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# СТАН ЕСТУАРІЮ РІЧКИ ПОРОНГ (ІНДОНЕЗІЯ) НА ОСНОВІ РІВНІВ ВМІСТУ КАДМІЮ У ДОННИХ ВІДКЛАДАХ ТА У МОЛЮСКАХ *CORBULA FABA* HINDS

*Фізичні та хімічні параметри водного середовища відіграють важливу роль у житті гідробіонтів. Метою роботи була оцінка якості води в естуарії р. Поронг (Індонезія) на основі визначення фізико-хімічних параметрів води, зокрема за вмістом кадмію у донних відкладах та у Corbula faba Hinds. Дослідження проводили у травні — червні 2019 р. Встановлено, що вміст розчиненого у воді кисню в середньому становив 8,7—14,2 мг/дм$^3$, середня температура — 30,8—31,4 °С, солоність — 9,0—30,6 ppt, а значення pH коливались у межах 7,80—8,46. Результати атомно-адсорбціонного аналізу показали, що вміст кадмію у донних відкладах та у тканинах Corbula faba в середньому становив відповідно 1,82 та 2,06 мг/кг. Базуючись на стандартах якості для донних відкладів і біоти, ці середні значення перевищують максимальний поріг, що свідчить про забруднення донних відкладів та молюсків Corbula faba таким важким металом, як кадмій.*

***Ключові слова:*** *якість води, вміст кадмію, донні відклади, молюски Corbula faba, естуарій р. Поронг.*

## Introduction

River water pollution is a process of excessive entry of organic and inorganic matter that adversely affects human health [13]. The estuary is a very productive area for the human activities of the Indonesian people [8]. The Porong River estuary area is surrounded by ponds where aquatic biota is cultivated [19]. However, the Porong River has been used as the Lapindo mud disposal site since 2006. The dumping of mud can change the physical and chemical properties of the Porong River. Another source of water pollution of the Porong River is factory and domestic waste [15] directly discharged into the river body without treatment.

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These pollutants contain various hazardous and toxic wastes. Their examples are heavy metals, pesticides [2], dyes [4], plastics [12, 23, 27], and hospital waste [17]. Hazardous waste affects the life of aquatic biota because it cannot be degraded and accumulates in sediments [3]. Then, the marine biota, including fish [1], shellfish [9], benthic fish [10], mullet fish [24] etc., will get heavy metals in the body [22].

The Porong River may be affected by industrial waste from surrounding factories. Water quality analysis can help identify the type and extent of pollution coming from industrial activities. The waste is disposed in the estuary before entering the sea; hence, it affects the quality of the water in the estuary. It has been found [14] that the distribution of chemical parameters such as dissolved oxygen has a lower value when approaching the estuary and a good value when it is far from the estuary. Meanwhile, temperature, salinity, and pH parameters are relatively the same.

Despite several studies examining water quality in the Porong River estuary, an assessment of water quality based on the level of cadmium (Cd) content has not been done yet. This study aimed to determine water quality in the mouth of the Porong River by determining its physical properties, such as temperature, and chemical properties, such as DO, salinity, pH, and Cd content in sediments and *Corbula faba*. Moreover, this research needs to be done so that the water quality in the Porong River estuary can be continuously monitored yearly and inform the industrial community to improve its waste disposal system further.

## Material and Methods

The research was conducted in May — June 2019 in the dry season so that the salinity in the estuary area was high and *Corbula faba* was easy to find. The samples in this study were the water, sediments, and mollusks *Corbula faba*. Sampling was done at five plots. The first plot was located at 7°33'42.68"S & 112°52'58.65"E, the second at 7°33'48.34"S & 112°53'6.95"E, the third at 7°33'56.47"S & 112°53'12.54"E, the fourth at 7°34'4.76"S & 112°53'17.69"E, and the fifth at 7°34'13.60"S & 112°53'22.60"E. The coordinates were determined using a GPS device. Each plot selected was 300 m away from each other and consisted of three sampling replications (Figure).

The data collected included pH, temperature, dissolved oxygen (DO) concentration, salinity, and Cd content. The tools used were pH meter, DO meter, hand-refractometer, distilled water, sticker paper, grab sediment sampler, atomic absorption spectrophotometry (AAS) set, and nets. Water physical measurements were conducted directly at the estuary according to the specified plot. Sediment samples were taken using a sediment grab, weighed as much as 10 g, put into plastic, and stored in an icebox. The *Corbula faba* samples were collected using a net since they live in the mud. After cleaning off the mud, *Corbula faba* samples were weighed 10 g per plot before being wrapped in plastic and stored in an icebox. The sediments and *Corbula faba* soft tissues were brought to the laboratory for Cd content analysis.

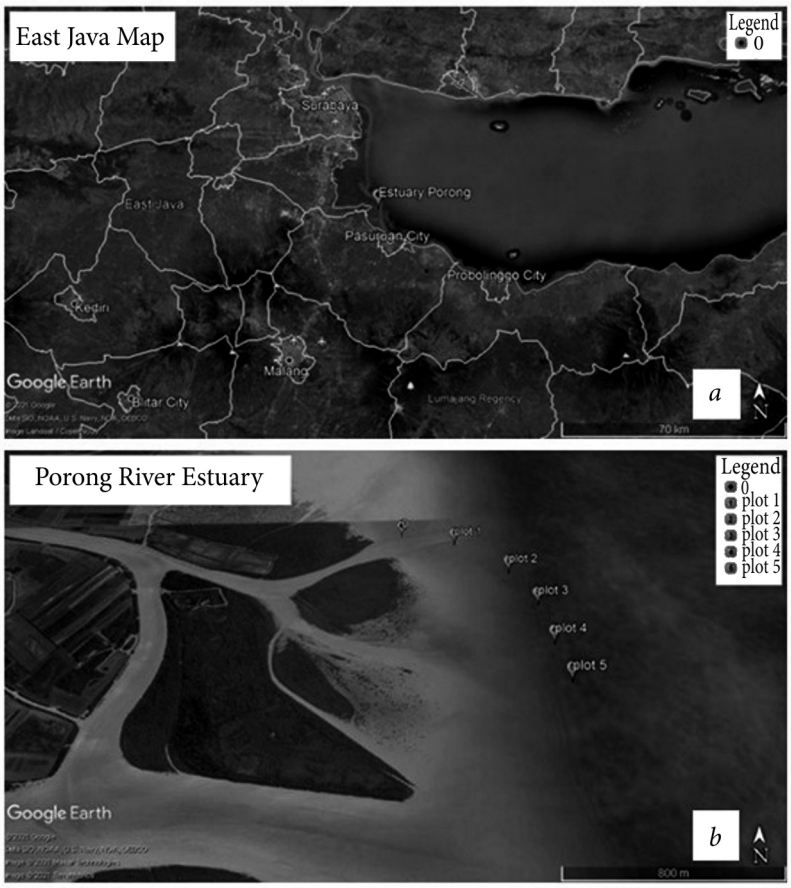


***Figure.*** East Java map showing the Porong River estuary (*a*) and the sampling plots of the sediments and *Corbula faba* (*b*)

*Sample selection and preparation*. Select and take the soft tissues of *Corbula faba* to be analyzed. Wash tissues with purified water to remove external contaminants. Sample drying (if required): carefully dry the tissue using an oven at low temperature, if needed. Sample digestion: weigh the prepared tissue and place it in a beaker or Erlenmeyer. Add nitric acid ($HNO_3$) to decompose the tissue. Carefully heat the mixture to achieve complete digestion. Be sure to control the temperature and ventilation to be safe and effective. Cooling and thawing (if required): allow the mixture to cool after digestion. In case of precipitation or crystallization, carry out liquefaction using an appropriate solvent. Volume adjustment: adjust the sample volume for analysis by using a solvent. Make sure the sample solution concentration is within the linear range of the AAS instrument. AAS instrument calibration: prepare a cadmium standard with a known concentration to create a calibration curve. Calibrate AAS using cadmium standard. Analysis using AAS: insert samples and standards into AAS instruments. Determine the concentration of Cd in the sample by refer-

ring to the calibration curve. Analysis validation: perform quality control and verify analysis results using internal or external quality control. Results reporting: report the results of the analysis of the Cd content in the soft tissues of *Corbula faba* in appropriate units.

Data analysis was performed descriptively. The water quality was analyzed according to the Indonesian Republic Government Regulation N 82 about Management of Water Quality and Water Pollution (2001) [29]. This analysis was based on the World Health Organization guidelines for drinking water quality [28] and the Decision of the Environmental State Ministry N 51 about Sea Water Standards (2004) [30].

## Results and Discussion

Based on the measurements of the physicochemical properties of the water in the Porong River estuary, the abiotic factor values were as follows (Table 1).

The mean DO was 8.7—14.2 mg/L, which exceeded the minimum standard quality of 6 mg/L according to the Indonesian Republic Government Regulation N 82 about Management of Water Quality and Water Pollution (2001) [29]. Based on these values, oxygen content in this river can still maintain the life of the biota [20]. The mean temperature was 30.8°C—31.4°C. According to the Decision of the Environmental State Ministry N 51 about Sea Water Standards (2004) [30], the permissible temperature range for aquatic biota is 28—32 °C. The high-water temperatures in the Porong River estuary region are caused by high solar intensity. Therefore, the temperature of the water in the estuary is in tune with changes in the power of solar radiation [21]. The distribution of sea water salinity is influenced by various factors such as water circulation, evaporation, rainfall, and river flow [18]. The mean salinity value recorded in five plots ranged from 9.0—30.6 ppt. Based on the Decision of the Environmental State Ministry N 51 about Sea Water Standards (2004) [30], the quality standards are determined based on their natural conditions. The ecosystems in the Porong River estuary are generally characterized as mangrove ecosystems, so the range of salinity obtained during the study still follows natural mangrove ecosystems [16]. The mean pH values in the Porong River estuary ranged from 7.80 to 8.46. These values were considered good since a pH of 9, the maximum threshold according to the Indonesian Republic Government

*Table 1*

**Mean of abiotic factors in the Porong River estuary**

| Plots | DO (mg/L) | Temperature (°C) | Salinity (ppt) | pH |
|---|---|---|---|---|
| 1 | 8.7 | 30.8 | 9.0 | 7.8 |
| 2 | 9.4 | 30.8 | 16.0 | 8.07 |
| 3 | 12.4 | 31.4 | 30.6 | 8.44 |
| 4 | 14.2 | 31.1 | 30.0 | 8.46 |
| 5 | 13.1 | 31.0 | 29.0 | 8.44 |

*Table 2*

**Mean Cd levels in the sediments and *Corbula faba* Hinds from five plots**

| Cd content | Sediments (mg/kg) | Corbula faba Hinds (mg/kg) |
|---|---|---|
| Mean | 1.82 | 2.06 |
| SD | 0.04 | 0.43 |
| Minimum | 1.38 | 1.66 |
| Maximum | 2.46 | 2.55 |

Regulation N 82 about Management of Water Quality and Water Pollution (2001) [29], was not exceeded. The pH value is essential for biota survival in these waters. If the pH is too acidic or alkaline, it will endanger the aquatic biota because it affects their metabolism and reproductive systems [11].

Physical and chemical factors can be used as indicators of water quality [25]. Based on the obtained physical and chemical values described above, the Porong River estuary can be considered lightly polluted [26]. The performed research [26] stated that water quality in the Porong River is included in the medium polluted category, as evidenced by the nine measurements of BOD, DO, nitrates, total phosphate, temperature, turbidity, total solids, pH, and fecal coliforms. Based on this study, BOD was 1.13—3.12 mg/L, DO concentration — 4.83—7.62 mg/L, nitrate content — 4.7—6.2 mg/L, total phosphate content — 0.036—0.109 mg/L, water temperature — 28—29°C, turbidity — 8—68, total dissolved solids — 9—223 mg/L, pH — 6.8—8.1, and fecal coliforms — 20—210 CFU/100 ml. Compared to the original study, DO, temperature, and pH values described in [28] were lower, which might be because of a different season when sampling was done.

Based on the AAS test results, the mean content of Cd in the sediment samples was 1.82 mg/kg, while in *Corbula faba* it was 2.06 mg/kg (Table 2). The average Cd content in the sediments exceeded Cd threshold in sediments, which is 0.9 mg/kg [7]. The content of Cd in sediments, which exceeds this threshold, will pollute the aquatic biota that lives in the sediments, such as shells like *Corbula faba*, which inhabits the mud. Following the Decision of the Environmental State Ministry N 51 about Sea Water Standards (2004) [30], the threshold of Cd content in aquatic biota is 0.001 mg/L. Thus, it can be said that *Corbula faba* living in the Porong River estuary has been contaminated with Cd. Moreover, since the mean value of Cd in *Corbula faba* exceeds the average value of Cd in sediments, this proves that there is an accumulation of Cd from the substrate that enters the body of *Corbula faba* [5]. This result is also supported by literature data [6], which stated that there is a correlation between heavy metal content in the water and its content in fish.

## Conclusion

Based on the results of determining physical and chemical parameters of the water in the Porong River estuary, this study concludes that the DO, tempe-

rature, salinity, and pH values could be considered livable since most of the aquatic biota can still inhabit water bodies under these values. However, the obtained results also showed that the Porong River estuary was slightly polluted. Moreover the content of Cd, a heavy metal, in the sediments and mollusks *Corbula faba* found in this study exceeded the maximum threshold for Cd content in sediments and aquatic biota. Thus, it shows that the sediments and shellfish in the Porong River estuary have been heavily polluted by Cd and need to be appropriately treated in the future.

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STATUS OF THE PORONG RIVER ESTUARY, INDONESIA BASED ON THE LEVEL OF CADMIUM CONTENT IN THE SEDIMENTS AND MOLLUSKS *CORBULA FABA* HINDS

The physical and chemical parameters of the water are critical for the life of aquatic biota. This study aimed to assess water quality in the Porong River estuary, Indonesia based on determining the physical and chemical parameters of the water, including the level of cadmium content, in the sediments and mollusks *Corbula faba* Hinds. This research was conducted in May — June 2019. The obtained results showed that the mean concentration of dissolved oxygen ranged from 8.7 to 14.2 mg/L, the mean temperature was 30.8—31.4°C, the salinity value was 9.0—30.6 ppt, and the pH value ranged from 7.80 to 8.46. It has been found that the Porong River estuary was slightly polluted, even though aquatic biota can still inhabit it. However, based on the atomic absorption spectrophotometry test, the mean values of cadmium content in the sediments and *Corbula faba* samples were 1.82 and 2.06 mg/kg, respectively. Based on the quality standards for sediments and aquatic biota, these mean values have exceeded the maximum threshold, indicating that the sediments and *Corbula faba* have been contaminated with the heavy metal cadmium.

***Keywords:*** *water quality, cadmium content, sediments, mollusks Corbula faba Hinds, the Porong River estuary.*