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Acute Toxicity of Zinc Sulphate ($ZNSO_4$) on the Estuarine Blood Clam *Anadara granosa* (Linnaeus, 1758)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Zinc is an essential trace element for taking role in electron transfer in many enzymatic reactions. However, its prolonged and excessive intake may lead to toxic effect. Aquatic organisms take up zinc in proportion to the dissolved concentration of the metal in water. Generally, uptake occurs throughout epithelial surfaces related to absorption and excretion of ions such as the gill membranes. Heavy metals can accumulate in the tissues of aquatic organisms and cause a range of hazardous effects to all organisms through bio-magnifications. There are a number of studies carried out on the toxicity of Zinc sulphate. The aim of this study was to investigate the acute toxicity effects of Zinc sulphate on the clam *Anadara granosa.* Clam samples were exposed to different concentrations (3, 6, 9, 12, and 15.00 mg/L) of Zinc sulphate for 96h and their cumulative mortality was calculated in 12 hours intervals. Results were analyzed by SPSS 20 to obtain number of cumulative mortality and lethal concentrations. The blood clam *Anadara granosa* LC_{50} and LC_{90} for zinc sulphate at 96 hours were 4.63 and 9.28mg/L in the current study. Mortality rate was increased with the increase in metal concentrations and time.

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1. INTRODUCTION

A heavy metal is an element that belongs to a broad group of elements that have metallic characteristics. It mostly consists of actinides, lanthanides, transition metals, and a few metalloids. Numerous definitions have been put forth, some based on chemical qualities, others on density, atomic weight, or atomic number. Damage to the central nervous system, decreased energy, harm to the lungs, kidneys, liver, and other essential organs, and blood composition can all be consequences of heavy metal toxicity. Long-term exposure can cause degenerative disorders of the muscles, brain, and body that advance slowly. Numerous foods and beverages, such as fish, poultry, vegetables, immunizations, dental fillings, and deodorants, might expose people to hazardous or heavy metals [1].

Any species of metal (or metalloid) could be deemed a "contaminant" if it manifests in an undesired location or at a concentration or form that has an adverse effect on people or the environment. Lead (Pb), copper (Cu), nickel (Ni), zinc (Zn), chromium (Cr), arsenic (As), cadmium (Cd), mercury (Hg), and selenium (Se) are examples of metals/metalloids. Singh et al. [2] list uranium (U), manganese (Mn), molybdenum (Mo), strontium (Sr), aluminum (Al), cesium (Cs), and cobalt (Co). These are other less common metallic pollutants. The soil type, which includes soil pH, organic matter content, clay mineral, and other soil chemical and biochemical properties, as well as crop species or cultivars regulated by genetic basis for heavy metal transport and accumulation in plants, which in turn influences the thresholds for assessing dietary toxicity of heavy metals in the food chain, are factors determining the thresholds of dietary toxicity of heavy metal in soil-crop systems [3].

Even though heavy metals are the oldest known toxins harmful to humans, heavy metal toxicity is still a topic that requires further investigation. Arsenic (As) contaminated underground water and arsenic based agricultural products have generated a worldwide increase of illnesses and deaths that are mainly due to various types of cancer and skin disorders. Industrialization and manufacturing made lead (Pb) poisoning a common occurrence, forcing governments to take measures to decrease lead usage. Mercury (Hg), being highly bioaccumulative and with an increasing presence in the environment, when consumed through food is proven to be especially harmful to lactating mothers, fetuses and children. The vast use of cadmium (Cd) for technological and agricultural purposes poses a high risk of occupational and non-occupational exposure of humans to that element, since it has been confirmed to cause carcinogenesis [4]. Large volumes of heavy metals, such as copper (Cu), nickel (Ni), and zinc (Zn) ions, are released by the electroplating and metalworking industries into their effluents. This is known to pose a serious risk to human health and aquatic life. Nickel exposure can range from skin irritation to harm to the lungs, neurological system, and mucous membranes. Copper is particularly hazardous since it is nonbiodegradable and carcinogenic. Copper has been documented to induce neurotoxicity often known as "Wilson's disease" due to deposition of copper in the lenticular nucleus of the brain and kidney failure. Although it is rare, high zinc consumption can lead to diarrhea and gastrointestinal upset [5].

Heavy metals in the environment have a negative impact on aquatic life. The surface water system's sediment composition and water chemistry both have a significant impact on toxicity [6]. Microorganisms mineralize the metals, which are then absorbed by plankton and other aquatic organisms. Finally, when a person eats fish that has been exposed to contaminated water, the metals have already been biomagnified multiple times [5]. The riverine and estuarine environments are extremely important to the surface of the world. Animal habitats and plant growth are supported by riverine and estuarine environments. Compared to compounds of heavy metals created by humans, heavy metals found in the environment are not as harmful. Some of the heavy metals that are added to the environment by contaminated water through various anthropogenic activities including mining, industry, and agriculture include arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel, and zinc. For the people living along the shore, estuaries are the primary source of food and a variety of economic activity. Elevated concentrations of heavy metals in estuaries have detrimental impacts on marine biota and pose a significant health risk to humans when consumed in seafood [7]. The objective of this study was to determine zinc sulphate's acute toxicity to the blood clam *Anadara granosa*.

2. MATERIALS AND METHODS

2.1 Collection and Acclimation of Experimental Clam

The *Anadara granosa* clam, which is harvested from the Cauvery estuary, is found in Tamil Nadu, India's southeast coast, close to Mayiladuthurai. The local clam collectors assisted in the hand-picking process of clam collection. The Cauvery River is a tributary of South India's main river, the Cauvery. The experiment began with the Clams being acclimated to laboratory conditions for a period of seven days. In this experiment, glass aquaria with a 10-liter marine water capacity were utilized. Every aquarium received fresh air via an air pump equipped with a capillary system.

2.2 LC_{50} Determination

Healthy *Anadara granosa* clams were selected for the static renewable bioassay LC_{50} measurement of zinc sulphate after acclimation. During the trial, clams were not fed. Stock solutions containing zinc sulfate were used to prepare test solutions at different concentrations (3, 6, 9, 12, and 15.00 mg/L). Ten lab-acclimated clams of the same species, identical in size, weight, and age, were added to each zinc sulfate test concentration. For every concentration, proper controls and triplicates were kept. The protocol for conducting toxicity studies was followed by Sprague, [8]. Using SPSS Ver.20 Log10 Base computation, Finney's, [9] probit analysis yielded the median fatal concentrations of 96 hours.

3. RESULTS AND DISCUSSION

In scientific literature, a number of elements, starting with beryllium and ending with actinides, are referred to as "heavy metals" [10]. According to Waldichuk [11], all groups from periods 3 to 7 of the Periodic Table's heavy metals are widely thought to have atomic numbers between 22 and 92. Except for those with high vapour pressure like mercury and those that could be present in the environment as particulates like vanadium, few metals are dangerous when they are pure. The issues in aquatic environments are caused by the soluble compounds of the metals. The various metal oxidation states influence an aquatic organism's level of toxicity. "Electronegativity" refers to an element's ability to both attract and accept electrons during the production of compounds. This ability has certain ecological implications, particularly in relation to an element's toxicity to aquatic organisms. As the electronegativity increases, so does the toxicity [11,12].

The goal of the current study was to find out how acutely poisonous zinc sulfate is to the clam *Anadara granosa*. After 96 hours of exposure to various zinc sulphate concentrations (3.00 to 15.00 mg/L), the cumulative mortality of the clam samples was computed every 24 hours. Plotting graphs between the percent mortality and the log concentrations of the toxicant helped calculate the LC_{50} value. The antilog value of the concentrations was computed by plotting a perpendicular line versus 50% mortality. The blood clam *Anadara granosa* LC_{50} and LC_{90} for zinc sulphate at 96 hours were 4.63 and 9.28 mg/L in the current study. The current investigations' findings (Fig. 1) made it abundantly evident that, for any given concentration, death rates rose with increasing concentration; similarly, for a given concentration, death rates increased with increasing exposure duration and a regular manner of toxicant due to accumulation up to dangerous level leading to death. The relationship between the zinc sulphate content and the blood clam *Anadara granosa* mortality rate is depicted in Fig. 1. Finney's probit analysis approach was used to assess the outcomes of 96-hour zinc sulphate clam toxicity trials. The concentration (mg/L) of zinc sulphate was shown to be correlated with death, with a R^2 value of 0.933.

Many inland waters and estuary environments have seen an increase in heavy metal contamination in recent years [13]. Large habitats including open ocean, reefs, sediments, sand and mud flats, sea grasses, salt marshes, and mangroves are what make estuaries so significant. A variety of fish species, as well as marine plants and animals, can be found in an estuary. Because they filter contaminants like pesticides, herbicides, and heavy metals that are present in the flow, estuaries are also crucial for the environment. Estuaries are the most significant component of coastal activity, which employ two thirds of the world's population. Since the coastal region depends heavily on industries like tourism and fishing for money, it is even more important to preserve this special ecology [7]. Due to its importance to plant growth, zinc is often utilized in fertilizers and pesticides. Although an excess of zinc can lead to weakness or exhaustion, it is also beneficial to

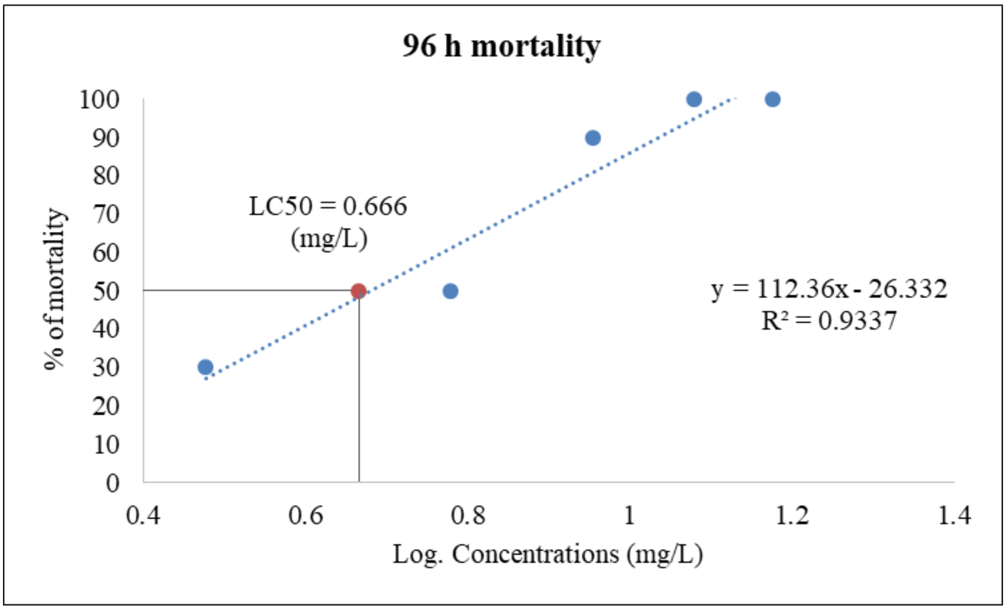

Fig. 1. Acute toxicity studies of zinc sulphate on blood clam *Anadara granosa*

humans. Zinc is utilized in a variety of applications, including the galvanization of metals, paints, weapons, cosmetics, batteries, plastic, and pharmaceuticals. Both manmade and natural sources contribute zinc to the estuaries. The utilization of zinc-containing lubricating oil has the potential to elevate the proportion of zinc in the estuarine ecosystem, hence increasing the potential health hazards to aquatic plants and animals [14]. Excessive zinc accumulation can have negative consequences on human health, including nausea, anemia, cholesterol, and the immune system [15].

Anadara granosa, commonly known as blood cockles, poses a risk of low-level, chronic heavy metal exposure. Low dose chronic exposure to lead (43, 86, and 172 µg/L), cadmium (55, 110, and 220 µg/L), and copper (7.1, 14.2, and 28.4 µg/L) has deleterious effects on antioxidant enzyme activity in *A. granosa* gonads, digestive glands, and gills [16]. Yap et al*.* [7] Laboratory studies were carried out on the blood cockle *Anadara granosa* to examine the buildup of Cu and Zn after four days of exposure to a single metal and its depuration after six days in natural saltwater. Ong and Din, [18] reported cadmium, copper, and zinc toxicity to the blood cock *Anadara granosa*, particularly zinc toxicity, which was observed in the LC_{50} range of 3.68 to 11.81 mg/L during 96 h. Similarly, the present study recorded zinc toxicity (LC_{50} = 4.63 mg/L) against *Anadara granosa* during 96 hrs.

4. CONCLUSION

The goal of the current investigation was to determine zinc sulphate's toxicity to *Anadara granosa* clams. *Anadara granosa* showed a comparatively higher toxic response in the acute toxicity test to these toxicants and can be recommended as a candidate species to monitor zinc toxicity. The blood clam *Anadara granosa* LC_{50} and LC_{90} for zinc sulphate at 96 hours were 4.63 and 9.28mg/L were observed. The clam toxicity study will be very helpful in the future to provide insight into the ecological impact.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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