***Introduction***

Zinc is an essential element in trace amounts for plants and animals. In mammals, it plays a vital role in the biosynthesis of nucleic acids, RNA polymerases, and DNA polymerases and, thus, is involved in the healing processes of tissues in the body. Other physiological processes such as hormone metabolism, immune response, and stabilization of ribosome and membranes also require zinc.

Zinc toxicosis is not a common problem, but zinc poisoning in humans (e.g., from acid foods or beverages stored in galvanized containers) and animals (e.g., from ingesting or exposure to galvanized metal objects, certain paints and fertilizers, zinc-containing coins, etc.) have been documented. Several factors such as water hardness, salinity, temperature, and the presence of other contaminants influence zinc toxicity in aquatic environments. This modification in zinc toxicity is the result of an effect on zinc availability and on sorption or binding of available zinc to biological tissues. The effect of water hardness on zinc toxicity is by far the most studied factor.

Clinical manifestations of zinc deficiency in animals include growth retardation, testicular atrophy, skin changes, and poor appetite. Zinc is ubiquitous in the environment and its deficiency in humans and animals may be considered an unlikely problem. Nevertheless, zinc deficiency and related problems in humans, animals, birds, and plants have been reported in the literature.

Zinc ranks fourth among metals of the world in annual consumption, behind iron, aluminum and copper. British Columbia, Ontario, Yukon, and Northwest Territories are the major producers of zinc in Canada. Zinc uses are many:

* as a rust-resistant coating for iron and steel products;
* in the manufacture of brass and bronze in the die-casting industry;
* as ingredients of many household items, including utensils, cosmetics, powders, ointments, antiseptics and astringents, paints, varnishes, linoleum, rubber, and others;
* in the manufacture of parchment papers, glass, automobiles tires, television screens, dry cell batteries, electrical apparatus, agricultural fertilizers, insecticides, hardeners in cement and concrete, in printing and dyeing of textiles, in production of adhesives, as a flux in metallurgical operations, and as wood preservatives;
* in the manufacture of smoke bombs used for crowd dispersal, fire fighting exercises, and by military for screening purposes; and
* as medicine in the treatment of zinc deficiency, various skin diseases, wound healing, and to reduce pain in sickle cell anaemia patients

Zinc is a metal. It is called an “essential trace element” because very small amounts of zinc are necessary for human health.  
  
Zinc is used for treatment and prevention of zinc deficiency and its consequences, including stunted growth and acute [diarrhea](http://www.webmd.com/digestive-disorders/digestive-diseases-diarrhea) in children, and slow wound healing.  
  
It is also used for boosting the immune system, treating the [common cold](http://www.webmd.com/cold-and-flu/default.htm) and recurrent [ear infections](http://www.webmd.com/cold-and-flu/ear-infection/), and preventing lower respiratory infections. It is also used for[malaria](http://www.webmd.com/a-to-z-guides/malaria-topic-overview) and other diseases caused by parasites.  
  
Some people use zinc for an eye disease called [macular degeneration](http://www.webmd.com/eye-health/macular-degeneration/default.htm), for [night blindness](http://www.webmd.com/eye-health/night-vision-problems-halos-blurred-vision-night-blindness), and for [cataracts](http://www.webmd.com/eye-health/cataracts/). It is also used for asthma; [diabetes](http://www.webmd.com/vitamins-supplements/ingredientmono-982-zinc.aspx?activeingredientid=982&activeingredientname=zinc); [high blood pressure](http://www.webmd.com/hypertension-high-blood-pressure/default.htm); acquired immunodeficiency syndrome (AIDS); and skin conditions such as [psoriasis](http://www.webmd.com/skin-problems-and-treatments/tc/Psoriasis-Topic-Overview), eczema, and acne.  
  
Other uses include treating attention deficit-hyperactivity disorder (ADHD), blunted sense of taste (hypogeusia), ringing in the ears ([tinnitus](http://www.webmd.com/a-to-z-guides/understanding-tinnitus-basics)), severe [head injuries](http://www.webmd.com/vitamins-supplements/ingredientmono-982-zinc.aspx?activeingredientid=982&activeingredientname=zinc), Crohn’s disease, [Alzheimer](http://www.webmd.com/alzheimers/default.htm)’s disease, [Down syndrome](http://www.webmd.com/vitamins-supplements/ingredientmono-982-zinc.aspx?activeingredientid=982&activeingredientname=zinc), Hansen’s disease, [ulcerative colitis](http://www.webmd.com/ibd-crohns-disease/ulcerative-colitis/default.htm), [peptic ulcers](http://www.webmd.com/vitamins-supplements/ingredientmono-982-zinc.aspx?activeingredientid=982&activeingredientname=zinc) and promoting weight gain in people with eating disorders such as [anorexia](http://www.webmd.com/mental-health/tc/Anorexia-Nervosa-Topic-Overview) nervosa.  
  
Some people use zinc for [benign prostatic hyperplasia](http://men.webmd.com/tc/Benign-Prostatic-Hyperplasia-BPH-Topic-Overview) (BPH), male [infertility](http://www.webmd.com/infertility-and-reproduction/default.htm), [erectile dysfunction](http://www.webmd.com/erectile-dysfunction/default.htm) (ED), weak bones ([osteoporosis](http://www.webmd.com/osteoporosis/default.htm)), [rheumatoid arthritis](http://www.webmd.com/rheumatoid-arthritis/default.htm), and [muscle cramps](http://www.webmd.com/pain-management/muscle-spasms-cramps-charley-horse) associated with liver disease. It is also used for [sickle cell](http://www.webmd.com/a-to-z-guides/sickle-cell-disease-topic-overview) disease and inherited disorders such as [acrodermatitis enteropathica](http://www.webmd.com/vitamins-supplements/ingredientmono-982-zinc.aspx?activeingredientid=982&activeingredientname=zinc), thalassemia, and Wilson’s disease.  
  
Some athletes use zinc for improving athletic performance and strength.  
  
Zinc is also applied to the skin for [treating acne](http://www.webmd.com/skin-problems-and-treatments/acne/acne-vulgaris-treatment-overview), aging skin, [herpes simplex](http://www.webmd.com/genital-herpes/guide/skin-simplex-viruses) infections, and to speed wound healing.  
  
There is a zinc preparation that can be sprayed in the nostrils for treating the common cold.  
  
Zinc sulfate is used in products for eye irritation.  
  
Zinc citrate is used in [toothpaste](http://www.webmd.com/vitamins-supplements/ingredientmono-982-zinc.aspx?activeingredientid=982&activeingredientname=zinc) and mouthwash to prevent dental plaque formation and gingivitis.  
  
Note that many zinc products also contain another metal called cadmium. This is because zinc and cadmium are chemically similar and often occur together in nature. Exposure to high levels of cadmium over a long time can lead to [kidney failure](http://www.webmd.com/a-to-z-guides/acute-renal-failure-topic-overview). The concentration of cadmium in zinc-containing [supplements](http://www.webmd.com/food-recipes/dietary-supplements-topic-overview) can vary as much as 37-fold. Look for zinc-gluconate products. Zinc gluconate consistently contains the lowest cadmium levels.

**How does it work?**

Zinc is needed for the proper growth and maintenance of the human body. It is found in several systems and biological reactions, and it is needed for immune function, wound healing, blood clotting, thyroid function, and much more. Meats, seafood, dairy products, nuts, legumes, and whole grains offer relatively high levels of zinc.  
  
Zinc deficiency is not uncommon worldwide, but is rare in the US. Symptoms include slowed growth, low insulin levels, loss of appetite, irritability, generalized hair loss, rough and dry skin, slow wound healing, poor sense of taste and smell, diarrhea, and nausea. Moderate zinc deficiency is associated with disorders of the intestine which interfere with food absorption (malabsorption syndromes), alcoholism, chronic kidney failure, and chronic debilitating diseases.  
  
Zinc plays a key role in maintaining vision, and it is present in high concentrations in the eye. Zinc deficiency can alter vision, and severe deficiency can cause changes in the retina (the back of the eye where an image is focused).  
  
Zinc might also have effects against viruses. It appears to lessen symptoms of the rhinovirus (common cold), but researchers can’t yet explain exactly how this works. In addition, there is some evidence that zinc has some antiviral activity against the herpes virus.  
  
Low zinc levels can be associated with male infertility, sickle cell disease, HIV, major depression, and type 2 diabetes, and can be fought by taking a zinc supplement.

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| **Water Use** | **Guideline (µg/L Total Zinc)** |
| Drinking Water | 5000 |
| Recreation and Aesthetics | 5000 |
| Marine Life | 10 |
| Livestock Watering | 2000 |
| Irrigation - soil pH less than 6 | 1000 |
| Irrigation - soil pH equal to or greater than 6  and less than 7 | 2000 |
| Irrigation - soil pH greater than or equal to 7 | 5000 |
| Freshwater Aquatic Life - maximum concentration ——  water hardness less than or equal to 90 water hardness equal to 100 water hardness equal to 200 water hardness equal to 300 water hardness equal to 400 | Use the Equation 33 + 0.75 x (hardness -90) —— 33 40 115 190 265 |
| Freshwater Aquatic Life - 30 day average concentration  —— water hardness less than or equal to 90 water hardness equal to 100 water hardness equal to 200 water hardness equal to 300 water hardness equal to 400 | Use the Equation 7.5 + 0.75 x (hardness -90) —— 7.5 15 90 165 240 |

***Recommended Guidelines***

**1. DRINKING WATER**

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| ***It is recommended that the total concentration of zinc in drinking water should not exceed 5000 µg/L.*** |

This guideline is consistent with the recent Health and Welfare Canada drinking water guideline.

The Health and Welfare Canada guideline is based on aesthetic considerations for three reasons: (a) food, not the drinking water, is by far the largest dietary source of zinc; (b) zinc toxicity to humans is unlikely because of efficient homeostatic control mechanism, and (c) water containing zinc at concentrations in excess of 5000 µg/L has an undesirable astringent taste and may be opalescent and develop a greasy film on boiling.

**2. RECREATION AND AESTHETICS**

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| ***It is recommended that the total zinc concentration in recreational water should not exceed 5000 µg/L.*** |

This guideline is consistent with the Health and Welfare Canada and the 1987 CCME (formerly known as CCREM) guidelines.

It is unlikely that zinc concentrations found in ambient waters will impair the use of recreational activities such as swimming. The aesthetic considerations discussed for drinking water are also valid for recreation.

**3. AQUATIC LIFE**

**Freshwater: Chronic**

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| ***To protect freshwater aquatic life from chronic effects, the average concentration of total zinc (µg/L) should not exceed 7.5 µg/L when water hardness is less than or equal to 90 mg/L*CaCO3*. When water hardness exceeds 90 mg/L*CaCO3*, the average concentration is determined by the following relationship:***  **Average Concentration (µg/L) = 7.5 + 0.75 (Water Hardness in mg/L CaCO3 - 90)** |

The recommended guideline at hardness values less than or equal to 90 mg/L CaCO3 is based on the lowest observed effect level (LOEL) of 15 µg Zn/L for copepod and a safety factor of 0.5. The safety factor was based on the ratio of the no effect levels and LOELs found in the literature. The linearity between zinc toxicity and water hardness was assumed for practical reasons. The slope in the above equation was obtained from the two LOELs at 90 (15 µg Zn/L) and 200 mg/L CaCO3 (180 µg Zn/L) after applying a safety factor of 0.5.

**Freshwater: Acute**

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| ***To protect freshwater aquatic life from acute and lethal effects, the maximum concentration of total zinc (µg/L) at any time should not exceed 33 µg/L when water hardness is less than or equal to 90 mg/L*CaCO3*. When water hardness exceeds 90 mg/L*CaCO3*, the maximum concentration is determined by the following relationship:***  **Maximum Concentration (µg/L) = 33 + 0.75 (Water Hardness in mg/L CaCO3 - 90)** |

The guidelines for maximum concentration are based on 96-h LC50 of 66 mg/L at 9.5 mg/L CaCO3for rainbow trout. The slope and the start of the relationship between zinc toxicity and water hardness was assumed to be the same as that for the chronic toxicity.

Acute LOELs lower than 66 µg/L were reported in literature. However, they were not used in development of the guidelines, because the data were dated, original articles were not available for confirmation of data quality, or data were incomplete (e.g., water hardness was not stated). Such rejection of suspect or incomplete data is consistent with the CCME and the Ministry of Environment, Lands and Parks protocols for the development of guidelines.

**Marine Water: Chronic**

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| ***To protect marine aquatic life in marine environments, the average concentration of total zinc should not exceed 10 µg/L.*** |

The recommended guideline is based on lowest observed effect (chronic) levels of 19-19.6 µg/L zinc for the marine algae *S. schroederi*and *S. constatum*. A safety factor of 0.5 was used.

**Marine Water: Acute**

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| ***To protect aquatic life from acute or lethal effects in the marine environment, the maximum concentration of total zinc at any time should not exceed 55µg/L.*** |

The recommended guideline is based on lowest observed acute values of 112-168 µg/L (96-h LC50) for Arctic grayling and 119-310 µg/L (48-h LC50) for Pacific oyster. A safety factor of 0.5 was used.

**4. IRRIGATION**

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| ***The maximum concentration of total zinc in irrigation water supplies should not exceed 1000 µg/L for soils with pH less than 6.0; 2000 µg/L for soils with pH ranging between 6.0 and 7.0, and 5000 µg/L for soils with pH greater than 7.0.*** |

These guidelines replace the 1987 CCME guidelines which were based on old (pre 1980) data.

**5. LIVESTOCK WATERING**

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| ***To protect livestock water use, the concentration of total zinc in livestock watering should not exceed 2000µg/L.*** |

This guideline replaces the 1987 CCME guideline which was based on old (pre 1980) data.

MATERIALS AND METHOD Location of sample spot Bandar Sunway is a town in the Klang Valley metropolitan area in Selangor, Malaysia. It is located in the district of Petaling Jaya, Selangor. Previously Bandar Sunway was known as Sungai Way Tin and it was developed by Sunway Group, also known as Sunway Holding Incorporated Berhad. Figure 1 shows the location of Bandar Sunway. Figure 1: Location of Bandar Sunway Source: http://www.dromoz.com/directory/place/?id=761&p=sunway Sunway Academic Journal 6 37 Water samples were taken from four different spots Sample 1: Sunway University College Sample 2: Sunway Villa Apartment Sample 3: Sunway Condominium Sample 4: PJS 7/11 Bandar Sunway Preparation of stock solution Stock solutions were prepared by weighing out a specific amount of metal (salt) Table 4 and the metal was transferred into a 100 ml volumetric flask. The metals were dissolved completely by adding deionized water (Greenberg, Clesceri & Eaton, 1992). Table 4: The amount of salt and acid used to prepare for each standard cation solution Element Chemical used Purity Mass (g) Supplier Ca Calcium carbonate 98.50- 100.0% 2.493x10-2 HmbG Pb Lead (II) nitrate 99.00% 1.598x10-2 Bendosen Zn Zinc chloride 98.00% 4.398x10-2 HmbG Cu Copper (II) sulfate 5-hydrate 98.00% 3.929x10-2 Bendosen Cr Chromium (III) nitrate nonahydrate >98.00% 2.829x10-2 R&M Cd Cadmium nitrate >98.00% 2.103x10-2 HmbG La Lanthanum (III) chloride heptahydrate, 99.00% >98.00% 1.337x101 Merck Sr Strontium nitrate 98.00% 2.415 HmbG Mg Magnesium sulfate 7-hydrate 99.00- 100.0% 1.014x10-1 HmbG HNO3 Nitric acid 69.00% 68.50- 69.50% BDH HCl Hydrochloric acid 37.00% 37.00- 38.00% Merck (Adapted from Greenberg, Clesceri & Eaton, 1992) Four calibration standards were prepared for Cu, Cr, Cd, Zn, Pb, Ca and Mg (Greenberg, Clesceri & Eaton, 1992; Hauser, 2002). The purity of the reagents and standards used to calibrate the AAS instrument is crucial to the analytical accuracy and precision of the results. Many samples have to be processed with special reagents to eliminate any matrix effects. Other samples may require dilution to adjust their concentration to the proper analytical range. Calibration standards have to be diluted for creating standard curves. Reagent blanks are also needed to zero the instrument. Therefore, lab reagent water must be of the highest quality to prevent interferences. 38 Preparation of Sample Pre-treatment process The pre-treatment process was conducted before the analysis has been done. The sample was collected in a clean polyethylene bottles. Polyethylene bottles were used in these analyses because these glass bottles absorb metals and therefore will cause inaccuracy to analysis (Roger, 2002). The water was filtered through a 0.45µm membrane filter as soon as possible after collection. The first 50 - 100 mL of sample was used to rinse the apparatus. The required sample volume was then collected. Acidification with (1+1) nitric acid to pH 2 or less was used to stabilize the metal content. An approximately 3 mL of (1+1) nitric acid per liter of sample was sufficient for acidification. If the suspended solids content was required, the same initial procedure was used. The difference is that the filter containing the suspended solids was retained and stored in a suitable container. No preservation was needed. For a total analysis, the whole sample was acidified with (1+1) nitric acid to pH 2 or less, preferably at the time of collection. The sample was not filtered (Greenberg, Clesceri & Eaton, 1992; Hauser, 2002). Treatment and analysis Dissolved metal analysis Firstly, the water sample was filtered through 0.45µm membrane filter as soon as possible after collection. The first 50-100 mL of sample was used to rinse the apparatus and discard the filtrate. Then, required sample volume was collected. Acidification with (1+1) nitric acid to pH 2 or less was used to stabilize the metal content (Greenberg, Clesceri & Eaton, 1992; Hauser, 2002). Suspended metal analysis Basically a similar method for soluble metal was used. The residues and membrane were transferred to a 250 mL beaker and 3 mL HNO3 was added. The beaker was covered with a watch glass that provides a surface to evaporate a liquid to hold solids while being weighed, or as a cover for a beaker. The sample was heated until all the water has been evaporated to dryness. Then, the solution was cooled and 3 mL of HNO3 was added. Then the solution was heated again until digestion was completed. This could be indicated by light color residue. Then, 2 mL of HCl (1+1) was added and heated gently again to dissolve the residue. Watch glass and beaker had been washed with H2O and then filtered. The filter was washed and then discarded. The filtrate was diluted with H2O to concentrate within the range of instrument (Greenberg, Clesceri & Eaton, 1992; Hauser, 2002). Total metal analysis Total metal analysis was obtained from the total of both dissolved and suspended metal ions (Greenberg, Clesceri & Eaton, 1992; Hauser, 2002). Triplicate of samples were run Sunway Academic Journal 6 39 independently in each case to ensure high accuracy in the quantitative results. Results of metal analysis were reported as X ± 2σ in ppm units. Calibration of Atomic Absorption Spectrometry (AAS) The characteristic concentration check value is the concentration of element (in mg/L) that will produce a signal of approximately 0.2 absorbance units under optimum conditions at the wavelength listed. By using the characteristic concentration check, the operator can determine whether instrumental parameters are optimized and whether the instrument is performing up to specifications. Calibration of AAS was carried out by using an external calibration curve. The external calibration curve was prepared from solution of known concentrations of the sample element, which was also known as stock solution. High purity metal salts dissolved in high purity acids were used to make the stock solution. Working standards were diluted from the stock standard.