RESEARCH ARTICLE

Toxicity of Fluoride on Essential Trace Elements of the Rat, *Rattus rattus* (Wister)

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ABSTRACT

Fluorine being most electronegative element holds its ubiquitous presence. Fluorides are naturally occurring harmful contaminant in the environment. The aim of the present study was to analyse fluoride – induced toxicity on trace element such as Zn, Cu, Mn and Fe on kidney and thigh muscles of rat, Rattus rattus (Wister). For the present study experimental sets were arranged, one was of 7 days and another was of 14 days. Both set was arranged as short duration exposure period. Each set were intoxicated with fluoride water for different concentration i.e for 7 and 14 days periods. Present study data reveals that rats exposed with fluoride disturbs the concentration of essential trace elements and imbalances the quantity of all studied trace elements as compared to control rat.

Key words: Fluoride, Rat, Days.

INTRODUCTION

Fluoride is an essential trace element for human beings and animals. In small amounts fluoride is beneficial as it is believed to impart stability to bone and enamel, thereby preventing dental carries and osteoporosis to some extent but its higher concentration is highly toxic to humans and animals alike. The permissible limits of fluoride in drinking water as suggested by Bureau of Indian Standards varies between 0.6 to 1.2 ppm BIS (1984), and World Health organization WHO (WHO 1984). permits a maximum of 1.5 ppm of it. Chronic exposure to fluoride above the permissible limits, causes a disease called "Fluorosis". Fluorosis is an important clinical and public health problem in several parts of the world. As fluoride is found in small quantities in almost all foods, it enters the human body mainly through the oral route along with food and water. It can be rapidly absorbed by passive diffusion through stomach, small intestine, mouth, lungs and skin.10 (Khandare *et al.,* 2001). High exposure to fluoride may occur from natural or industrial sources and from misuse of fluoride-containing dental care products.(Borke and Whitford ,1999) The most obvious early toxic effects of fluoride on humans are dental and skeletal fluorosis that are endemic in areas with elevated exposure to fluoride. Detrimental effects of high fluoride intake also affect soft tissues, (Zhavoronkov, 1997: Monsour and Kruger, 1985) including the liver, (Kolodziejczyk *et al.,* 2000) lungs, (Chen *et al.,* 1999) brain, (Shivarajashankara *et al.,* 2002) and kidneys (Borke and Whitford ,1999).

MATERIALS AND METHODS

Chemicals

Sodium fluoride (NaF) were obtained from Chaiga traders.

Experimental Animals

20 Adult albino rats, 60-day-old (weighing 250-300g) were obtained from wadhwani pharmacy Collage Yavatmal. The animals were kept under standard laboratory conditions at 21± 2 °C, fed with balanced diet and water ad-libitum and exposed to 12h light / 12 h dark cycle for one week prior to the start of the experiments. The rats were housed in cleaned and husk filled sterilized polypropylene cages and fed with pellet feed and purified water *ad libitum*. The temperature and humidity were maintained at 23±2ºC and 50 to 70%, respectively. The present study was approved by the Institutional Animal Ethics Committee and conducted as per the guidelines of the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA). 20 albino wister rats were divided into four groups, Control groups given deflouridated, deionized water, while experimental groups 2, group 3, and group 4 administered sodium fluoride (Naf) of different concentration for 72 days. At the end of the experiment, animals were sacrificed and their kidney and thigh muscles, will quickly excised. Metal concentrations in the tissue digest will be determined by Atomic absorption spectrophotometer.

Mineral concentrations:

Tissue samples were blotted to remove extra water, weighed, and wet digested with a 3:1 mixture of 70% nitric acid and 70% perchloric acid by heating below 80ºC.12 The digested samples were cooled, and diluted with triple glass-distilled water to a final volume 5.0 ml. The concentrations of Zn, Cu, Fe, and Mn were measured with an atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

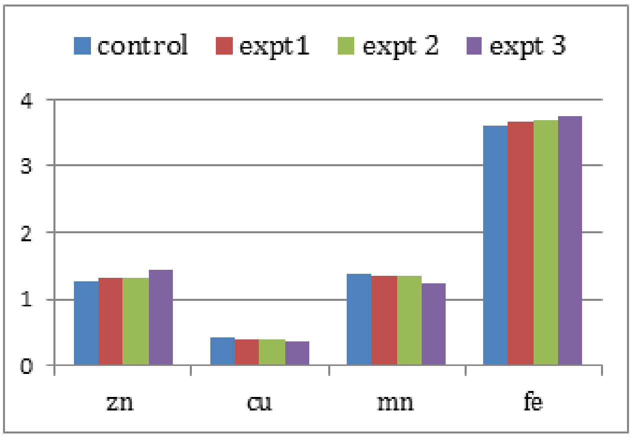
Manganese is a cofactor in many enzymatic systems and has roles in bone formation and metabolism of carbohydrates and cholesterol (Santos *et al*., 2013). This enzyme is involved in fatty acid and protein synthesis as well as melanin and dopamine production. (Carbonell *et al.*,2008) After oxidation in its trivalent form, manganese is bound to transmanganin and is successfully deposited in the liver, skin, and skeletal muscle.

Table 1: Changes in level of trace elements (Zn, Cu, Mn and Fe) in Kidney of rats given varied concentration of sodium fluoride in drinking water 7 days.

Parameters	Control	Expt- 1	Expt- 2	Expt- 3
Zinc	1.66±1.29	1.69±1.3	1.70±1.3	1.72±1.31*
Copper	0.184±0.42	0.182±0.42	0.179±0.42*	0.177±0.42
Maganese	1.95±1.39	1.92±1.38	1.91±1.38	1.89±1.37**
Iron	13.22±3.63	13.19±3.63	13.15±3.62*	13.02±3.61**

Table 2: Changes in level of trace elements (Zn, Cu, Mn and Fe) in Thigh muscles of rats given varied concentration of sodium fluoride in drinking water 7 days.

Parameters	Control	Expt- 1	Expt- 2	Expt- 3
Zinc	2.49±1.56	2.46±1.57	2.44±1.56	2.40±1.54**
Copper	0.092±0.30	0.096±0.30	0.097±0.31*	0.102±0.31**
Maganese	1.36±1.16	1.38±1.17	1.39±1.18*	1.40±1.81*
Iron	12.63±3.55	12.56±3.55	12.69±3.56*	12.69±3.56*



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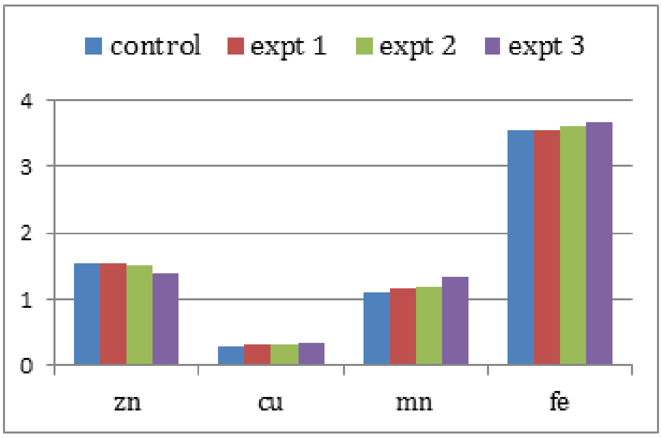

Fig. 2: Changes in level of trace elements (Zn, Cu, Mn and Fe) in Thigh muscles of rats given varied concentration of sodium fluoride in drinking water 7 days.

Table 3: Changes in level of trace elements (Zn, Cu, Mn and Fe) in Kidney of rats given varied concentration of sodium fluoride in drinking water for 14 days.

Parameters	Control	Expt- 1	Expt- 2	Expt- 3
Zinc	1.64±1.28	1.71±1.31	1.71±1.31	1.73±1.31*
Copper	0.183±0.42	0.178±0.42	0.177±0.42*	0.173±0.41**
Maganese	1.92±1.38	1.88±1.37	1.85±1.36	1.80±1.34**
Iron	13.09±3.61	13.04±3.61	13.01±3.60	12.94±3.59*

Table 4: Changes in level of trace elements (Zn, Cu, Mn and Fe) in Thigh muscles of rats given varied concentration of sodium fluoride in drinking water for 14 days.

Parameters	Control	Expt- 1	Expt- 2	Expt- 3
Zinc	2.51±1.58	2.49±1.57	2.46±1.56*	2.38±1.54*
Copper	0.093±0.30	0.099±0.31	0.104±0.32	0.111±0.33*
Maganese	1.37±1.17	1.41±1.18	1.43±1.19	1.52±1.23*
Iron	12.62±3.55	12.67±3.55	12.74±3.56	12.79±3.57*

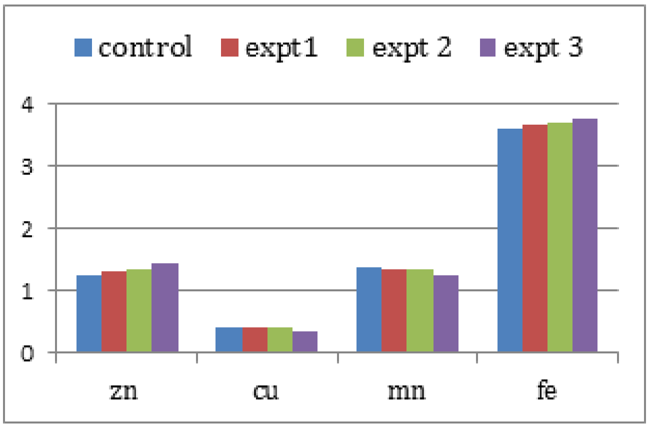

Fig. 3: Changes in level of trace elements (Zn, Cu, Mn and Fe) in Kidney of rats given varied concentration of sodium fluoride in drinking water for 14 days.

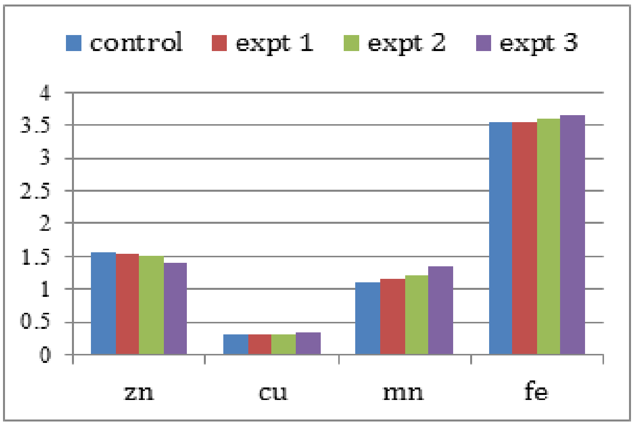

Fig. 4: Changes in level of trace elements (Zn, Cu, Mn and Fe) in Thigh muscles of rats given varied concentration of sodium fluoride in drinking water for 14 days.

Zinc is an essential nutritional and biochemical component , its deficiency has adverse health consequences. Conversely, excessive exposure to Zn is relatively uncommon, and occurs only under heavy exposure to this metal. Zn does not accumulate in proportion to it consumption, as the body content of Zn is modulated by homeostatic mechanisms that act principally on its absorption and on regulation of its liver levels (Berthof, 1988; Goyer,1991; Underwood, 1977). Level of Zn fell significantly in muscles but increases in kidney. Zinc is an essential component of numerous enzymes and is part of the structure of many proteins. Zinc containing enzymes are found in all parts of the major metabolic pathways involved in carbohydrate, lipid, protein, and nucleic acid metabolism, epithelial tissue integrity, cell repair and division, and vitamin A transport and utilization (Kaneko, 1989).

Copper (Cu) is plentiful in the environment and essential for the normal growth and metabolism of all living organisms(Schroeder *et al*., 1966; Carbonell and Tarazona ,1994).In the present study Cu fell significantly in kidney while increased in muscles. Abnormal levels of copper intake may range from levels as low as to induce a nutritional deficiency to levels as high as to be acutely toxic. Copper is an essential component of the animal system and plays an important physiological role in haematopoiesis, myelin formation, phospholipids formation, connective tissue metabolism and enzyme systems.

Fe level increases significantly in kidney and muscles similar reports observed by Bhatnagar *et al.,* 2003. Iron is one of the important mineral elements necessary for the effective metabolism of the mammalian body. Although it is present in very small amounts in the body, iron plays an important role in many metabolic processes Fe is important in formation of haemoglobin molecule. It is essential consitituent of myoglobin and repiratory enzymes. Deficiency of Fe is related to restlessness, tiredness and imbalances in brain iron homeostasis during development which result into symptoms of neurodegenerative (Vaderveer, 1990) In present study level of Fe increases significantly in kidney and muscles.

Statistical analysis of the mean and standard deviation of treated and control groups was done by one –way ANOVA without replication. Data related to trace metal concentration in control and experimental tissue are summarized in Table 1 and 2 changes observed in Cu, Mn, Fe and Zn level in kidney and muscles of the rat intoxicated by fluoride

CONCLUSION

Body has an elaborate system for managing and regulating the amount of key trace metals circulating in blood and stored in cells. When this system fails to function properly, abnormal levels and ratios of trace metals can develop. One of the most common trace-metal imbalances is elevated copper and depressed zinc. The ratio of copper to zinc is clinically more important than the concentration of either of these trace metals. Zn is the second most abundant transition metal in organisms after iron and it is the only metal which appears in all enzyme classes, while copper is present in every tissue of the body, but is stored primarily in the liver, with fewer amounts found in the brain, heart, kidney, and muscles. In the above experiment slight changes in the concentration is observed, comparing both experiment i.e 7 days and 14 days short day exposure changes are more in 14 days sodium fluoride intoxication.

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Conflicts of interest: The authors stated that no conflicts of interest.

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