**Zinc Induced Occupational Toxicity**

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**Abstract**

With five stable isotopes, zinc is the 24th most abundant element in the crust of the earth. Zinc is a vital trace element that is required for both prenatal and postnatal development in humans, animals, plants, and microorganisms. It is the only metal that is present in every class of enzyme and is the second most common trace metal in humans, after irons. It is a co-factor for the folding of proteins and necessary for cellular metabolism. It has pleiotropic effects on the physiology of cells, and either an excess or a deficiency can lead to pathologies such as stroke and diabetes that have disastrous consequences. Additionally, zinc is a cofactor for over 80 metalloenzymes that are involved in the transcription of DNA and the synthesis of proteins. Zinc is used in many industries as a coating to prevent corrosion on a variety of metal objects through the hot-dip galvanization process. Workers are most at risk from zinc fumes during this process, which can have negative health effects. "Spetter chills, zinc fever, and smelter shakes" are common disorders caused by prolonged exposure to zinc.

**Key Words:** Zinc, Occupational Toxicity.

**Introduction**

Zinc is a chemical element with the symbol Zn and atomic number 30. Zinc is a slightly brittle metal at room temperature and has a shiny-greyish appearance when oxidation is removed. It is the first element in group 12 (IIB) of the periodic table. In some respects, zinc is chemically similar to magnesium: both elements exhibit only one normal oxidation state (+2), and the Zn2+ and Mg2+ ions are of similar size. Zinc is the 24th most abundant element in Earth's crust and has five stable isotopes. The most common zinc ore is sphalerite (zinc blende), a zinc sulfide mineral. The largest workable lodes are in Australia, Asia, and the United States. Zinc is refined by froth flotation of the ore, roasting, and final extraction using electricity.

Zinc is an essential trace element for humans, animals, plants and for microorganisms and is necessary for prenatal and postnatal development. It is the second most abundant trace metal in humans after iron and it is the only metal which appears in all enzyme classes. Zinc is an essential nutrient element for coral growth as it is an important cofactor for many enzymes.

Zinc is an essential mineral in cellular metabolism. It is a cofactor for the activity and folding of proteins. Because of the pleiotropic effects of zinc on every aspect of cell physiology, zinc deficiency or excessive rise in its cellular concentration, can have catastrophic consequences and are linked to major patho-physiologies including diabetes and stroke.

The plasma concentration of zinc is about 15 µmol/L, principally bound to albumin and a third of which is bound to α2-macroglobulin. Zinc occupies 10-20 % of plasma, is a constituent of the human genome, acts as a site-specific antioxidant, acts as an active site in enzymes, and is essential for the action of insulin.

Lead and zinc are mostly present at the same occupational source, usually found as co-contaminants at specific sites and are among the top 10 substances found most frequently at national priorities list (NPL) sites with a completed expo-sure pathway (ASTDR 2001). Lead has been classified as possible human carcinogenic (group 2B) by the International Agency for Research on Cancer (IARC 1987), while inorganic lead has been classified as probable human carcinogen (group, 2A) (IARC 2006). A vast number of studies has shown serious health effects due to lead exposure that include nephrotoxicity, neurotoxicity and other deleterious effects related to haematological and cardiovascular systems (ASTDR2007, Wani et al. 2015). The occupational exposure poses serious health risks which include the effects like anaemia and hypertension as well as gastrointestinal tract, nervous system, reproductive system, and cardiovascular effects. Lead has also been attributed to increase risks of miscarriage and still-birth (WHO, 2000; Wixson and Davies 1994). In addition, lead has been shown to interfere with the number of enzymes and other biochemicals to disrupt their biological action. Zinc on the other hand is an essential micronutrient and its deficiency leads to number of debilitating diseases in both animals and plants.

A zinc-coating process called hot-dip galvanization is used for protecting metal items from corrosion. The greatest risk in the galvanization process is the exposure of workers to zinc fume rising from the metal bath surface. With the efficient homeostatic control of zinc, it does not accumulate in the organism in excessive amounts. However, inhalation of zinc fumes or accidental ingestion of unusually large amounts of zinc can cause adverse effects on exposed humans.

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Zinc is a silvery bluish grey metal with a comparatively low melting and boiling point of 420C and 907C respectively. Though zinc is brittle at ordinary temperature, it is malleable at 100C, and can be readily rolled. Normally found in brittle form, when heated it gets converted into a malleable metal. Zinc is the fourth most widely used metal globally after steel, aluminium and copper and the third most-used non-ferrous metal. The most common zinc mineral is sphalerite also known as zinc blende. This mineral crystallises from the hydrothermal solution as pure zinc sulphide and is found in almost all currently mined zinc deposits. Zinc is often mined in association with lead, copper, silver and other metals.

Any toxic properties of zinc resulting in chronic industrial disease are commonly denied. Recognition is given to an acute form of zinc poisoning under such designations as "spelter chills," "zinc fever," "brass founders' ague," "smelter shakes," etc. As early as 1888, Simon1 in his description of this acute zinc poisoning records the absence of any chronic manifestations. Hayhurst2 states, "The physician must get away from the idea of attempting to diagnose chronic zinc or brass poisoning, as there probably is no such condition." Later this statement is mitigated in discussing the possible chronic effects of brass poisoning2: "In Chicago the fact that 85 per cent of 1,761 foundry workers (brass) were under 40 years of age, and only 1 per cent over 50 years, was explained by employers as due to `slowing up' or beginning decrepitude, and by workmen, as gradual incapacitation from the inhalation of brass fumes.

Some trace elements have been identified as potential hazards following long term exposure, and recently there has been intense work on different elemental exposure studies. Hair being the most convenient biopsy material has enabled the study of these elements in the human body and periodic sampling provides rates for their uptake.

**A Case Study of Zinc Toxicity in Occupational Workers of Meerut (U.P.)**

The air in the work environment usually contains a number of chemicals, which inhaled and absorbed by the body, pose a potential risk for workers’ health. In the recent years, evidence has accumulated that interactions between air pollutants and living tissues may cause disturbance of pro and anti-oxidant balance of the body (Orisakwe et al. 2007). The result in the present study showed that occupational exposure to zinc significantly increases the values of creatinine and uric acid. Zinc is an important cofactor in the body and is essential for normal function; however, increased levels of zinc can become toxic. There are three types of exposure that can lead to toxicity: inhalation, oral, and dermal.

**Table. 1. Estimation of Specific Gravity, Creatinine and Uric Acid.**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sample No.** | **Specific Gravity** | **Creatinine** | **Uric Acid** |
| 1. | 1.022 | 5.57 | 17.38 |
| 2. | 1.030 | 3.42 | 11.59 |
| 3. | 1.030 | 6.57 | 13.63 |
| 4. | 1.012 | 2.28 | 16.36 |
| 5. | 1.017 | 4.57 | 17.50 |
| 6. | 1.025 | 6.42 | 12.72 |
| 7. | 1.020 | 5.00 | 1.95 |
| 8. | 1.022 | 3.28 | 14.09 |
| 9. | 1.026 | 4 | 17.15 |
| 10. | 1.034 | 7.28 | 13.63 |
| 11. | 1.004 | 0.02 | 8.29 |
| 12. | 1.005 | 1.57 | 10.79 |
| 13. | 1.003 | 0.85 | 8.79 |
| 14. | 1.030 | 6.42 | 15.45 |

**Fig: 1 Showing value of Specific Gravity in Zinc Worker**

**Fig: 2 Showing value of Creatinine in Zinc Workers**

**Fig: 3 Showing Value of Uric Acid in Zinc Workers.**

Creatinine, which is a waste product produced by the muscles, gets filtered out by the kidneys. Elevated creatinine in the urine can be a sign of impaired kidney function. This can lead to chronic kidney disease. High creatinine levels usually indicate that the kidneys are not working as they should. Possible causes of this dysfunction include: a kidney infection, [glomerulonephritis](https://www.kidney.org/atoz/content/glomerul), which is [inflammation](https://www.medicalnewstoday.com/articles/248423) of the kidney structures that filter the blood, [kidney stones](https://www.medicalnewstoday.com/articles/154193) that block the urinary tract or kidney failure.

The uric acid values in the zinc factory workers was also found to be higher than the expected range which indicates kidney disfunction. Occupational exposure may be associated with an increased risk of developing hyperuricemia (Chen et al. 2022)

Prolonged, intensive or excessive heavy metal exposure can induce related systemic disorders. Kidney is a target organ in heavy metal toxicity for its capacity to filter, reabsorb and concentrate divalent ions. The extent and the expression of renal damage depends on the species of metals, the dose, and the time of exposure (Lentini et al. 2017).

# The study includes observations viz specific gravity, creatinine, and uric acid concentration with reference to the zinc factory workers.

# Specific Gravity; The highest value of specific gravity found in zinc worker is (Sample -10) 1.034 and the lowest value found is (Sample-13) 1.003.

# Creatinine; The expected range for urine creatine is 1.1- 3.0 g/lit. the urine creatinine values observed in zinc factory workers ranges from 0.02 g/lit to 7.28 g/lit. the creatinine value in most of the workers is high as compared to the expected range.

# Uric acid; The expected uric acid range is 3.4 -7.0 mg/dl. The highest uric acid value observed in zinc factory workers is 17.95 mg/dl (Sample-7) and the lowest value is 8.29 mg/dl (Sample-11). Rest of the workers also showed elevated uric acid values then the expected range.

Also, as observed sample number 10 shows the highest value of specific gravity that is 1.034 and of creatinine that is 7.28 g/lit and sample number 13 show the lowest value of specific gravity that is 1.003 and of creatinine that is 0.85 g/lit. This trend is observed as both specific gravity and creatinine co-relates to each other. However, both the sample shows elevated values of uric acid.

**Impact of Zinc Toxicity on Human health**

Zinc is an essential trace element, and the human body has efficient mechanisms, both on systemic and cellular levels, to maintain homeostasis over a broad exposure range. Consequently, zinc has a rather low toxicity, and a severe impact on human health by intoxication with zinc is a relatively rare event.

Nevertheless, on the cellular level zinc impacts survival and may be a crucial regulator of apoptosis as well as neuronal death following brain injury. Although these effects seem to be unresponsive to nutritional supplementation with zinc, future research may allow influencing these processes via substances that alter zinc homeostasis, instead of directly giving zinc.

Whereas there are only anecdotal reports of severe zinc intoxication, zinc deficiency is a condition with broad occurrence and potentially profound impact. Here, the application of “negative zinc”, i.e., substances or conditions that deplete the body of zinc, constitute a major health risk. The impact ranges from mild zinc deficiency, which can aggravate infections by impairing the immune defence, up to severe cases, in which the symptoms are obvious and cause reduced life expectancy.

**Conclusion**

Urine samples were used in this study as a bioindicator of zinc toxicity in workers who smelt zinc coatings. Samples of urine were taken from a small-scale industry in the Meerut (U.P.) Indian district of Partapur. Only fourteen employees consented to provide urine samples. Three parameters were examined in the laboratory when analysing urine samples: uric acid, creatinine, and specific gravity. Four out of the fourteen samples had high specific gravity, ten samples had high creatinine, and eleven samples had high uric acid.

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