

# ZINC INDUCED OCCUPATIONAL TOXICITY

## 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 iron. 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.

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## I. INTRODUCTION

The chemical element zinc has the atomic number thirty and the symbol Zn. At room temperature, zinc is a little brittle metal that turns shiny-greyish after oxidation is removed. It is the first element in the periodic table's group 12 (IIB). Zinc and magnesium are chemically similar in certain ways: both elements have only one normal oxidation state (plus 2) and the sizes of the Zn<sup>2+</sup> and Mg<sup>2+</sup> ions are comparable. With five stable isotopes, zinc is the 24th most plentiful element in the crust of the Earth. The most common zinc ore is the zinc sulfide mineral sphalerite, often known as zinc blende. Australia, Asia, and the US contain the biggest viable lodes. By roasting, froth flotation of the ore, and ultimate extraction, zinc is refined. An important mineral for cellular metabolism is zinc. It functions as a cofactor in the folding and activation of proteins. Due to the pleiotropic effects of zinc on all facets of cell physiology, excessive increases in the concentration of zinc within cells, or deficiencies in zinc itself, can have disastrous results and are associated with major pathophysiologies such as stroke and diabetes.

About 15  $\mu\text{mol/L}$  of zinc are found in plasma; most of it is associated to albumin, with a little amount being bound to  $\alpha_2$ -macroglobulin. Ten to twenty percent of plasma is made up of zinc, which is also found in the human genome, functions as an active site in enzymes, operates as a site-specific antioxidant, and is necessary for the action of insulin.

Lead and zinc are among the top 10 compounds most commonly detected at national priority list (NPL) sites with a completed exposure pathway. They are primarily present at the same occupational source, typically observed at specific sites as co-contaminants. The International Agency for Research on Cancer (IARC) categorized lead as possibly carcinogenic to humans (group 2B), while inorganic lead was categorized as likely carcinogenic to humans (group 2A) (IARC 2006). Numerous studies have demonstrated that exposure to lead can have major negative impacts

on health, such as nephrotoxicity, neurotoxicity, and other negative effects on the cardiovascular and haematological systems (ASTDR 2007). Serious health risks are associated with occupational exposure, including effects on the gastrointestinal tract, nervous system, reproductive system, and cardiovascular system in addition to effects like anemia and hypertension. Moreover, lead has been linked to higher chances of stillbirth and miscarriage (WHO, 2000; Wixson and Davies 1994). Lead has also been demonstrated to interfere with several other biochemicals and enzymes, impairing their biological activity. On the other hand, zinc is a necessary micronutrient that, in both plants and animals, deficiency causes a variety of crippling illnesses.

Metal objects are coated with zinc using a process known as hot-dip galvanization to prevent corrosion. The exposure of workers to zinc fume rising from the metal bath surface is the biggest risk associated with the galvanization process. Zinc is effectively under homeostatic control, preventing excessive accumulation in the organism. On the other hand, humans who are exposed to zinc fumes or accidentally consume unusually high levels of zinc may experience negative side effects.

Lead and zinc are among the top 10 substances most commonly found at national priorities list (NPL) sites with a completed exposure pathway. They are primarily present at the same occupational source, typically found as co-contaminants at specific sites (ASTDR 2001). The International Agency for Research on Cancer (IARC) categorized lead as possibly carcinogenic to humans (group 2B), while inorganic lead was categorized as likely carcinogenic to humans (group 2A) (IARC 2006). Numerous studies have demonstrated that exposure to lead can have major negative effects on health, such as nephrotoxicity, neurotoxicity, and other negative effects on the cardiovascular and haematological systems (ASTDR 2007). Serious health risks are associated with occupational exposure, including effects on the gastrointestinal tract, nervous system, reproductive system, and cardiovascular system in addition to effects like anemia

and hypertension. Lead has also been linked to higher chances of stillbirth and miscarriage. Lead has also been demonstrated to interfere with several other biochemicals and enzymes, impairing their biological activity. Conversely, zinc is a crucial micronutrient that, insufficient in, can cause a variety of crippling illnesses in both plants and animals.

It is a crucial component for normal transcription and replication as well as brain, neurogenesis, and cognitive development. On the other hand, lead plays a significant part in the reduction of cognitive efficiency.

With a relatively low melting and boiling points of 420°C and 907°C, respectively, zinc is a silvery-bluish grey metal. Zinc is brittle at room temperature, but at 100C it becomes malleable and easily rolls. Usually found in brittle form, this metal becomes malleable when heated. After copper, steel, and aluminum, zinc is the fourth most used metal worldwide and the third most used non-ferrous metal. Phalerite, sometimes referred to as zinc blende, is the most prevalent zinc mineral. This mineral, which is present in practically all currently mined zinc deposits, crystallizes as pure zinc sulphide from the hydrothermal solution. Zinc is frequently mined alongside other metals such as lead, copper, and silver.

Zinc's toxic qualities that cause long-term industrial illnesses are usually refuted. Under names like "spelter chills," "zinc fever," "brass founders' ague," "smelter shakes," etc., an acute form of zinc poisoning is recognized. In his account of this acute zinc poisoning from 1888, Simon<sup>1</sup> notes that there were no long-term symptoms. According to Hayhurst<sup>2</sup>, "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 on, when talking about the potential long-term consequences of brass poisoning, this assertion is tempered<sup>2</sup>: Employers in Chicago explained that the high percentage of under-40 and over-50 foundry workers (85%) was caused by 'slowing down' or beginning decrepitude, while workers attributed

the high percentage to gradual incapacitation from inhaling brass fumes.

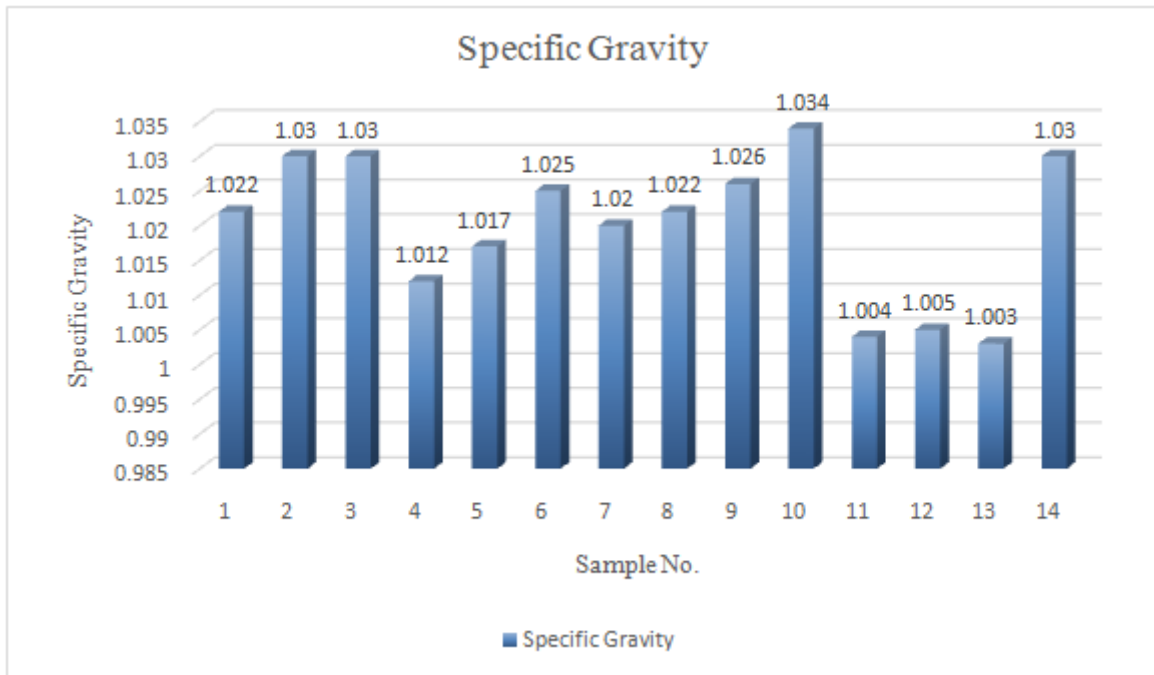
**Historical Account:** Zinc is used in many different products, including paints, plastics, rubber, dyes, corrosion-resistant coatings, dry-cell batteries, alloys, wood preservatives, and cosmetics. According to Modestra et al. (2017), the primary sources of man-made pollution are the industrial combustion of coal, waste incineration, metal production processes, and worn rubber tires on automobiles. According to studies, of the 162 wastewater treatment plants in the UK, 50% had effluent streams with zinc levels above the Environment Agency's recommended level (0.017 ppm or 0.26 mM). Local aquatic ecosystems may be greatly impacted by the release of wastewater containing zinc into the environment. Heavy metals have been extracted from wastewater streams using a variety of treatment techniques. Nevertheless, the majority of these techniques, like chemical precipitation and coagulation-flocculation, need the use of chemical reagents and are only effective when handling high concentrations of heavy metals (such as >1000 ppm). Other techniques, like membrane filtration and ion exchange, can remove heavy metal ions from wastewaters with specificity, but they require a lot of energy and money for upkeep (Dominguez-Benetton et al., 2018). Consequently, wastewaters with medium to low metal concentrations require treatment using an economical yet efficient method.

Zinc is essential for the synthesis of hormones and their receptors in humans (Chasapis et al., 2012; Roohani et al., 2013). According to reports, the human body contains a total of 2-3 gm of zinc, with the majority of that concentration found in the muscles and bones. The majority of zinc in the bloodstream is carried by red blood cell enzymes such as carbonic anhydrase and superoxide dismutase during bodily transportation (Vallee and Falchuk, 1993). Nonetheless, the majority of Zn that is transported is bound to albumin in plasma, where it is found at a concentration of roughly 12–16  $\mu\text{M}$  (Rink and Gabriel, 2000).

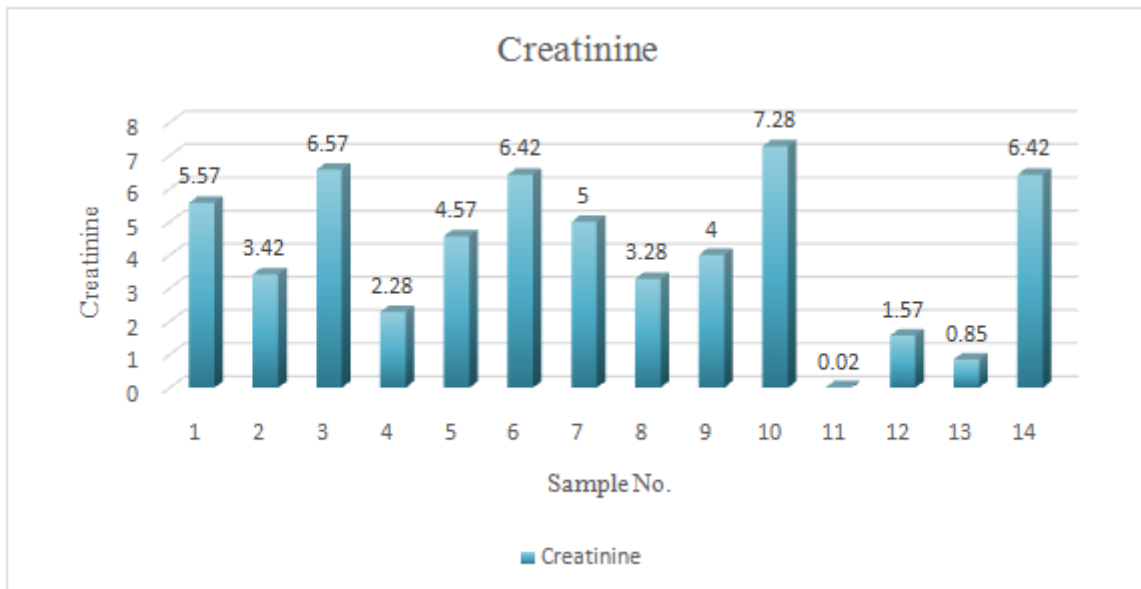
**A Case Study of Zinc Toxicity in Occupational Workers of Meerut (U.P.):** Many chemicals are typically present in the air at work, and when inhaled or absorbed by the body, they can be harmful to an employee's health. Evidence has mounted in recent years suggesting that interactions between air pollutants and living tissues may upset the body's equilibrium between pro- and anti-oxidants (Orisakwe et al. 2007). The current study's findings demonstrated that uric acid and creatinine levels are considerably raised by occupational zinc exposure. Although the body needs zinc as a cofactor for normal function, excessive zinc levels have the potential to be hazardous. Toxicological effects can result from three different forms of exposure: oral, dermal, and inhalation.

**Table1:** 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

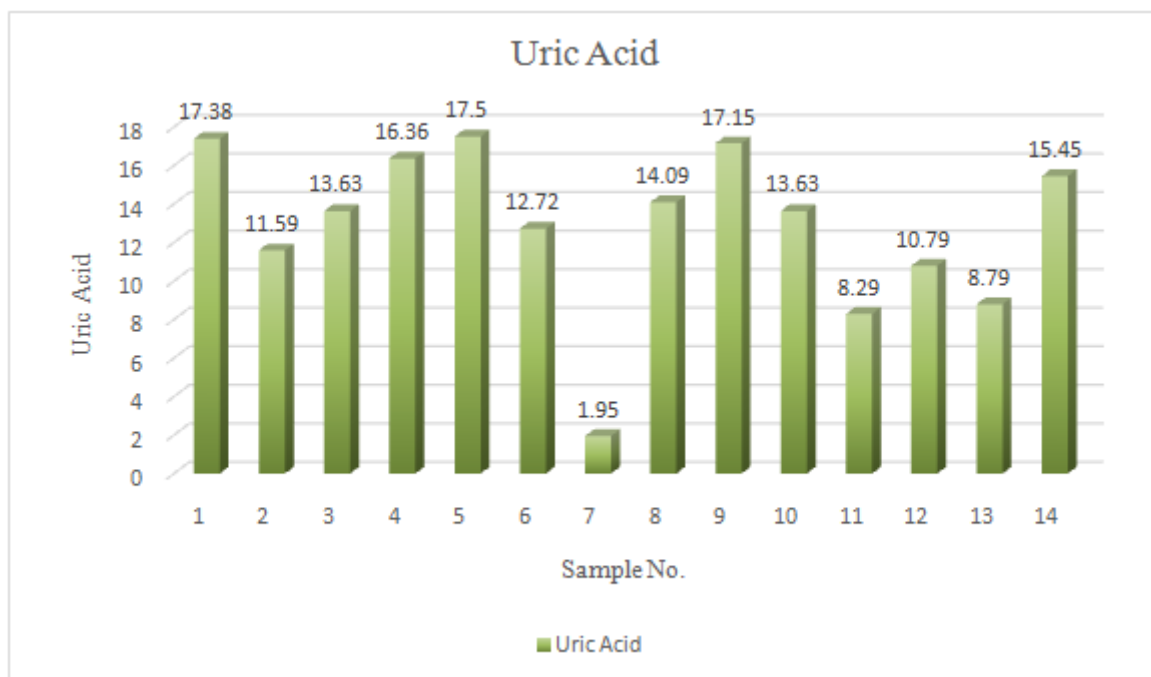


**Figure 1:** Showing value of Specific Gravity in Zinc Worker



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





**Figure 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, which is inflammation of the kidney structures that filter the blood, kidney stones 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 (Table: 1).

**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.

## II. IMPACT OF ZINC TOXICITY ON HUMAN HEALTH

The human body has effective systems for maintaining homeostasis over a wide range of exposures, both at the systemic and cellular levels. Zinc is an essential trace element. As a result, zinc has a relatively low toxicity and intoxication with zinc rarely has a serious negative effect on human health.

However, zinc affects survival at the cellular level and could play a key role in controlling both apoptosis and neuronal death after brain injury. Even though zinc supplements do not appear to have any effect on these effects, further research may be able to influence these processes by substances that change zinc homeostasis rather than by administering zinc directly. While severe zinc intoxication is only anecdotally reported, zinc deficiency is a widespread condition with potentially significant effects. In this case, applying "negative zinc," or substances or circumstances that cause the body to lose zinc, poses a serious risk to health. Impacts range from mild deficiencies in zinc, which can worsen infections by weakening the immune system, to severe deficiencies, which have clear symptoms and shorten life expectancy.

### III. 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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