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The natural and artificial radionuclides in drinking water samples and consequent population doses

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ABSTRACT

Concentration levels of ^{226}Ra, ^{228}Ra, ^{40}K and ^{137}Cs were determined in 52 drinking water samples collected from the different supplies in Samsun province to evaluate annual effective dose due to the ingestion of the drinking water samples. The activity concentrations of ^{226}Ra, ^{228}Ra and ^{40}K natural radionuclides in the drinking water samples varied from <27 to 2431 mBq L^{-1}, <36 to 270 mBq L^{-1} and <47 to 2880 mBq L^{-1} respectively. The activity concentrations of the artificial radionuclide ^{137}Cs in the drinking water samples were lower than minimum detectable activity except in one drinking water sample (DW14) with an associated activity concentration of 2576 mBq L^{-1}. Contributions of the consumed water samples to annual effective dose from ^{226}Ra, ^{228}Ra and ^{40}K varied from 1.6 to 33.4 μSv y^{-1} with a mean of 6.1 μSv y^{-1}, 2.2 to 46.8 μSv y^{-1} with a mean of 8.6 μSv y^{-1}, 4.7 to 97.5 μSv y^{-1} with a mean of 17.9 μSv y^{-1} for infants, children and adults, respectively. The results showed that all values of the annual effective dose of ingestion of these water samples were below the individual dose criterion of 100 μSv y^{-1} reported by World Health Organization (WHO).

1. Introduction

Drinking water contains naturally occurring radionuclides such as such as uranium–radium (^{238}U–^{226}Ra) and thorium (^{232}Th) decay series, their decay products and potassium (^{40}K) and artificial radionuclides (^{137}Cs, ^{134}Cs, ^{90}Sr, etc.) coming from the fallout from atmospheric nuclear weapons testing and the accidents at nuclear reactors. In consequence of radioactive fallout after the Chernobyl nuclear reactor accident in 1986, ^{137}Cs radionuclide ($T_{1/2} = 30.07$ y) was widely dispersed in the Turkish environment (Turhan et al., 2012). These radionuclides could present a risk to human health (WHO, 2011). Low doses caused by ingestion of these radionuclides in drinking water can increase the radiological risk of longer term effects.

Radium isotopes (^{226}Ra and ^{228}Ra) are the most radiotoxic and dangerous element in case of ingestion due to their similarity in behaviour to calcium, an element commonly fixed in bones (Martín Sánchez, Rubio Montero, Gomez Escobar, & Jurado Vargas, 1999). The ^{226}Ra ($T_{1/2} = 1600$ y) and ^{228}Ra ($T_{1/2} = 5.75$ y) can dissolve easily in water and travel within the aquifer. The most common source of them in drinking water is from radiological decay of naturally occurring ^{238}U and ^{232}Th found in the earth's crust (Landsberger & George, 2013). ^{40}K is present as a very small fraction of naturally occurring

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potassium (^{39}K), which is an element found in the earth's crust, oceans, and all organic material. Once taken in, ^{40}K behaves in the body in the same manner as other potassium isotopes. Humans require potassium to sustain biological processes, with most (including ^{40}K) being almost completely absorbed upon ingestion, moving quickly from the gastro intestinal tract to the bloodstream. The ^{40}K that enters the bloodstream after ingestion or inhalation is quickly distributed to all organs and tissues. It can present both an external and an internal health hazard. The health hazard of ^{40}K is associated with cell damage caused by the ionizing radiation that results from radioactive decay, with the general potential for subsequent cancer induction (ANL, 2005). Caesium (^{137}Cs) reacts with water producing a water-soluble compound. After drinking ^{137}Cs contaminated water, it gets more or less uniformly distributed throughout the body, with the highest concentrations in soft tissue, where it would expose living tissue to gamma and beta radiation. Therefore, determining of the concentration levels of the natural and artificial radionuclides in drinking water is an important factor for public health studies, which allow the assessment of population exposure to radiation by the consumption of water.

Recently, studies relate to the determination of the natural radioactivity in drinking water from different sources were performed worldwide (Agbalagba, Avwiri, & Ononugbo, 2013; Al-Amir, Al-Hamarneh, Al-Abed, & Awadallah, 2012; Beyermann, Bünger, Schmidt, & Obrikat, 2010; Desideri, Roselli, Feduzi, & Meli, 2007; Gorur & Camgoz, 2014; Islam Salih, Pettersson, & Lund, 2002; Janković, Todorović, Todorović, & Nikolov, 2012; Jia, Torri, & Magro, 2009; Kehagia et al., 2007; Landsberger & George, 2013; Osman Alfatih et al., 2008;

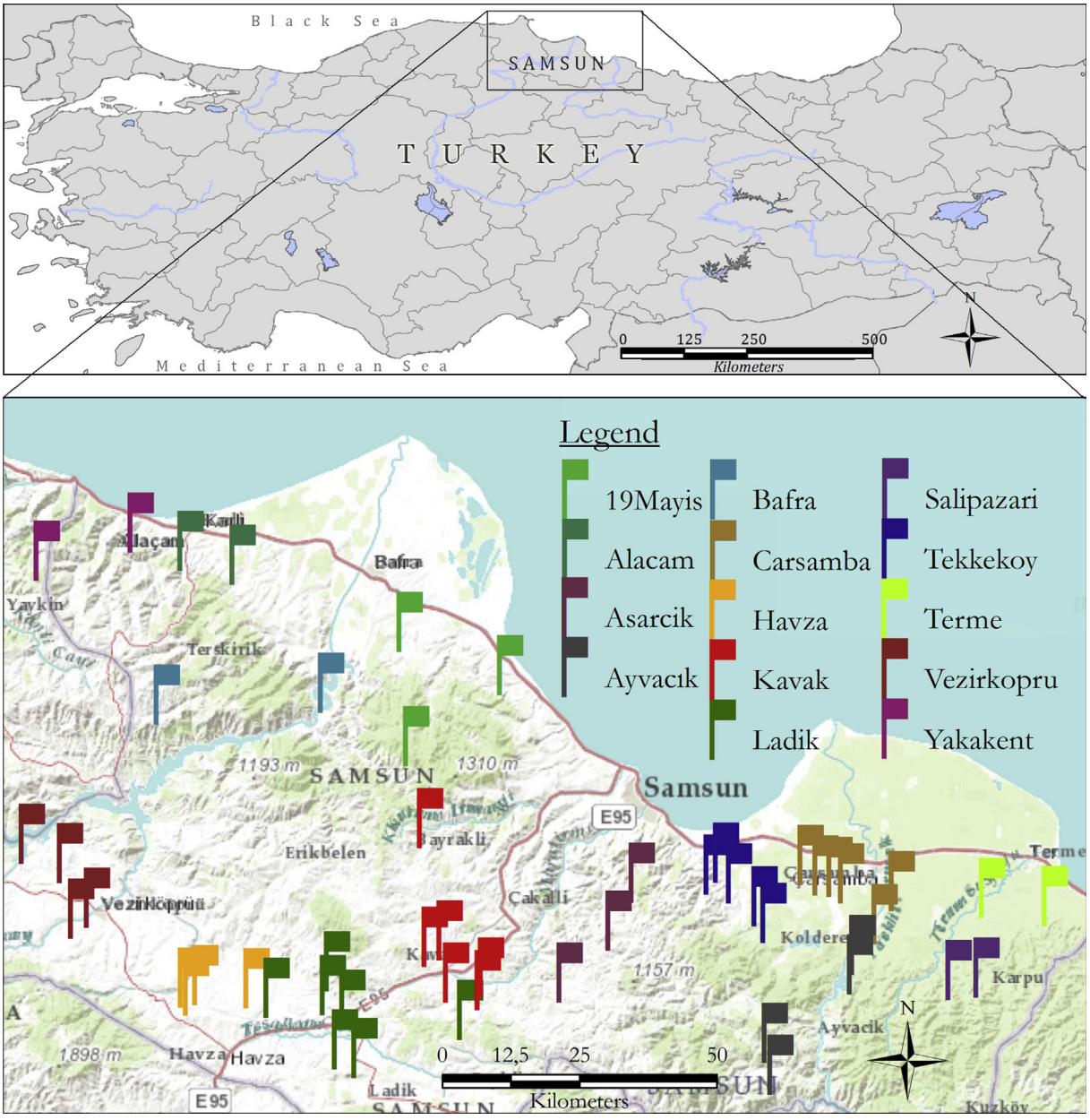

Fig. 1 – The location of sampling sites.