

## Effective of different factors on trace elements concentrations in Iraqi lactating mother's milk

Mona Al-Terehi<sup>1</sup>, Haider K. Zaidan<sup>2</sup>, Ayad M.J. AL –Mamoori<sup>2</sup>;  
Ali Hmood Al-Saadi<sup>2</sup>, Israa Harjan.<sup>1</sup>

<sup>1</sup>University of Kufa, College of Science, Iraq.

<sup>2</sup>University of Babylon, College of Science, Iraq.

**Abstract:** Study aims to determination some trace elements in lactating mothers human milk and study effect different factors on its concentration, Age , Body mass index, Home and Smoking habitat, atomic absorption flame less used to measured (Mn, Cd, Co and Zn) in 70 sample of lactating mothers milk which digested using tricolor acetic acid 24%. Result show that concentration of these elements increasing than normal value of these elements, Mn was 1801.40, Cd was 114.64, Co was 288.52 and Zn was 212.10. Also factors were studied effect on minerals concentration, increasing age was non effected on minerals concentration, over weight causes increasing it, urban resident causes increasing in Mn concentration while rural residence causes increasing in others minerals, negative smoking habitat causes increasing in Cd and Co concentrations.

**Key words:** trace element, lactating mother's human milk, atomic absorption.

### Introduction

Environmental factors increasingly gain importance in public health, Children are affected more than adults from environmental pollution and harmless effects, Children's exposure to environmental hazards may cause defective effect and will continue during adulthood, at the last decades, there has been high level of health awareness in the world of the health and developmental risks associated with environmental exposure to toxic minerals, such as, lead (Pb), mercury (Hg), cadmium (Cd), Iron (Fe), Cobalt (Co), and Nickel (Ni) table (1). While exposure to toxic levels of any of these environmental contaminants causes weakness in adults health , the toxicological effects of these metals are often more destructive in the developing central nervous system and physiological systems in children<sup>1</sup>. Environmental pollution in different country, in rural areas may effect on human life. Air currents, mixing of water sources with metals, the use of leaded gasoline, lead pipes in drinking water transport, and traditional methods of food storage containers in rural sector can make the world more risky in terms of environmental pollution<sup>2</sup>.

Human milk is unique biological matrix for monitoring certain environmental contaminants because it can provide exposure information about both the mother and the breastfed infant through a non-invasive method of collection. Human milk is considered as one of the most important organism to be monitored for the presence of Persistent Organic Pollutants (POPs), Better understanding of exposure to harmful environmental chemicals will help to better manage such chemicals by eliminating or reducing pollutions emissions of such POPs or by limiting their presence in the food supply<sup>3</sup>.

There are some chemical structures of minerals in human milk, such as inorganic ions and salts, or as components of other organic molecules, including proteins, fats, and nucleic acids. They subscribe to a different

physiological functions, like structural components of body tissues to essential parts of many enzymes and biologically important molecules. Sodium, potassium, chloride, calcium, magnesium, phosphorus, and sulfate make up the macro minerals found in human milk. Citrate is found as a water-soluble portion of human milk that can bind some minerals<sup>4</sup>. early determinant of macro mineral concentration in human milk is the duration of lactation, during which sodium and chloride decrease, and potassium, calcium, magnesium, and free phosphate increases over time. Yet human milk minerals also effected by nutritional status of the mother, environmental and anther factors<sup>5</sup>.

Microelements or trace elements are found in human milk in variety concentration with different functions and affected by many factors, these microelement include, sodium, potassium, chloride, manganese, and etc... table (1). in normal state of affairs deficiency of some minerals don't occurs like sodium, potassium, or chloride. However, low concentration of sodium and chloride occur under standard condition, such as chronic diarrhea, heavy perspiration, or renal disease, also potassium depletion occur in situations where there are large alimentary or renal losses<sup>6</sup>.

Sodium, potassium, and chloride concentration in breast milk decrease with lactation duration, from a reported 480, 740, and 850 mg/L in colostrum, respectively, to 160, 530, and 400 mg/L respectively. No correlation has been identified between maternal intake and the concentration of these minerals in human milk. Sodium, potassium, and chloride in human milk are present almost entirely as free ions<sup>5</sup>.

Cobalt is dispersed in the environment, thus humans can exposed to it by different way such as breathing air, drinking water and eating food that contains cobalt. Skin contact with soil or water that contains cobalt may enhance exposure. cobalt partials which not bound to soil or sediment these particles uptake by plants and animals in higher level thus this causes accumulation effect<sup>7</sup>.

Cadmium (Cd), is one of the most toxic elements may be exposed at work or in the environment. Once absorbed, Cd is retained in human body. Cd is mostly toxic to the kidney, especially to the proximal tubular cells, the main site of accumulation. Cd also cause bone demineralization, either through direct bone damage or indirectly as a result of renal dysfunction. In the industry, excessive exposures to airborne Cd may impair lung function and increase the risk of lung cancer. All these effects have been described in populations with relatively high exposures to Cd in the industrial or in heavily polluted environments<sup>8</sup>.

Manganese (Mn) is a very common compound that can be found everywhere on earth. Manganese is one out of toxic essential trace elements, It means that it is not only necessary for humans physiological function, but it is toxic when found at high concentrations<sup>9</sup>. the uptake of manganese by humans mainly takes place through food, The food that contain the highest concentrations are grains and rice, soya beans, eggs, nuts, olive oil, green beans and oysters. After absorption in the human body manganese will be transported through the blood to the body organs liver, the kidneys, pancreas and the endocrine glands<sup>10</sup>.

Zinc (Zn) is substantially useful in biological systems. It is involved in many biochemical processes that important to life and required for physiological functions, Zinc uptake can result in severe injury to the mouth, throat and stomach. Initial symptoms include burning of the mouth and pharynx with vomiting and may be accompanied by erosive pharyngitis, esophagitis, and gastritis. Complications may include gastrointestinal hemorrhage and acute pancreatitis<sup>11</sup>.

**Table (1) Mineral Composition of Mature Human milk<sup>12</sup>.**

Mineral	Concentrations	Mineral	Concentrations
Sodium (mg/L)	207±94	Copper (µg/mL)	0.2-0.4
Potassium (mg/L)	543±78	Manganese (ng/mL)	3-6
Chloride (mg/L)	453±53	Iodine (ng/mL)	12-178
Calcium (mg/L)	259±59	Fluoride (ng/mL)	4-15
Magnesium (mg/L)	31.4±5.9	Selenium (ng/ml)	15-20
Phosphorus (mg/L)	142±25	Aluminum (ng/mL)	4-14
Iron (µg/mL)	0.4-0.76	Chromium (ng/mL)	0.2-0.4
Zinc(µg/mL)	1-3	Molybdenum (ng/mL)	1-2

## Materials and methods

Breast milk samples were collected at 1-51 weeks postpartum from the respondent lactating mothers who volunteered to participate in this study.

Before the self manually expressing milk using a conventional breast pump; the breast was washed by distilled water to a void contamination with environmental minerals.

Ten (10) ml of milk was collected in sterile polypropylene tube, samples were immediately transferred to a special cooling box with thermometer. The samples were transferred to the chemical laboratory of the DNA research center lab. In the college of science – Babylon University and stored in at  $-20^{\circ}\text{C}$  waiting for analysis for minerals. Data of samples (age, home, habitats, length and weight) were collected in Questionnaire which constructed for present study.

Body Mass Index (BMI) was calculated according to the following.  $\text{BMI} = \frac{\text{Weight in Kilograms}}{\text{Height in square meters}}$

1. BMI between 18.5 – 24.9 = normal
2. BMI between 25- 29.9 = overweight
3. BMI more than 30 = obesity

### Milk samples were digested according to given below:

1. Tow ml of the human milk were mixed with five (5)ml of the digestive solution (24%TCA W/V) , then shacked well for 30 minutes .
2. The mixture was centrifuged at 4000 rpm for 10 minutes.
3. The supernatant was filtered by filter paper; then the solution was transferred to new tube for detection by the Atomic Absorption spectrophotometer (AAS, Shimadzu .Japan 7000).Using SPSS version / 17 statistical software, a t-test analysis and the Analysis of Variance (ANOVA - one way) were performed to determine the relationships between different variables. Differences were considered as statistically significant at values  $P < 0.05$ .

## Results and discussion

Results of present study show that mothers which milk samples collection consist from five categories of age (Table 2) under 25 years was more frequented than other, while age above 38 years was low frequented, this because age between 20-37 was perfect age for pregnant in women.

When samples classified according to body mass index, over weight was more frequented than other it was 43.33%, this is because incorrect habitats of feeding during pregnancy and postpartum. Also don't follow daily exercise. Obese was lower percentage of samples it was 23.33%.

According to home 67.18% of lactating mothers were from urban and 31.18% were from rural. No smokings mothers in present study but high percentage of mothers suffer from negative smoking it were 62.85 % while non-smoking mothers were low percentage in present study.

**Table (2) Classification of milk samples according to Age, home, BMI and smoking habitat**

Categories	% sample no	Categories	% sample no
<b>Age</b>		<b>Home</b>	
20-25	47.69%	urban	67.18%
26-31	35.38%	Rural	31.18%
32-37	9.23%		
38-42	7.69%		
<b>BMI</b>		<b>Smoking habitat</b>	
Normal weight	33.33%	Non smoking	37.14%
Over weight	43.33%	Negative smoking	62.85%
Obese	23.33%		

Trace elements in present study were measured using atomic absorption, four trace elements were measured (Manganese, Cadmium, Cobalt and zinc) in lactating mother's milk in ppm ( $\mu\text{g/ml}$ ), and then result was analysed according to factors showed in (table 2) to clarify effective of these factors on trace elements concentrations on human milk.

Table (3) Show minerals concentrations according to mothers age categories, Mn was don't effected by age, it increased in third category and decreased in forth. Cd was no affected by increasing age. Cobalt increased in second and forth categories and zinc was trivial changes with age.

**Table(3) Trace elements concentrations  $\mu\text{g/ml}$  in lactating mothers milk according to mother's age**

Categories	Mn	Cd	Co	Zn
20-25	1837.73 $\pm$ 118.29	114.65 $\pm$ 0.03	272.34 $\pm$ 59.57	212.13 $\pm$ 4.63
26-31	1811.65 $\pm$ 188.65	114.67 $\pm$ 0.05	349.54 $\pm$ 87.31	215.54 $\pm$ 4.63
32-37	1979.37 $\pm$ 254.30	114.53 $\pm$ 0.04	138.10 $\pm$ 10.17	195.31 $\pm$ 6.63
38-42	1518.19 $\pm$ 185.99	114.66 $\pm$ 0.07	253.52 $\pm$ 134.75	210.02 $\pm$ 11.57

**Me $\pm$ Seanova-one way at ( $p < 0.05$ ), no significant**

In all studies that deal with evaluation of heavy metals concentrations take body mass index in its consideration for its effected on minerals concentration, in present study Mn was higher in obese but low in overweight, Cd has small changes with BMI, Co increased in overweight and Zn also increased in overweight table (4) Study suggested that minerals concentrations were increased with body weight but in present study it's don't deal with this role because other factors interacted with BMI such as exposure to heavy metals source, dose of exposure and times of exposure. Also mistakes manner of mothers in their life may be affected on minerals concentrations. Nikniazet *al*<sup>14</sup> found significant negative correlation between Fe levels in human milk with BMI when they studied effect different factors on breast milk minerals. Ozkan and others<sup>15</sup> studied effect lactating period on iron and others milk substances, they found and 4 months after birth.

Iron concentration in the present study decreased with increasing in BMI, this may be because of anemia associated with increasing Pb level, or lactating period<sup>16</sup>.

**Table (4) trace elements concentrations  $\mu\text{g/ml}$  in lactating mothers milk according to Body mass index.**

Categories	Mn	Cd	Co	Zn
Normal weight	1927.14 $\pm$ 131.93	114.65 $\pm$ 0.06	203.73 $\pm$ 6.14	203.97 $\pm$ 6.14
Over weight	1538.59 $\pm$ 154.08	114.70 $\pm$ 0.04	424.68 $\pm$ 86.16	220.48 $\pm$ 6.14
Obese	2038.70 $\pm$ 209.14	114.59 $\pm$ 0.04	205.04 $\pm$ 79.36	217.63 $\pm$ 8.02

**Me $\pm$ Seanova-oneway at ( $p < 0.05$ ), no significant**

Home of lactating mothers affected on milk minerals concentrations in urban Mn was increased while Co and Zn increased in rural. Home affected on minerals concentration resulted from pollution level in urban was higher than rural because present industrials institution and large number of vehicles. Also most mothers in urban are workers and exposure to pollution source was more than others mothers in rural, This may be due to persistent exposure to those environmental pollutants in extensive way in addition to the role of high concentrations of these metals in the working environment or the exposure of women during their transportations to the work place; many local studies explained the high concentrations of these metals in the local environment (air, water and food)<sup>17,18,19</sup>.

Sometimes some minerals are increased in rural than urban because of using some chemical fertilizer which form from minerals, vegetable and water polluted by these fertilizer consider important source of minerals. this may be because this metal can exist in soils in several forms: inorganic crystalline minerals or precipitates, complexes or adsorbed on organic cation surfaces or on inorganic cation exchange surfaces, water-soluble, free-ion or chelated metal complexes in soil solution<sup>20,21,22</sup>.

**Table (5) trace elements concentrations  $\mu\text{g/ml}$  in lactating mothers milk according to home**

Categories	Mn	Cd	Co	Zn
Urban	1976.94 $\pm$ 85.16*	114.59 $\pm$ 0.28	240.06 $\pm$ 47.56	202.57 $\pm$ 4.00
Rural	1484.46 $\pm$ 172.73	114.73 $\pm$ 0.05	428.42 $\pm$ 104.91	227.39 $\pm$ 9.202

**Me $\pm$ Set-test,\* significant at (p<0.05),**

All study pointed to disadvantage of smoking on human health especially on new born if their lactating mother milk was polluted by minerals. In present study no smoker mothers in samples by negative smoking was higher percentage than no smoking mothers, only Cd and Co were increased in low level. Other factors may be interacted with smoker hesitate also for detected minerals level and smoker role in human milk study need to further sample of smoker mothers, type of smoking and cigarette number per day.

Smoking habits in the family (smoking during pregnancy and/or being exposed to smoke from other family members) or (negative smoking) increased cadmium concentration in milk. A tendency toward higher cadmium concentration in smokers was observed also in the Swedish and Creation lactating women<sup>23,24,25</sup>, estimated that the infants of smoking mothers were exposed 20 - 40 % more to cadmium than the infants from non-smoking mothers and the concentration of cadmium in milk were increased by 17,18% and 28 % due to the mother's smoking habits before pregnancy; father's smoking habits and smoking at home, respectively<sup>26</sup>. Ursinyova and Masanova<sup>27</sup> observed higher cadmium concentration in the milk in women from families with smoking habits, but differences were not statistically significant.

**Table (6) trace elements concentrations  $\mu\text{g/ml}$  in lactating mothers milk according to smoker habitat.**

Categories	Mn	Cd	Co	Zn
Negative smoking	2162.84 $\pm$ 72.33	115.99 $\pm$ 1.42	140.53 $\pm$ 1.86	191.19 $\pm$ 2.51
Non smoking	2261.53 $\pm$ 114.07	114.55 $\pm$ 1.42	138.68 $\pm$ 2.67	194.5 $\pm$ 5.26

**Me $\pm$ Set-test at (p<0.05), no significant**

Total concentration of minerals which detected in present study recorded increased in these concentrations compare with normal value of its in human milk, increasing in minerals concentrations causes different effected on human health especially in new born. The uptake of manganese by humans mainly takes place through food, such as spinach, tea and herbs. The foodstuffs that contain the highest concentrations are grains and rice, soya beans, eggs, nuts, olive oil, green beans and oysters. After absorption in the human body manganese will be transported through the blood to the liver, the kidneys, the pancreas and the endocrine glands. Chronic Manganese poisoning may result from prolonged inhalation of dust and fume. The central nervous system is the chief site of damage from the disease, which may result in permanent disability. Symptoms include languor, sleepiness, weakness, emotional disturbances, spastic gait, recurring leg cramps, and paralysis. A high incidence of pneumonia and other upper respiratory infections has been found in workers exposed to dust or fume of Manganese compounds. Manganese compounds are experimental equivocal tumorigenic agents<sup>28</sup>.

Studies improved that Manganese is a very common compound that can be found everywhere on earth. Manganese is one out of three toxic essential trace elements, which means that it is not only necessary for humans to survive, When people do not live up to the recommended daily allowances their health will decrease. But when the uptake is too high health problems will also occur. high concentrations are present in a human body has been shown to accumulate in maternal liver and to cross the placenta in rats<sup>29</sup>. also increased manganese in the diet of pregnant and lactating rats led to accumulation of manganese in the brains of their offspring, as well as altered concentrations of other metals in their brains (i.e., zinc and chromium)<sup>30</sup>.

Cobalt is beneficial for humans because it is a part of vitamin B<sub>12</sub>, which is essential for human health. Cobalt is used to treat anemia with pregnant women, because it stimulates the production of red blood cells. The total daily intake of cobalt is variable and may be as much as 1 mg, but almost all will pass through the body unabsorbed, except that in vitamin B<sub>12</sub>, too high concentrations of cobalt may damage human health. When we

breathe in too high concentrations of cobalt through air we experience lung effects, such as asthma and pneumonia. This mainly occurs with people that work with cobalt. Also plants that grow on contaminated soils they will accumulate very small particles of cobalt, especially in the parts of the plant we eat, such as fruits and seeds. Soils near mining and smelting facilities may contain very high amounts of cobalt, so that the uptake by humans through eating plants can cause health effects.<sup>7</sup>

Recent studies suggest that the chronic low environmental exposure to Cd now prevailing in industrialized countries can adversely affect the kidneys and bones of the general population. These studies show consistent associations between various renal and bone biomarkers and the urinary excretion of Cd used to assess Cd body burden. The public health impact of these findings are still unknown. Further research is needed to ascertain that these associations are truly causal and not secondary to parallel changes in Cd metabolism and in the bone or kidney function occurring because of ageing or diseases unrelated to Cd exposure<sup>31</sup>.

Although humans can handle proportionally large concentrations of zinc, too much zinc can still cause eminent health problems, such as stomach cramps, skin irritations, vomiting, nausea and anemia. Very high levels of zinc can damage the pancreas and disturb the protein metabolism, and cause arteriosclerosis. Extensive exposure to zinc chloride can cause respiratory disorders<sup>11</sup>. In the work place environment zinc contagion can lead to a flu-like condition known as metal fever. This condition will pass after two days and is caused by over sensitivity. Zinc can be a danger to unborn and newborn children. When their mothers have absorbed large concentrations of zinc the children may be exposed to it through blood or milk of their mothers<sup>32</sup>

The present study concluded that there are many factors which effect on heavy metals concentrations in lactating mothers in Iraqi population thus some life style habitat must be changes and more studies can be investigated to detected other milk minerals and components.

**Table (7) Comparison between minerals concentration  $\mu\text{g/ml}$  in present study and normal value in human milk.**

Minerals	Mn	Cd	Co	Zn
Normal value	0.003- 0.006	<0.001	0-0.00044	0.0004-0.008
Present study	1801.40 $\pm$ 89.16	114.64 $\pm$ 0.027	288.52 $\pm$ 43.91	212.10 $\pm$ 3.53

## References

1. Landrigan J. P H. ,Sonawane B. ,Mattison D. , McCally, M. Garg. Chemicals contaminants in breast milk and their impact on children's health; an overview. *Enviro.Health, prespect.* 2002, *110*,313-315.
2. Nickerson K. Environmental contaminants in breast milk. *J.Midwifery women health*, 2006,*51*,26-34.
3. Environmental Health Series (EHS) No34, Levels of PCBs, PCDDs, and PCDFs inbreast milk,1989, WHO Regional Office for Europe, Copenhagen, Denmark.
4. Tripathi, R. M. Raghunath, R. Sastry, V. NjKrishnamoethy, T. M., Daily intake of heavy metals by infants through milk products. *Sci. Total Environ.* 1999,*227* , 229-235.
5. Guo MR, Hendricks GM. . Human milk and infant formula. In: Guo MR Ed. *Functional Foods: Principles and Technology*. CTI Publications, Inc. Maryland; 2007,*9*: 299-337.
6. Flynn A. (1992) Minerals and trace elements in human milk. *Adv. Food Nutr Res.**36*: 209-52.
7. lenntech ,(2013) Health effects of cobalt . <http://www.lenntech.com/periodic/elements/mn.htm#Health%20effects%20of%20manganese#ixzz2iHXvMTsD>.
8. WHO (2007). Health risks of heavy metals from long-range transboundary air pollution.
9. Greaney K.M. An assessment of heavy metal contamination in the marine sediments of Las Perlas Archipelago, Gulf of Panama, 2005,School of Life Sciences, MSC. Thesis. lenntech ,(2013)
10. Health effects of manganese . <http://www.lenntech.com/periodic/elements/mn.htm#Health%20effects%20of%20manganese#ixzz2iHXvMTsD>.
11. Prasad AS. Zinc in human health: effect of zinc on immune cells. *Mol Med* 2008; *14*: 353-7.
12. Picciano M.F, Trace elements and mineral nutrition during lactation. In: Bogden JD, Klevay LM Eds. *Clinical Nutrition of Essential Trace Elements and Minerals; The Guide for Health Professionals*. Humana Press, Inc.: Totowa,2000, NJ. 139-152.

13. Gadzik J. How much should weight? Quantities equaton, upper weight limits and body mass index prime. connect medicine,200670,81-88.
14. Nikniaz L., Mahdavi R., Gargari B. GayemmagamiS. And Nikniaz Z. , Maternal body mass index dietary intake and socioeconomic status differential effect on breast milk zinc, copper and Iron content. Health promotion perspectives,2011,1, 55-61.
15. Ozkan B. T., Duraz N., Erdemir G. and Llcol Y., Trace elements concentrations in breast milk and sera, relation with lactation. J. of boil environ. SCI.2007,1,143-147.
16. Chierici R., Saccomandi D., and Vigi V. Dietary supplements for the lactating mother: influence on the trace element content of milk. ActaPaediatrSuppl, 1999, 430, 7-13.
17. Salman J.M. , Hassan M.F. and Saleh M. M. , Concentrations of nine heavy metals in muscles of fish *Barbus lutesheckel* , *Aspiusvoraxheckel*, *Barbusgrybusheckel* and *hypophthalmicthyesmolotrix* Richardson collected from Euphrates river. J. of Environmental ,2007,1, 5-19.
18. Hassan, M. F. , Saleh M. M. and Salman J. M, A study of physicochemical parameters and nine heavy metals in the Euphrates river, Iraq , E-J. of Chemistry 2010,7, 685-692.
19. Taha N. D.,Hashem K. A. and Abd-alameer S. I, Determiration lead in Hilla city air. First Environmental research conference 2005.,Babylon University.
20. Clarkson, T.W. , Biological Monitoring of Toxic Metals; plenum press: New york, 1988, 265-282.
21. Scott-FordsmandJ.J ,Toxicity of nickel to soil organisms in Denmark. Rev. Environ. Contam. Toxicol.1997, 148, 1.
22. Bennett B.G. Exposure of man to environmental nickel an exposure commitment assessment. sci. Total. Environ.1982,22 , 203.
23. PalmingerH, I.; Jorhem, L.; Lagerkvist, B. and Oskarson, A. Lead and cadmium levels in human milk and blood. Sci. Total Environ. 1995, 166 , 149-155.
24. Frkovic, A.; Kras, M. and Alebic-Juretic, A. Lead and cadmium content in human milk from the Northern Adriatic area of Croatia. Bull. Environ. Contam. Toxicol. 1997, 58,16-21.
25. Eynon, G. R.; McKenzie-Parnell, J. M. and Robinson, M. F, Cadmium in non-smoking New Zealand women immediately following child birth. Proceedings of the University of Otego Medical School,1985,63, 38-40.
26. Leotsinidis, M.; Alexopoulos, A. andKostopoulou-Farri, E, Toxic and essential trace elements in human milk from Greek lactating women: Association with dietary habits and other factors. Chemosphere,2005,61, 238-247.
27. Ursinyova, M.; Masanova, V., Cadmium, lead andmercury in human milk from Slovakia. Food Addit. Contam.2005, 22, 579-589.
28. Zhang, B.Y. "Effect of manganese on heat stress protein synthesis of new-born rats."World J.Gastroenterol. 2002, 8(1):114-118.
29. Jarvinen, R., and A. Ahlstrom. Effect of the dietary manganese level on tissue manganese, iron, copper and zinc concentrations in female rats and their fetuses." Med.Biol.1975,53(2):93-99.
30. Garcia, S.J. "A manganese-enhanced diet alters brain metals and transporters in thedeveloping rat." Toxicol.Sci.2006,92(2):516-525
31. Bernard, H. Cadmium & its adverse effects on human health , Indian J Med Res.2008,128, 557-564.
32. Nriagu, J. Zinc Toxicity in Humans, MOL MED 2007,14(5-6)353-357.

\*\*\*\*\*