Assessment of Zinc Heavy Metal in Agricultural Soil Near Textile Industry: Detrimental to Humans

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ABSTRACT: This paper aims to assess the amount of Zinc in agricultural soil near industries in barnala region in Punjab (India) and to know its toxic effect on humans and plants. There are three industries in barnala district, naming Yarn factory, Gatta factory and Trident Company. These industries discard their waste without any treatment into drain and pollute water by reaching into ground water through seepage, when farmers use this ground water in their fields and heavy metals reached in the agricultural soil. In order to know the effect of industrialization on agricultural soil,samples of soil were collected from four different villages which are located near to industries such as Rure ke kalan, Gunas, Handiaya, and Cheema from five different layers (0-10cm; 10-20cm; 20-30cm; 30-40cm and 40-50cm depth). Handiaya village has high value of Zinc while Gunas village has lowest value of Zinc. The concentration of Zinc was determined by Flame Atomic Absorption Spectrometry. Zinc enter into human body through water, soil and food.

Keywords: Heavy metal, Zinc, soil contamination, Human health, Textile industries

INTRODUCTION

Zinc is an important trace mineral that people need to stay healthy. Of the trace minerals, this element is second only to iron in its concentration in the body.It is found in cells throughout the body. It is needed for the body's defensive (immune) system to properly work. It plays a role in cell division, cell growth, wound healing, and the breakdown of carbohydrates. It is also needed for the senses of smell and taste. During pregnancy, infancy, and childhood the body needs zinc to grow and develop properly. Zinc also enhances the action of insulin.

Recent information from an expert review on zinc supplements showed that:

1. When taken for at least 5 months, zinc may reduce your risk of becoming sick with the common cold.
2. Starting to take zinc supplements within 24 hours after cold symptoms begin may reduce how long the symptoms last and make the symptoms less severe. However, supplementation beyond the RDA is not recommended at this time.

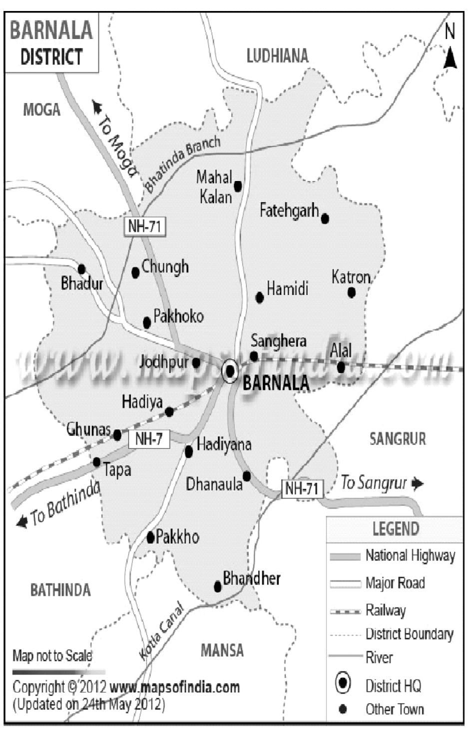
Zinc is likely safe for most adults when applied to the skin, or when taken by mouth in amounts not larger than 40 mg daily. Routine zinc supplementation is not recommended without the advice of a healthcare professional. In some people, zinc might cause nausea, vomiting, diarrhea, metallic taste, kidney and stomach damage, and other side effects. Using zinc on broken skin may cause burning, stinging, itching, and tingling.

It is possibly safe when taking by mouth in doses greater than 40 mg daily. There is some concern that taking doses higher than 40 mg daily might decrease how much copper the body absorbs. Decreased copper absorption may cause anemia.It is possibly unsafe when inhaled through the nose, as it might cause permanent loss of smell. In June 2009, the US Food and Drug Administration (FDA) advised consumers not to use certain zinc-containing nose sprays (Zicam) after receiving over 100 reports of loss of smell. The maker of these zinc-containing nose sprays has also received several hundred reports of loss of smell from people who had used the products. Avoid using nose sprays containing zinc.Taking high amounts of zinc is likely unsafe. High doses above the recommended amounts might cause fever, coughing, stomach pain, fatigue, and many other problems.Taking more than 100 mg of supplemental zinc daily or taking supplemental zinc for 10 or more years doubles the risk of developing prostate cancer. There is also concern that taking large amounts of a multivitamin plus a separate zinc supplement increases the chance of dying from prostate cancer.Taking 450 mg or more of zinc daily can cause problems with blood iron. Single doses of 10-30 grams of zinc can be fatal.

MATERIALS AND METHODS

Barnala (Punjab, India) is situated between 30° 23'North and 75° 33' East. It has a mean elevation of 227 meters (745 feet). It is locatedon the Bathinda-Chandigarh highway (no-7) and the Jalander-Rewari national highway (no-71), The Sirsa-Ludhiana state highway(no-13) are passes through it. It is 65 km from Bathinda and 85 km from Ludhiana. According to 2011 census, the total population of Barnala district is 595527. It was 526931 in 2001.Soil samples were collected from four different sites.1st site is Rure ke kalan village which is at Barnala-Mansa Road in District Barnala 148107, Punjab.2nd site is Gunas village which is located in Barnala District 148108, Punjab.3rd site is Handiaya village is located in Barnala District 148107, Punjab.4th site is Cheema village is located in Barnala Tehsil of Barnala district 148103, Punjab, India.

MAP OF BARNALA DISTRICT



Sample collection

The sampling time was between 4:30 pm to 5:30 pm on 9th November, 2016. Plastic polythene bags were used to collect soil samples. Within 48 hours samples were carried to laboratory for testing in order to prevent the deterioration of soil samples. Testing was done in Environ Tech Laboratories (NABL Accredited Laboratory) Department of Science and technology, India S.A.S nagar (Mohali), Punjab. Soil samples were collected from agricultural fields of four villages such as Rure ke kalan, Gunas, Handiaya and cheema which are present near to industrial sites. These four villages are located in Barnala district (Punjab, India).Soil samples were collected from five sampling depths 0-15 cm, 15-30 cm, 30-45 cm, 45-60 cm and 60-75 cm.Five sub-samples were taken within an area of 100 m^2 from each sampling location.About 1 kg weight of each sub- sample were collected. The collected soil samples were dried at 60 °C, sieved through a 2.0-mm Nylon sieve to remove sand, gravel, and plant debris, and stored in glass bottles at room temperature.

Samples (20 g) of dried soils were finely powdered by an agate ball-grinder and sieved to pass 0.15-mm Nylon sieve.The powdered samples (0.2 g) were then digested by trace metal grade acids (9.0 mL of HNO3 and 3.0 mL of HF) using a microwave digestion system.

Determination of Zinc heavy metal in soil by Tri-Acid Mixture Digestion Method using AAS

1. Apparatus and Reagents
   a) Tri-acid mixture:- Mix 10 parts of conc.HNO3, 1 part of Conc.H_2SO_4 and 4 parts of $HClO_4$
   b) Conical flask, 250 ml capacity
   c) Hot plate
   d) Whatman filter paper No.42
   e) AAS
2. Preparation of sample
   a) Take 5.0 gm of oven dried (105°C) sample thoroughly ground and sieved through 0.2 mm sieve in a conical flask
   b) Add 30 ml tri-acid mixture, cover it with a small glass funnel for refluxing. Digest the sample at 200°C on a hotplate till the volume is significantly reduced with a whitish residue

c) After cooling, filter the sample with whatman filter paper No.42, make up to 100 ml in a volumetric flask with distilled water.

3. Analysis

In case of zinc, treat the sample with sodium boro hydride (NaBH4) in hydride generation assembly attached to AAS.

4. Principle

The metals in different matrix wastes, in general, are digested in mineral acids, viz.,nitric acid, hydrochloric acid, etc. and mixture of mineral acid.

The digested metal ions in solutions are estimated using atomic absorption spectrophotometer.

5. Apparatus and materials-

a) Electric Hotplate

b) Hot air Oven

c) Porcelain Crucible 25,50 ml capacity

d) Analytical Balance with 0.001 gm accuracy

e) AAS with all necessary accessories for its operation

f) Usual Lab. Glassware.

6. Reagents

a) Conc.HNO3 AR grade

b) Conc. HCl AR grade

c) H2O2 (30%) AR grade

d) Double distilled water (DDW) with a conductivity less than 3 µS/cm

e) Dil.HNO3 (1:1) – Mix equal volume of conc. HNO3 and DDW

f) Dil.HCl (1:1) – Mix equal volume of conc. HNO3 and DDW

g) Reagent Blank Solution:- Slowly add 100 ml conc. HNO3 to 250 ml DDW in 1 liter volume flask with constant cooling. Add 30 ml H_2O_2followed by 50 ml Conc. HCl with cooling under tap water. Make up the solution to 1 liter with DDW.

h) Stock Standard solution :- It may be prepared from high purity metals, metal oxide or non-hydroscopic reagent grade salts using HCl or HNO3. All salts must be dried for one hour at 105°C,unless otherwise specified.

7. Sample Preparation

a) weigh a representative sample of 1.0 to 2.0 g portion and transfer to 250 ml beaker.

b) Add 10 ml of 1:1 HNO3, mix the slurry and cover the beaker with a watch glass. Heat the contents of beaker to 95°C reflux for 10 to 15 minutes without boiling.

c) Allow the sample to cool, add 5 ml Conc. HNO3 , replace the watch glass and reflux for 30 minutes.

d) Allow the solution to evaporate to 2 to 3 ml volume of solution.

e) Cool the sample, add 2 ml DDW and 3 ml of H_2O_2. Cover the beaker with watch glass and return the covered beaker to the hot plate for warming and to stall the peroxide reaction. Heat the beaker until the effervescence subsidized and cool the beaker.

f) Continue to add H_2O_2 in 1 ml aliquots with warming until the effervescence is minimal. Do not add more than 10 ml H_2O_2.

g) Add 5 ml of Conc. HCl and 10 ml of DDW. Return the covered beaker to hot plate and reflux for an additional 15 minutes without boiling.

h) After cooling, dilute to 100 ml with DDW. Filter the sample. The diluted digested solution contains approximately 5%(v/v) HNO_3.The sample is now ready for analysis by flame AAS.

8. Analytical Procedure
Prepare a series of working calibration standard metal solutions (minimum 5 working standards for each metal) in the working range. Follow the AAS operating instructions to operate the AAS instrument. Prepare and run the reagent blank along with the sample and standards.

9. Preparation of standard of Zinc-
Dissolve 1.0 gm of Zinc granules in a minimum vol. of 1:1 HCl. Dilute it to1.0 liter with 1:1 HCl to give a 1000 ppm Zn solution.10. Operation

1. Power on from UPS
2. Open gases and set out Pressure AIR = 2-4(3kg/cm^2), Acetylene C2H2 = 1-1.5(3kg/cm^2), Argon=3kg/cm^2
3. Switch on main unit of AAS from Power button.
4. Switch on PC and double click on Icon "AAS 7000 SP Analysis System" on desk top of PC.
5. AAS Data Analysis System AA7000 asp work stat window will appear. Click on this window.
6. Initialize Device screen will appear and then disappears after 5 second.
7. Go to icon tool bar and click "Analysis" and click at set instrument Parameter (F7).
8. window "set instrument Parameters will appear. Select element HCl Lamp of interest. Set wavelength , method etc. Then Click at "Next" select element lamp screen will appear. When successes appear then click at "close"
9. Auto set parameters window will appear. Wait for 15-20 minutes for warm up the lamp.
10. Then click at "scan" when completed click "Adjust lamp", adjust lamp position screen will appear. Close the window 5 seconds after adjustment.
11. Click at "balance" screen "energy balance" will appear where status shows balance-4. Now click OK and then "Finish".
12. Now go to "file" at toolbar and click at new project. Window will appear , write "project name", "description" and "conc. Units" in their columns. Select measuring method as "standard curve" and calibration line as "crossing from origin", put 3 at measure time. Enter standards (0.5,1.0,2.0…) and click "Finish".
13. The window will appear. Then go to "control" at toolbar.And click at "set fuel gas flow rate.A window will appear, put value 2.0 and click set. Then ignite the instrument by pressing ignition button till flame appears. Adjust flame by putting value 1.7 in place of 2.0 then click close.
14. Now inject double distilled water and click "Auto balance" on tool bar. Now go to "Analysis" then "auto zero". Click "start" and blank and then inject "blank". Click 3 times in each case of blank or samples. Inject all samples one by one while putting distilled water between each sample as per PC demand. The window will appear with analysis date.

RESULTS AND DISCUSSION

Table 1
Of Rure ke kalan

Depth of Soil (cm)	*Conc. of Zinc (mg/kg)*
0-15	72
15-30	75
30-45	76
45-60	78
60-75	81
Mean ± S.D	76.4 ± 3.36

Table 2
Of Gunas

Depth of soil (cm)	*Conc. of Zinc (mg/kg)*
0-15	43
15-30	46
30-45	49
45-60	50
60-75	52
Mean ± S.D	48 ± 3.53

Table 3
Of Cheema

Depth of soil (cm)	*Conc. of Zinc (mg/kg)*
0-15	52
15-30	55
30-45	56
45-60	59
60-75	60
Mean ± S.D	56.4 ± 3.20

Table 4
Of Handiaya

Depth of soil (cm)	*Conc. of Zinc (mg/kg)*
0-15	77
15-30	80
30-45	83
45-60	85
60-75	86
Mean ± S.D	82.2 ± 3.70

In case of site A the values of Zinc of the Soil samples ranged from 72 mg/kg to 81 mg/kg with an average value of 76.4 mg/kg (S.D = 3.36, N=5).The highest value of zinc was found in Depth of 60-75cm of soil and lowest value of zinc was found in soil sample taken from depth of 0-15cm.

In case of site B the values of zinc of the soil samples ranged from 43 mg/kg to 52 mg/kg with an average value of 48 mg/kg (S.D = 3.53, N= 5)

In case of site C the values of zinc of the soil samples ranged from 52 mg/kg to 60 mg/kg with an average value of 56.4 mg/kg (S.D = 3.20, N=5).

In case of site D the values of zinc of the soil samples ranged from 77 mg/kg to 86 mg/kg with an average value of 82.2 mg/kg (S.D = 3.70, N=5).

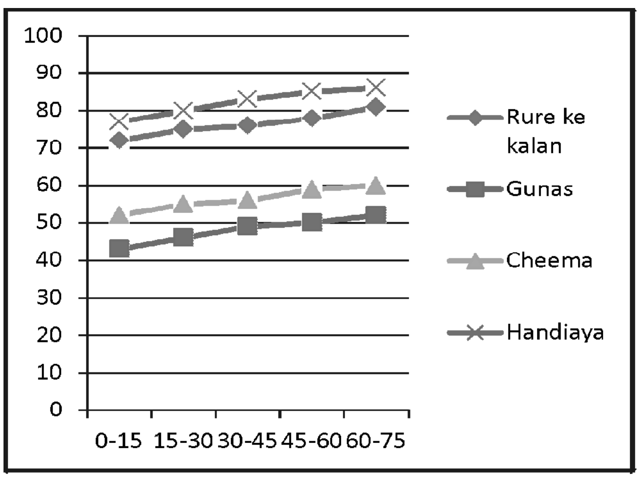


Table 5

Sites	*Absorption (X)*	*Conc. of Zinc(µg/L) (Y)*
Rure ke kalan	0.0470	0.5993
Gunas	0.0288	0.3672
Cheema	0.0346	0.4412
Handiaya	0.0503	0.6413

Statistical analysis

The data obtained subjected to statistical analysis. In statistical analysis, a correlation developed between Absorption (nm) and Conc. of Zinc in µg/L by using KARL PEARSONS Coefficient of correlation.

Calculation of KARL PEARSON's Coefficient of correlation

Correlation coefficient between Absorption (X) and Conc. (Y) calculated as

$$r = \frac{\Sigma xy}{\sqrt{x^2 + y^2}} = 0.999$$

Where $x = X - \bar{X}, y = Y - \bar{Y}, \bar{X} = \frac{\Sigma X}{n}, \bar{Y} = \frac{\Sigma Y}{n}$

where n is the number of sites

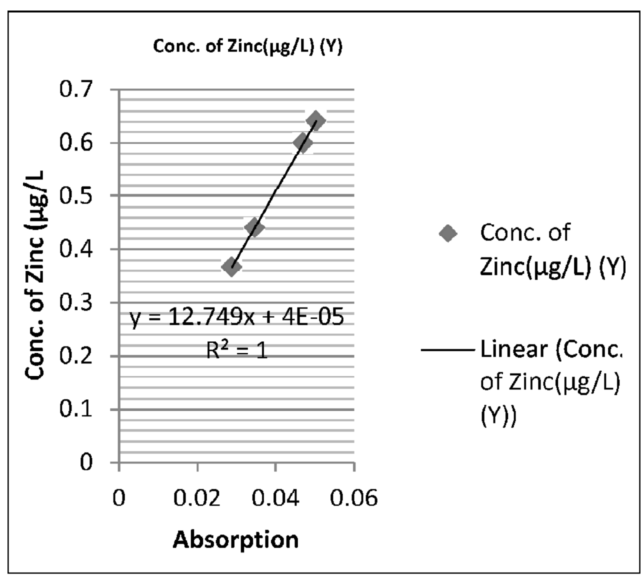
For good correlation value of r should be between - 1 < r < 1.

Calculation of Regression equation: The term regression stands for some sort of functional relationship between two or more related variables. It measures the nature and extent of correlation and predicts the unknown values of one variable from known values of another variable. Following regression equation is used to established correlation between Absorption and Conc. of Zinc

$$Y - Y = b_{yx} (X - \bar{X})$$

The above equation called regression line equation of Y on X and byx called regression coefficient of Y on X and calculated as

$$b_{yx} = \frac{\Sigma XY}{\Sigma X^2}$$



Harmful effects of Zinc

Zinc supplements taken in large amounts may cause diarrhea, abdominal cramps, and vomiting. These symptoms most often appear within 3 to 10 hours of swallowing the supplements. The symptoms go away within a short period of time after stopping the supplements. An excess intake of zinc can lead to copper or iron deficiency. People who use nasal sprays and gels that contain zinc may have side effects, such as losing their sense of smell.

CONCLUSION

From the above results and discussion it is concluded that concentration of Zinc increases with increase in depth of soil. Handiaya village has high value of zinc than other three villages because this village is situated near to textile industry.

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