Edible Salt: A Possible Source of Heavy Metal Intake in Sri Lanka

WMCJ Wijekoon[1], MN Kaumal[2] and PABN Perumpuli[3]*
[1]Department of Soil Science, [3]Department of Food Science and Technology, Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, Sri Lanka
[2]Department of Chemistry, Faculty of Science, University of Colombo, Sri Lanka

Abstract
Salt is an essential component in the human diet. Salt contains minute quantities of essential and non-essential metal elements, other than sodium and chloride. Salt requirement of Sri Lanka is almost entirely fulfilled by seawater processing in the salterns located in semi-arid regions (Northwestern and South-southeastern) of the country. The surface circulation pattern of the seawater around Sri Lanka indicates possible contaminant loading and concentration in seawater. This may affect the quality of the edible salt produced from the seawater. Thus, the current study was conducted to investigate the amount of heavy metals in commercially available table salt products in Sri Lanka. Two salt samples representing two major salterns (located in South-southeastern and the Northwestern region) were randomly selected from the local market and analyzed for Cu, Fe, Pb, Cd, Cr, and Zn levels using Atomic Absorption Spectroscopy. Only Fe and Cd were detected in both salt samples, and higher concentrations of both the ions were observed in the salt produced in the South-southeastern region than the Northwestern region. This could be linked with swirling and mixing of seawater currents, loaded with contaminants while moving along the west coast, in the south-southeastern region resulting in concentration of metal elements in seawater. The estimated Fe intakes with salt (0.059 and 0.092 mg per 6 g of salt per day, for Salt A and B, respectively) was less than the daily requirement of 15 mg specified by the WHO, whereas the estimated daily Cd intakes from salt A and B (0.018 and 0.024 mg per 6 g of salt) appeared to be similar to the provisional tolerable monthly intake of 0.025 mg/kg of body weight. Therefore, findings of this inceptive study suggest that detailed investigation on the composition of salt products including temporal and geographical variability, possible contaminations in the production process and daily dietary salt intake levels would add valuable information to the avenues of heavy-metal intake.

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Corresponding author: buddhikap@fst.ruh.ac.lk

Introduction
Salt is essential for the health of people and animals, and is used universally as a seasoning agent. Other than sodium and chloride, minute quantities of potassium (K), magnesium (Mg), calcium (Ca), sulphate ions (SO_4^{2-}), iron (Fe), zinc (Zn), nickel (Ni), chromium (Cr), cadmium (Cd), manganese (Mn), copper (Cu), and cobalt (Co) also present in salt in varying levels. Human body needs both essential and non-essential metal elements in minute amounts. Salt is a good source of various such minerals. The health authorities have recommended a daily intake of salts in terms of 3400 mg/day of chlorides and 2400 mg/day of sodium. Thus, the total quantity of daily salt consumption should be maintained at about 5-6 g (WHO 2002).

Salt requirement is fulfilled almost entirely by seawater processing in the salterns located in semi-arid regions (northwestern and south-southeastern) in Sri Lanka. Studies on seawater contamination in various parts of the world have indicated the presence of heavy metals at varying levels, especially in the areas close to industrial sites and human settlements (Bazzi 2014; Pérez-López *et al.*, 2003). An assessment of the surface circulation patterns of the Indian ocean near Sri Lanka by Vos *et al.* (2013) indicates that the ocean currents reaching northwestern and southern part of the country comes along the densely populated Indian coast as well as capital of Sri Lanka. This signals that the seawater could be loaded with contaminants along its path. Furthermore, mixing of ocean currents coming along the west coast and the east coast can also be observed in the southern region of Sri Lanka. This may lead to concentration of the contaminants in the seawater.

Since salt is a frequently used basic food item in daily routine of Sri Lankans, this study aims to investigate whether the commercially available salts samples contain substantial amount of heavy metals, and the possible relationship between the pattern of surface ocean currents and the metal concentrations in the salts.

Materials and Methods
Two commercially available table salt samples representing salterns located in North Western

(Salt 1) and South-southeastern (Salt 2) regions of Sri Lanka were randomly purchased from the local market. The samples were analyzed through flame Atomic Absorption Spectroscopy (AAS-GBC932+) for the determination of selected trace elements and heavy metals (Cu, Fe, Pb, Cd, Cr, and Zn). The precision of analysis was checked by triplicate measurement of target metal ions. Surface ocean current behavior was adopted from the findings of Vos *et al.* (2013).

Results and Discussion

The distribution of essential and non-essential heavy metals in two salt samples is summarized in Table 1.

In the case of essential heavy metals, Fe was found in both of the salt samples where the highest amount was detected in the sample from South-southeastern region. On the other hand, Zn was not detected in both of the tested salt samples where the minimum detectable level of Zn was 0.25 ppm. According to the results, the daily uptake of Fe calculated on the basis of 6 g of salt 1 and salt 2 per day were 0.059mg and 0.092mg respectively, and was less than the recommended total daily intake of 15mg/day (FAO/WHO 2001).

Table 1: Concentrations of selected trace metal elements in two tested salt samples

Sample	Essential heavy metals		Non-essential heavy metals			
	Fe (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Cr (mg/kg)	Cu (mg/kg)	Pb (mg/kg)
Salt 1	9.75±0.016	N.D.	2.97±0.005	N.D.	N.D.	N.D.
Salt 2	15.28±0.015	N.D.	4.07±0.004	N.D.	N.D.	N.D.

N.D. = Less than minimum detectable limit
Salt 1: North Western saltern Salt 2: South-southeastern saltern

Both salt samples were also tested for non-essential heavy metals including Cd, Cr, Cu, and Pb. Cd were observed in both salt samples, while Cr, Cu, and Pb were not detected (minimum detectable level 1 ppm). As same as in Fe, the level of Cd was found to be high in the commercial salt sample produced in the Southern Province of Sri Lanka. Furthermore, the daily intake of Cd from salt 1 and salt 2 calculated on the basis of 6 g of daily intake of salt was found to be 0.018 and 0.024mg, respectively. According to the world health organization guidelines, the provisional tolerable monthly intake of cadmium is 0.025 mg/kg body weight (World Health Organization 2010). Thus, when compare with the WHO recommendations, both of the salt samples can be considered as a Cd rich sources.

Furthermore, the results indicate that the salt 2 from the South-South Eastern region of Sri Lanka is having higher Fe and Cd levels than the salt 1 obtained from North Western Province. The surface ocean currents loaded with the contaminants while moving along the populated west coast mixing and swirling in the south-southeastern region may have concentrated the metal elements in seawater compared to the seawater in the northwestern region.

Conclusions

According to the findings, the estimated intake of Cd along with the edible salt appears to be at a higher level and needs attention. However, the result of this study is limited to two commercially available salt products sampled instantaneously. Furthermore, the other conditions leading to the contamination of salts with heavy metals, such as underlying soil properties of the salterns and the quality of the production process, are not addressed in this study. Despite the aforesaid limitations, the results of the study provides an insight into the importance of initiating a detailed investigation on the intake of trace elements along with the edible salt and the water quality issues related to the salt production process.

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