Selenium concentration in soil of Iran

L. Nazemi[A,H], Sh. Nazmara[B], MR. Eshraghyan[C], M. Younesian[D], H. Sereshti[E], A. Moameni[F], J. Shahtaheri[H] and S. Nasseri[B]

[A]Department of Nutrition and Biochemistry, School of Public Health, Tehran University of Medical Sciences, Iran.
[B]Department of Environmental Health Engineering, School of Public Health, Tehran University of Medical Sciences, Iran.
[C]Department of Epidemiology and Biostatistics, Tehran University of Medical Sciences, Iran.
[D]Department of Environmental Health, School of Public Health, Tehran University of Medical Sciences/ Tehran, Iran. Environmental Research Centre, Iran.
[E]Faculty of Sciences, Faculty of Chemistry, Tehran University, Iran.
[F]Soil and Water Research Institute, Tehran, Iran.
[G]Department of Occupational Health, Environmental Research Centre. School of Public Health, Tehran University of Medical Sciences, Iran.
[H]Corresponding author. Email snazmara@razi.tums.ac.ir

Abstract
Selenium (Se) plays a key role in the maintenance of normal health in human population. This micronutrient is a crucial nutrient for human health. Se enters the food chain through plants and its concentration in foods is determined by a number of geological and geographical factors. The content of Se in food depends on the Se content of the soil where plants are grown or animals are raised. Since no precise report has been drawn up on Se status for soil and water in different regions of Iran, this research measured soil Se in selected areas of North, South, and Center of Iran (from east to west) for continuing complementary research in the future. Sampling was performed in 51 locations. 17 samples of surface cultivated soil (at depth between 0-20 cm) were collected in each area. Upon preliminary preparation of samples at a research laboratory, the Se rate was measured with ICP-OES Model Varian Vista-MPX. The results of this study demonstrate that some parameters such as rainfall conditions in sampling time, rainfall condition in the days before sampling, the elevation above sea level of sampling points, spraying poison condition, and irrigation methods such as underground water, subterranean, dry farming had significant effects on soil Se rates.

Key Words
Selenium, soil, Iran, rainfall situation, pesticide used, type of irrigation.

Introduction
Selenium (Se) is a trace element that depending on its concentration, it is both toxic and an essential part of nutrition. Se, as an essential part of nutrition was first reported in 1957 by Schwarz and Foltz, who called it factor 3 (Schwarz and Foltz 1957). Factor 3 is an operational name given to an incompletely characterized selenium-containing natural product that, in minute amounts, prevents liver damage in rats due to deficiency of vitamin E. Se is an essential trace element that is an integral part of many proteins, with catalytic and structural function. The antioxidant properties of some selenoproteins, such as glutathione peroxidase, may be particularly important in carcinogenesis and heart disease. The content of Se in food depends on the Se content of the soil where the plants grown or animals are raised. In accordance with the outcomes generated by several surveys, it has been specified that, Se deficiency resulting from Se relates to the high risk of diseases such as cancer, cardiomyopathy, myocardial deaths, arthritis rheumatoid, as well as the lesions affected on failure-to-thrive (F.T.T.) (Rayman 2000; Clark *et al.* 1996; Willett *et al.* 1983; Alissa *et al.* 2003; Bergqvist *et al.* 2003; Altekin *et al.* 2005; Kosar *et al.* 2006). The aim of this study was to measure Soil Se concentration in some areas on North, South, and Center (from east to west) of Iran for the first time.

Materials and methods
Sampling was performed on north, south, and central (from east to west) regions of Iran. Using map of Iran and specifying length of sampling route, dimensions were computed 850 km northward; 2000 km southward, and 2350 km toward the central region, approximately. Consequently, the taken samples were determined in northern region at an approximate distance of 50 km; in southern region at an approximate distance of 118 km and in central region at an approximate distance of 138 km.

In every selected area in North, South, and Central of Iran, 17 samples of surface soil (at a depth of 0-20 cm) samples were collected at the points indicated in Figure 1. In this study, cultivated soil was collected. A questionnaire related to geographical and regional special particulars such as rainfall situation, pesticide used, types of irrigation, and elevation of sampling points were used and filled. Samples are kept in special

sampling vessels, refrigerated, and sent to the research laboratory of Faculty of Science, Faculty of Chemistry, Tehran University to determine Se rate. Upon preliminary preparation using Aqua Regia digestion method for soil samples, the Se rates were measured with ICP-OES Model Varian Vista-MPX. The results were statistically analyzed through SPSS Ver. 11 to determine the relations between Se concentrations and the data collected by questionnaire.

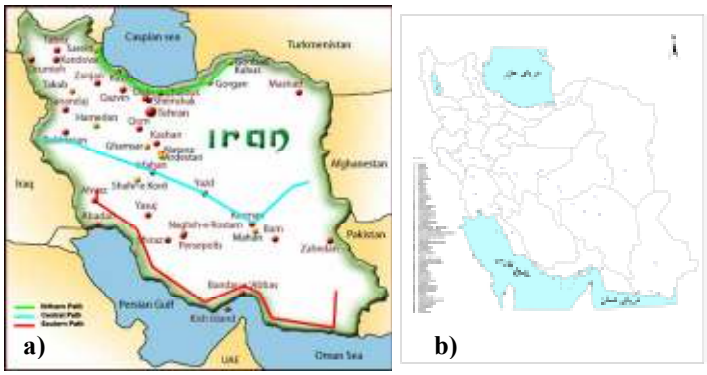

Figure 1. Soil Selenim sampling paths(a) and points(b) of Iran.

Results

Results demonstrated that, there are a statistical significant difference between the mean of soil Se in the different selected areas of North, South, and Center of Iran (Sd = 0.08)(PV <0.0001). The highest mean of total soil Se in north of Iran was seen in Astara – Abassabad areas with (0.28 ppm Se), Ramsar, and Gonbadkavos (0.27 and 0.25 ppm Se) respectively, and the lowest mean soil Se was belonging to Sari and Kord Koy (0.04 and 0.05 ppm Se) respectively (Figure 2). The highest total soil Se in South of Iran was seen in Behbahan with (0.41 ppm Se) and Omidiye and Chahbahar (0.39 and 0.39 ppm Se) and the lowest total soil Se were belonging to Bandare Khamir and Jahloo Kenare (0.15 and 0.16 ppm Se respectively) (Figure 3). The highest total soil Se in center of Iran was seen in Yazd with (0.45 ppm Se) and Shabab and Kerman (0.36 ppm Se) and the lowest mean soil Se were belonging to Nay Band and Daran with (0.11 and 0.12 ppm Se, respectively) (Figure 4).

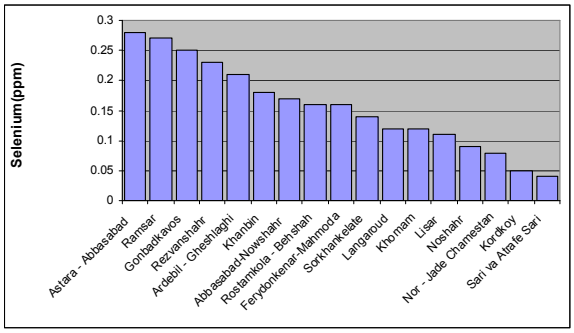

Figure 2. Mean of total soil Se in selected areas of North of Iran (2006-2007).

According to the WHO classification (< 0.05 ppm total soil Se = deficiency), the rate of soil Se in 2 areas in North of Iran (Sari and surburbs, Kord Koy, 0.04, 0.05 ppm total soil Se respectively) were at the range of low or deficient. But in according to the Tan's classification, the rates of soil Se in 10 regions of total 51 soil samples in North and Center of Iran were less than < 0.15 ppm Se, and are thus low or deficient in Se. Most of the soil samples (n = 32) in North, South, and Center of Iran (62%) were classified in moderate values of

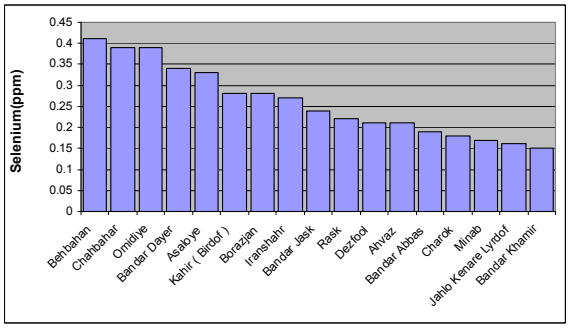

Figure 3. Mean of total soil Se in selected areas on the South of Iran (2006-2007).

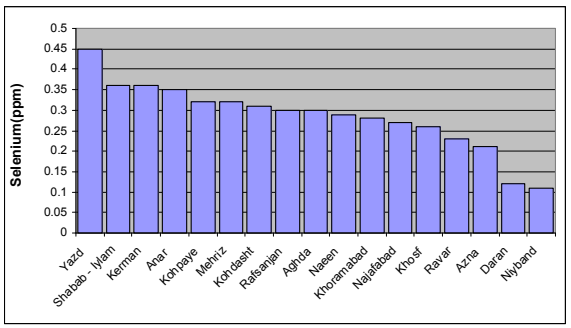

Figure 4. Mean of total soil Se in selected areas of Center of Iran (2006-2007).

total Se in the soils (0.175-0.40 mg/kg total soil Se). The total soil sample of 11 areas have low Se rates (< 0.15 ppm soil Se, (21.56%) and in the six areas the amount of total soil Se were be low and deficiency (11%) but total soil Se in Yazd, in Center, and Behbahan in South of Iran were 0.45 and 0.41 ppm which categorized in high Se rate (> 0.40 ppm Se)(Tan *et al.* 1994). A total soil Se content exceeding 0.5 ppm could be regarded as potentially toxic (Kubota and Allaway 1972; Pureves 1985). There are statistical significant difference between soil Se rate in North, South and Center of Iran and rainfall status in selected areas (PV <0.001). In high rainfall areas = (0.18 ± 0.019 ppm Se). In low rainfall areas = (0.28 ± 0.016 ppm Se). Between the total mean rate of soil Se and the kind of irrigation, there was a significant statistical difference. To this case, in the areas which were cultivated by dry farming, the mean rate of soil Se was more than the regions that irrigated by underground water, subterranean. There are statistical significant differences between the mean soil Se rate in North, South, and Center of Iran, and the height of region from the sea level, that is the areas which had (200–1000 meter height from the sea level) the highest total mean soil Se rate (0.30 ppm Se) in comparison with the regions that had lower total mean soil Se rate (0.16 ppm Se) with elevations under the sea level. There were statistical significant difference between the mean rate of soil Se and the use of spray poison: the mean soil Se rate in the areas that spray poison, at least once a year was higher than the regions where spraying poison has never been performed (P<0.021).

Discussion

Se is a trace element used in proteins, in the form of the twenty-first naturally occurring amino acid (selenocysteine) (Science News 2008). The major determinant of Se status in humans is the level of available Se in the soil, where plants are grown or animals are raised. (Rayman *et al.* 2000; Combs *et al.* 2001). Most Se ingested by animals and humans comes from the soil, through plants. Levels of Se available in soils are highly variable globally. Areas that are notably low in Se include parts of China, Siberia, Central Africa, Eastern Europe, and New Zealand (Combs *et al.* 2001). Although large areas have not yet been mapped for Se, it is apparent that many people have too little Se to support maximum selenoenzyme expression (Rayman 2002). In this study, for the first time it was found that, there were significant difference among the total soil Se rate in selected areas of North, South, and Center of Iran. The highest total soil Se was found in central regions of Iran, and the lowest amount was found in the north of Iran. Se in many European countries is relatively low due to the low soil Se concentrations or poor bioavailability of soil Se in a great part of Europe (Bugel *et al.* 2008).

Comparison of the rates of total soil Se levels in three parts (North, South, and Center) of Iran showed that, the lowest level was in the North regions of the country. Bioavailability of Se may have fallen in the areas subject to acid rain or excessive artificial fertilization of soils, in which, both of them reduce plant absorption of the mineral (BMJ 1997). Findings were in accordance to the results of above research. As it has demonstrated, there were the statistical significant differences between the soil Se rate in North, South, and Center of Iran and rainfall status in selected areas (PV <0.001). In high rainfall areas = (0.18 ± 0.019 ppm Se). In low rainfall areas = (0.28 ± 0.016 ppm Se). Also, this study showed that, in some areas in North of Iran, where the soil was poor in Se. For this reason there is a need to do more researches in these regions. Finland is the first country decided to increase the Se content of Finnish feed and food by the addition of sodium selenate to fertilizers, at a concentration of 16 or 6 mg/kg for cereal and grassland crops, respectively (Koivistoinen and Huttunen 1986). Total average water Se level in all of selected areas in North, South, and Center from east to west of Iran was less than 0.010 ppm. WHO's Guidelines for drinking water quality - the international reference point for Standard Setting and drinking water safety- set up in Geneva, in 1993, demonstrated that Se can be normally found in fresh water/surface water/ ground water is less 0.01 mg/L Therefore, Se in water samples was in a standard setting (Lenntech 1998). WHO set the health-based guideline for Se in drinking water at 10 µg/L (WHO 2004, 2006).

Acknowledgments
We thank the Center for Environmental Research, and Tehran University of Medical Sciences for funding; Mrs Sohyla Samadi, analytical services at Department of Chemistry, Faculty of Science, and Tehran University for his skilled technical assistance to do ICP analysis.

References

Lobanov A, Hatfield D, Gladyshev V (2008) Reduced reliance on the trace element selenium during evolution of mammals. *Genome Biology Science News* **9**, R62 doi:10.1186/gb-2008-9-3-r62

Alissa EM, Bahijri SM, Ferns GA (2003) The controversy selenium and cardiovascular disease: a review of the evidence. *Med Sci Monit.* **9**, 9-18.

Altekin E, Coker C, Sisman AR, Onvural B, Kuralay F, Kirimli O (2005) The relationship between trace elements and cardiac markers in acute coronary syndromes. *J Trace Elem Med Biol*. **18**, 235-242.

Bergqvist AG, Chee CM, Lutchka L, Rychik J, Stallings VA (2003) Selenium deficiency associated with cardiomyopathy: a complication of the ketogenic diet. *Epilepsia* **44**, 618-620.

Rayman MP (1997) Dietary selenium: time to act - low bioavailability in Britain and Europe could be contributing to cancers, cardiovascular disease, and subfertility. *British Medical Journal* **314**, 387-388.

Clark LC, Combs GF,Turnbull BW (1996) Effects of Selenium Supplementation for cancer prevention in patients with carcinoma of the skin: a randomized controlled trial. *J. AM.Med. Assoc.* **276**, 1957-1963.

Combs GF (2001) Selenium in global food systems. *Br J Nutr* **85**, 517-547.

Koivistoinen P, Huttunen JK (1986) Selenium in food and nutrition in Finland. An overview on research and action. *Ann. Clin.Res.* **18**,13 -17

Kosar F, Sahin I, Taskapan C, Kucukbay Z, Gullu H, Taskapan H, Cehreli S (2006) Trace element status (Se, Zn, Cu) in heart failure. *Anadolu Kardiol Derg.* **6**, 216-220.

Kubota J, All away WH (1972) Geographic distribution of trace element problems in Agriculture. In 'Micronutrients in agriculture' pp.523-553. (Soil Science Society of America,Madison).

Lenntech (1998) 'EU'S drinking water Standards'. Council Directive 98/83/Ec on the quality of water intended for human consumption.

Medilexicon. Medical Dictionary, http://www.medilexicon.com/medicaldictionary.php?t=31610

Pureves D (1985) 'Trace-element Contamination of the environment'. (Elsevier SciencPublishers: The Netherlands).

Rayman MP (2000) The importance of selenium to human health. *Lancet* **356**, 233-241.

Rayman MP (2002) The argument for increasing selenium intake. *Proceeding of the Nutrition Society* **61**, 203–215.

Schwarz K, Foltz CM (1957) Selenium az an integral part of factor 3 against dietary necrotic liver degeneration. *J. Am. Chem. Soc.* **19**, 3292-3293.

Tan JA, Wang WY, Wang Dc, Hou SF (1994) Adsorption volatilization and speciation of selenium in different types of soils in China. In Selenium in the Environment'. (Eds WT Frankberger, S Benson) pp 47-68. (Marcel Dekker, Inc.: New York)

WHO (2004) 'Guidelines for Drinking-Water Quality'. Vol 1: Recommendations. 3rd editon. (Geneva: World Health Organization).

WHO (2006) 'Guidelines for Drinking-Water Quality', Addendum to Volume 1: Recommendations. 3rd edition. (Geneva: World Health Organization)

WHO (2001) 'Selenium - Poison Information Monograms 483.Geneva, International program on Chemical Safety'. (Geneva: World Health Organization)