Presidential address: Zinc—man's best friend?

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Synopsis

The metal zinc has been around since only about 1400 AD. This may sound like a long time, but when compared to fellow base metals copper and lead, which were discovered in 5000 and 4000 BC respectively, it is evident that zinc is a fairly new kid on the block. This may also be the reason why many new facts and benefits of zinc are still being discovered. For instance, it has been discovered only in the last few decades that virtually no life on earth is possible without zinc.

In this address it will be shown that zinc is not only very useful to mankind, but is in fact vitally important for all forms of life. It will be shown that zinc is natural, zinc is essential for life, zinc protects, zinc contributes to the well-being of society and that zinc is fully recyclable.

It is therefore hoped, that by the end of this address, zinc will no longer be viewed only as the metal that is responsible for the nice colour of roofing sheets and steel buckets, but may indeed be man's best friend.

Introduction

Zinc has been around, commercially for only about 600 years. I say 'only' because it is a relatively unknown metal when compared with iron, copper, etc. Zinc was officially recognized as metal for the first time in India in 1374, and in Europe in 1546[1]. If one compares that with copper and lead, which were smelted from their ores already by 5000 BC and 4000 BC respectively[2], it is clear that zinc is the 'new kid on the block'. It is therefore quite understandable that its usefulness to man is still increasing daily. In fact, a number of important discoveries about its positive impact on human health have been made only in the last decade or so.

Many people, for instance, think that the only application of zinc is for corrugated iron (galvanized steel) roofing sheets. On the contrary, virtually no life on earth is possible without zinc.

In this paper I want to give a bit more insight into zinc and hope that the reader will be much better informed about its uses, applications and benefits. I am pretty sure most readers, after reading this paper, may be tempted to agree that zinc may actually be man's best friend—rather than our furry friend the canine.

In the following paragraphs I will show that zinc is natural, zinc is essential for all forms of life, zinc protects, zinc is fully recyclable and zinc contributes significantly to the well-being of society. However, before discussing these unique characteristics of zinc, I shall first give a brief overview of the metal zinc and the zinc industry.

Zinc metal

Zinc exists naturally in air, soil and water and is the 27th most common element in the earth's crust. It is constantly mobilized and transported by rain, erosion, wind, etc. to collect again in a different location as sediment, or is transported further[1]. The table below gives the most important physical data of zinc.

Table I

Basic physical and chemical data of zinc[3]

Chemical symbol	Zn
Atomic number	30
Atomic weight	65.37
Density (25°C) (g/cm^3)	7.14
Melting point (°C)	419.6
Boiling point (°C)	907
Crystal structure (20°C)	Hexagonal close packed

It is clear from Table I that zinc has a high density and low melting point, both of which contribute to many of its useful applications.

The main mineral from which zinc is recovered, is zinc sulphide (zinc blende), which is associated with iron, lead, copper and cadmium sulphide. Zinc also occurs naturally as oxides, silicates and carbonates.

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Photo 1—Two-ton jumbos stacked at Zincor, Kumba Resources Ltd, in Springs, South Africa

Zinc sulphides are normally concentrated by means of flotation at the mine site in a primary concentrator. The zinc sulphide concentrate (± 45–62% Zn) is further beneficiated at a zinc refinery where a reliable supply of electricity at low cost is required. More than 80% of the world's zinc is produced by the roast-leach-electrowin process route[4] (See Figure 1). Through this route, the zinc sulphide is roasted to zinc oxide in fluidized bed reactors at about 900°C to 950°C, yielding sulphide sulphurs of less than 0.7%.

The zinc oxide (calcine) is subsequently leached under acidic conditions (sulphuric acid), purified to remove impurities such as Cu, Cd, Fe, Co, and then the zinc is electrowon (electro deposited onto aluminium cathodes from the electrolyte). The key to producing high purity zinc is the purification step where impurities are removed to the parts per million levels. Because zinc is the most electronegative metal capable of being electrodeposited from an aqueous solution, basically any other depositable metal will be co-deposited with zinc. Production of zinc by this method was established in 1916[2] and almost immediately thereafter it was possible to produce 99.99% pure metal. Electrowon zinc is melted down in induction furnaces and cast into ingots (± 25 kg) or jumbos (1–2 tons). See Photo 1. Different qualities are produced, with the purest grade being special high grade (SHG) at 99.995% Zn. For galvanizing purposes, various zinc-aluminium alloys are produced.

Industry overview

Uses of zinc

The downstream usage of zinc can be divided into two major segments, namely, 'first-use' and 'end-use'. The 'first-use' zinc is mainly for galvanizing and alloys whereas the major 'end-use' is for the construction and transport sectors of the global economy. Figure 2 shows the global uses in 2003.

Figure 3 shows the average growth in zinc consumption since 1960 of about 2% per year. It also follows that supply and demand are fairly closely matched. As with many commodities, most of the recent growth was generated in China. Figure 4 shows how consumption has taken off in China since 1981.

If one studies the graph of zinc consumption per capita (Figure 5) and interprets it in terms of Figure 4, it is clear that as the demand for cars, white goods, etc. increases in China, the demand for zinc will increase even more. This trend is already manifested in the fact that China became a nett importer of zinc for the first time in 2004.

Figures 6 and 7 show the zinc mine production in the world (2002), as well as the metal production by region (2002).

It follows from Figures 6 and 7 that Europe produces a significant quantity of global zinc metal, but a fairly small quantity of zinc in concentrates. The Americas, on the other hand, export large quantities of ore—primarily from Canada and South America. Australia, part of Asia/Pacific, is a primary producer of zinc metal, but it also exports large quantities of concentrates worldwide.

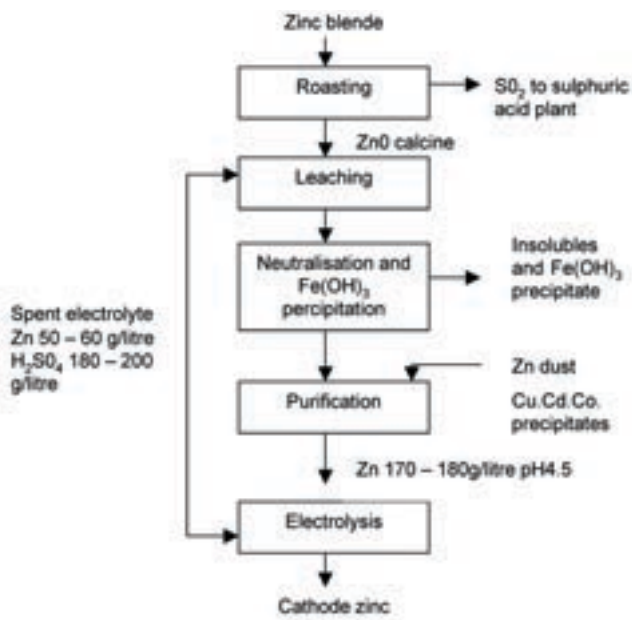
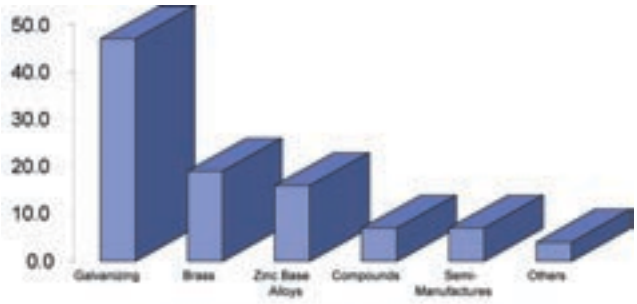
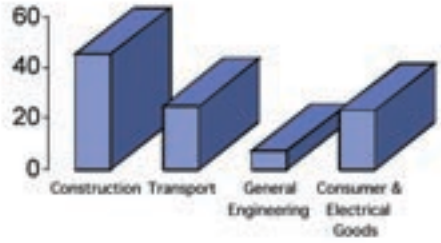


Figure 1—Basic flow sheet of electrolytic processing of zinc[5]



2003 Zinc consumption: first-use (%)



2003 Zinc consumption: end-use (%)

Figure 2—Zinc 'first-use' and 'end-use' in 2003[6]

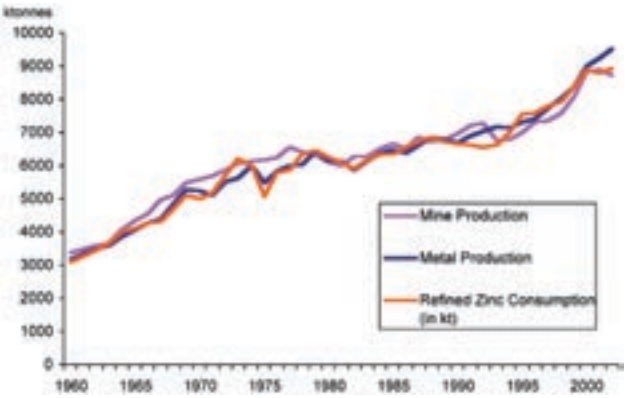


Figure 3—Growth in world production and consumption of zinc since 1960[6]

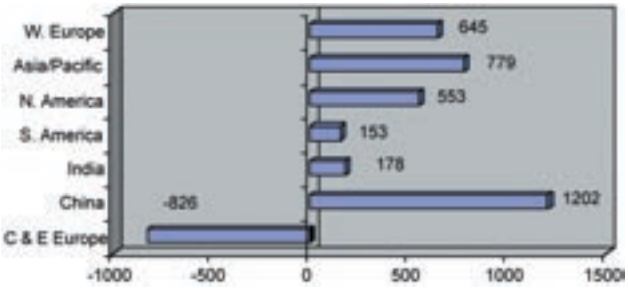


Figure 4—Changes in regional zinc demand in thousand metric tons[6]

The most important conclusion from this short overview of the zinc industry is that the demand for zinc is healthy and continued growth is expected. The next paragraphs will focus on the various benefits of zinc and indicate why demand is strong and should remain strong.

Zinc and health

Zinc deficiency

It was discovered less than 100 years ago that zinc is essential for the growth of plants and animals, and only as recently as the 1960s was clear evidence found that zinc is in fact essential for human life[7]. Since then many studies confirmed the necessity of sufficient zinc intake, especially by children. It was, for instance, found that a zinc deficiency

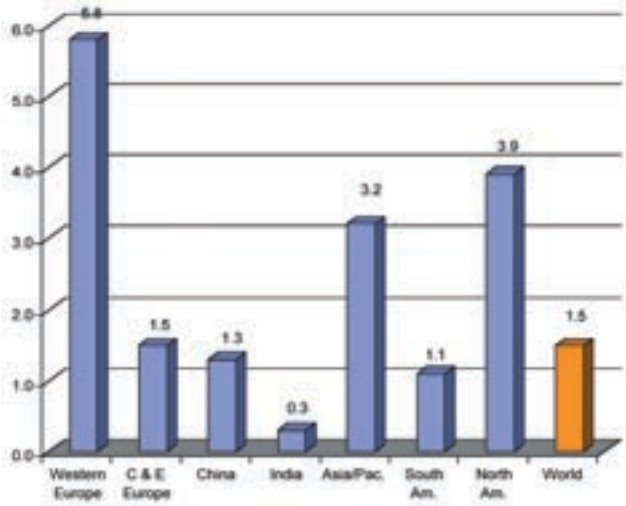


Figure 5—Annual consumption (kg) of zinc per capita in 2000 over a three-year period[6]

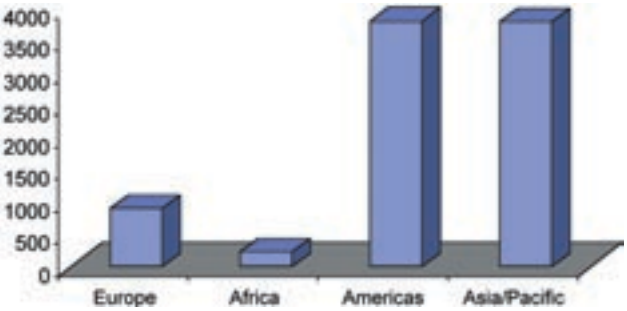


Figure 6—World zinc mines production (thousand tons) per region in 2002[6]

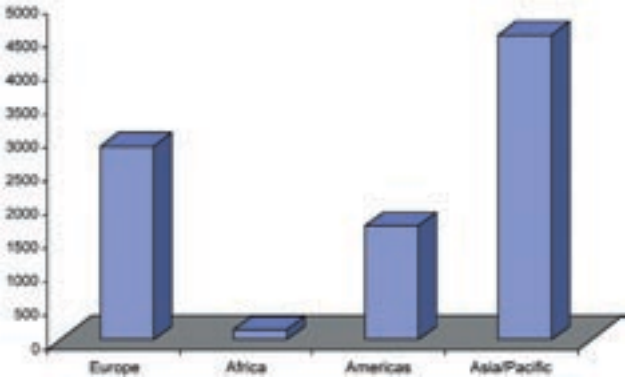


Figure 7—World primary zinc metal production (thousand tons) by region[6]

in children can cause dwarfism and delayed sexual maturity[7]. It was also shown that zinc supplementation reduces the prevalence of common childhood infections such as pneumonia[7].

In a recent report—'Assessment of the risk of zinc deficiency in populations and options for its control'—by the IZiNCG (International Zinc Nutrition Consultative Group), it was found that one-third of pre-school children in low-income countries have stunted growth. Much of this growth failure is ascribed directly to a zinc deficiency[7].

Zinc deficiency is now recognized as one of the leading causes of illness and disease in low-income countries. In fact, it is ranked fifth among the ten leading risk factors in developing countries. (See Table II.)

Quite significant is the fact that it rates above risks such as tobacco, iron deficiency and blood pressure. Even on a global scale it is rated no. 11 out of 20 leading risk factors[7].

Most of the countries with high risk for zinc deficiency are in Africa[7]. Although there is no simple quantitative biomarker of zinc status that can be used to quickly identify zinc deficiency in individuals, experts do believe that zinc deficiency is very common in most low-income countries. Various options are available to combat zinc deficiency on a national scale, e.g. changing poor dietary habits, supplements and fortification of common foods.

By providing foods rich in zinc, the risk of zinc deficiency can be addressed effectively. Foods rich in zinc include meat, fish, eggs and dairy products. Nuts, seeds, legumes, cereals, fruits and vegetables are also relatively high in zinc. (Table III).

Numerous studies have shown that zinc supplementation causes dramatic improvements in the quality of health. For example, in studies of lower respiratory infections conducted in India, Jamaica, Peru and Vietnam, it was shown that the incidence of pneumonia in children decreased by 41%[7]. In India it was found that daily zinc supplements in infants born with low birth weights, reduced mortality by 68%[7]. The amount of zinc required by a child of 4 to 8 years old weighing approximately 21 kg, is only 4 mg/day or approximately 75g of meat per day.

Supplements such as zinc acetate, zinc sulphide and zinc gluconate are available at low cost and can easily be taken daily—either as tablets, syrup, etc. or dry micronutrients that are added to the food at the time of serving.

Fortification—adding nutrients to commonly eaten foods—has played a major role in eliminating micronutrient deficiencies in industrialized countries. Foods that are often fortified are infant formulas, instant breakfast cereals and wheat/corn flours used for bread. Fortification programmes are highly effective from both a medical and cost point of view. For example, the cost of zinc fortification is just $1.03/ton of fortified flour if performed as part of an iron fortification programme[7].

The reason why zinc deficiency has such a major impact on human health is probably because zinc is the most ubiquitous of all trace elements involved in the metabolism of human beings[7]. It participates in all major biochemical processes and plays a major role in cellular division. This is probably because zinc easily participates in exchangeable ligand binding with organic molecules[8]. More than 300 enzymes require zinc to assist in their catalytic functions.

Clearly, a few milligrams per day of zinc can make the difference for millions of people between health and illness.

Table II

Leading 10 risk factors in developing countries as percentage causes of disease burden (measured in disability adjusted life years)[7]

Underweight	14.9%
Unsafe sex	10.2%
Unsafe water	5.5%
Indoor smoke	3.7%
Zinc deficiency	3.2%
Iron deficiency	3.1%
Vitamin A deficiency	3.0%
Blood pressure	2.5%
Tobacco	2.0%
Cholestrol	1.9%

Table III

Zinc content (mg/kg) of various food groups[7]

Bread	9.8	Green vegetables	3.9
Cereals	9.9	Potatoes	3.3
Meat	52	Other vegetables	2.4
Offal	52	Canned vegetables	4.2
Meat products	25	Fresh fruit	0.85
Poultry	15	Fruit products	0.63
Fish	8.0	Beverages	0.14
Oils & fats	0.5	Milk	3.9
Eggs	13	Milk products	12
Sugars & preserves	5.5	Nuts	30

Zinc for enhanced performance in sports

Apart from the minimum zinc requirements from a health point of view, it was shown that zinc can also enhance physical performance in sportspersons where prolonged deficiency is clearly not the issue.

Many athletes use zinc supplements to boost their immune systems and to speed up recovery between workouts. The 'enhanced' performance can probably also be related to addressing zinc deficiency, but on a short-term basis. Exercising increases zinc losses from the body and can, in severe cases, compromise muscle function. In these cases, zinc supplements may also prove to be very important[9]. In a study where 16 female athletes' muscle strength and endurance were studied, it was found that the athletes supplemented with 135 mg zinc per day for 14 days had significantly higher isokinetic strength[10]. A crossover experiment on the same group confirmed this.

A similar study on male athletes found that 20 mg per day of zinc improved the flexibility of red blood cells during exercise, which could improve blood flow to muscles[11].

Clearly, zinc also has a major role to play in the enhancement of the performance of sportsmen and women.

Zinc in animal health

Due to the importance of zinc for humans, it would be logical to assume that zinc would play just as important a role in animals. This assumption was evaluated and found indeed to be the case. The quotes below, taken from articles on animal health and nutrition, confirm this:

> 'Zinc is essential to all animals and plays significant roles in the metabolic activity of the grazing ruminant.'[12]

'Early effects of Zn deficiency include reduced feed intake, reduced growth rate and feed efficiency followed by skin disorders.'[12]
'Zinc deficiencies in the animal have resulted in a decreased ability by the animal to produce these various immune system components.'[13]

Clearly zinc is also a very important micronutrient for animals. Furthermore, as is the case for humans, supplementation is also a common and effective way to address zinc deficiency in animals.

Conclusions on zinc and health

Following from the short discussions above, it is quite evident that zinc is essential for human and animal health. It is also clear that zinc deficiency in humans is a serious global problem. Children need it to grow and adults need it to remain healthy. The main ways in which zinc contributes to good health are by[14]

Maintaining the senses of sight, smell and taste
Boosting the immune system and accelerating healing
Protecting the prostate
Protecting against cancer
Decreasing cholesterol deposits
Promoting hair and skin health
Ensuring proper cell maintenance
Preserving mental faculties in the elderly.

Below is the recommended daily zinc intake in milligrams/day[1].

Children (1–10 years)	10
Men (11–51+)	15
Women (11–51+)	12
Lactating women	19

Crop nutrition

Closely linked to the effects of zinc as a micronutrient for human and animal life, is its impact on plants and crops.

Zinc is essential for the normal healthy growth and reproduction of plants[15]. It plays a vital role as a structural constituent and as a regulatory co-factor in many biochemical processes[15]:

Carbohydrate metabolism (in photosynthesis and conversion of sugars to starch)
Metabolism of protein
Auxin (a growth regulator) metabolism
Formation of pollen
Membrane maintenance
Infection resistance.

The importance of zinc in plants was first identified in 1869 by Raulin when it was found that the common bread mould could not grow in the absence of zinc[15]. However, it was only in 1932 that zinc deficiency in crops was identified—in Californian apple orchards and South Australian citrus trees[15].

Zinc deficiencies in plants result in visible symptoms of stress such as yellowing of leaves, bronzing of chlorotic leaves, abnormally shaped leaves, etc. (See Photo's 2 and 3). Even a marginal deficiency can often result in greatly reduced (up to 40%) crop yields[15]. This will obviously have a major impact on the farmer due to a resultant loss of income. In developing countries this may even lead to a shortfall in food production.

There are numerous reasons why crops can be zinc deficient[16]:

Low zinc content in soil
Restricted access in soil for roots, e.g. compacted zones
Soils with high pH values (pH>7.4). In these soils (normally calcareous) the solubility of zinc is low. Although there may be high levels of zinc, its availability, to be absorbed by the plants, is low
Soils that are low in organic matter. These soils are normally unable to retain zinc
Soils with microbially inactive zinc. In these soils, it was found that zinc-sensitive crops, when planted after a crop such as sugar beet, experience a reduction in the availability of zinc
Low soil temperatures. Poorly developed root systems could result in insufficient zinc uptake when the soil temperatures are low e.g. in early spring
Differences in plant species and varieties. It was found that plants differ markedly in their tolerance of zinc deficiency

Photo 2—A zinc deficient citrus tree[15]

Photo 3—Chlorotic leaves of citrus trees with a zinc deficiency[15]

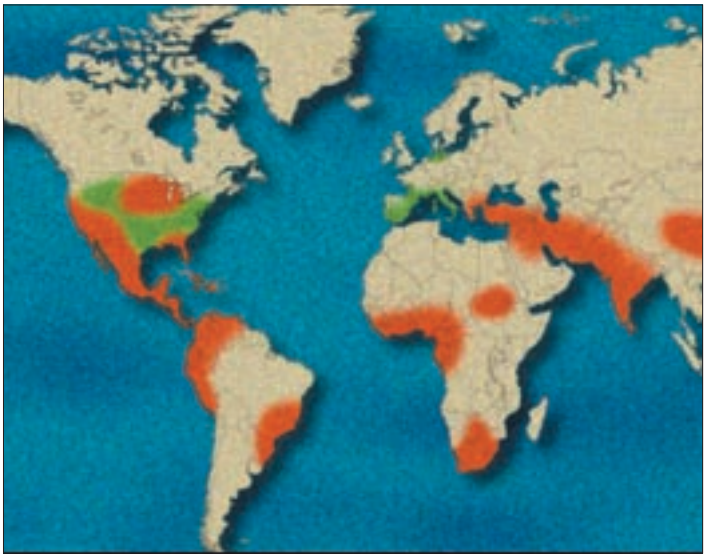


Figure 8—General distribution of zinc deficient soils in the world (Orange: wide spread deficiency; Green: medium deficiency)[15]

High availability of phosphorus. It is believed that an excess of phosphorus can interfere with the metabolic functions of zinc

Nitrogen seems to have a dual impact. After nitrogen-containing fertilizer additions, zinc can be retained in the root as a zinc-nitrogen complex limiting growth. Alternatively, acidic nitrogen-containing fertilizers can lower the soil pH and thereby increase zinc availability.

From the above, it follows that at least six of the nine reasons for zinc deficiency are directly related to the soil. These conditions can normally be easily rectified with the correct application of fertilizers.

Four types of compounds are used as zinc fertilizers:[15]

Inorganic compounds, e.g. zinc oxide, zinc carbonate, zinc nitrate and zinc sulphate

Synthetic chelates, e.g. Zn-EDTA (Na_2Zn—ethylene-diamine tetra acetic acid)

Natural organic complexes

Inorganic complexes, e.g. ammoniated zinc sulphate solution.

Of these different compounds, zinc sulphate is the most commonly used source. In South Africa it is also widely used and, as shown in Figure 8, South Africa is an area with a high risk of zinc deficiency in crops.

From the above discussion it follows that zinc is a very important micronutrient in plants. Its main function is to promote the growth and yield of crops. Fortunately a zinc-deficient situation can easily be rectified by the addition of fertilizers.

Zinc protects

Probably the feature for which zinc is best known, is to protect steel surfaces. Through a process known as galvanizing, steel is coated with a thin layer of zinc.

Photo 4—The structure of the jig plant of the Leeuwpan coal mine of Kumba Resources Limited in Mpumalanga, South Africa

The first person to report this process was the French chemist, P.J. Malouin who reported about dipping iron sheets in molten zinc to the Académie Royale in 1742.[2] The process was quickly exploited commercially and by 1778 zinc-coated utensils were well known in parts of France.[2] The name 'galvanizing' was established in 1837 when a patent by Sorel referred to the coating of steel by dipping it in molten zinc as 'galvanizing'. The word 'galvanizing' was derived from the name of Luigi Galvani, the Italian physiologist who made the classic observation that the legs of dead frogs suspended on copper wires twitched when they touched iron.[2]

Galvanizing steel by dipping it into molten zinc was gradually extended to semi-fabricated products. Today there are basically four main areas of galvanizing:[2]

Sheet galvanizing: this is normally performed in a continuous fashion by steelmakers
Wire galvanizing: this is also effected through a continuous process by wire fabricators
Tube galvanizing: this segment has developed into a separate industry since the 1860s
General galvanizing: although water tanks, buckets, etc. are still galvanized, this sector of the industry focuses mostly on galvanizing structural steel. Photo 4 shows an industrial structure erected with hot dip galvanized steel in 2005.

Apart from galvanizing, numerous other zinc-coating processes have been developed and are used commercially. They are electroplating, mechanical coating, adhesive bonding of zinc foil, sherardizing (diffusion of zinc between the component and zinc dust), zinc spraying and zinc dust paints.

Discussing these processes in detail falls beyond the scope of this paper. However, two examples of galvanizing will be discussed in a bit more detail, but the principles of the protection of steel by galvanizing will first be highlighted.

Normal carbon steel corrodes or rusts when exposed to air and water. Basically, corrosion is an electrochemical process, which means that there is a passage of small electric currents between the corroding metal and any other metal that makes electrical contact or between different areas on the surface of the metal that is corroding. It also implies that an electrolyte (e.g. moisture) is required to act as an ionic conductor, as well as oxygen, as corrosion is mostly an oxidation process.

Clearly, the simplest way of preventing corrosion would be to seal off the surface with a barrier coating. Examples include painting or bitumen-based coatings. The problem with these coatings is that, once damaged, corrosion can occur underneath the barrier coating and therefore destroy the main component rather rapidly. Galvanizing, because it forms a chemical bond with steel, does not have this drawback and can protect steel for decades.

In addition to protection via the barrier-coating mechanism, zinc also protects steel by means of a sacrificial effect. Basically, how this works, is as follows:[2]

When the galvanized coating becomes damaged (e.g. scratched), current will flow from the steel (less electronegative) to the zinc (more electronegative) so that the zinc becomes an anodic electron-producing area and therefore corrodes in preference to the steel. This sacrificial protection is called cathodic protection.

On top of this, further protective action occurs at small damaged areas where impervious corrosion products (e.g. $ZnC0_3$ or $CaC0_3$ in hard water conditions) accumulate and increase the resistance to electrical action.[2]

Zinc therefore protects steel through three mechanisms, namely:

Tough coating, which seals the underlying steel
Cathodic protection when the coating is damaged
Zinc corrosion products form a barrier layer.

To further enhance the life of a galvanized steel structure, it can be painted to form a 'duplex' coating.

Below are two examples of how well galvanized steel has served mankind over nearly two centuries.

Storms River Bridge[17]

The first example is that of the well-known Storms River Bridge constructed on the N2 between Plettenberg Bay and Port Elizabeth—about 10 km from the coast in the Eastern Cape Province of South Africa.[17]

The widening and strengthening of the bridge was carried out in 1986. The bridge was widened from 8.180 m to 11.450 m using lightweight plate rib, which supported the precast concrete slabs. Other steel sections included the balustrades, guard-rails, stanchions, draining channels and some of the fasteners. Hot dip galvanizing was chosen as the method of rust protection because of long service life before first maintenance and lowest lifetime costs. Other reasons included competitive first costs, speed of application when compared to painting, and coating toughness.

In 2004 the HDGASA (Hot Dip Galvaniser's Association of Southern Africa) evaluated the performance of the zinc protection applied to the Storms River Bridge. They found that even after 18 years since the steelwork was galvanized, the coating was still in excellent condition. In fact, all coating thicknesses were far in excess of the 105 µm heavy-duty coating originally requested.

Photos 5,6, and 7 show how well the steelwork of the Storms River Bridge has withstood the corrosive coastal climate.

Corrugated iron

The second example is that of corrugated iron. This construction material is used all over the world and millions of roofs and walls have been built with it since about 1830 when it was first made in London[17]. These first sheets were hot dip galvanized by the conventional way of dipping them into a bath of molten zinc. Today 'corrugated iron' used for roof-sheeting is continuously galvanized. The really great characteristic of these sheets, apart from their durability, is that they can be re-used and eventually be recycled to recover both the steel and the zinc. In South Africa, with our thousands of informal shacks, Photo 8 is a very common sight.

History has it that when President Paul Kruger's farmhouse near Rustenburg was constructed in the early part of the twentieth century, an insufficient quantity of corrugated roof-sheeting was ordered.[17] President Kruger apparently used his ox wagons to ride over them and flattened the corrugations. This sufficiently widened the sheets to cover the roof. It is furthermore rumoured that this plan made by President Kruger was the initiation of the famous saying ''n Boer maak 'n plan' (Afrikaans for a Boer makes a plan).

Zinc is fully recyclable

Zinc can be recycled indefinitely without impairing its characteristics. About 30% of the total zinc supply comes from recycling.[6] Zinc is recycled from all phases of the manufacturing process, as well as from discarded products. These can include cars, tyres, appliances and many more. Even zinc-coated products, which have survived more than a century, are fully recyclable. Figure 9 indicates the main sources of recycling.

Photo 5—The Storms River Bridge in the Eastern Cape Province, South Africa after 18 years of service since its widening in 1986[17]

Photo 6—General view of the walkway and the coating thickness measurement[17]

Photo 7—Sections of the balustrades[17]

Photo 8—Second-hand corrugated iron used for the construction of an informal shack[17]

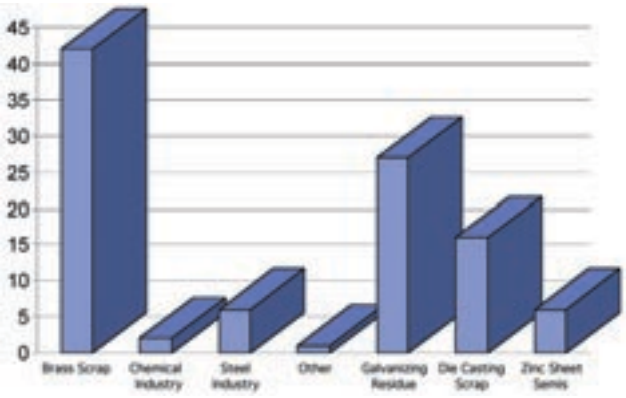


Figure 9—Main sources of zinc for recycling (%)[6]

Because zinc is fully recyclable, it has obvious benefits for the environment, but some less known secondary benefits are:[6]

Saving energy—by prolonging the life of steel, zinc saves vast amounts of energy that would have been required to replace corroded goods and structures. Corrosion can cost an industrialized country as much as 4% of its GDP. This can be significantly reduced by using galvanizing.

Saving forests—a typical American steel-framed house can be built from the steel of six scrap cars rather than from the timber from 0.4 hectares of forest.

Purifying of water—zinc is used in advanced water purification systems, both for potable and industrial use.

Improving air quality—one of the most exciting developments of the last decade or so is that of zinc-air batteries. These batteries, which are still being optimized, can potentially revolutionize the battery industry. Prototype vehicles powered by zero-emission zinc-air batteries have been successfully tested.

Zinc contributes to the progress and prosperity of society

The uses of zinc are too many to mention and, therefore, this section will just touch on some of the important, and sometimes not such well-known applications. In preceding paragraphs the use of zinc in nutrition, crops, protection of steel, etc. was well covered and will not be referred to again.

Brass

Brass[3] is a range of copper/zinc alloys (5 to 40% zinc), which can be used for thousands of products. Brass is versatile and can be machined, cold worked or cast.

Examples of brass products are :

Locks and hinges

Ammunition shells
Light fittings
Plumbing accessories
Heat exchanger tubing
Bushings
Architectural applications.

Figure 10 shows the growth in the use of zinc for brass.

Die-casting

Die-casting is a process in which identical parts are cast at maximum rate by forcing molten metal into metal molds.[3] As soon as the casting has solidified, the dies are unlocked and opened, and the hot casting is ejected, ready for the next casting. Because of the excellent fluidity of the liquid and strength of the subsequent casting, zinc-based alloys are ideal for die-casting. From household appliances and fittings, such as taps, to toy cars and from computer parts to car, train and plane components, life is almost unthinkable without die-cast zinc alloys.

The growth in the die-casting of zinc is shown in Figure 11.

Use of zinc in the car industry

Zinc is used extensively throughout motor cars (see Table IV).

What is probably not well known is that the average car tyre contains about 0.1 kg of zinc as zinc oxide. The zinc oxide is used as a vulcanizing activator for rubber.

Because of the effectiveness of zinc coatings on the chassis and bodies of cars, all major car manufacturers nowadays offer corrosion protection guarantees of between 6 and 12 years, and some even up to 30 years.[6]

Use of zinc in architecture

Zinc is widely used for aesthetic, as well as anti-corrosion purposes in architecture. Zinc gutters, for instance, provide longer life/cost than aluminium gutters. Photos 9 and 10 show the office complexes of MTN and Vodacom in South Africa; both used galvanized steel extensively.

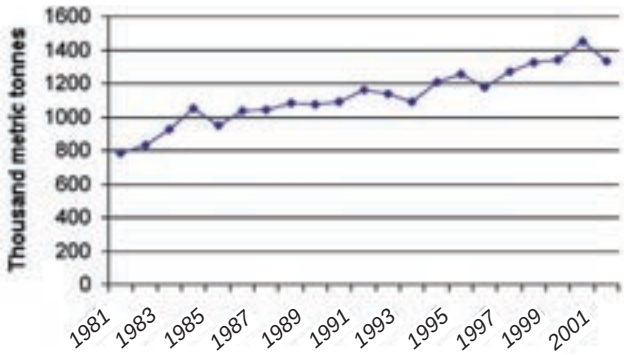


Figure 10—Use of zinc for brass 1981–2001[6]

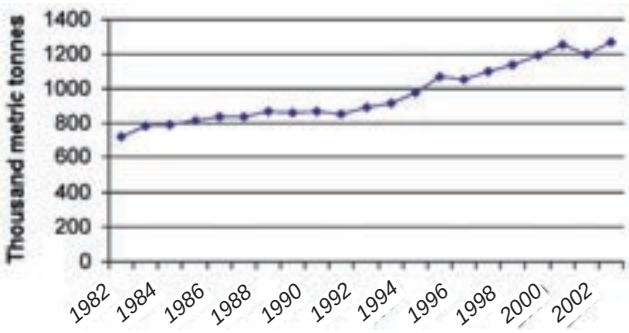


Figure 11—Use of zinc for die-casting components 1981–2001[6]

Table IV

Use of zinc in cars[6]

Average zinc use per car	kg
Die-castings	4.9
Coatings	3.2
Tyres	0.5
Other	1.6
Whole car	10.2

Photo 9—MTN office complex in South Africa[18]

Photo 10—Vodacom office complex in South Africa[18]

In general, galvanized steel has ten advantages over wood for the home-builder:[6]

It is strong and lightweight
It does not warp
It does not expand or shrink with changes in humidity
It produces less scrap on site
It has a reduced fire risk
It is not damaged by termites
It has better resistance to earthquakes and hurricanes
It can be assembled in sections off site
Both the steel and zinc are 100% recyclable
It is faster to erect and therefore makes building cheaper.

General uses

As mentioned earlier, zinc is used so widely that it is impossible to list and discuss all its uses in a paper of this nature. However, Table V gives an additional list of some of zinc's uses and applications not previously discussed.

Conclusions

In this paper, which is basically a brief overview of the benefits, uses and applications of zinc, it was shown that:

Human, animal or plant life is not possible without zinc
Zinc is natural and occurs abundantly in nature
Zinc can enhance the physical performance of athletes
Zinc protects steel
Zinc is fully recyclable and has various environmental benefits
Zinc contributes to the prosperity of society
Zinc has hundreds of applications beneficial to mankind.

Given all of this, it is probably not so far-fetched to claim that zinc is truly man's best friend.

Table V

Additional uses and applications of zinc compounds[2]

Compound	Use/application
Zinc oxide	White pigment in paints
Zinc oxide	Glazes, enamels and ceramics
Zinc sulphide	Pigments
Zinc chlorides	Final finish of textiles
Zinc nickel ferrites	Magnetic material
Zinc borates	Flame-proofing of textiles
Zinc carbonate	Textile dying
Zinc phosphide	Pest control agent
Zinc silicate	Fluorescent material
Zinc phosphate	Inhibitive pigment in paints
Zinc diacrylate	Golf balls

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