is set near a river so that incoming water can be easily obtained.
Figure 2. Raffia-cord with different density

Water is flowed from 09.00 to 18.00 WIB, for 9 hours continuously. Water suction can only be done at high tide. Sampling was carried out before and after passing the raffia-cord with an interval of 1 month at 13.00 WIB. For heavy metals, it takes one month to form a biofilm in order to absorb heavy metals (Pb and Cr) properly. The biofilm formation process with a residence period of 7 days is more effective than 3 days [7]. The experimental model of this study was carried out randomly (Figure 3).

Figure 3. Experimental design sketch

Water from artificial trench

Water sample from Sail River

| 1 | P1171 |
| 2 | P1171 |
| 3 | P1171 |
| 4 | P3171 |
| 5 | P3171 |
| 6 | P3171 |
| 7 | P3171 |
| 8 | P0172 |
| 9 | P0172 |

Which:

\[ P_1 \] : low density
\[ P_2 \] : medium density
\[ P_3 \] : high density
\[ U_{1,2,3} \] : test-1, 2 and 3

2.3. Data analysis

For Nitrate, Phosphate, and Ammonia analyzed by spectrophotometric method at Marine Chemistry Laboratory, Faculty of Fisheries and Marine Universitas Riau. For Lead and Chrome, analyzed with Atomic Absorption Spectrophotometer (ASS) Perkin Elmer 3110 (\( \lambda \) for Cd is 217.3 nm; \( \lambda \) for Cr is 357.9 nm) in the Soil Laboratory, Agriculture Faculty Universitas Riau. For water samples analyzed in the Laboratory of ecology and aquatic environmental management, Faculty of Fisheries and Marine.
The data obtained from the measurement results were statistically processed using the single factor Completely Randomized Design (CRD) method.

The mathematical method of single factor RAL is as follows:

\[ Y_{ij} = \mu + \tau_i + \varepsilon_{ij} \]

Which:
- \( Y_{ij} \): observational value of the raffia-cord treatment on the test
- \( \mu \): overall average score
- \( \tau_i \): main effect on density level
- \( \varepsilon_{ij} \): the effect of error I on the i-th main factor and the j test

To determine the effectiveness of reducing nitrate, phosphate, ammonia, and heavy metal levels in water in artificial trenches. Raffia-cord test with raffia media using equation [8]:

\[ EP = \frac{C_{in} - C_{out}}{C_{in}} \times 100\% \]

Which:
- \( EP \): decrease effectiveness value
- \( C_{in} \): concentration at the inlet
- \( C_{out} \): concentration at the outlet

The amount of titrant used is recorded and calculated using the DO formula as the initial DO. Then the remaining sample that has been diluted is put into a 125 ml BOD\(_5\) bottle and wrapped in aluminum foil and left for 5 days (incubation period). After the sample was incubated for 5 days, the final DO measurement was carried out and BOD\(_5\) could be calculated using the formula:

\[ BOD_5 (\text{mg/l}) = DO_0 - DO_5 \times fp \]

Which:
- \( DO_0 \): dissolved oxygen content on the first day
- \( DO_5 \): dissolved oxygen content on the fifth day
- \( fp \): diluent factor

For COD can be calculated using the formula:

\[ \text{COD (mg/l)} = \left( \frac{A-B}{N \times 8000} \right) \times \text{ml sample} \]

Which:
- \( A \): ml titration for blank
- \( B \): ml titration of each sample
- \( N \): Normality

3. Results and Discussion

The Sail River is one of the tributaries of the Siak River [9]. This river has a sandy, muddy, gravel substrate and the water is not clear [2]. Unclear water is also caused by waste from various sources that accumulates in the waters of the Sail River. This is due to the large number of people living around the river. Rivers are polluted due to domestic, industrial and agriculture [10][12]. Waste will reduce water quality and will be toxic to organisms [13]. The research was carried out downstream, because the downstream has accumulated waste from upstream to downstream. Therefore, this research was carried out to reduce river pollutants by using Raffia-cord. The use of plastic rope is not only because it is easy to find, but also because it is a good biofilter media [6].
Nitrate levels (Figure 4) at the inlet ranged from 0.136-0.347 mg/L, still among the quality standards set in accordance with PP No. 82 of 2001 that a good nitrate level is 0.2 mg/L. The nitrate content in the lower reaches of the Musi River is 1.97-3.13 mg/L [14]. Nitrates and phosphates are limiting factors for water productivity. In the waters, a lot of nitrate comes from domestic waste [15]. Agricultural fertilizers can also increase the amount of nitrate in the water [14]. Nitrates and phosphates have an influence on the growth and development of living organisms in the waters. If the amount is excessive, it will become a pollutant that can reduce water quality [16]. Concentrations of nitrate and phosphate will increase the production of phytoplankton, but can produce harmful types of phytoplankton and can reduce the dissolved oxygen content in the waters [17]. For humans, it will cause digestive problems [18].

![Figure 4](image)

**Figure 4.** Nitrate level, Phosphate level, Ammonia level

The difference in density was able to reduce nitrate in the water of the Sail River to 0.075-0.117 mg/L. Average reduction effectiveness in each treatment, including P1 of 35.66%, P2 of 44.23% and P3 of 42%. The decreasing value of low, medium and high density did not differ much. Phosphate levels at the inlet ranged from 0.339-0.381 mg/L, indicating that the phosphate value had exceeded the PP No. 82 of 2001 that a good nitrate level is 0.2 mg/L. The difference in density can reduce phosphate in the water of the Sail River to 0.205-0.267 mg/L. The average reduction effectiveness in each treatment, including P1 of 29.38%, P2 of 40.94% and P3 of 33.18%. The decreasing value of low, medium and high density did not differ much.

Ammonia levels at the inlet ranged from 0.093-0.108 mg/L, indicating the value of ammonia is still below the quality standard in accordance with PP No. 82 of 2001 of 0.5 mg/L. The difference in density was able to reduce ammonia in the water of the Sail River to 0.027-0.076 mg/L. The average reduction effectiveness in each treatment was P1 of 28.70%, P2 of 58.38% and P3 of 51.94%. Based on density, the treatment that had a higher reduction was medium density, the average decrease was 0.0605 mg/L, while in low and high density the decrease was 0.0277 and 0.0498 mg/L. If the concentration of nitrate, phosphate and ammonia in the water is high, then the water has been polluted [19].

The bacteria found in the Raffia-cord, P1 *E. coli* bacteria was found, P2 found two types of bacteria, namely *Proteus* sp. and *Bacillus* sp., and P3 *Providensia stuartii* bacteria were found. Meanwhile, the phytoplankton found were *Aphanizomenon flosaquae*, *Cylin-drocapsa* and *Microspora stagnorum*. Human activities will affect coliform bacteria. Coliform bacteria are used as indicators of water quality. *E. coli* is a pathogenic bacterium [20].

Heavy metal levels of Pb and Cr (Figure 5) at the inlet were found to be in the range of 0.107-0.110 mg/L for Pb and 0.067 mg/L for Cr. Both levels of heavy metals have exceeded the Sail River quality standard threshold set by PP. 82 of 2001 where the quality standard for heavy metal Pb is 0.03 mg/L and heavy metal Cr is 0.05 mg/L, so that the Sail River has been polluted by heavy metals Pb and Cr. Heavy metals come from natural or anthropogenic sources, including agriculture, farm, domestic, and industrial [11]. Pb comes from transportation [14]. Over time, heavy metals will settle to the bottom of the water. Heavy metals is one indicator of the contamination in the water [21].
At the outlet the levels of Pb and Cr metal ranged from 0.031 - 0.036 mg/l for Pb and 0.011 - 0.012 mg/L for Cr, already below and according to the quality standard threshold according to PP No. 82 of 2001. The value of the effectiveness of reducing heavy metal Pb obtained ranged from 67.146% - 70.465% and the effectiveness of reducing heavy metal Cr obtained ranged from 79.868% - 83.335%. There were 3 types of phytoplankton that were attached, namely Microspora stagnorum, Aphanizomenon flosaque and Cylindrocapsa.

The BOD$_5$ concentration at the inlet ranged from 8-10.3 mg/l and the COD concentration at the inlet ranged from 33.6-41.1 mg/l (Figure 6). According to PP No. 82 of 2001 concerning water quality management and control of class II water pollution, the BOD$_5$ quality standard threshold is not more than 3 mg/l and the COD quality standard is no more than 25 mg/l. Based on this regulation, the concentration of BOD$_5$ and COD at the inlet has exceeded the quality standard threshold. The high BOD value is due to the large amount of organic matter from the waste entering the waters. The COD value is determined by the waste factor that can be oxidized and uses the oxygen contained in the waters. If the COD content is high, the DO value will be lower [15].

The BOD$_5$ concentration at the inlet ranged from 2-3 mg/l and the COD concentration at the inlet ranged from 20-24 mg/l already below and in accordance with the threshold of quality standards according to PP no. 82 of 2001. This is due to the presence of microorganisms contained in the raffia-cord which serves as a place to hold microorganisms and will form biofilms. The biofilm process is carried out by draining the Sail River water into an artificial ditch containing raffia-cord for the breeding of microorganisms. The bacteria found attached to the fine fibers of raffia-cord consisted of several types, namely E. coli, Bacillus sp., Proteus sp. and Providence stuartii. E.coli, Proteus sp. and Providence stuartii belongs to the Enterobacteriaceae family which is a gram-negative and pathogenic bacteria. E-colit is a microorganism that threatens rivers. E-colit will contaminate water [12]. The value of the effectiveness of reducing BOD$_5$ was obtained in the range of 62.5 - 80.6% and the effectiveness of COD reduction was obtained in the range of 34.1-51.3%.

4. Conclusions
Water quality can be determined by comparing the conditions of the research results with the established quality standards. Raffia-cord was able to reduce the levels of nitrate, phosphate, Pb, and
Cr. The presence of raffia-cord was also able to reduce the concentration of COD and BOD₅ in the water of the Sail River.

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