Chemistry Today

2025, Vol. 01 Issue 01
15-21

Research Article

The Impact of Consuming Janitor Fish (*Hypostomus plecostomus*) on Cadmium (Cd) Levels in the Blood

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ARTICLE INFORMATION

Received: November 29, 2025
Revised: December 4, 2025
Accepted: December 4, 2025
Available online: December 7, 2025

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DOI
https://doi.org/10.68712/3kmefg08

A B S T R A C T

Cadmium (Cd) is a toxic heavy metal that pollutes waters and has negative health effects. Janitor fish (*Hypostomus plecostomus*) live at the bottom of waters and are at high risk of accumulating Cd from contaminated sediments. Therefore, consuming this fish has the potential to cause toxic hazards due to the ingestion of Cd. This study aimed to determine the impact of consuming Janitor fish on Cd levels, particularly in the blood. The study used a post-test only control group design with an experimental approach. A total of 30 white rats were divided into two groups: a control group fed a standard diet and an experimental group fed 5 g of Janitor fish daily for 14 days. Blood samples were analyzed using Atomic Absorption Spectrophotometry (AAS) at a wavelength of 228.8 nm. The average Cd level in the blood of rats in the control group without consuming Janitor fish was 1.1642 ppm, while the average Cd level in the blood of rats in the treatment group after consuming Janitor fish was 1.1726 ppm.

Keywords: *Cadmium; heavy metal; Hypostomus plecoctomus; cadmium toxicology; blood*

1. Introduction

Rivers are aquatic ecosystems that play a vital role in the hydrological cycle, serving as water catchment areas and providing resources for the livelihoods of surrounding communities (Mustafa et al., 2024; Naigaga et al., 2011). However, river function is now significantly disrupted by increasing human activity, including households, industries, garment factories, livestock farms, and workshops, which discharge waste directly into water bodies without prior treatment (Baehaki et al., 2020). This waste disposal leads to an increased pollutant load, particularly persistent, hazardous chemical compounds. One group of pollutants of concern is heavy metals, due to their non-biodegradable nature, their easy accumulation in sediments, and their ability to migrate to aquatic organisms. The presence of heavy metals in river ecosystems not only degrades water quality but also poses toxic risks that can have widespread impacts on human health and the sustainability of aquatic environments (Budiastuti et al., 2016).

Cadmium (Cd) is a highly toxic heavy metal, even at relatively low concentrations (Agency for Toxic Substances and Disease Registry, 2012; Genchi et al., 2020; United Nations Environment Programme, 2010). Cd release can originate from natural processes, such as rock weathering, or from anthropogenic activities such as mining, metallurgy, battery manufacturing, plastic stabilization, and the combustion of fossil fuels (Ali et al., 2019). Cd waste disposal in developing countries is often poorly managed and mixed with other waste, ending up in open landfills or directly in water bodies (United Nations Environment Programme, 2010). This makes Cd highly likely to pollute river water and impact aquatic organisms. Because it is non-biodegradable, Cd can persist for long periods in the environment and gradually accumulate in the food chain. Consequently, the presence of Cd in the environment poses a threat not only to aquatic biota but also to humans who depend on these water resources.

Cd is a major concern in environmental health due to its toxicity to humans, animals, and plants (Das & Al-Naemi, 2019; Irawanto, 2015). Cd exposure is known to cause various organ damage, including kidney, liver, and lung damage, as well as disorders of the reproductive system and cardiovascular system, and even an increased risk of cancer (Branca et al., 2020; Genchi et al., 2020; Nordberg & Nordberg, 2022; Rahimzadeh et al., 2017; Rani et al., 2014). The mechanism of Cd toxicity is primarily through the induction of oxidative stress, which leads to increased free radicals, DNA damage, lipid peroxidation, and decreased antioxidant

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enzyme activity (Rasin et al., 2025; Sabolić et al., 2010; Tinkov et al., 2018). These impacts are not only associated with acute cell damage but also trigger chronic damage that is progressive and difficult to repair. Furthermore, Cd can also cause teratogenic and mutagenic effects that exacerbate long-term health risks (Amzal et al., 2009; Andjelkovic et al., 2019; Rasin et al., 2025). Therefore, Cd pollution in the environment cannot be considered trivial because it has broad consequences for both individuals and populations.

Cd accumulation in aquatic biota occurs through direct contact with polluted media, either through water, sediment, or consumed food. One of the aquatic organisms most susceptible to Cd accumulation is the janitor fish (*Hypostomus plecostomus*), due to its nature as a benthic fish that lives on the water's bottom and tends to eat organic and inorganic particles (Dhika, 2013; Hasnidar et al., 2021; Ismi et al., 2019). This makes the janitor fish high potential as a bioaccumulator of heavy metals, including Cd. On the other hand, although known as an environmental cleanser fish, some people still consume janitor fish as an alternative source of cheap protein. In fact, this fish is often processed into foods such as otak-otak, pempek, siomay, and meatballs (Dhika, 2013; Ismi et al., 2019; Trisnawati, 2007). This situation presents a dilemma, as fish that have the potential to act as bioindicators of pollution actually enter the human food chain, increasing the risk of Cd exposure through daily consumption.

This situation is a serious concern because consuming janitor fish from polluted waters can lead to Cd entering the human body (Ismi et al., 2019). Cd accumulated in fish tissue, particularly muscle, can be transferred to the human body and cause toxic effects. However, there is still little scientific information specifically highlighting the Cd content in janitor fish and its potential risks to public health. Many previous studies have focused solely on identifying Cd in the environment or in other types of fish for consumption, resulting in limited data on Cd bioaccumulation in janitor fish consumed by the public. This lack of information often overlooks the risk of Cd exposure through janitor fish, even though regular consumption can pose long-term health risks.

This study was conducted to determine the relationship between consumption of janitor fish from polluted waters and Cd levels in the blood of white rats (*Rattus norvegicus*). Using a laboratory experimental design, this study is expected to provide a direct relationship between Cd bioaccumulation in janitor fish tissue and Cd levels in the blood of consumer organisms. This approach is important because it can represent the real risk that may occur to humans who consume janitor fish from polluted waters (Chovanec et al., 2003; Mustafa et al., 2024; Naigaga et al., 2011; Rajeshkumar & Li, 2018). The results of this study are expected to contribute to the development of environmental toxicology, particularly in understanding the mechanisms of Cd exposure through the food chain. In addition to providing scientific understanding, these findings also have practical benefits, both for the public who need to be more selective in choosing food sources and for the government as a basis for developing regulations to control heavy metal pollution in waters.

2. Methods

This research is an experimental study with a quantitative approach using a post-test-only control group design. This design was chosen because it allows comparing blood Cd levels between the control and treatment groups without conducting baseline measurements. The study was conducted in the laboratory of State Vocational High School 7 Bandung, Indonesia, in August 2025.

2.1 Data collection

Preparation of test animals

The test animals used were 6–8-week-old male white rats (*Rattus norvegicus*) weighing 150–200 grams. Sample selection was conducted by purposive sampling with the criteria of being healthy, active, and free from disabilities. A total of 30 test animals were divided into two groups: a control group of 15 animals fed standard feed and mineral water, and a treatment group of 15 animals fed standard feed and an additional 5 grams of janitor fish (*Hypostomus plecostomus*) per day for 14 days (Hastuti, 2013; Setyaningsih et al., 2006).

Tools and materials

The instruments used in the study included an Atomic Absorption Spectrophotometer (AAS) with a wavelength of 228.8 nm, a digital scale, a hot plate, a centrifuge, a measuring pipette, a measuring cylinder, an Erlenmeyer flask, a cuvette, filter paper, and a syringe and EDTA tube for blood sampling. The research materials consisted of janitor fish meat, standard rat feed, mineral water, concentrated nitric acid (HNO_3), concentrated hydrochloric acid (HCl), distilled water, a standard solution of $Cd(NO_3)_2$, and rat blood samples.

Treatment of test animals

 https://doi.org/10.68712/3kmefg08

The research procedure began with 7 days of acclimatization of the test animals in individual cages under controlled environmental conditions, including temperature, humidity, and a light-dark cycle. During the acclimatization period, the mice were fed standard feed and mineral water. After acclimatization, the test animals were divided into two treatment groups. The control group received only standard feed, while the treatment group received standard feed plus 5 grams of janitor fish per animal per day for 14 days (Kusuma et al., 2017; Setyaningsih et al., 2006).

Measurement of Cadmium levels in the blood

After the treatment period ended, 1–2 ml of blood was drawn from the jugular or tail vein using a sterile syringe containing EDTA anticoagulant. The blood sample was then added with HNO_3 and HCl solutions, heated on a hot plate, filtered, and placed in a cuvette. Cd levels were analyzed using SSA at a wavelength of 228.8 nm, and the sample absorbance was compared to a standard $Cd(NO_3)_2$ solution (Dhika, 2013; Fernanda, 2012).

2.2 Data Analysis

All data obtained in the study regarding the levels of cadmium (Cd) in the blood of white rats fed sau-sapu fish are presented descriptively. The data are presented in tabular form and averaged to illustrate the difference in Cd levels between the control and treatment groups.

3. Results and Discussion

3.1 Measurement of Cadmium Standard Solution

The measurement of cadmium (Cd) levels in rat blood began with the creation of a calibration curve using standard solutions with concentrations of 0 ppm, 0.1 ppm, 0.2 ppm, 0.3 ppm, and 0.5 ppm. The measurements of these standard solutions were measured using atomic absorption spectrophotometry (AAS) at a wavelength of 228.8 and the following results were obtained.

Table 1. Results of Absorbance Measurement of Cadmium Standard Solution

Concentration (ppm)	Absorbance
0	0.1811
0.1	0.4599
0.2	0.6731
0.3	0.7995
0.5	1.0590

From the results of the standard absorbance measurements obtained, a standard curve was then created as in Figure 1 below.

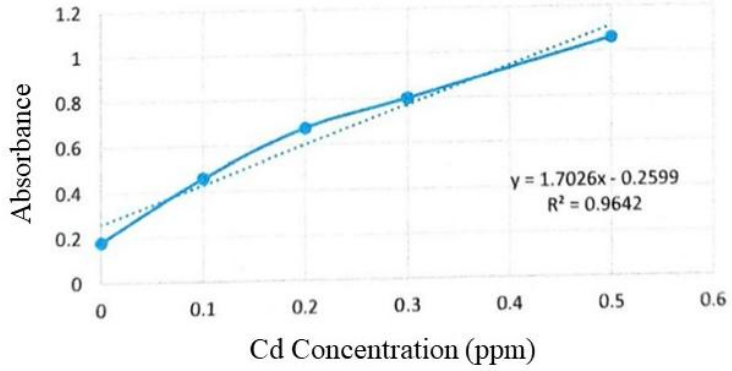


Figure 1. Cadmium Standard Curve

The curve above shows the relationship between Cd concentration (ppm) and the absorbance value of the spectrophotometric measurement results. It can be seen that the higher the Cd concentration, the higher the absorbance value produced. This is in accordance with the Lambert-Beer law, namely that absorbance is

directly proportional to the solution concentration. The results of the linear regression analysis produce the equation y = 1.7026x - 0.2599 with a coefficient of determination R^2 = 0.9642. The R^2 value close to 1 indicates that the linear regression model is very good in describing the relationship between Cd concentration and absorbance. This regression equation can then be used to determine the concentration of the Cd sample based on the absorbance value obtained from the measurement results.

3.2 Measurement of Cadmium levels in the blood

Measurement of samples in rat blood using an atomic absorption spectrophotometer was used to determine the absorbance to measure the Cd levels in the blood of untreated (TP) rats fed standard feed and treated (P) rats fed with janitor fish. The results of the absorbance measurements can be seen in Table 2.

Table 2. Sample Concentration Measurement

Untreated group	Absorbance	Cadmium Concentration (ppm)	Treatment group	Absorbance	Cadmium Concentration (ppm)
TP1	0.1323	1.1518	P1	0.1378	1.1679
TP2	0.1318	1.1503	P2	0 1277	1.1676
TP3	0.1368	1.1650	P3	0.1421	1.1805
TP4	0.1357	1.1618	P4	0.1377	1.1676
TP5	0.1333	1.1547	P5	0.1380	1.1685
TP6	0.1348	1.1591	P6	0.1381	1.1688
TP7	0.1341	1.1571	P7	0.1381	1.1688
TP8	0.1376	1.1673	P8	0.1379	1.1682
TP9	0.1366	1.1644	P9	0.1388	1.1709
TP10	0.1388	1.1709	P10	0.1389	1.1712
TP11	0.1357	1.1618	P11	0.1438	1.1855
TP12	0.1369	1.1653	P12	0.1399	1.1741
TP13	0.1364	1.1638	P13	0.1406	1.1761
TP14	0.1395	1.1729	P14	0.1417	1.1794
TP15	0.1386	1.1703	P15	0.1398	1.1738
Mean		1.1624			1.1726

The results showed that the average Cd level in the treatment group was 1.1726 ppm, slightly higher than the control group, which had an average of 1.1624 ppm. Although the difference in levels was relatively small, this data illustrates a tendency for Cd to increase in the treatment group. Cd levels in the rats' blood showed different variations in each group. In the untreated group, Cd levels had an average of 1.1624 with a median of 1.1638. The very small difference between the mean and median indicates a relatively balanced distribution of the data. The standard deviation value of 0.0068 indicates a relatively narrow distribution of the data, with the lowest value being 1.1503 and the highest being 1.1729, resulting in a range of only 0.0226. This condition shows that the data in the untreated group was quite consistent and did not show extreme variations between individuals. In the treatment group, the average Cd level increased to 1.1726 with a median of 1.1709. The standard deviation value of 0.0056 indicates a narrower data distribution than the untreated group, with a minimum value of 1.1676 and a maximum of 1.1855, resulting in a range of only 0.0179. This indicates that the data in the treated group is more homogeneous.

Comparing the two groups, a pattern of increased blood Cd levels is observed in the treated group compared to the untreated group. The average difference of approximately 0.0102, although relatively small, still indicates a consistent difference. The mean is used to center the data because the mean represents the entire data set. The median only looks at the midpoint and does not represent the entire data set. This suggests that although the control rats also had Cd levels in their blood, feeding the treated group janitor fish could potentially increase the accumulation of this heavy metal.

In this study, the blood Cd levels of the control rats showed quite high levels even though they were not fed janitor fish. This could be due to several factors. First, the standard feed used may have contained small amounts of Cd, given that Cd can accumulate in food. Second, environmental factors in the rat breeding

 https://doi.org/10.68712/3kmefg08

environment can also potentially be sources of Cd exposure, such as air, drinking water, or the cage environment (Nordberg & Nordberg, 2022; Satarug, 2018). This is consistent with several findings that Cd can enter animals' bodies through the food chain and exposure to polluted air and environments (Irawanto, 2015; Ismi et al., 2019; Sunarsih et al., 2018). Therefore, even without treatment, Cd levels in the blood of control mice were still detectable.

In the treatment group fed janitor fish, the average blood Cd level was higher, at 1.1726 ppm. This increase is thought to be due to the nature of janitor fish as a benthic feeder that lives in polluted sediments and has the ability to bioaccumulate heavy metals (Chovanec et al., 2003; Dhika, 2013; Mustafa et al., 2024; Rajeshkumar & Li, 2018). Previous research supports this finding, with Munandar & Eurika (2016) reporting that janitor fish in the Bedadung River exceeded the threshold, while Ismi et al. (2019) found Cd, Pb, and Hg in janitor fish in the Ciliwung River at levels above the Indonesian Food and Drug Authority regulations. Therefore, consuming janitor fish increased blood Cd levels in mice compared to controls.

Cd is a heavy metal with high toxicity and a long biological half-life, making it easy to accumulate in the body. Exposure to Cd in the blood can cause oxidative stress, disrupt enzyme function, and bind to plasma proteins, inhibiting normal metabolism (Das & Al-Naemi, 2019). After entering the body, Cd binds to erythrocytes and albumin, then accumulates in the kidneys, liver, and intestines (Satarug, 2018). Cd excretion is very slow, with a biological half-life of 25–30 years, making chronic accumulation inevitable. Cd is primarily excreted in urine, although it can also be excreted in saliva and milk during lactation. This accumulation can cause serious health problems, including kidney and liver damage, pulmonary edema, testicular disorders, osteomalacia, adrenal damage, and hematopoietic system disorders (Genchi et al., 2020; Tinkov et al., 2018). Furthermore, Cd is also associated with an increased risk of cardiovascular diseases such as coronary heart disease, stroke, peripheral arterial disease, and atherogenic changes in lipid profiles (Genchi et al., 2020).

From a mechanistic perspective, Cd causes oxidative stress by increasing reactive oxygen species (ROS), damaging DNA, proteins, and lipids, and causing mitochondrial dysfunction that inhibits energy production, thus triggering apoptosis and cell necrosis (Branca et al., 2020). The body does have a defense mechanism through metallothionein that can bind Cd, but with excessive exposure, this mechanism is ineffective in preventing its toxic effects (Sabolić et al., 2010). Furthermore, Cd can disrupt epigenetic regulation, increasing the risk of cancer. Based on the International Agency for Research on Cancer (IARC) classification, Cd is classified as a human carcinogen. Mechanisms of carcinogenicity include activation of proto-oncogenes, inactivation of tumor suppressor genes, disruption of cell adhesion, and inhibition of DNA repair. DNA damage in the form of double-strand breaks and DNA-protein cross-links leads to genomic instability, which ultimately triggers abnormal proliferation, impaired apoptosis, and cancer development (Rahimzadeh et al., 2017).

This finding is a serious warning, given that some people still use janitor fish as a cheap alternative protein source. In some areas, this fish is even used as an ingredient in processed foods such as otak-otak, empek-empek, siomay (dumplings), and meatballs (Dhika, 2013; Hasnidar et al., 2021; Ismi et al., 2019; Trisnawati, 2007). However, the bottom-dwelling nature of janitor fish makes it susceptible to accumulating heavy metals, including Cd, from sediment and polluted water (Ismi et al., 2019). Therefore, consuming janitor fish not only provides protein but also has the potential to increase Cd accumulation in the human body.

Considering the research results, it can be concluded that janitor fish (*Hypostomus plecostomus*) has the potential to be a source of cadmium (Cd) exposure for organisms that consume it. Although the increase in Cd levels in the treatment group compared to the control group was relatively small, these results indicate a tendency for Cd accumulation due to janitor fish consumption. The Cd levels detected in the control group indicated baseline exposure from both feed and the environment, while levels in the treatment group indicated additional accumulation, likely from consumption of janitor fish. This is consistent with previous studies reporting that janitor fish living in polluted waters can accumulate heavy metals in their tissues (Dhika, 2013; Hasnidar et al., 2021; Ismi et al., 2019; Munandar & Eurika, 2016). Therefore, janitor fish originating from polluted environments have the potential to increase Cd levels in the blood of test animals.

4. Conclusion

Based on the results of research on the description of cadmium (Cd) metal levels in the blood of white rats (*Rattus norvegicus*) fed with janitor fish (*Hypostomus plecostomus*), it can be concluded that the results of the examination of the blood Cd levels of control rats without consuming janitor fish have an average of 1.1624 ppm. Meanwhile, the results of the examination of the blood Cd levels of treated rats after consuming janitor fish have an average of 1.1726 ppm. This finding is important not only from a toxicological aspect, but also from a public health and food safety perspective. Consuming janitor fish from polluted waters can potentially

increase the risk of heavy metal accumulation in the body, which in the long term has the potential to cause serious health impacts. Therefore, janitor fish from polluted waters should not be consumed.

Acknowledgement

The researcher would like to express his deepest gratitude to his parents, friends, supervisors, the Rajawali Health Institute, and all parties who have been involved in this research process.

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