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Levels of ^{210}Po and ^{210}Pb in mussel and sediments in Candarlı Gulf and the related dose assessment to the coastal population

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ABSTRACT

^{210}Po and ^{210}Pb in mussel (*Mytilus galloprovincialis*) and sediment samples collected at Candarlı Gulf during the period of 2010–2012 are presented and discussed. The activity concentrations of ^{210}Po and ^{210}Pb were measured by means of alpha spectrometry. Activity concentrations of ^{210}Po and ^{210}Pb in mussels are in the ranged of 332 ± 17–776 ± 23 Bq kg^{-1} dw and 14 ± 1–40 ± 5 Bq kg^{-1} dw, for sediments the ranges for 52 ± 5–109 ± 8 Bq kg^{-1} dw and 38 ± 5–92 ± 9 Bq kg^{-1} dw, respectively. The estimated consequent annual effective ingestion dose due to ^{210}Po and ^{210}Pb from mussel consumption in Candarlı Gulf coastal region were calculated. The highest dose due to ^{210}Po and ^{210}Po were calculated to be 4232 ± 126 μSv and 126 ± 16 μSv, respectively.

1. Introduction

^{210}Po and ^{210}Pb, two important members of ^{238}U series, are found in varying concentrations in environment.^{210}Po is an alpha emitter radionuclide with half life of 138 d and high specific activity of 10^{17} Bq kg^{-1} (Kelecom and Santos Gouvea, 2011). ^{210}Pb is a beta emitter with a half life of 22.17 years. ^{210}Po and ^{210}Pb are introduced into coastal marine environments following waste discharges from phosphate, oil, and gas industries causing local increase of radionuclide concentrations (Carvalho et al., 2010).

In the marine environment ^{210}Po is strongly accumulated in the marine biota and transferred to man with ingested food (Carvalho and Fowler, 1994; Carvalho et al., 2011). ^{210}Po is considered to be the most important contributor of radiation dose received by humans via fish and shellfish consumption (Skwarzec and Fabisiak, 2007; Suriyanarayanan et al., 2008). Many countries have determined the concentrations of this radionuclide in seafood and the annual intake and hence the radiation doses due to its consumption have been evaluated (Mishra et al., 2009).

Mussels are an important element of the human diet and organisms which are commonly used for pollution monitoring due to their sedentary, filter feeding habits and their ease for being sampled (Carvalho et al., 2010; Aközcan and Uğur Görgün, in press). It is well known that, sediments reflect in general the relative contamination of the marine environment and play an important role as reservoirs of a fraction of the pollution in aquatic systems (Saçan et al., 2010). Therefore it is important to understand the behaviour of ^{210}Po in terrestrial, aquatic and atmospheric environment of a region (Narayana and Rajashekara, 2010). There are several studies in the world and Turkey have estimated the ^{210}Po and ^{210}Pb in sediment and biota (Narayana and Rajashekara, 2010; Sirelkhatim et al., 2008; saçan et al., 2010; Aközcan and Uğur, 2013; Aközcan and Uğur Görgün, in press; Khan and Wesley, 2011).

Candarli Gulf in the coastal area of the Aegean Sea is well develop, with beaches being utilized for recreation and also as large amounts of fish and seafood are consumed from the coastal water, the study of radioactivity in this area is of great interest. So far, there is almost no information available from the published literatures on the nuclides in sediments and mussels in the Gulf.

This paper reports the results of ^{210}Po and ^{210}Pb in mussels (*Mytilus galloprovincialis*) and sediments collected from the area of Candarlı Gulf coast. In addition, the aim was also to make a total annual effective dose assessment received from these radionuclides by mussel consumption for population living in the region.

2. Method and materials

2.1. Study area

Sampling, which are used for the determinations of ^{210}Po and ^{210}Pb in mussel (*M. galloprovincialis*) and sediment from Candarlı Gulf in the 2010–2012. The sampling stations are shown in Fig. 1.

Candarli Gulf (38.67°–38.95°N, 26.83–27.08°E) is a semi-enclosed gulf located in the eastern Aegean Sea. Gulf has been strongly affected by growing population and industrialization. Major industrial developments located in the coastal area of Candarli, have been discharging solid and liquid wastes raw into Bakircay or Candarli Gulf or after minimal treatment. There are iron and steel factories, fuel storage yards, fertilizer factories, natural gas power plant, electrical substations and other medium and small establishments in the region (Pazi et al., 2012).

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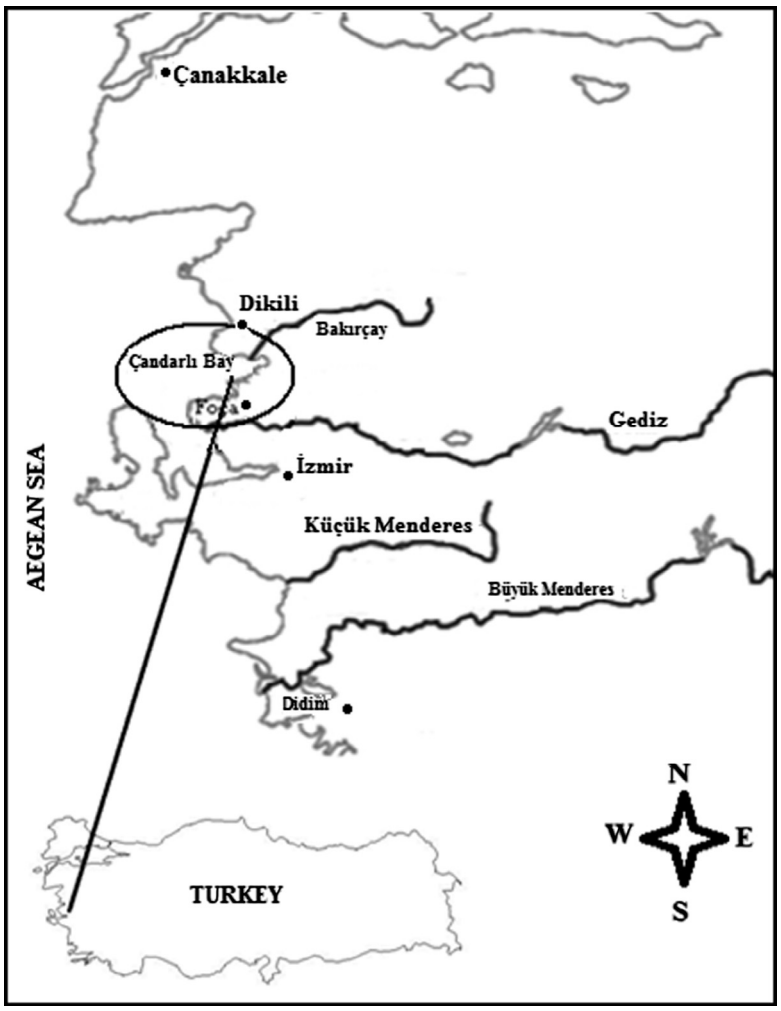

Fig. 1. Map of sampling locations.

The other possible source for enhanced ^{210}Po is the discharge of Bakırcay river. Bakircay river is a highly contaminated stream passing through the most heavily industrialized area (Kucuksezgin et al., 2012). The river course large cities, agricultural areas and technological activities such as Soma coal-fired power plant are present. Aliaga town located in the southern part of Candarli Gulf and also petrochemical industry on the coast of Aliaga would be also another agent for high level of natural radionuclide in the region. In addition this region is a ship dismantling area.

2.2. Sampling

The samples were collected continuously from 2010 (January, May, August, and November) to 2012 (January, May, August, and November) at Candarlı Gulf, seasonally. In each sampling period mussels were collected about 2–3 kg. Immediately after collection, abundant mussel samples were transported to the laboratory and mussels 3–5 cm in shell length were chosen and cleaned with seawater. 40 mussels of equal size (3–5 cm shell length) were randomly selected to determine the level ^{210}Po and ^{210}Pb in the mussel. The soft tissue, including interstitial fluid, were extracted from each sample and the samples were stored in a freezer until the arrival to the laboratory. All the samples were dried at 80 °C (to prevent polonium losses) to constant weight, homogenized and ^{210}Po and ^{210}Pb were quantitatively determined from 1 g of dried sample.

Sediment samples were taken using Van-Veen Grab from the 0–5 cm depth of sediments. Immediately after collection, the sediments were placed in acid cleaned polyethylene bottles. Thereafter, samples were dried in an oven at 80 °C, and then sieved to separate the <2 mm fraction and homogenized.

2.3. The radiochemical analysis and measurements

^{209}Po (4.88 MeV, $t_{1/2}$:109 y) was used as an internal tracer for determination of ^{210}Po radiochemical recovery. A working solution of 0.2 Bq mL^{-1} was prepared from a standard solution purchased from Eckert& Ziegler. ^{210}Po and ^{210}Pb were quantitatively determined from 1 g of dried sample. After standard addition of polonium tracer, each sample was dissolved using three portions of concentrated 20 mL HNO_3 and then 2 mL H_2O_2 evaporated to near dryness on a hot plate. To the remainder, three portions of 20 mL HCl were added and the solution was evaporated to dryness. For sediment samples HF is also used in dissolving process. Polonium was spontaneously plated onto a silver disc from a dilute HCl medium in the resence of ascorbic acid to reduce of Fe^{3+} to Fe^{2+} (3) (Flynn, 1968). ^{210}Po was measured with an alpha spectrometry system (Ortec, Alpha Duo) equipped with ion-implanted silicon charged particle detectors (active area of 600 mm^2, and approximately 30% efficiency). The recovery rates of standardized tracer for the mussel and sediment samples varied from 75% to 90% and 70 to 80%, respectively.