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Influence of Zinc and Molybdenum Contents in Soil and Drinking Water for the Development of Esophageal Cancer: A Cross Continental Study

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Abstract

There are several endemic areas (hot spot) of esophageal cancer (EC) around the world and the geochemical structure of that area has a vital role for the endemicity. Different elements in soil are lixiviated in water which is the major source of different elements needed for the living system. Thus, the elemental status of soil and drinking water of a particular area influences the elemental status ofliving system. In human system, the deficiencies of Zn and Mo have got an important role for the development of esophageal cancer. So, Zn and Mo contents of soil and drinking water of an endemic area of esophageal cancer may be related to the development of deficiencies of these elements in human system.

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In the present investigation, a comparative evaluation of Zn and Mo contents in soil and drinking water of a hot spot and a cold spot of EC was carried out. The samples of soil and drinking water (underground water) were taken from Eastern Cape, South Africa (RSA) (a hot spot) and West Bengal, India (INDIA) (a cold spot). The soil and drinking water were analyzed for Zn and Mo contents using Atomic Absorption Spectrophotometer (AAS). The results showed that both soil and drinking water of Eastern Cape, South Africa was significantly deficient in Zn and Mo contents as compared to West Bengal, India. Apart from other environmental risk factors the deficiencies of Zn and Mo in both soil and drinking water of Eastern Cape, South Africa are the major contributors for the development of an endemic area of esophageal cancer.

Keywords: Esophageal Cancer; Trace elements; Zinc; Molybdenum; Soil; Water; Eastern Cape; South Africa; West Bengal; India.

1. Introduction

Among the three top ranking areas having the high incidence of esophageal cancer in the world, Linxian Province of China and the Caspian Littoral region are ranking behind Transkei of South Africa which is called as epicenter of the disease in Africa [1]. During the period of 1998-2002, the contribution of esophageal cancer to total male cancer was 41.8% and to total female cancer was 31.3 % [2]. During the period of 1998- 1999, the age-standardized rate (ASR) of EC in this region was much higher than the national average [3]. On the other hand, West Bengal, a state in Eastern India the incidence of EC is much lower in comparison to that of Eastern Cape, South Africa (RSA) or other global hotspots [4].

The distribution pattern of an endemic disease varies with geographical location. This variation in the distribution pattern may be due to the exposure of living system to the geographical environmental factors like geomorphology, geochemical structure, lithology, soil, food grain, water etc. Different essential trace elements in soil are lixiviated in water and easily absorbed by plant and other living systems. So, different biochemical processes in human system are influenced by the qualities of drinking water primarily and soil secondarily [5, 6, 7, 8, 9]. The medical geology of esophageal cancer reveals that both deficiency and excessive concentrations of some elements play important roles for the development of the disease [10, 11, 12. 13, 14, 15, 16, 17]; but the role of trace elements in the development of hotspot of EC is conflicting [18, 19, 20]. While studying with cancerous patients as well as animal models, the roles of trace elements like, Zn, Se, Mo, Mg etc. for the development of EC has been justified by many researchers [21, 22, 23, 24, 25, 26, 27]. Our earlier report indicated that the deficiency in Zn and Mo in food grain of Eastern Cape, South Africa has been reflected in the hair of the inhabitants [28]. In the present study we have measured the levels of Zn and Mo in soil and drinking water of Eastern Cape, South Africa (RSA) and West Bengal, India (INDIA) to explore the influence of soil and drinking water for the development of an area endemic with EC.

2. Materials and Method

2.1. Sampling

The objective of the sampling was to identify the relationship between the incidence of EC and levels of Zn and

Mo in soil and drinking water. High incidence area for EC in Eastern Cape, South Africa (RSA) was taken as hotspot for EC. Thirty composite near-surface (20–30 cm, below A0) soil samples were collected randomly from local land of the high incidence area used for the cultivation of staple food (maize). The source of drinking water of the inhabitants of Eastern Cape, South Africa (RSA) is the underground water. Thirty underground water samples were collected randomly from the tube-well used by the inhabitants of high incidence area.

A rural area of Bankura District of West Bengal, India (INDIA) was chosen as a cold spot for EC where cultivation of rice (the staple food of West Bengal) is the main source of income and underground water is used as drinking water. Composite near-surface (20–30 cm, below A0) soil samples were collected randomly from local land for cultivation. Again, the underground water samples were collected from tube-well used by the inhabitants. The number of samples was thirty for both soil and water.

2.2. Analysis of Zn and Mo

Zn and Mo levels in soil and water were analyzed according to the standard methods of American Public Health Association [29].

Soil samples were air-dried, grinded and sieved through 2 mm sieve. Soil sample (2 g) was digested in 40 ml of aqua regia (HNO_3 and HCL in the ratio of 1:3) and 4 ml of perchloric acid in a conical flask on hot plate. After cooling it was filtered and made up the volume with de-ionized water. A blank was similarly prepared without soil sample. The filtrate was analyzed by Atomic Absorption Spectrophotometer (AAS) (GBC make 908 Model).

Water sample (100ml) was digested in 10ml of aqua regia and 1 ml of perchloric acid in a conical flask on hot plate. After total digestion and subsequent cooling the volume was made up with de-ionized water. A blank was prepared with de-ionized water and analyzed by AAS (GBC make 908 Model).

2.3. Statistical analysis

Excel 7.0 (Microsoft Office Excel 2007 for Windows) was used for data management and statistical analysis. Level of significances between different groups was calculated using Student t test.

3. Results and Discussion

Our study shows that the soil of RSA is significantly deficient in Zn & Mo with respect to India (both Zn & Mo: $p < 0.0001$) (Figure 1A; Table 1). This pattern has also been reflected in case of water (both Zn & Mo: $p < 0.0001$) (Figure 1A; Table 1).

Some earlier studies have indicated that the deficiency of Zn and Mo in EC patient is strongly correlated to the deficiency of the elements in the diet [21-28]. The available minerals are absorbed form the soil by plants and the plant products are taken by humans as their diet. So, soil is the main supplier of nutrient elements. Apart from food, water is also an important route for the supply of nutrient elements. The contents of elements in water also depend on soil and different geochemical factors. Thus, the deficiency of elements in water is a reflection of the deficiency in soil which is indicated by our results about Zn and Mo.

Table 1: Comparison of levels (ppm) of Zn & Mo in water and soil between INDIA & RSA

	Level of Zn			Level of Mo		
	RSA	INDIA	p-value	RSA	INDIA	p-value
Soil	36.19±11.27	82.27±23.48	1.45×10^{-14}	85.62±16.56	118.31±27.96	3.67×10^{-7}
Water	0.11±0.06	0.299±0.07	2.63×10^{-10}	0.18±0.1	0.85±0.5	4.9×10^{-10}

*Data represents the Mean ± standard deviation.

In case of soil we are in agreement with an earlier report of Kibblewhite and his colleagues where Zn and Mo levels in soils tended to be substantially lower in the high-risk regions for EC in the Butterworth District, Transkei [30]. A report from Golestan province of north Iran made by Keshavarzi and his colleagues about the Zn content of drinking water is also consistent with our report where they found that Zn content in water increases from high incidence to low incidence areas of EC [20].

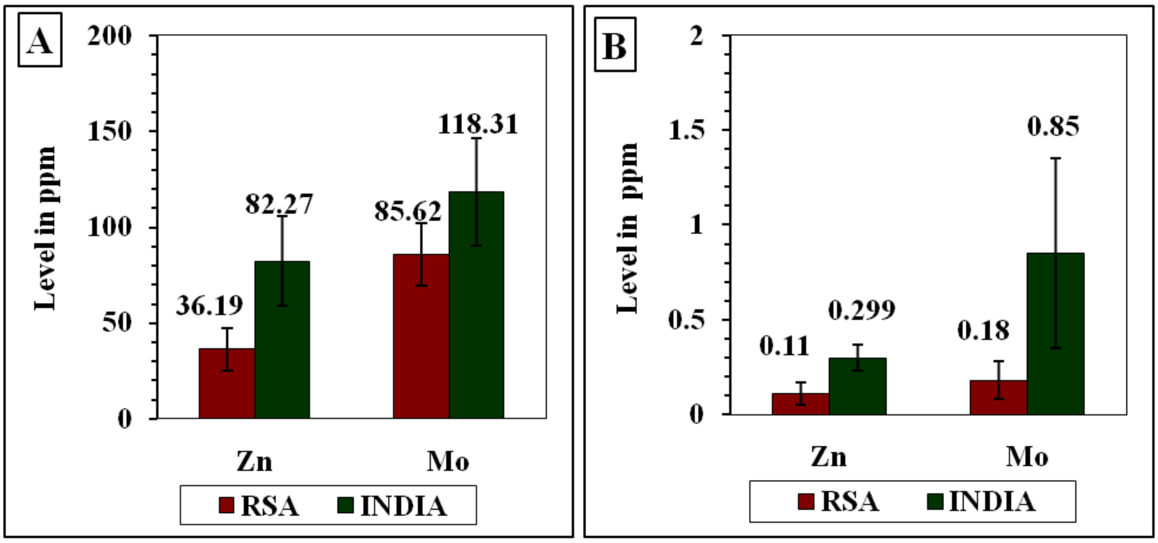

Figure 1: Comparison of levels of Zn and Mo in soil (A) and water (B) between INDIA & RSA

The sources of the mineral elements for plants, animals and human are soil and water which pass through the food chain to humans [31]. Therefore, deficiencies of elements in soil and groundwater are circulated to human system through food chains and create deficiencies in human system.

4. Conclusion

In this paper we have studied the geochemical and environmental role behind the development of hotspot for EC in Eastern Cape. Deficiencies of Zn & Mo in soil and water have been found as one of the major causes for the

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