

Zn



ZINC

A Sustainable Material
Essential for Modern Life



ZINC, WITH ITS KEY ATTRIBUTES OF ESSENTIALITY, DURABILITY, VERSATILITY AND RECYCLABILITY, IS WELL POSITIONED AS A MATERIAL OF CHOICE FOR A SUSTAINABLE SOCIETY.

ZINC - SUSTAINABLE & ESSENTIAL FOR MODERN LIFE

Zinc is a versatile element, essential to life and important in many industrial processes that often go unseen.

So what are the uses for zinc? Over 60% of the more than 14 million tons produced each year go to protecting steel from rust and corrosion through galvanizing. 17 percent of zinc’s annual production goes into die casting, and another 9 percent is used in brass. The rest goes to other manufacturing uses, such as zinc sheet in buildings and chemical compounds, such as zinc oxide, that are used in everything from fertilizers to sunscreens to solar cells.

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Zinc is Natural

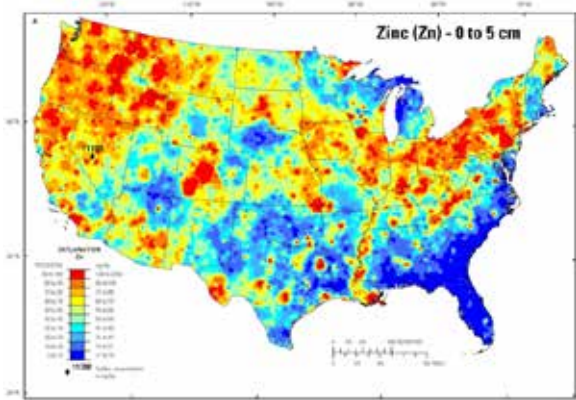
Zinc is a natural component of the earth’s crust and an integral part of our environment. Zinc is present in rock, soil, air, water and the biosphere.

Zinc is a natural part of the earth’s crust and moves constantly throughout the environment by a process called natural cycling. Rain, snow melt, ice, solar heat, and wind erode zinc from rocks and soil. Wind and water carry minute amounts of zinc to lakes, rivers and the sea, where it collects on organic material and eventually settles into the sediment. Other natural phenomena, such as volcanic eruptions, forest fires, dust storms and sea spray, contribute to the continuous cycling of zinc.

While the natural levels of zinc present in soils and water varies, the variable range is relatively consistent from place to place. For example, the natural amount of zinc in rivers has been measured from less than 5 to over 100 micrograms per liter. These ranges are consistent across different regions and have been comprehensively documented in Europe and North America (Alexander, 1997; Salminen, 2005).

The zinc contained in soils directly influences background concentrations found in rivers. Natural levels in soil can range from less than 10 to over 1000 milligrams per kilogram (Figure 1).

Figure 1. Zinc levels in the top five centimeters of soil across the United States.



Source: Smith DB et al. 2014. Geochemical and Mineralogical Maps for Soils of the Conterminous United States. Open-File Report 2014-1082. U.S. Geological Survey (<http://mrddata.usgs.gov/soilgeochemistry/#/detail/element/30>)

These variations are the result of many geological factors, including glacial activity, volcanic activity, and transport along river systems. Even falling leaves in autumn lead to seasonal zinc fluctuations in soil and water.

The zinc industry has supported numerous studies in aquatic, terrestrial and atmospheric systems to further the understanding of the natural variations of zinc in the environment. In practice, accounting for background concentrations of zinc in the environment provides context for biological acclimation and adaptation when conducting environmental assessments.

It is estimated that natural emissions, including the mobilization of zinc due to uptake by plants, collectively amounts to over 10 million metric tons of zinc each year. By comparison, annual anthropogenic emissions of zinc are estimated to be only 10% of that from natural sources (Klee, 2004; Meylan, 2016).

Zinc is Essential for the Environment

All life on earth has evolved in the presence of zinc. Due to its general availability and unique characteristics, zinc has become an essential component of many metabolic processes that sustain life for all organisms.

Zinc's Biological Role

Organisms take up the essential elements they need from their environment, directly from air, water, soil, or food. When their requirements are met, growth and development are optimized.

In all forms of life, zinc works at the cellular level by enhancing protein and enzyme function (Hambridge, 2007). Zinc serves many functions related to gene maintenance, immune function, eyesight, organ and tissue growth, and synaptic plasticity (learning), to name a few.

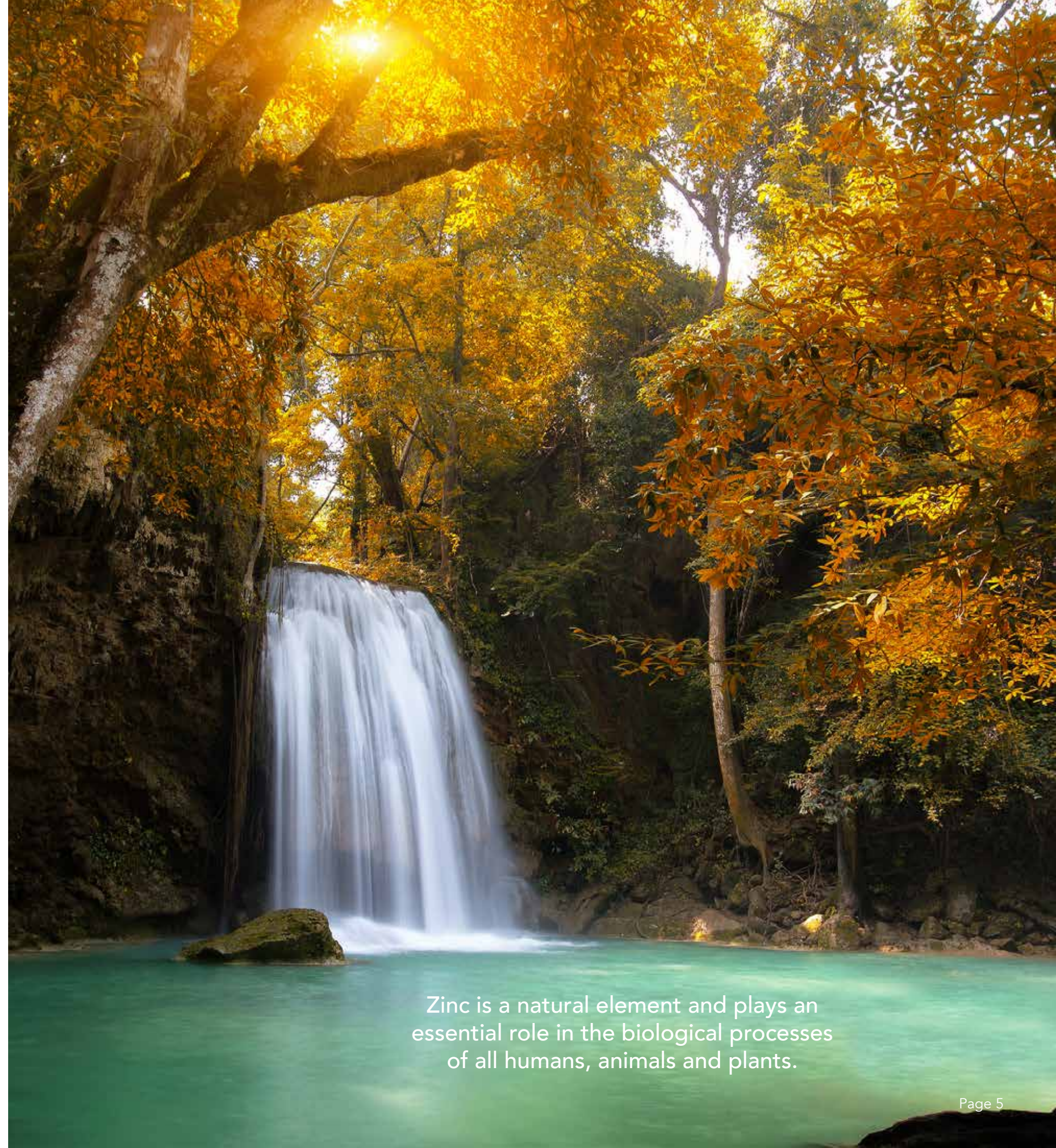
Given the number of biological processes involving zinc, the most important factor controlling uptake and assimilation from the environment is bioavailability. Bioavailability is the extent to which a substance can be absorbed and used by a living organism (via water, soil, or food). As a consequence, human beings, animals and plants have varying nutritional requirements and abilities to extract zinc from water, soil, and diet.

Zinc in the Environment

The environmental significance of zinc – and of all essential elements – cannot be assessed in the same way as synthetic chemicals. Because zinc occurs naturally, eliminating it from the environment is not possible. Moreover, because zinc is essential, achieving such a goal would lead to detrimental effects throughout an ecosystem (Janssen, 2000). In other words, “less” is not necessarily “better.” A comprehensive environmental assessment of zinc in Europe concluded that “the current uses of zinc and zinc compounds do not per se lead to the elevated regional levels found in surface water and sediment”(EU JRC, 2008).

The distribution, transport and effects (bioavailability) of zinc in water, sediment and soil depend largely on the site-specific chemical and physical characteristics of the environment and an organism's condition (i.e., age, size, prior history of exposure). For these reasons, environmental assessments of zinc must take all of these factors into account to be meaningful (USEPA, 2007).

The zinc industry is funding research to develop tools that help scientists predict zinc bioavailability in different environmental conditions and matrices.



Zinc is a natural element and plays an essential role in the biological processes of all humans, animals and plants.

Zinc deficiency in humans is a widespread and global issue with about one-third of the world's population not receiving sufficient zinc through their diets.



Zinc is Essential for Human Health

Zinc is an essential micronutrient for human health. It is vital for activating normal growth and neurological development in infants, children and teenagers. Zinc is found in all parts of the body. It is a component in more than 300 enzymes and influences hormones (McCall et al, 2000). Zinc also accelerates cell division and enhances the immune system. It is also vital in protecting the body from illnesses and fighting infections, and can reduce the duration and severity of a common cold or halt diarrhea (UN Food and Nutrition Bulletin, 2004).

More than two billion people worldwide are not getting enough zinc in their diets. Zinc deficiency is a major health problem in developing countries, especially among young children. Zinc deficiency weakens their immune system and leaves them vulnerable to conditions such as diarrhea, pneumonia and malaria. Over 800,000 people and 450,000 children are estimated to die each year indirectly from zinc deficiency (Black et al, 2008). Although diarrhea is preventable and treatable, in developing countries, less than 35% of children receive the recommended treatment of oral re-hydration salts and zinc supplements. In some countries such as India, this number is less than 1%. Due to the impact zinc can have in saving children's lives, the former UN Secretary General Ban Ki-Moon named zinc a "life-saving commodity" (UN Commission Report, 2012).

In 2008, the Copenhagen Consensus, a group of internationally acclaimed economists, including five Nobel Laureates, concluded that combating the world's malnutrition problem through the provision of vitamin A and zinc was ranked the highest among the various cost-effective solutions to the world's pressing problems.

In light of this global health issue, the zinc industry, through IZA, launched the Zinc Saves Kids initiative in support of UNICEF's global micronutrient supplementation program to address zinc deficiency for at-risk children. This initiative started in Nepal and Peru, where the programs' success in improving human health lead to the governments' adopting national programs to address zinc deficiency. Since then, IZA and the zinc industry have expanded efforts to save children's lives with zinc micronutrient programs in numerous other countries such as India, the DRC, Senegal, Laos and Mexico.

Zinc is Essential for Crops

Zinc deficiency takes an enormous toll on both humans and agricultural significantly increasing crop yield, boosting nutritional value in humans

Zinc is lacking in 50% of the world's soils and is recognized as the most common micronutrient deficiency in crops (FAO, 2006). Zinc deficiency in soils creates reductions in crop yield, crop quality and nutritional value.

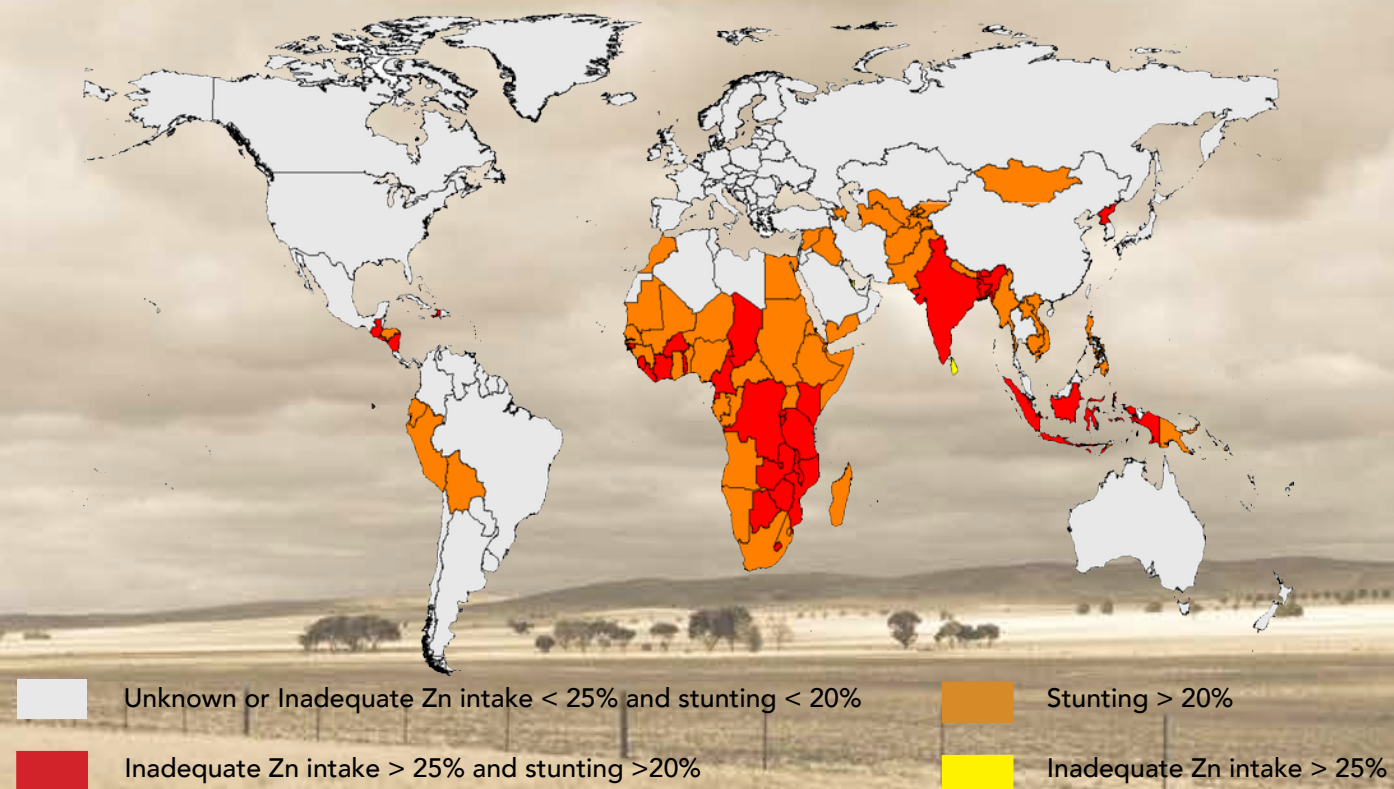
Recent advances in zinc nutrition, however, provide innovative and promising solutions to sustainably help eliminate zinc deficiency. When soils are deficient in zinc, the zinc grain concentrations of the crops grown in those soils are lower. People then eating these crops receive less zinc from their diets and are placed at high risk of zinc deficiency, which can lead to severe, life-threatening health consequences. The link between zinc-deficient soils and zinc deficiency in humans is especially prevalent in those developing nations that rely on cereal grains as their main source of calorie intake.

crop productivity. Adding zinc to soils is a sustainable approach to and improving farmer incomes.

The International Zinc Association's Zinc Nutrient Initiative addresses zinc deficiency in soils, crops and humans through the increased use of zinc-containing fertilizers. IZA first focused on China and India, the two largest countries with the highest zinc deficiencies. Since then, ZNI has expanded to work in Brazil, Bangladesh, Thailand, Malawi, Peru and the DRC. The efforts have been successful – and ongoing collaborations continue with governments, academia and the fertilizer industry to improve agronomic practices with zinc. In China alone, an additional 10 million farmers are now using zinc fertilizer, resulting in over 20 million tons of Zn-enriched grain improving nutrition for over 100 million people, including 35 million children.

Ensuring that crops receive an adequate supply of zinc is a simple, inexpensive and sustainable method of improving food and nutrition security, human health and increasing farmer incomes.

Figure 3. Estimated global prevalence of zinc deficiency. Results based on zinc availability in national food supplies and the prevalence of stunting. (<http://www.izincg.org/riskzincdeficiency/>)



THE FAO PROJECTS THAT THE GLOBAL POPULATION WILL INCREASE TO OVER 9 BILLION PEOPLE IN 2050. TO ENSURE THAT EACH PERSON HAS ENOUGH FOOD, THE WORLD MUST INCREASE ITS AGRICULTURAL OUTPUT BY 70%.

Zinc: Contributing to a Circular Economy

Unlike a traditional linear economy (extract, make, use, dispose), in a circular economy, each new object is designed for maximum longevity and future reuse and, at the end of its life, becomes a potential resource, rather than an item of waste for disposal.

Circular economy encompasses more than the production and consumption of goods and services; it aims to disconnect economic growth from the depletion of natural resources.

Given its many attributes, including being essential, versatile, durable, and infinitely recyclable, zinc contributes to a circular economy in numerous ways.

Efficient Zinc Recycling

- Zinc keeps its physical properties across its life cycle.
- 30% of zinc produced worldwide originates from recycled or secondary zinc.
- The level of zinc recycling increases each year.

Decreased Environmental Impacts

- Fuel savings due to enabling lightweight automobiles.
- Contribution to global CO₂ reduction due to keeping steel in service longer.

Costs Reduction

- The global cost of corrosion is \$2.5 trillion. By significantly increasing the service life of steel, zinc reduces these costs and protects valuable steel resources for future generations.

Sustainable Increased Service Life

- Zinc protects steel from corrosion in transportation and infrastructure.
- Zinc coatings extend the service life of solar and wind energy applications.
- The service life of many zinc products exceeds 50 years:
 - Zinc metal roofs and facades have a product life of 100 years or more.
 - Hot-dip galvanizing provides protection from 10 to 170 years.

Sustainable Improved Profitability

- In addition to improving nutritional value, zinc increases crop yields which improves farmer's income.

Abundant Natural Resources

- Zinc is the 24th most abundant natural element.
- Zinc is essential for all living organisms.

Sustainable Production

- IZA members have adopted a set of commitments to sustainability as set out in the Sustainability Charter.¹
- Increased energy efficiency of zinc production. Since 2005, zinc producers have achieved a 24% reduction in primary energy needs.



¹ <http://www.zinc.org/sustainability>

Zinc is Durable

One of zinc's most exceptional qualities is its ability to protect steel from corrosion. When left unprotected, in almost any environment, steel will corrode. Zinc coatings protect steel by providing a physical barrier as well as cathodic protection for the underlying steel, allowing its service life to be significantly extended.

Damage caused by corrosion results in expensive and time consuming repairs and is estimated to cost at least four percent of a country's gross domestic product (GDP). By protecting steel from corrosion, zinc performs an invaluable service. It helps to save natural resources by significantly prolonging the life of steel and capital investments. The long-term durability provided by zinc coatings is achieved at relatively low environmental burden in terms of energy and other globally relevant impacts, especially when compared to the energy value of the steel it is protecting.

General galvanized steel ensures the long-term protection of a wide variety of steel components and structures used in construction, infrastructure and other sectors. Zinc sheet and zinc-coated steel sheet are excellent and extremely durable materials for roofing, cladding, window frames, rain-water collection systems, heating/cooling equipment and counter tops. Brass and zinc die castings are used extensively in plumbing, builder's hardware and many other applications. Zinc is equally at home in old and historic buildings as well as in new, modern architecture. Zinc building components are weatherproof, corrosion resistant and immune to the harmful effects of UV rays, ensuring a very long service life without degradation.

In addition to durability, zinc coated steel framing is fire and pest resistant and can bear higher loads than traditional framing materials. This imparts a high degree of design flexibility but also saves considerably on material usage.

When a building reaches the end of its life, its zinc-containing products can be fully recycled, and in some cases directly re-used to extend their functional service e.g., lighting, hardware, etc. More than 95% of the zinc products used in buildings are collected at end-of-life. This collected zinc is recycled without loss of quality. Because metallic bonds are restored upon re-solidification, metals continually recover their original performance properties, even after multiple recycling loops. This allows them to be used again and again, in many cases for the same application. By contrast, the performance characteristics of most non-metallic materials degrade after recycling.



Mobility:

Zinc coatings play a key role in public transportation and infrastructure by extending the life of steel used in bridge rails and support beams, railway tracks and public transportation hubs and terminals. Zinc also extends the life of, and time between maintenance of concrete bridges, parking garages and piers by protecting the steel reinforcing bar contained within from early failure by corrosion.

Zinc also protects the lighter and stronger next generation steels that enable vehicle designs with greater fuel efficiency and lower emissions. Through its Galvanized Autobody Partnership (GAP), IZA is working with the global steel industry and auto manufacturers on next generation steels to enable automakers to produce steel-based vehicles that meet targets of increasing the corporate average fuel economy (CAFE) and reducing CO₂ emissions.

Zinc Supports Sustainable Energy

The 24% reduction in Primary Energy Demand realized in the 2014 LCA for primary zinc was accompanied by a 34% increase in the use of renewable energy resources (hydro, wind and solar).

Galvanizing has long protected steel transmission towers which form the backbone for much of the world's electricity grids. However, sustainability considerations are also bringing significant changes to the energy sector. A growing portion of energy now comes from renewable and alternative fuels where time in service is a critical factor in their economic viability.

Zinc coatings such as galvanizing, thermal spray and zinc-rich paints, significantly extend the service life of wind turbines and also greatly reduce costly maintenance and downtime caused by corrosion, especially in hostile near-shore and off-shore environments.

Zinc also plays a critical role in solar energy. Galvanized steel is utilized in the structures that support and align solar panels, while zinc is also a component of the solar cells themselves. Researchers using thin layers of zinc oxide have recently fabricated the highest efficiency small gallium-arsenide solar cells ever created.

Increased use of fuel cells would also result in increased demand for metal catalysts such as zinc and platinum. With regard to fuel cells, zinc's very high energy potential has made it

a leading candidate in a range of fuel cell and battery designs under development for grid storage and micro-grid generation.

Helping Renewable Power Become 24-Hour Power

Zinc-based energy storage systems have tremendous advantages including high specific energy, recyclability, safety, low cost and zero emissions. As a result, zinc is used in the manufacture of a variety of battery chemistries, both primary and rechargeable, consumer and industrial. The most familiar of these chemistries are the primary zinc-carbon and alkaline batteries.

Zinc-air and zinc-silver "button cell" batteries are widely used in the electronics industry to power items such as hearing aids, wrist watches and calculators. Industrial zinc-silver, nickel-zinc and zinc-air batteries are of critical importance in a variety of marine, aeronautic and military applications. Nickel-zinc batteries have been developed for motive power applications, while stationary zinc-air and zinc bromide are being studied for Remote Area Power Supply (RAPS) installations.

Zinc is Recyclable

Zinc's unique metallurgical and chemical properties have made it the material of choice for an extensive range of applications in modern society. At the end of useful life, the zinc recovered from these products can be recycled without loss of physical properties.

Approximately 70% of the zinc produced worldwide originates from mined ores and the remaining 30% from recycled or secondary zinc. This mature recycling infrastructure results in reduced energy use, reduced emissions, and minimized waste disposal.

A systematic life cycle for zinc is illustrated in Figure 3. Zinc is recycled at all stages of production and use, and all types of zinc-containing products are recyclable. New scrap – zinc containing waste generated during manufacturing – becomes immediately available for recycling. Old scrap in the form of recycled galvanized steel and zinc alloys also provides an important new source of raw material.

The presence of a zinc coating on steel or in alloys does not affect their recyclability. The recycling of zinc-rich dusts from steel recycling has been boosted both by technology breakthroughs and their economic value, leading to higher recycling rates and less waste. The recycling loop is endless; zinc can be recycled again and again without loss of physical or chemical properties.

For zinc and other highly durable products, the End of Life (EoL) recycling rate is the preferred measure as it offers a more comprehensive approach by incorporating recycling efficiency, product lifetimes and historical production patterns. The EoL recycling rate quantifies the amount of zinc actually recovered at the end of product life (old scrap) and recycled into new zinc metal.

Globally, approximately 45% of available zinc at the end of life is recovered and recycled. For developed regions like Europe and North America the EoL recycling rates are significantly higher. In some cases this rate can exceed 95% for products such as zinc sheet roofing and brass.

Figure 3. Zinc recycling circuit



The zinc industry continues to advance technologies for recovering zinc from products at end of life. For example, the global capacity to recover zinc from galvanized steel scrap (electric arc furnace) is continually growing. The International Zinc Association, in collaboration with Yale University, has developed models to quantify zinc recycling rates to demonstrate the recyclability of products and effectiveness of recycling programs.

Zinc is a Sustainable Resource

The world is naturally abundant in zinc. There is an estimated 2.8 billion metric tons of zinc contained in the earth's crust in a form and amount that economic extraction is currently or potentially feasible (Resources in Figure 4; Erickson, 1973). Not all of this zinc, however, is immediately available for extraction. The interaction of economic, political, and environmental considerations dictate whether a particular ore body will be developed. The most recent estimate of Reserve Base (meets specified minimum physical criteria related to current mining and production practices) was made in 2009 and calculated to be roughly 480 million tonnes (USGS, 2009). Zinc Reserves, reported at 250 million tonnes (USGS, 2011), are geologically identified ore bodies whose suitability for recovery is economically based (location, grade, quality, and quantity).

Since exploration and mine development is an ongoing process, the amount of zinc reserves is not a fixed number and sustainability of zinc ore supplies cannot be judged by simply extrapolating the combined mine life of today's zinc mines. This concept is well supported by data from the United States Geological Survey, which illustrates that although refined zinc production increased by 80% between 1990 and 2010, the life-time reserves for zinc has remained unchanged.

Available zinc resources also include in-use stocks or secondary (recycled) sources of zinc. Due to zinc's unique metallurgical properties and long lifetime in product applications, the stock of material currently in use, about 300 million tonnes, is larger than that considered as reserves (Gerst, 2008). As zinc-bearing products come to the end of their useful life (old scrap), they are collected, processed, and recycled into new products. In 2010, nearly 4 million tonnes of zinc was recovered and returned to use through mature recycling networks. Additionally, the amount of zinc that is still in-use represents approximately 60% of the total amount of zinc extracted and refined throughout history.

The zinc industry is also investing in new technologies to increase the efficiency of extraction and processing. Recycling of zinc products by the industry also provides an opportunity to conserve natural zinc reserves.

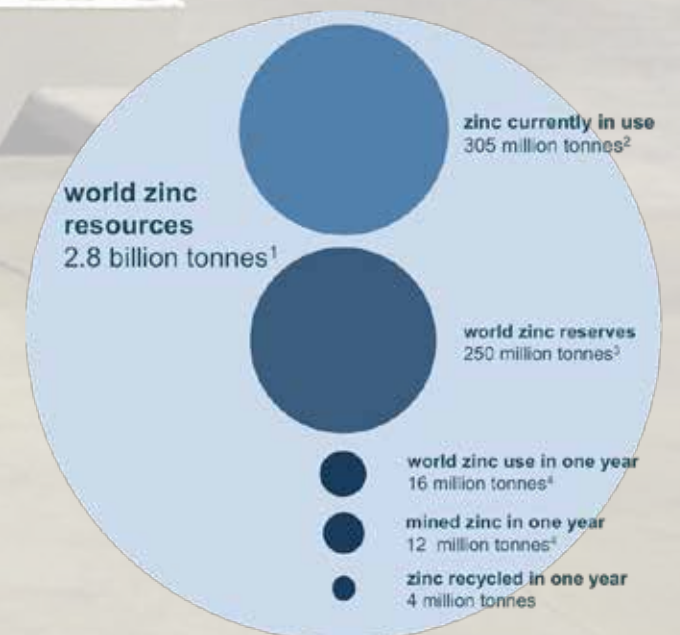


Figure 4. Global estimates of zinc resources, reserves, production, and use in 2010 (drawn to scale).

Sources: 1) Erickson, 1973 2) Gerst & Graedel, 2008 3) USGS, 2011 4) International Lead Zinc Study Group, 2015

Zinc Industry and Sustainable Development

Assessing the sustainability of zinc and zinc products through the development of sound scientific information.

The concept of Sustainable Development encompasses the need for a careful balance of social, economic and environmental aspects considering both present and future needs. Recognizing this, the zinc industry has engaged in a long-running and growing Sustainable Development program which has had many key activities and achievements.

IZA Sustainability Charter

Members of IZA produce, distribute, use and recycle zinc to satisfy human needs for shelter, transportation, infrastructure, consumer products and food production. Zinc is a sustainable material that is necessary for modern society and is essential to human, animal and crop health and well-being. The International Zinc Association works to enhance zinc's contribution to society and to ensure that its production and use are in harmony with the natural environment and the present and future needs of society. In order to contribute to the betterment of society and build value for shareholders, IZA members adopted a set of commitments to sustainability as set out in the Sustainability Charter (www.zinc.org/sustainability).

Guiding Principles

IZA developed a set of eleven Guiding Principles that provide guidance and resources for our members on several key issues including; Community Consultation, Employee Health and Safety, Product Stewardship, Business Ethics, Children's Rights in the Workplace, Sustainability Reporting, Mine Closure, Environmental Management, Managing Minor Elements, Climate Change and Mine Tailings and Residue Management.

Life Cycle Assessment

Increasingly the zinc industry is being asked to provide information to downstream users of zinc and zinc containing products on the environmental footprint of the materials it produces. Understanding the environmental footprint of zinc starts with documenting the resource requirements (energy and non-energy) and environmental releases associated with upstream operations i.e., mining and refining; but it also involves understanding the impacts and benefits of using zinc during other stages in the product life cycle. These benefits can arise in use e.g., extending the life of galvanized steel products, and through end-of-life recycling e.g., by utilizing recycled zinc to create new products.

Data for the most recent Life Cycle Assessment (LCA) for primary zinc production was provided by IZA members. Participants represented mining and smelting operations in Asia, Australia, Europe, North America, Africa, and South America. The study represented 4.9 million tonnes of zinc concentrate production and 3.4 million tonnes of Special High-Grade Zinc production.

Relative to the previous LCA for primary zinc, primary energy demand and emissions to air decreased by 15% or more. The 24% reduction in primary energy demand was accompanied by a 34% increase in the use of renewable energy resources (hydro, wind, solar). Similarly, all LCA indicators, except for a relatively stable result for Eutrophication Potential, also decreased by up to 26%. In particular, Global Warming Potential decreased by 15%. These results show that the zinc industry is making progressive improvements to production technologies that benefit both downstream users and global sustainability goals as a whole.

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