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*Regional Case Study*

# Potential of Heavy Metal Pollution (Cd) in the Kapuas Kecil River

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## Abstract

The Kapuas Kecil River is a river that becomes the lifeblood of the people of Pontianak in supporting their lives. It is raw water source for Municipal Waterworks, industry, fisheries, agriculture, animal husbandry, tourism, and transportation. The variety of activities carried out on the banks of the Kapuas Kecil River contributed to the occurrence of pollution by heavy metals such as Cd. Currently, the Kapuas Kecil River flow is already crowded with industrial shipbuilding activities, which are one of the contributors to Cd metal pollution in the waters. This study aims to identify the source of Cd pollutants and determine the concentration of Cd in the Kapuas Kecil River. Sampling was carried out in October at four sampling points at low tide, then compared with the allowable Cd concentration according to PP 22/2021 which is 0.01 mg/L, and the status of water quality was determined by the pollutant index method. Based on the results of the study, the Cd concentration was still below the quality standard with a value of >0.001 mg/L, and the water quality status met the quality standard.

**Keywords**: Cadmium; pollution; kapuas kecil river

## 1. Introduction

The Kapuas River is nationally strategic and influential in West Kalimantan Province. More than 2 million people of West Kalimantan Province live in the Kapuas watershed and depend directly or indirectly on the Kapuas River and its tributaries. The Kapuas Kecil River is part of the Kapuas watershed, which is one of the tributaries of the Kapuas River. The Kapuas Kecil River has become the lifeblood of life, namely as a source of raw water for Municipal Waterworks, industry, fisheries, agriculture, animal husbandry, tourism, and transportation. The variety of activities along the Kapuas Kecil River put pressure on the aquatic environment through the waste produced.

Most domestic and industrial waste contains heavy metals that are toxic to aquatic biota and endanger human health if they enter the food chain (Rahayu, 2022). Cadmium (Cd) is a heavy metal widely used in industrial activities such as paint and plastic dyes, electronics, communications, energy generation, aerospace industry, metal coating industry, PVC/plastics, and batteries. Cadmium can also come from phosphate fertilizers, waste deposits, and waste from the use of coal and oil (Darmono, 1995; Wardhani et al., 2016). This causes Cd to have a wide distribution of contamination in the aquatic environment, so we must be aware of its spread and toxicity (Azizah dan Mamay Maslahat, 2021).

The Kapuas Kecil River is threatened by Cd metal pollution originating from the activities of the docking industry and ports along the Kapuas Kecil River. In addition, the Kapuas Kecil River area is also crowded with shipping activities as public transportation. Activities in shipyards, such as painting ships, are thought to increase Cd contamination in the waters. The content of Cd in the paint raw material used

functions as a pigmentation for ship paint, coloring coating so that the paint can dry quickly, and as an anti-rust paint material on the ship's hull. Shipping activities are also suspected of having the potential to contribute to the increase in Cd levels in the waters through oil spills from motor boats that use gasoline containing Cd. Cadmium has a highly toxic effect even at low concentrations, cannot be destroyed (non-degradable) by living organisms, and can accumulate in the environment (Mamoribo dkk, 2015) . Based on surface water quality criteria for chronic toxicity level, Cd metal ranks first with a toxicity value of 0.25 µg/L. The International Agency for Research on Cancer (IARC) ranks Cd as the most dangerous carcinogen (Adhani, 2017).

Seeing the condition of the Kapuas Kecil River in Pontianak City and various shipbuilding industry activities, this study aims to determine the content of Cd metal in the Kapuas Kecil river around the shipyard industry location. This research is essential because the area suspected to be contaminated by Cd is used for various living purposes, namely as the primary raw water for Municipal Waterworks in Pontianak City and Kubu Raya Regency, fisheries (Floating Cages), and large or small scale food industry activities. Water contaminated by Cd metal is hazardous to human health. This research is expected to be of benefit to other researchers, namely that it can be used as reference material and can be developed by further research on cadmium levels in the waters of the shipyard area. Factors that affect the concentration of the heavy metal cadmium, so that it can be improved and developed for further research.

## 2. Methods

This research is a quantitative descriptive study. This research was chosen to get an overview of the condition of the Kapuas Kecil River because of the sources of pollution along the river flow, which can pollute the river. Data collection was carried out to obtain information related to this phenomenon. The river water sampling method refers to SNI 6989.57:2008. Sampling locations were carried out at three points on the Kapuas Kecil River and one point in the shipbuilding industry effluent, which became a source of pollution in the river flow (**Figure 1**). The sampling point area covers the Kapuas Kecil River with a length of ±880 meters. The selection of this research location is accompanied by several reasons, namely the existence of shipbuilding industry activities which are a source of cadmium (Cd) pollutants that can pollute river flows. Sampling is used to represent the condition of water bodies in that segment, so that water quality and distribution of parameters of heavy metal cadmium (Cd) can be identified in the Kapuas Kecil River.

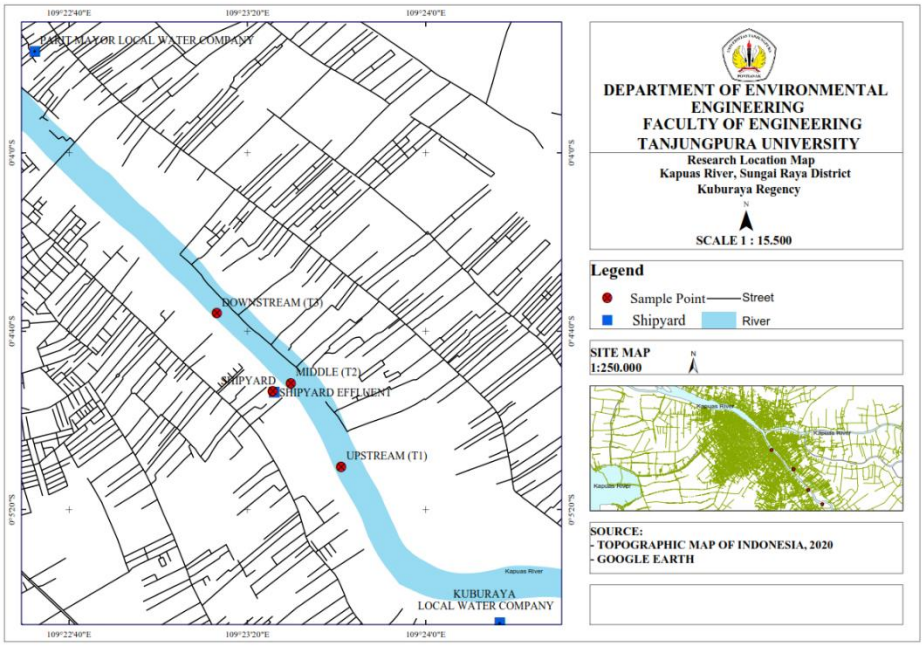


**Figure 1.** Research sites

Determination of the sampling location was determined by purposive sampling by considering the input location of the pollutant source of heavy metal cadmium (Cd) by considering the shipyard activities, which are suspected of having a noticeable effect on the concentration of heavy metals in the waters of the Kapuas Kecil River as the research object. The sampling location also considers the direction of the current and the distance from each sampling location. The sample for sampling in industrial effluents is a grab sample, a water sample taken at a specific location. A sampling at low tide pursuits to look the water exceptional circumstance in reaction to the access of pollutant hundreds withinside the worst conditions.

The tools used in this research are cork, raffia rope, plastic wrapping, a measuring instrument 100 meters' meter, a stopwatch, Van Dorn Water Sampler-KC Denmark vertical to take water samples, pH-009 (I), a pen-type pH Meter, a water thermometer mercury, Refractometer Getra Type (RHB-90-ATC), GPS (Global Positioning System) GARMIN Monterra, cool box, five glass sample bottles, and stationery. The materials used in this study were water samples, aquades, and $HNO_3$ solution.

The procedure for taking water samples for dissolved metals, in general, can be carried out with the following steps, the first stage is to prepare five sample containers, then wash the container and cover with detergent, then rinse with clean water, then rinse with 1:1 nitric acid ($HNO_3$), then rinse again with analyte-free water for three times and allow to dry, after drying, close the bottle tightly. Water samples were taken according to a predetermined sampling point and put into a sample container for analysis. Furthermore, field parameters were tested, namely temperature, pH, salinity, and flow velocity, then recorded the results of field tests and labeled the sample container. Laboratory tests on cadmium (Cd) parameters were preserved by adding nitric acid ($HNO_3$) to pH <2, then cooling. Cd testing in water samples was conducted in an accredited laboratory, Sucofindo Pontianak.

The Pollution Index is decided for a designation; then, it may be evolved for numerous functions for all elements of a water frame or a part of a river. Management of water best primarily based totally in this Pollution Index may be offer enter to decision-makers with a view to determine the best if there may be a lower in best because of pollutant compounds. The Pollution Index consists of diverse unbiased and significant companies of best parameters.

Analysis of water great the usage of the pollutants index in keeping with the Decree of the Minister of the Environment No. 115/2003 Appendix II concerning the willpower of water great status, to decide the extent of river cadmium pollutants the usage of the subsequent equation (1):

$$IPj = \sqrt{\frac{\left(\left(\frac{Ci}{Lij}\right)^2 M + \left(\frac{Ci}{Lij}\right)^2 R\right)}{2}} \qquad (1)$$

Source: The Minister of the Environment No. 115/2003

IPj = pollution index for the designation j
Ci = concentration of water quality parameter i
Lij = concentration of water quality parameter i, listed in the water designation standard j
M = Maximum
R = Average
The cost of the water nice of the Pollution Index is decided from end result of the most cost and The common cost of the awareness ratio in line with parameter to the cost of the nice standard.

# 3. Result and Discussion

## 3.1 Water Quality Analysis

The results of observations of the bodily and chemical situations of the waters accomplished in the course of the have a look at offer an outline of the situation of water pleasant with inside the waters of the Kapuas Kecil River, specifically as follows.

**Table 1.** The results of the water quality measurement of the Kapuas Kecil River

| Parameter | Sample | | | | Quality Standard PP 22 in 2021 |
|---|---|---|---|---|---|
| | Point 1 | Point 2 | Point 3 | Point 4 | |
| Cd (mg/L) | 0.001 | 0.001 | 0.001 | 0.001 | 0.01 |
| pH | 5.6 | 5.2 | 5.5 | 5.7 | 6-9 |
| Temperature (°C) | 29 | 30 | 30 | 30 | deviation ± 3 |
| Salinity (‰) | 1 | 1 | 1 | 1 | - |

One of the primary sources of cadmium heavy metal contamination in waters is the activities of the shipbuilding industry. Cadmium heavy metal in shipbuilding activities, is often used as a paint colorant. This heavy steel cadmium is especially tiny in water, however its awareness can growth because of commercial waste disposal (Rachmaningrum, 2015). Heavy metals together with Cd are non-important metals which might be dangerous for dwelling organisms, even in low concentrations (Darmono, 1995; Wardhani et al., 2016).

In general, physical and chemical parameters in water can affect heavy metals solubility. The examination results of physical and chemical parameters at the four locations have a range of values that are not too far away, such as the pH value of 5.2-5.7. The low pH value in the Kapuas Kecil River is encouraged with the aid of using the land across the Kapuas Kecil River, which is a peatland. According to Widjaja Adhi (1988) in Suriadikarta (2012), peat acidity happens because of the decomposition procedure of natural count in peatlands. The acidity of tropical peat soils is typically high, particularly pH 3-5, because of negative hydrolysis situations of natural acids, that are ruled via way of means of fulvic and humic acids. Peat water carries dissolved natural compounds that reason the water to show brown and acidic, and this happens in observations for the pH of water withinside the Kapuas Kecil River, which has a pH fee beneath 7.

The degree of acidity (pH) of water has a major influence on the physical and chemical forms of metals and metal compounds in aquatic environments because pH controls the solubility and concentration of metal species. Increasing the acidity of the solution increases the concentration of free metal ions in the solution. Heavy metal toxicity will increase if there is a decrease in pH. According to Bryan (1976) in (Emilia and Hanafiah, 2013) an increase in pH can reduce the solubility of heavy metals in water, because an increase in pH causes metals to bind to particles in water and experience deposition, that is, heavy metals will be difficult to dissolve in water because they are in the form of suspended particles. The increase in pH causes $Cd^{2+}$ ions to react with $OH^-$ ions, which will then go through an absorption process and the influence of currents of $Cd^{2+}$ ions will precipitate in the sediment. The pH value has a range of 5.2 – 5.7 so that the possibility of the Cd species in the Kapuas Kecil River is $Cd^{2+}$. The dominant Cd species in natural waters is $Cd^{2+}$ and is the most toxic. According to Adhani (2017), these Cd2+ species are quickly absorbed by aquatic organisms. The presence of $Cd^{2+}$ ions in water depends on the level of salt and acidity (pH). Water with high levels of salt and alkalinity will accelerate the speciation of $Cd^{2+}$ ions by forming ion pairs (Akbar et al., 2014).

Sampling become completed while the climate situations have been sunny and cloudy with a pretty excessive depth of sunlight, and the water temperature become measured with inside the variety of 29°C – 30°C. The common water temperature is around ± 30C from the air temperature, so the size temperature of the Kapuas Kecil River follows the first-rate widespread of Government Regulation

Number 22 of 2021, that's a deviation of ± 3°C. High temperatures can increase the levels of heavy metals in the water. High temperatures will boom the formation of heavy steel ions, thereby growing the deposition process, which ends withinside the absorption of heavy metals in sediments. In addition, temperature additionally impacts the metabolic pastime and improvement of organisms. This additionally follows Suryono (2006) in Suryani and Febrita (2014), statement, which says that the temperature will increase the metabolism of aquatic biota and also can boom the toxicity of heavy metals withinside the waters. Waykar et al. (2012) stated that an increase in water temperature tends to increase the accumulation of heavy metals. Metals in water tend to form bonds with organic or inorganic materials. This is because metals have electronegativity, namely the ability of an atom to bind electrons.

The results of salinity measurement do not change and are relatively low, and this is because the measurements are carried out at low tide so that the direction of flow is from the river (freshwater) to the sea (salt water). Based on the research, the salinity value is relatively low, and the salinity value is seen to be constant at 1 ‰ while the concentration of heavy metal cadmium (Cd) is also low and constant at 0,001 mg/L. According to Febriyanti (2017), water salinity tends to fluctuate due to several factors, including water circulation patterns, rainfall, and the influx of fresh water. Salinity can have an effect on the presence of heavy metals with inside the waters, if there may be a lower in salinity, it'll purpose a boom with inside the poisonous electricity of heavy metals, and the extent of bioaccumulation of heavy metals will boom. This is according to the assertion of Supriharyono (2003) in Suryani and Febrita (2014), which states that during waters with low salinity, there may be an excessive content material of heavy metals, even as at excessive salinity, there may be a low content material of heavy metals. High salinity can cause low concentrations of heavy metals in waters and vice versa (Pradifta and Leidonald, 2017). Compared with the solubility of heavy steel Cd in water, it did now no longer have a giant impact on the four sampling locations.

The cadmium concentration at the sampling location was below the quality standard with a value of <0.001 mg/L. According to PP 22 of 2021 in Appendix VI, the Cd quality standard for class II water is 0.01 mg/L. The Kapuas Kecil River is included in class II water quality standard because, in PP 22 of 2021, Chapter XIIX article 527, point f states that if the Government or Regional Government has not set Water Quality Standards for surface water bodies, it uses class II water quality standards as listed in Appendix VI, which is an integral part of this government regulation. So that the Kapuas Kecil River is included in the class II water quality standard.

The awareness of heavy metal cadmium on the sampling area is low, and it does now no longer imply there's no cadmium supply with inside the Kapuas Kecil River. Based on the sector survey results, thirteen shipyards alongside the Kapuas Kecil River are suspected as reassess of cadmium pollutants from paint spills withinside the portrayal process. The raw material contained in paint is the heavy metal cadmium which functions as a coloring (pigment) and coating to facilitate the drying process (Komari, et al. 2013). This is likewise supported through water sampling information from the Kapuas Kecil Municipal Waterworks Pontianak City in 2020 that the awareness of heavy steel cadmium (Cd) with inside the Kapuas Kecil River is rated at 0.02 mg/L, which exceeds the excellent standard. This method that heavy metal cadmium has polluted the Kapuas Kecil River.

Many factors affect cadmium concentration in the waters of the Kapuas Kecil River. The concentration of cadmium is influenced by discharged, current, rainfall, mass transfer, fluctuating dynamics, and potential sources of waste at each sampling point at the study site. Self-Purification is the natural ability of rivers to liquefy, reduce, and eliminate pollutants, dirt, or waste that enter the river (Saily, 2019). The big Kapuas Kecil River discharge can perform a self-purification process. Rivers are dynamic, so the exceptional of river water is likewise dynamic. Fluctuations in water exceptional are due to the sort and quantity of pollution from numerous pollutant sources, the regions traversed, and the incidence of physical, chemical, and organic techniques with inside the waters. In addition, the hydrological situations of the river and the impact of fluctuating tides will even have an effect on water exceptional. River currents impact fluctuations in Cd attention with inside the Kapuas Kecil River.

According to Hutagalung et al. (1997) in Nurhastuti (2019), the amount of heavy metal content in waters in areas with calm currents will be much higher than in waters with strong currents.

According to Emilia and Hanafiah (2013), heavy metal levels in the water undergo a dilution process with the influence of tidal current patterns. Sampling was carried out at low tide to the lowest non-tide so that the distribution of heavy metals in the water decreases due to dilution (Nadia, 2018). According to Firmansyah et al. (2013), heavy metals will mix in the waters through adsorption, emulsion, and dilution processes before settling in the primary substrate. The decrease in heavy metal content in water at a location can change due to the hydrodynamic influence of the waters, such as currents, tides, and waves.

The difference in the results of the heavy metal cadmium (Cd) concentration test conducted with the Municipal Waterworks test is also influenced by rainfall due to rainwater dilution so that heavy metals do not accumulate in water bodies. According to Ayu et al., (2017), the metal content will be higher in the dry season because the metal becomes concentrated. The rainfall in the Pontianak throughout 2021 has been a wet month. Wet months are when the average rainfall is more significant than 200 mm. A sampling of water in the Kapuas Kecil River was carried out in October, which in that month has high rainfall, so dilution is possible. The weather data observed throughout 2020 and 2021 shows pretty significant differences. In 2021, there will be more frequent rains with a high severity level, thus allowing for dilution during sampling. The decrease in concentration in the rainy season is often caused by the dispersion function in the transportation of heavy metal pollutants, which makes it easier for heavy metals to spread from one point to another so that they are not concentrated in one point.

### 3.2. Water Quality Status

The legal basis for determining the water quality status is the Decree of the State Minister for the Environment Np. 115 of 2003 concerning Guidelines for Determining Water Quality Status. Determination of quality status can use the STORET method and the Pollution Index. Determination of quality status in this study used the Pollutant Index method with Class II water allotment. The Pollution Index method is used in this study because the data used is not a data series, so the STORET method cannot be used.

According to (Mahyudin, et al. (2015), the status of river water quality shows the amount of contamination of a water source at the category level, compared to water quality standards. A river can be said to be polluted if it cannot be used according to its designation normally or goes beyond a predetermined threshold.

According to (Puji Saraswati *et al.*, 2014) the Pollutant Index method when compared to the STORET method will show results that do not reflect field conditions in estimating the quality status of a water body. This is because determining the pollutant index score for the pollutant parameter that has the maximum (Ci/Lij) is considered the most important in determining the pollutant index score, compared to the average of all water quality parameters. Status of water quality shows the level of quality condition of source water by comparing the quality standards that have been set.

The calculation of the Pollutant Index on this observe is primarily based totally on the sampling factor and predetermined take a look at parameters, particularly pH and heavy metallic cadmium (Cd), which refers back to the high-satisfactory requirements of Government Regulation No.22 of 2021 regarding the Implementation of Life Protection and Management with Class II water classification. Quality Status with Pollution Index cost may be visible in **Figure 3**.

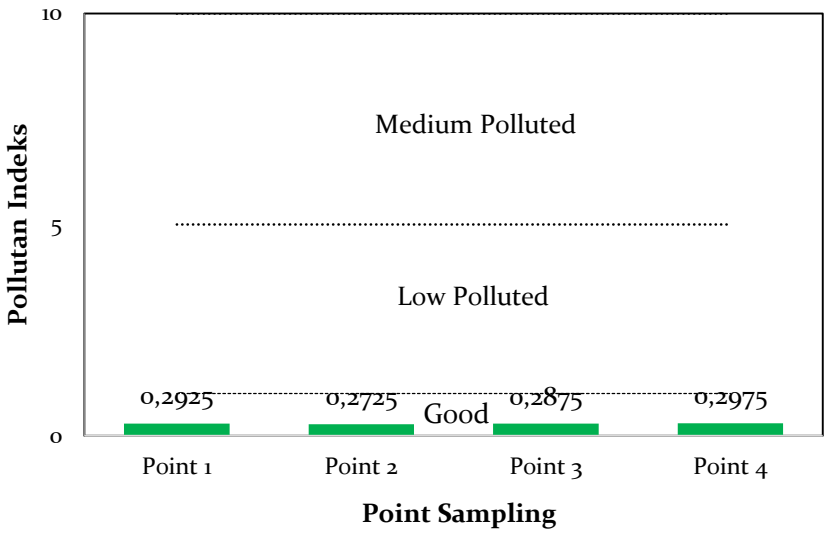


**Figure 3.** Water quality status

From **Figure 3**, primarily based totally at the Decree of the Minister of the Environment No. a hundred and fifteen of 2003 regarding Guidelines for Determining the Status of Water Quality primarily based totally at the pollutants index, it may be visible that factors 1-four have the fame of water pleasant meets the pleasant standards, with a pollutants index price of 0.2. This is due to the fact the laboratory check values for cadmium pollution at factors 1-four are rated at 0.001 mg/L.

The results of this study indicate that the Kapuas Kecil River, which is suspected of being polluted by the heavy metal cadmium due to shipyard activities, actually has good water quality status (meets quality standards). The results of this study have differences with the results of cadmium concentrations with water sampling information from the Kapuas Kecil Municipal Waterworks Pontianak City in 2020 that the awareness of heavy steel cadmium (Cd) with inside the Kapuas Kecil River is rated at 0.02 mg/L, which exceeds the excellent standard.

Many factors affect the concentration of cadmium in the waters of the Small Kapuas River. The concentration of cadmium is influenced by discharge, currents, rainfall, mass transfer, fluctuating dynamics, and potential sources of waste at each sampling point in the study location. The frequency of rainfall has a very important influence on the water quality of the cadmium concentration in the Kapuas Kecil River. If other researchers want to develop this research, it is recommended that samples be taken at different periods, namely in months with high rainfall and low rainfall. Apart from looking at the comparison of cadmium concentration results at different periods, we also get water quality results under the worst conditions, namely during the dry season or low rainfall, because during low rainfall it can avoid dilution or self-purification of the river.

## 4. Conclusions

Based on the results of the research that has been done, it can be concluded that 13 shipyards along the Kapuas Kecil River were identified that were suspected as sources of cadmium pollutants. The concentration of the heavy metal cadmium (Cd) in the Kapuas Kecil River is still below the quality standard with a value of 0.001 mg/L, according to Government Regulation No. 22 of 2021 in Appendix VI Class 2, namely 0.01 mg/L.

Advice that can be given academically is the need to pay attention to predictions of rainfall and rainy days when conducting sampling in order to avoid dilution at the research location. Sampling should be done in two periods, namely in the dry season and the rainy season. The reason for taking samples in the dry season is to determine levels Cd metal which is affected by a smaller amount of water or drought due to the dry season.

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