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STUDIESIMPACT OF ARSENIC (AS) AND CADMIUM (CD) ON ENVIRONMENTAL QUALITY DETERIORATION

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Abstract

Arsenic has various colors according to its shape, namely arsenic trioxide (As2O3) which is white and gray, but this form is rare. Cadmium is a heavy metal that is silvery white in color. Cadmium is often used in the metal plating industry, and is the end result in the ore processing industry. Cadmium has a bad effect on the environment and humans, because it can cause breast cancer, respiratory problems, kidney failure and death. Cases that occur in the world, namely the case of arsenic pollution in Bangladesh, cadmium pollution, namely itai-itai disease that occurred in Japan. Regulations and laws have regulated a lot regarding the prevention and handling of heavy metals by the industry, namely PP no. 18 of 1999 juncto PP no. 85 of 1999 concerning hazardous waste, and PP no. 74 of 2001 concerning hazardous and toxic materials also regulates waste that can damage the environment. The various impacts above underlie the writing of this literature. This writing was made based on various journals, articles both national and international related to the heavy metals arsenic and cadmium. So that people are able to recognize the types of heavy metals and the impact they will have on the environment and themselves. In the end, the community can manage the presence of waste properly and protect the environment from unwanted impacts. articles both nationally and internationally related to the heavy metals arsenic and cadmium. So that people are able to recognize the types of heavy metals and the impact they will have on the environment and themselves. In the end, the community can manage the presence of waste properly and protect the environment from unwanted impacts. articles both nationally and internationally related to the heavy metals arsenic and cadmium. So that people are able to recognize the types of heavy metals and the impact they will have on the environment and themselves. In the end, the community can manage the presence of waste properly and protect the environment from unwanted impacts.

Keywords-Arsenic, Cadmium, Hazardous Waste.

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I. INTRODUCTION

Cadmium (Cd) has the characteristic silvery white color like aluminum metal, heat resistance, corrosion resistance. Cadmium (Cd) is used for electrolysis, a pigment for the paint, enamel and plastic industries. Cadmium (Cd) is a type of heavy metal that is dangerous because this element has a high risk for blood vessels, Cadmium affects humans

in the long term and can accumulate in the body, especially the liver and kidneys (Palar, 2004).

Based on the level of hazard that has been described above, it is important to understand where the source of the formation comes from, what types of industries produce waste containing arsenic and cadmium, how the process is exposed to the environment, what impacts will be caused and how efforts are made to overcome them. From a variety of sources, both literature, journals, and articles in print and electronic media, reviews are created about the impact of the heavy metals As and Cd. The community is expected to be able to use this information as a guideline for maintaining environmental quality in the future.

II. LITERATURE REVIEW

Arsenic and cadmium are indeed found in relatively small amounts but the level of toxicity is very high because they are included in heavy metals (Bunce, 1994, Fergusson, 1990). All heavy metals occur naturally in the environment resulting from industrial waste in increasing amounts. Based on the opinion of Kovacs (1992).

Metals that contribute to toxicity in water are lead, cadmium, mercury and aluminum. Sources of heavy metals lead, cadmium and mercury in water, either in the form of solutions or solids are often found behind rocks, found in the form of sulfides originating from contaminated industrial waste/waste, leachate from uncontrolled secure landfills, mining activities bad conditions, and leaks in waste storage ponds (Bunce, 1994).

A. *Arsenic characteristics*

Arsenic in groundwater is divided into two forms, namely the reduced form formed under anaerobic conditions, often called arsenite. The other form is the oxidized form, occurring under aerobic conditions, commonly referred to as arsenate (Jones, 2000). Arsenic is an element of medicinal components since ancient times. The compound arsenic trioxide, for example, has been used as a tonic, namely at a dose of 3 x 1-2 mg. In the long term, the use of this tonic has caused symptoms of chronic arsenic intoxication. Arsenic was also used as a remedy for parasitic infections, such as protozoa, helminths, amoebae, sprirochetes, and trypanisoma, but has since fallen out of use as a remedy in homeopathic recipes.

Table 1

ContentNatural Arsenic in Nature

Stone Type	**ConcentrationArsenic (mg/kg)**
Frozen Rock	
Ultrabasic	0.3-16
Basalt	0.06-113
Andesite	0.5-5.8
Granite	0.2-13.8

Sedimentary Rock	
Clay	0.3-490
Posporit	0.4-188
Sandstone	0.6-120
Limestone	0.1-20
Coal	
bituminous	9.0±0.8
Lignite	7.4±1.4
Peat	16-340

Source: (Jacks and Bhattacharya, 1998)

B. *Arsenic Chemical Properties*

Arsenic is found in 200 mineral forms, including arsenate (60%), sulfides and sulfosalts (20%), and small groups in the form of arsenide, arsenate, silicate oxide, and pure arsenic (Onishi, 1969). The majority of arsenic is found in the main constituents of asenopyrite (FeAsS), realgar (As4S3), and orpiment (As2S3). Realgar (As4S3), and orpiment (As2S3) usually reduce the form of arsenic itself. Other natural conditions are loellingite (FeAs2), safforlite (CoAs), nicolite (NiAs), rammelsbergite (NiAs2), arsenopyrite (FeAsS), cobaltite (CoAsS), enargite (Cu3AsS4), gerdsorfite (NiAsS), glaucodot ((Co,Fe)AsS), and elemental arsenic (Greenwood and Earnshaw, 1989). The following is Table 1 of As Conditions in Nature.

In aquatic environments, under oxidative stress arsenic forms pentavalent arsenate (As(V)), whereas under reduced conditions it forms trivalent arsenite (As(III)), and its mobility and uptake by sediments, clays and soil minerals depend on arsenic form. Under anoxic conditions, microbial activity can form arsenic in methylate, which is solid and capable of entering the atmosphere (Nriagu et al., 2007).

C. *Characteristics of Cadmium*

Cadmium is a silver-white metal, soft, shiny, insoluble in bases, easy to react, and produces Cadmium Oxide when heated. Cadmium (Cd) is generally found in combination with chlorine (Cd Chloride) or sulfur (Cd Sulphite). Cadmium forms Cd2+ which is unstable. Cd has an atomic number of 40, an atomic weight of 112.4, a melting point of 321°C, a boiling point of 767°C and a density of 8.65 g/cm3 (Widowati et al., 2008).

Cadmium metal (Cd) has the characteristics of a silvery white color like aluminum metal, heat resistance, corrosion resistance. Cadmium (Cd) is used for electrolysis, a pigment for the paint, enamel and plastic industries. Cadmium metal (Cd) is usually mixed with other metals, especially in lead and zinc mining (Darmono 1995). Cadmium (Cd) is a silvery white crystalline metal. Cd is obtained together with Zn, Cu, Pb, in small amounts. Cadmium (Cd) is obtained in the alloy industry, Zn purification, pesticides, and others (Said, 2008).

D. *Pollutant Sources*

Arsenic presence in nature (including presence in rocks (soil) and sediments, air, water, and biota), arsenic production in industry, uses and sources of arsenic pollution in the environment.

Cadmium metal (Cd) has a very wide distribution in nature. Based on its physical properties, cadmium (Cd) is a malleable metal, white in color like silvery white. This metal will lose its luster when it is in wet or humid air and will quickly deteriorate when exposed to ammonia (NH3) and sulfur hydroxide (SO2) vapors (Palar, 2004). In mining activities, cadmium is usually found in mineral ores including green ockite (=xanthochroite) sulfide, otative carbonate, and cadmium oxide. These minerals are formed in association with sphalerite ores and their oxides, or are obtained from the remaining dust from electrolytic sludge processing (Herman, 2006).

E. Sources of Industrial Pollutants

- Metal Ore Processing Industry
- Pesticide Industry
- Mining Industry
- Metal Coating Industry
- Paint Removal Process (Paint Stripping)

F. Pollution Cases by Arsenic and Cadmium

- Arsenic Pollution Case in Bangladesh

Cases of arsenic contamination have been reported in Bangladesh. Residents in Bangladesh use well water contaminated with arsenic as their main source of drinking water. It is estimated that 35 to 57 million people in this country are victims of pollution cases. The government of Bangladesh and non-governmental organizations are playing an active role in combating this problem (Paul, 2004). Bangladeshis use pumped wells to extract water from the groundwater table. According to data, the use of drinking water from these pumped wells reaches 95% of the entire population of Bangladesh. The people of this country suffer from very disastrous diseases, ranging from melanosis to skin cancer and gangrene. In several reports revealed that polluted well water has killed 3000 people and made 125000 victims of skin cancer.

The Public Health Engineering Department of Bangladesh detected wells contaminated with arsenic for the first time in 1993. The spread of arsenic exposure began in the central plains, which is the center of Bangladesh, and spread to the north and south, where the land is lower, through the underground layers (Paul, 2004). Another allegation is the assumption that there is arsenic content in sulfide minerals at a depth of 66-330 feet below the main river, namely the Ganges which flows in 2 countries, namely India and Bangladesh. Below is Figure 2.6 regarding the distribution of arsenic concentrations in the Bangladesh region. The country of Bangladesh has a high arsenic content in its soil layer. Arsenic, which is often found in the form of deposits, naturally decomposes with the help of a high pH. At a certain pH arsenic easily decomposes from its deposits, then the arsenic will dissolve in the water flowing in the local river. The water-soluble arsenic also seeps into the groundwater and is consumed by the local population.

- Cases of Cadmium Pollution in Japan (Itai-itai Disease)

Itai-itai disease that occurs in Japan was first encountered in a highly polluted area in the Jinzu river valley, located in Toyama Prefecture, Japan. This disease itself shows symptoms of nephropathy and osteomalacia. Both of these diseases are diseases that arise due to the presence of cadmium content in the body. The local health office or the Public Welfare Office of Toyama (Toyama Community Welfare Office) identified areas polluted with Cd that since 1967, 97% of the 132 residents who died were victims of itai-itai disease (Kawano et al, 1984).

This cadmium poisoning case occurred at a time when Japan was intensively producing weapons for military needs. Mining carried out by Mitsui Mining and Smelting Co., Ltd. has indirectly caused the suffering of the people on the Jinzu river to have a lasting effect. Due to the acute effects, patients with itai-itai disease experience excruciating pain due to cadmium poisoning for the rest of their lives. There are also many cases of death of patients affected by this disease after consuming Jinzu river water and eating rice irrigated by the river (Nogawa and Suwazono, 2011).

In 1967, the contents of cadmium, zinc and copper were identified from 34 irrigation areas using the Jinzu River irrigation system and 16 irrigation areas using other irrigation systems. Jinzu river watering area with the most severe heavy metal content. 34 rice paddy fields around the Jinzu river found 4.04 ppm heavy metal content in the water entering the area, 2.42 ppm heavy metal content in the middle of the rice field area, and 2.24 ppm in the irrigation outlet area. Meanwhile, cadmium metal itself ranges from less than 1.0 ppm in all rice fields.

The result of the hypothesis is that cadmium enters the human body, presumably because the rice produced in that area is contaminated with cadmium. The Cd concentrations of all rice studied varied from 1.0 ppm to the highest reaching 6.88 ppm (Nogawa and Suwazono, 2011). This research sheds light on how local people are poisoned by the heavy metal cadmium, in general they consume rice produced by local agriculture. This is also the conclusion from the previous article that cadmium poisoning is indeed oral (oral) which continues into digestion. Cases of Cd pollution in Japan when referring to legislation in Indonesia are indeed included in the category of heavy pollution. It was stated that the cadmium content in rice in polluted areas ranged from 1.00 ppm to 6.88 ppm and 4. 04 ppm in the Jinzu river is not in accordance with the Minister of Environment Regulation of 2010 which stated that only 0.1 mg/l of industrial area wastewater quality standards are permitted. Cadmium levels in the Jinzu river should also not be consumed as drinking water when referring to the drinking water quality standard set by the ministry of health in this country which only allows 0.003 mg/l.

III. RESULTS AND DISCUSSION

A. *Mechanism of Metal Pollution in the Environment*

The release of contaminants into nature is unavoidable, this is a process due to the existence of factories and the result of waste handling and final waste disposal processes. After being released into the environment, contaminants will react quickly, sometimes very slowly absorbed by living things and accumulate in them.

Contaminants are exposed in nature through 3 phases namely liquid, solid and gas. In the liquid phase, contaminants are exposed in various ways, namely through runoff, directly discharged into surface water bodies, and leachate into the groundwater layer. Meanwhile, gas emissions are released by means of solid emissions from lakes and direct exposure from chimneys due to incomplete combustion (including CO2 and H2S combustion products and gas used for burning organic matter). In the solid phase, these contaminants can be mixed in gas and water (both dissolved and insoluble in water (LaGrega et al, 1994). Release of contaminants from the soil into the ocean is absorbed by marine biota, then accumulated by biota for a certain period. Exposure to contaminants also enters the ocean sediments which are eventually absorbed by seabed plants.

Heavy metals generally enter the environment in two ways, namely naturally and anthropogenic (apart from human intervention or unnaturally entering the environment). The natural condition for the release of heavy metals into the environment is due to the weathering of sediments, erosion, and volcanic activity. Meanwhile, the anthropogenic release of heavy metals due to human activities includes electroplating, mining, smelting, use of pesticides, soil fertilizers, and so on (Ali et al., 2013).

Metals are generally found in nature in natural forms (Forstner et al, 1995). According to Darmono (2001) the main objectives to determine metal concentrations in the aquatic environment are:

a. Knowing the concentration of metal content in aquatic animals, both marine and fresh water animals. So that it can prevent the occurrence of chronic and acute toxicity in people who eat it.

b. Knowing the concentration of metals in water and sediment, which will be used as irrigation water or drinking water. So that its use does not have a bad effect on people who consume it.

B. Impact of Pollution on Humans and the Environment

Arsenic is known to be a carcinogen or can cause cancer. People who are exposed to too much arsenic from consuming drinking water are called arsenicosis. Victims of this arsenicosis will not have an impact in the near future, but the impact will only be seen after a long period of time (long-term). Various effects, including skin pigmentation, gangrene, and keratosis, have only been seen for at least 5 years due to accumulated arsenic. Because arsenic poisoning cannot be seen immediately, the most likely action is prevention (Paul, 2004).

Cadmium has a very unique effect on children, which can help brain development in children. But on the other hand, cadmium has effects that are not good for adult humans, including increasing the risk of breast cancer, cardiovascular or lung disease, and heart disease. Other effects that indicate cadmium toxicity are kidney function failure, gout, arthritis formation, as well as bone damage (Chen, 2009). Cadmium metal (Cd) will undergo a process of biotransformation and bioaccumulation in living organisms (plants, animals and humans). In the body of aquatic biota the numbermetalaccumulated will continue to increase (biomagnification) and in the highest biota food chain will experience more cadmium (Cd) accumulation (Palar, 2004). Cadmium can accumulate in the human body and can only be excreted from the body, but with waiting times ranging from 20-30 years. Effects in the body also vary, ranging from hypertension to cancer (Watts, 1997).

Pollutants that enter the aquatic environment will experience three kinds of accumulation processes, namely physical, chemical, and biological. Industrial waste disposal containing hazardous materials with high toxicity and the ability of marine biota to accumulate polluting metals immediately accumulates physically and chemically and then settles to the bottom of the waters. The metabolism of hazardous materials occurs through a biological food chain called bioaccumulation (Hutagalung, 1984).

The levels of heavy metals contained in the bodies of aquatic organisms are higher when compared to the levels of heavy metals found in their environment. Heavy metal elements can enter the body of organisms in three ways, namely through the food chain, gills, and diffusion through the skin surface. Removal of heavy metals from the body and gills as well as stomach contents and urine (Bryan, 1976). Accumulation in organisms occurs due to the tendency of heavy metals to form complex compounds with organic substances contained in the bodies of organisms so that heavy metals are fixed and not immediately excreted by the organisms concerned (Waldichuk, 1974).

Technology for Handling the Impact of Heavy Metal Pollution

- Arsenate and arsenite removal with zerovalent iron

Arsenate (As(V)) and arsenite (As(III)) can be removed with zerovalent iron present in aqueous solution. This was proven from a study conducted, which showed the effectiveness of reducing the content of arsenate and arsenite in two reactors. Researchers combined the 4 types of Fe0 (zerovalent iron) to get the proper ratio in 0.01 M NaCl. Fisher electrolysis of Fe0 shows the fast movement of arsenic. Fe0 damages the surface of the aqueous solution then forms a kind of magnetic corrosion on the surface of Fe0. This ultimately creates interactions between metals, namely between Fe0 and As. In this experiment, the pH has a very strong effect where a pH below 7 is the most effective pH in helping ion interactions between metals.

This study shows that zerovalent iron is indeed very effective for removing arsenate and arsenite dissolved in water. The graph also shows that acidic pH can accelerate removal until finally the removal stagnates at pH 8 (Su and Puls, 2001).

- *Phytoremediation*

a) Phytoremediation technique with Alnus firma

Phytoremediation is considered as a way of repairing or eliminating heavy metals in nature. Phytoremediation itself is a bioremediation process that uses various plants to remove, move and/or destroy contaminants in soil and groundwater (Subroto, 1996).

*Alnus firm*can survive in many mining sites in Korea. What makes Alnus firm successful in resisting stress under conditions of heavy metal contamination lies in the bacteria in its roots which are able to react positively with heavy metals such as As, Cu, Cd, Ni, Pb, and Zn. The way of interaction is very unique, namely, Alnus firma provides nutrient-rich enzymes to support microbial life and microbes help absorb the existing xenobiotic environment and isolate it. This symbiosis goes on and on which is mutually beneficial to both parties. Alnus firma plants are able to grow well naturally on land with relatively high levels of heavy metals. This is supported by the isolation carried out by the bacterium Bacillus thuringiensis GDB-1 in the roots of the Alnus firma plant. GDB-1 refers to naming during research, later it was found that the sample was B. thuringiens bacteria. The symbiosis between these plants and rhizosphere bacteria isolates heavy metals while reducing the level of plant stress to the presence of heavy metal pollutants. The performance of these bacteria is optimal at pH 4-9, at this pH the ability of the bacteria to last up to 90% of heavy metal isolation (Babu et al, 2013).

b) Phytoremediation Techniques in Mining Lands Pollution that often occurs is on site

mining, where mining waste (tailings) inevitably produces waste containing heavy metals.

In a case of processing polluted land in Iran, more precisely in the Angouran mining.

According to Chehregani, et al., among the 5 plants tested as accumulators of heavy metals in the mining area, namely Amaranthus retroflexus, Polygonum aviculare, Gundelia tournefortii, Noaea mucronata, and Scariola orientalis, the results showed that the soils contaminated with heavy metals

*N. mucronata*is the best plant in absorbing Pb, Zn, Cu, Cd, and Ni. While metal iron (Fe) is best accumulated by A. retroflexus. In this study the results showed that N. mucronata was able to accumulate a cadmium content of 14 mg/Kg.

c) Phytoremediation Techniques with Eichhornia crassipes Eichhornia crassipes is a type of plant that lives

in water which is better known as water hyacinth in Indonesia. Research conducted by Li and colleagues showed an increase in the absorption of heavy metals found in water. Water hyacinth is first burned to form a powder. Furthermore, the solution containing heavy metals was spiked with water hyacinth powder. Optimization was carried out at pH 5.0-6.0 and at 30°C. This absorption involves the exchange of ions in solution, namely the heavy metal ions that coalesce into water hyacinth. The analysis is performed with the help of X-ray photoelectron spectroscopy.

d) TechniquePhytoremediation with Paulownia tomentosa Paulownia tomentosa is said to be a plant

alternative in phytoremediation techniques that can absorb heavy metals. This plant is a type of phytoextraction plant that transfers pollutants from the soil to the area around the plant or to the plant stems. The resistance of P. tomentosa in holding heavy metal pollutants was not very significant. This is due to limitations on the number of leaves, and stem diameter. The bigger the plant, the bigger the ability

*P. tomentosa*to absorb metals accumulated in the soil (Doumett et al., 2008).

D. *Regulations and Legislation*

Ministry of Environment Decree no. 51 of 1995 also includes general liquid waste quality standards for industrial activities. The quality standard is a threshold reference for other industries besides the industries mentioned above, where industries that are not listed by the ministerial decree are suspected of producing other heavy metal waste. Especially for arsenic and cadmium, respectively 0.1 mg/L and 0.05 mg/L for waste with a temperature of 38°C. Whereas for the second group of waste with a temperature of 40°C the content of arsenic and cadmium complies with the quality standards of 0.5 and 0.1 mg/l.

The effluent quality standard for industrial areas is determined in accordance with the Regulation of the State Minister for the Environment No. 03 of 2010. This quality standard specifically provides a limit of 0.1 mg/L for cadmium content. Liquid waste quality standards are also strictly regulated at the provincial level as stipulated in the Decree of the Governor of East Java No. 45 of 2002 concerning liquid waste quality standards for industry or other business activities in East Java

The Ministry of Health of the Republic of Indonesia stated through the Regulation of the Minister of Health of the Republic of Indonesia no. 492 of 2010 concerning drinking water quality requirements where there are standard standards for water suitable for consumption after experiencing clean water treatment. The quality standards for drinking water also state that 0.01 mg/l for arsenic and 0.003 mg/l for cadmium are permitted for the presence of these two heavy metals.

Permenkes RI no 492 of 2010 concerning requirements for drinking water quality is also supported by the classification of water quality stipulated in accordance with Government Regulation no. 82 of 2001 in article 8 where there are 4 classes, namely class one, class two, class three and class four. According to PP no. 82 of 2001 shows that the content for arsenic and cadmium which is allowed as a standard source of drinking water is 0.05 mg/l and 0.01 mg/l. As for irrigation, class 2, class 3, and class 4 standards can be used.

In general, based on the quality standard values described above, the average maximum levels allowed in water are 0.05 mg/l for arsenic and 0.01 for cadmium, respectively.

Arsenic and Cadmium are included in the category of B3 waste based on their toxicity. According to Government Regulation no. 18 of 1999 concerning Hazardous and Toxic Waste Management article 1, where the impact caused by As and Cd can damage the environment and human health so that it is categorized as B3 waste. The PP was further revised, resulting in PP no. 85/1999 concerning Amendments to PP No. 18/1999 (Trihadiningrum, 2000). The latest regulation that regulates B3 is PP no 74 of 2001 concerning the management of hazardous and toxic materials.

IV. CONCLUSION

Conclusions from the results of writing

include:

1. The mechanism of heavy metal pollution comes from 2 sources, namely natural and anthropogenic.
2. The impact produced on living things by heavy metal pollution is almost the same, that is, it is accumulative in nature and causes a decrease in human health.
3. Cases that serve as examples in this paper are arsenic pollution cases in Bangladesh and cadmium pollution cases in Japan.
4. Phytoremediation technique for heavy metal polluted areas is the most effective step
5. In Indonesian laws and regulations, according to quality standards, the allowable levels of arsenic and cadmium are 0.05 mg/l for arsenic and 0.05 mg/l for cadmium.

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