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Radioactivity levels in the mostly local foodstuff consumed by residents of the high level natural radiation areas of Ramsar, Iran

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ABSTRACT

Among High Level Natural Radiation Areas (HLNRAs) all over the world, the northern coastal city of Ramsar has been considered enormously important. Many studies have measured environmental radioactivity in Ramsar, however, no survey has been undertaken to measure concentrations in the diets of residents. This study determined the ^{226}Ra activity concentration in the daily diet of people of Ramsar. The samples were chosen from both normal and high level natural radiation areas and based on the daily consumption patterns of residents. About 150 different samples, which all are local and have the highest consumption, were collected during the four seasons. In these samples, after washing and drying and pretreatment, the radionuclide was determined by α-spectrometry. The mean radioactivity concentration of ^{226}Ra ranged between 5 ± 1 mBq kg^{-1} wet weight (chino and meat) to 725 ± 480 mBq kg^{-1} for tea dry leaves. The ^{226}Ra activity concentrations compared with the reference values of UNSCEAR appear to be higher in leafy vegetables, milk and meat product. Of the total daily dietary ^{226}Ra exposure for adults in Ramsar, the largest percentage was from eggs. The residents consuming eggs from household chickens may receive an elevated dose in the diet.

1. Introduction

Among High Level Natural Radiation Areas (HLNRAs) all over the world, the northern coastal city in Iran, Ramsar, has been a main concern due to very high natural radioactivity levels. Natural radionuclides, especially ^{226}Ra and its decay products, are distributed through the local hot springs that are used by inhabitants and visitors. These hot springs contain high ^{226}Ra concentrations such as 146 kBq m^{-3}. Also the other origin of the Naturally Occurring Radioactive Materials (NORM), in Ramsar, is mainly due to the presence of very high amounts of ^{226}Ra in soil such as 38 kBq kg^{-1}, related to geological and geochemical processes ((Ghiassi-Nejad et al., 2005; Shabestani-Monfared et al., 2004; Sohrabi, 1990; and Ghiassi-nejad et al., 2002).

^{226}Ra with 1602 year half-life decays through α-emission to ^{222}Rn. Among natural radionuclides, the α-emitters are significant due to of their potential internal human radiation exposure (Hosseini and Fathivand, 2004).

In Iran, a number of studies have been previously undertaken to measure radioactivity in foodstuffs and environmental samples in normal and HLNRAs (Ghiassi-Nejad et al., 2003; Fathivand and Amidi, 2006; Hosseini et al., 2006a; and Hosseini et al., 2006b). Notably the study undertaken by Ghiassi-Nejad et al., (2003) determined the soil-to-vegetation concentration ratio (CR) of ^{226}Ra in HLNRAs of Talesh Mahalleh and estimated the effective dose due to ingestion of edible vegetables. However this did not consider exposure through other food types in the diets of residents

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in this region (Ghiassi-Nejad et al., 2003). Another study was conducted to establish a reliable method for measuring low concentrations of ^{226}Ra and ^{224}Ra in fruit and vegetables samples taken from Ramsar (Hosseini and Fathivand, 2004).

In most cities, the diets of residents include products both locally grown and raised and imported from other regions, including Ramsar where they have their own agriculture and animal husbandry activities. Local foodstuff may have elevated radioactivity concentrations because they could be cultivated in high NORM areas in Ramsar. Local foodstuff would be one of the noticeable exposure pathways (Scheibel and Appoloni, 2007; Assunta Meli et al., 2013 and Asaduzzaman et al., 2015).

The aim of this study was to present ^{226}Ra activity concentrations in different kinds of local food samples representing the daily diet of Ramsar residents. The reason for selection of ^{226}Ra was due to its high concentration in the area as evidenced by the results of the previous studies. Therefore it was hypothesized to contribute a large proportion to the annual public effective dose (Ghiassi-Nejad et al., 2005; Shabestani-Monfared et al., 2004; Sohrabi, 1990; Ghiassi-nejad et al., 2002). Among different kinds of measurement methods for ^{226}Ra determination, alpha–spectrometry was chosen due to its lower detection limit (Hosseini and Fathivand, 2004). FAO and IAEA have established guideline levels for the artificial radioactive substances in foodstuffs moving in international trade (IAEA, 1989; IAEA, 2011), but there are no guidelines for local foodstuffs.

2. Material and methods

2.1. Geographical location and radiation map of Ramsar

Ramsar is a coastal city in the province of Mazandaran, Iran, located on the west side of Caspian Sea. Ramsar is known to have a high background radiation and from this perspective we can divide the city into different regions:

1) High level of natural radiation areas (HLNRAs),
2) Normal level of natural radiation areas (NLNRAs) (Mortazavi and Karam, 2002),

Figure 1 shows the geographical location and radiation map of Ramsar. (Ghiassi-Nejad et al., 2003)

2.2. Foodstuff sample collection and preparation

A range of local food samples were collected during the four seasons. The specific foods selected were based on a survey questionnaire of the diets of 100 residents. Twenty six kinds of foodstuff, which included major food groups meat, eggs, milk, grain, fruit and vegetables, were selected and analyzed by alpha spectrometry.

These samples were obtained from local distribution centers that stock foods from both normal and high radiation regions. Furthermore, some edible vegetables were collected directly from the farms and some samples of beef, mutton, chicken and milk were directly provided from the livestock owners. The fish samples were taken from local rivers and Caspian Sea.

To prepare samples, first they were washed and non-edible parts were removed, and then they were weighed for determination of their wet weight. Then samples were turned to ash for about 16 h at 300 °C in the first oven, and then turned to ash again in the next oven at 700 °C for 16 h (Hosseini et al., 2006b). Table 1 presents the ratio between ash and wet weight in selected samples.

2.3. Radioactivity measurement and calculations

Among different kinds of measurement methods for ^{226}Ra, alpha–spectrometry has been chosen because of its lower detection limit (Hosseini and Fathivand, 2004). A quality assurance system according to ISO-17025 requirements was implemented.

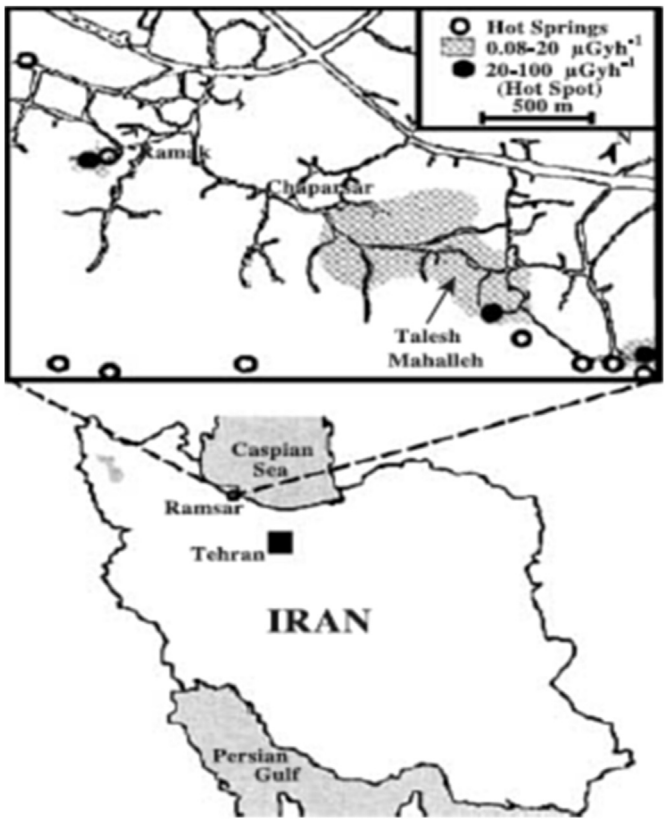

Fig. 1. The geographical location and radiation map of Ramsar (Ghiassi-Nejad et al., 2003).

Table 1
The ratio of ash weight to wet weight of foodstuff staples of Ramsar.

Type of foodstuff	W_{ash}/W_{wet} (gr)
Meat	0.035
Chicken	0.096
Fish	0.026
Egg	0.008
Duck egg	0.015
Lentil	0.014
Rice	0.004
Garlic	0.012
Milk	0.096
Cheese	0.068
Basil	0.014
Mint	0.013
Coriander	0.012
Parsley	0.014
Radish	0.014
Radish leaves	0.026
Carrot	0.008
Chard	0.019
Broad bean	0.014
Greengage	0.004
Tea	0.059
Lettuce	0.009
Orange	0.005
Tangelo	0.004
Chino	0.004
Bean	0.015