



HAZARDS AND TOXIC EFFECTS OF CADMIUM ON THE VARIOUS LIVING ORGANISM AND ITS RELATED SAFETY: A REVIEW

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Abstract

For the health of humans, soil, and aquatic life, cadmium is a hazardous, non-essential metal. In the microbes of soil and soil ecology, cadmium has a deleterious impact. Additional harmful consequences of cadmium for people Cadmium causes poor bone mineralization, which raises the risk of osteoporosis and bone fractures. Furthermore, it produces bone-related nerve discomfort. The corrosive resistance of cadmium is good, and it stabilizes polyvinyl chloride. In fish, exposure to cadmium reduces growth rate and causes pathophysiological harm. Continuous exposure harms larvae and slows their rate of development. Fluid replacement, supplementary oxygen, and mechanical breathing may be helpful if cadmium toxicity develops. Gastric lavage is also helpful after exposure.

Keywords: Cadmium Effects, Sources of Cadmium, Toxicity, Reproductive Biology.

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1. Introduction

Cd (cadmium) is an easily recyclable byproduct of zinc or lead processing. Cadmium enters the soil through agricultural applications of pesticides, fungicides, fertilizers, and sludge *Baby, J., et al. (2010)*. Cadmium plays a negative role in soil organisms and soil ecology. Cadmium is harmful, non-essential, and dangerous for human health. *Magrath, S.P. (1999)*. It has good corrosive resistance properties; hence, its coating provides better protection in the marine environment and aerospace applications where safety and reliability are essentially required. It has been found that the coating of cadmium preferentially corrodes the material on which it is applied. Cadmium is used as a pigment in paints. It is a good stabilizer for polyvinylchloride because it prevents degradation of the material due to direct exposure to sunlight.

Routes of Cadmium Exposure

The toxicity of cadmium, which has been extensively employed in industry for several applications, was first discovered in the middle of the twentieth century. As was mentioned in the introduction, Cd may be found in the ores of zinc, copper, and lead. Volcanic eruptions temporarily raise the amount of cadmium in the environment. Excessive cadmium exposure and buildup have extremely harmful consequences for the human body.

By the Natural Environment

Groundwater rarely contains high levels of Cd, since unreacted wastewater from industries and mining operations is not involved. Cadmium is dissolved from water lines in the presence of Soft or acidic water; its raised level in water is also due to leaching from household pipes and fittings. But these are neglected in the case of the clinical toxicity of Cd. Cadmium occurs in the air as particulate matter as Cadmium Oxide through soldering, smelting, or other industrial processes carried out at high temperatures.

By the Food Chain

From the soil system, cadmium uptake takes place in plants like tobacco, rice, potatoes, vegetables, and grains. Cadmium is accumulated, particularly in the liver and kidneys. High concentrations of Cadmium in Shellfish and mushrooms in certain areas also affect human health due to regular consumption.

Chemical Properties

Cd is a transition metal that contains 1 mmHg of pressure at 394°C. Cd is odourless and corrosive resistant. Cadmium metals and their oxides do not

dissolve in water. Cadmium has a (+2) oxidation state. Solid Cd is not flammable, but powdered Cd will burn and produce corrosive and toxic fumes **National Toxicology Program (2004) & Schaefer, H. R., et al (2020)**. The salts of cadmium in chloride, sulphate, and nitrate dissolve in water. Some of the cadmium salts are insoluble, but they dissolve in water when they mix with acids or are exposed to light or oxygen. At 321°C, cadmium melts.

Cd Half-Life

Singh, J., Kaushik, R. D., et al. (2017) reviewed some kinetic literature on aromatic compounds, including o-Anisidine. The half-lives of aromatic amines in blood plasma range from 1.5 to 80 hours, whereas benzoquinone has a half-life of around 8 to 21 days. As a result, when compared to aromatic amines, the half-life of cadmium in the kidney varies from six to thirty-eight years, while that in the liver is four to nineteen years. *Schaefer, H. R., et al. (2020)*.

Hazardous effects of Cd

Cadmium emissions or dust may impact an unborn child's reproductive system and organs. It is poisonous to aquatic organisms and causes long-term damage to water bodies.

Effects on the Environment

After a threshold level of heavy metal concentration, it becomes harmful to aquatic animals and human health and also affects the ecological balance. Heavy metals accumulate in soft tissues and have a toxic effect on the human body. The aquatic organisms are exposed to heavy metals via their body surface, gills, and consumption of food. *Baby, J., et al. (2010)* Human exposure is caused by the combustion of fossil fuels, phosphate fertilizers, activities associated with the production of iron, steel, and cement in industries, and also through the production of municipal solid waste and its related activities. *Morrow, H. (2000)*.

Effect on Human Health

In the human body, heavy metals enter through air, water, and food. Agricultural activities and the involvement of humans in the manufacturing of pharmaceuticals cause the absorption of toxic heavy metals through the skin. Cd is considered a carcinogen and causes lung cancer *Liu, W. (2010)*. Inhalation of Cd through dust (fine), vapours, or intake of vastly soluble complexes of cadmium (Cd) may cause pneumonitis, pulmonary oedema, and death *Morrow, H. (2000) and Hayes, A.W. (2008)*. As an endocrine disruptor, Cadmium can interact with hormonal activity, as noted in some laboratory studies. Cadmium

easily binds to estrogen, which influences transduction along the estrogen and MAPK signalling pathways at low doses, **Fechner, P. et al. (2011)** & **Stoica, A et al. (2000)**., & **Ali, I et al. (2010)**, **Ali, I et al. (2012)** & **Johnson, M. D et al. (2003)**.

Effects of Cd on Reproductive Biology

Cd affects the ovarian steroidogenic pathway in rats. The direct effects of in vitro Cd exposure on steroidogenesis in rat ovaries are the subject of research by **Piasek et al.** Cadmium typically interferes with hormones like progesterone and testosterone. **Piasek M, et al. (1999)** Although large doses of Cd hinder ovarian progesterone production, modest doses of Cd increase it **Henson MC et al. (2004)**. After some literature review, we found that Cd is a potent nonsteroidal estrogen both in vivo and in vitro. Rats' uterine weight and the growth of their mammary gland were both enhanced by cadmium precipitation. **Johnson MD, et al. (2003)**.

Respiratory Effects

Inhaling an excessive amount of Cd fumes and their associated chemicals may result in lung illness. Production of Cd alloy, Cd coated steel welding, Cd smelting, and Cd refinement Fever, a cold, and myalgia—symptoms that resemble the flu—are the earliest signs of cadmium poisoning. Later phases might lead to the development of dyspnea, coughing, and chest discomfort **Davison, A. G, et al. (1988)**.

Gastrointestinal Effects

Consider consuming cigarette smoke, acidic foods or drinks, and badly kept Cd-coated foods. exhibits signs of gastrointestinal issues such as vomiting, cramping and discomfort in the belly, loose bowels, and tenses while irritating the stomach epithelium **Bowers, N., et al. (1997)**, & **Schaefer, H. R., et al. (2020)** & **Saini, S., et al. (2020)**. High doses of cadmium irritate the gastric epithelial tissue **Nordberg GF (2004)**.

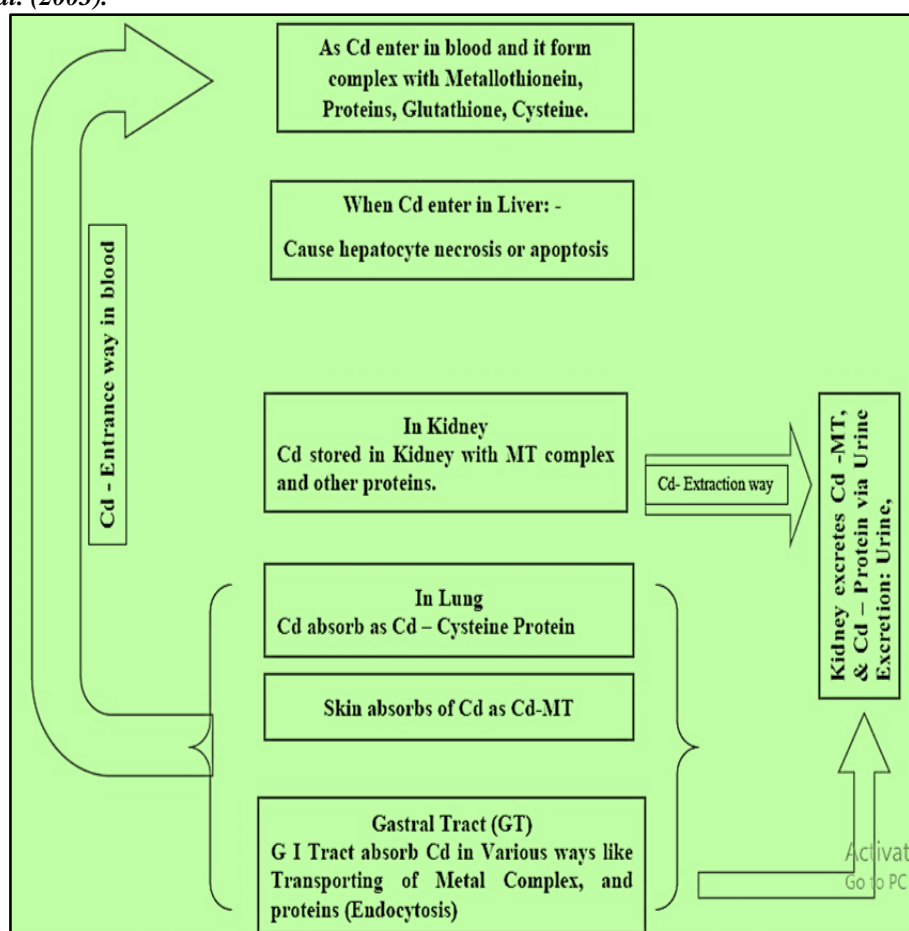


Fig. 1 Effect on Human Health by Cd

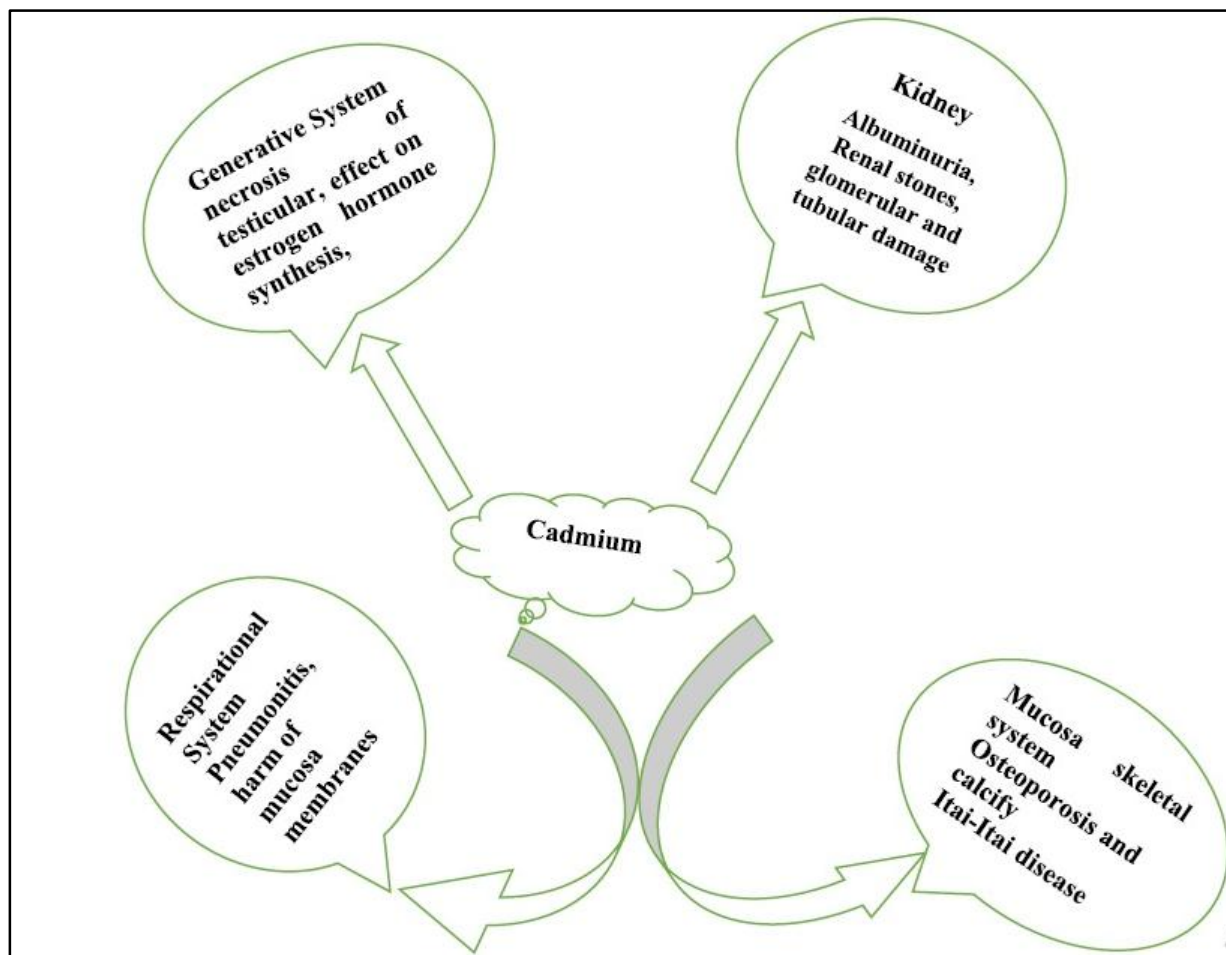


Fig. 2: Affected organs by Cd

Effect on Aquatic Ecosystem

When Cd enters freshwater, it precipitates in huge amounts and is located at the bottom as residue. So, sediment is the main source of Cd for the aquatic environment (WHO, 2000). Cd has direct and indirect effects on aquatic organisms, populations, and ecosystems due to its toxic nature. Cd is considered a pollutant and can change the trophic levels of aquatic organisms like fish. Sorensen, E.M.B. (1991). Cd uptake from sediment bottom and feeding by fauna and sediment-rooted flora circulate the food chain in fish with specific paths Irwin, R.J. et al. (1997).

Toxic effects of Cd on fish

Due to the toxic nature of Cd, it is a tensioning agent for fish. The results of Cd exposure cause pathophysiological damages as well as growth rate reductions in fish. Annabi, A., et al. (2013); Hansen, J.A., et al. (2002) In mammals and fish, Cd causes

hepatic and renal injuries with the probable inducement of oxidative stress Kim, J.H., et al. (2010) Cd causes hypocalcemia when it interacts with calcium and during its metabolism process. The higher concentrations of calcium in the water protect fish from Cd uptake. The Cd should be chronically toxic due to long-time exposure. Continuous exposure to cadmium destroys the larva and decreases the rate of growth. Cadmium has an acute toxic effect, but organisms may die due to higher concentrations of Cd for a short period. AMAP (1998). After the above discussion, we find that how much impact Cd will have on aquatic organisms depends upon the Cd chemical forms because Cd and its salts have different types of toxicities and bio-concentrations. This form binds with metallothionein and decreases its toxicity; it normally occurs in fish's liver. though the higher concentration of Cadmium produces toxic effects. Bradl, H., (2005) & Wright, D.A. et al. (2002).

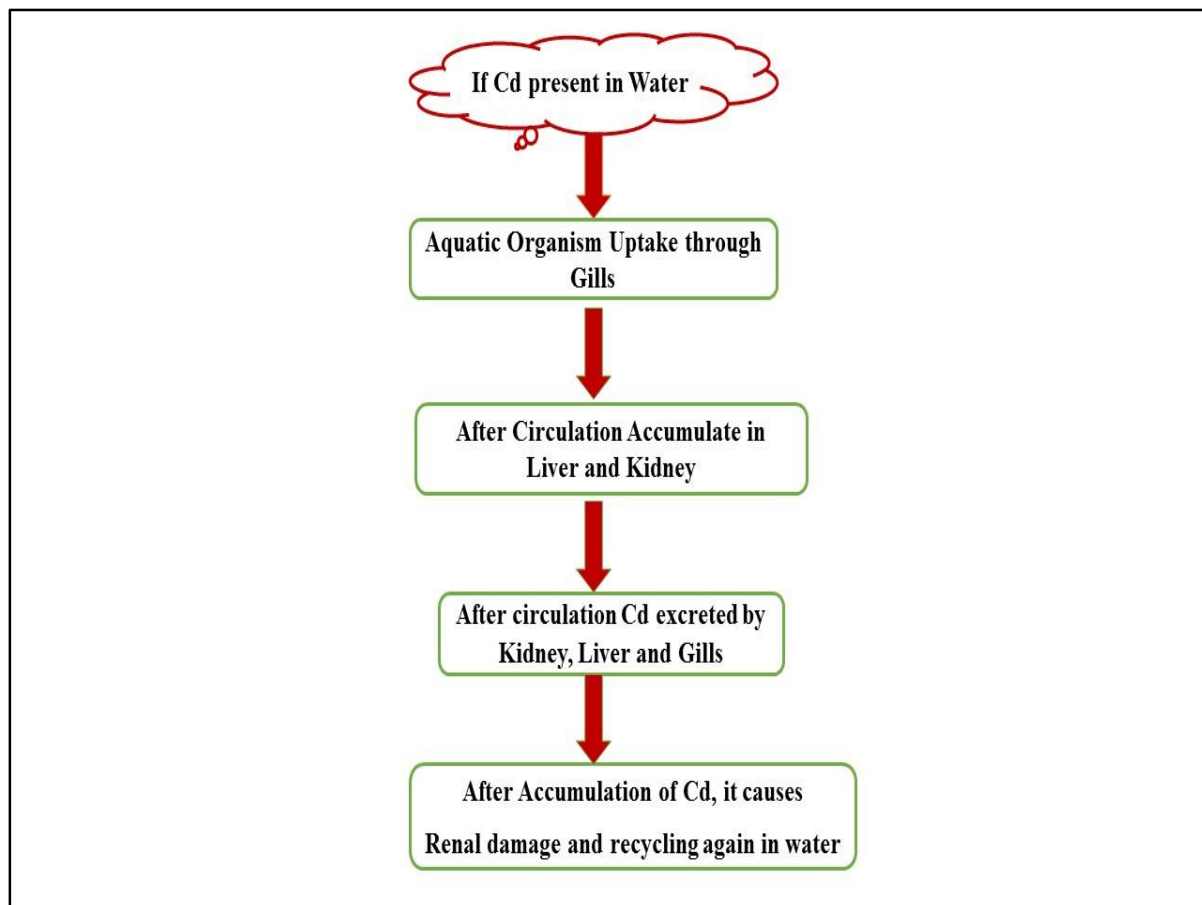


Fig. 3 Effect of Cd on Aquatic Life

Safety Assessment

If the dust or fumes of cadmium Oxide are inhaled, they may cause cancer. Cadmium dust or fumes damage the fertility and organs of the fetus and cause lifelong injuries to aquatic life, so a precautionary system is necessary. Before handling not only Cd but also any chemical species, we first understand the handling procedure and safety measures and then use them. *Soni, R. K., et al. (2021); and Singh, O. (2021)*. Before handling the cadmium First, read and understand the safety precautions. Choose a well-ventilated area for cadmium-related work. Wear a respiratory safety mask for breathing. When using this product, wash your hands properly before eating, drinking, or smoking. As cadmium gets wet, it should be explosive, so avoid moisture or another surface because it may leave traces and accumulate. Also, ensure that any effluent or solid waste is disposed of, and consider a dry, covered area. Substances like polyphenolic compounds, mostly present in plants, prevent the harmful effects of Cd. Polyphenolic compounds involve biological activity and have

antioxidant properties. Such a compound has at least one aromatic ring with an active phenolic group. Some relevant substances that contain polyphenolic groups are given below. Cloves, Plums, Cocoa Powder, Apples, Walnuts, Almonds, Green Olives, Spinach, Red Onion, Red Wine, Green Tea, Black Tea, Coffee, Black Chokeberry, Peppermint, etc.

2. Applications and Uses

1. Normally Cd is used as electric batteries, and pigments, *Buxbaum, Gunter; et al (2005)*. Cd used as coating agents, *Smith C.J.E.; et al. (1999)*.
2. Another use of Cd is electroplating. In Nuclear fission work as Neutron absorber *Scoullou, Michael J.; et al. (2001)*.
3. Batteries; Nickel-Cd, *Krishnamurthy, N. et al. (2013)*.
4. In Television technology, such as QLED TVs, *Maynard, Andrew (2017)*.
5. In the medical field cd is used as an Anticancer drug, *Abyar, Selda; et al. (2019)*.

6. In past years Cd oxide was used in black and white television **Lee, Ching-Hwa; et al. (2002)**.
7. The photoconductive surface used CdS coating for photocopier drums. **Miller, L. S.; et al. (1991)**.
8. Cd is used as light, heat, &also used as a weathering stabilizer in polyvinylchloride, **Jennings, Thomas C. (2005)**.

3. Future Directions

Cadmium toxicity in plants is a key source for future research directions and how to mitigate this toxicity-related problem. Understand the interactivity, quality of water, condition, and cadmium in fish, as well as the existence of other metal interactions, protection, future threats, and the genetic influence of Cd bioaccumulation. Invents new agricultural tools for mitigating Cd-related harmful problems, identification, and genetic reasons that will give more resistant species in the future.

Some possible directions for addressing Cd toxicity in the future:

Alternative methods and materials:

The primary goal of research and development should be to identify substitute materials and methods for Cd-containing compounds in diverse applications. This involves looking into Cd-free catalysts, batteries, pigments, and semiconductors. Cd toxicity concerns can be decreased by funding sustainable technology and supporting eco-friendly alternatives.

Recycling and waste management:

By creating effective recycling procedures for Cd-containing items like batteries and electronics, we can lessen the likelihood that Cd will be improperly disposed of and end up in the environment. To reduce the danger of Cd leaking into soil and water, appropriate waste management techniques must be put into place, including adequate handling and containment of waste containing Cd.

Phytoremediation and bioremediation:

The development of plants or microorganisms that can absorb or detoxify Cd from polluted soil and water may be facilitated by technological advancements. These phytoremediation and bioremediation methods may be used in polluted areas and provide a practical, eco-friendly way to reduce Cd toxicity.

Cooperative research and international cooperation:

Promoting cooperation among scientists, researchers, and stakeholders from various nations might encourage the flow of information and assets to

address Cd toxicity on a worldwide scale. The creation of established procedures, best practices, and creative answers to efficiently handle Cd contamination can be facilitated through international cooperation.

4. Purpose of this manuscript

A very hazardous heavy metal with negative effects on both human health and the environment, cadmium, is examined in this review article. It investigates the origins and prevalence of cadmium, human exposure routes, and related health impacts such as respiratory problems, kidney damage, and cancer. It discusses existing regulations and mitigation strategies while emphasizing the need for proactive measures to minimize cadmium exposure and protect human health and the environment.

5. Conclusion

Due to the non-biodegradable and toxic nature of cadmium, it is a very serious problem for emerging countries. It affects the photosynthesis process in plants and crop productivity, not only in the harvest but also in human health. The most well-known reason is Cigarette smoking, which causes lung or kidney disease. Use new methods for mitigating Cd-related problems like microbial remediation and phytol degradation, and implement Cd-counter agricultural tools. The European Commission has proposed limits like 60–20 mg of cadmium per Kilogram. Displacement of Fluid, supplementary oxygen, and better or instant ventilation may be very effective. In the case of ingestion of Cadmium, gastrointestinal distillation via vomiting or gastric lavage may be effective after exposure to Cadmium.

By being aware of potential sources and adhering to safety precautions, you may reduce your exposure and protect yourself against Cd poisoning. Maintain proper hygiene, especially by washing your hands after touching anything that contains Cd. Use suitable handling and disposal techniques while handling and disposing of Cd-containing products at work. Maintain a healthy lifestyle, which includes eating a portion of balanced food, quitting smoking, and not drinking too much alcohol.

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