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Evaluation of natural radioactivity content in high-volume surface water samples along the northern coast of Oman Sea using portable high-resolution gamma-ray spectrometry

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ABSTRACT

Portable high-resolution gamma-ray spectrometry was carried out to determine the natural radioactivity levels in high volume surface water samples of the northern coast of Oman Sea, covering the coastal strip from Hormoz strait to Goatr seaport, for the first time. The water samples from 36 coastal and near shore locations were collected for analysis. Analyses on the samples collected were carried out to determine ^{226}Ra, ^{232}Th and ^{40}K contents. The concentration of ^{226}Ra, ^{232}Th and ^{40}K in surface water samples ranged between 2.19 and 2.82 Bq/L, 1.66–2.17 Bq/L and 132.6–148.87 Bq/L, respectively. The activity profile of radionuclides shows low activity across the study area. The study also examined some radiation hazard indices. The external hazard index was found to be less than 1, indicating a low dose. The results of measurements will serve as background reference level for Oman Sea coastlines.

1. Introduction

It is important to determine the baseline level of radionuclides in different environmental compartments before any pollution or contamination event happens (Labrecque et al., 2010; Ahmad et al., 2010; Zare et al., 2012). Monitoring of radioactivity inventory in I.R. Iran marine environment is necessary, not only for additional information to enhance the existing baseline data for the nation but also for worldwide database. Nuclear accidents, such as the Chernobyl and Fukushima accidents, have released large amounts of radionuclides into the environment (Marzano and Triulzi, 1994; Matisoff et al., 2011; Inoue et al., 2006). Furthermore, oil industries, mining activities, and intensified navigation activities are non-nuclear pollution sources that could have serious impacts on the marine environment and the coastal ecosystems (Abdi et al., 2006a,b). Therefore, isotopic determinations of natural and anthropogenic radionuclides are required for environmental monitoring, nuclear safeguards, and nuclear forensic studies (Al-Sulaiti et al., 2010; Faheem et al., 2008). To the knowledge of the authors, there currently exists no peer reviewed literature on levels of environmental, naturally occurring radioactivity in the Oman Sea. For this reason, a baseline data for the radioactivity concentration in Oman Sea surface water needs to be established. Measurements of the natural background level are essential parameters in determining the natural radioactivity concentration levels and their behaviour in the environment (Malain et al., 2010; Abdi et al., 2006a,b). Such data are used to assess the biological effects of natural radiation in the environment and can also serve as a baseline from which any future artificial release of radionuclides

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can be determined (Abdi et al., 2009; Agusa et al., 2004). Thus, the current research aims at investigating natural radioactivity levels using portable gamma-ray spectrometry, characterizes environmental naturally occurring radioactive materials in Oman Sea surface water, and seeks to establish baseline map of radioactivity in Oman Sea surface water (El-Gamal et al., 2007; Xu et al., 2010; Abdi et al., 2008).

2. Materials and methods

2.1. Sampling

The regional sampling was performed according to the previous work (Zare et al., 2012). Surface water samples were taken from 36 marine spots in the northern coast of Oman Sea, covering the coastal strip from Hormoz strait to Goatr seaport, between (56, 30) and (61, 30) in longitude and 25–26 in latitude, in May 2011. Sampling spots are shown in Fig. 1. Furthermore, some properties of water were recorded by CTD system (Zare et al., 2012). Due to the expected low concentration of natural radioactivity in the marine environment, high volumes of seawater were collected. For each spot, about 100 L of coastal surface water was collected using a pump (SCUBA Series, LOWARA, manufactured in Italy) from 1 m below the sea surface (Ahmad et al., 2010). The surface Water samples were collected in 20 L capacity plastic containers and were acidified to pH 1 with HNO_3 immediately after sample collection to avoid adsorption of radionuclides onto the walls of the containers (Onoja, 2010; Agbalagba and Onoja, 2011). Plastic containers of 20 L capacity, previously washed, rinsed with dilute HNO_3 and dried to avoid contamination, were filled with known volumes of the water sample. This sampling covered 900 km along the northern coast of Oman Sea in May 2011.

2.2. Measurement setup

The study is aimed at exploring the possibility of using a portable high-resolution gamma-ray detection system and a large volume container (140 L) to measure natural radioactivity in coastal water samples (de Meijer et al., 1996; Talha et al., 2010). Fig. 2 shows the portable HPGe detector (with 41.3% relative efficiency), which has a crystal of 6 cm length and 6 cm diameter, mounted on top of a 80 cm height and 46 cm diameter plastic container. A polyethylene holder

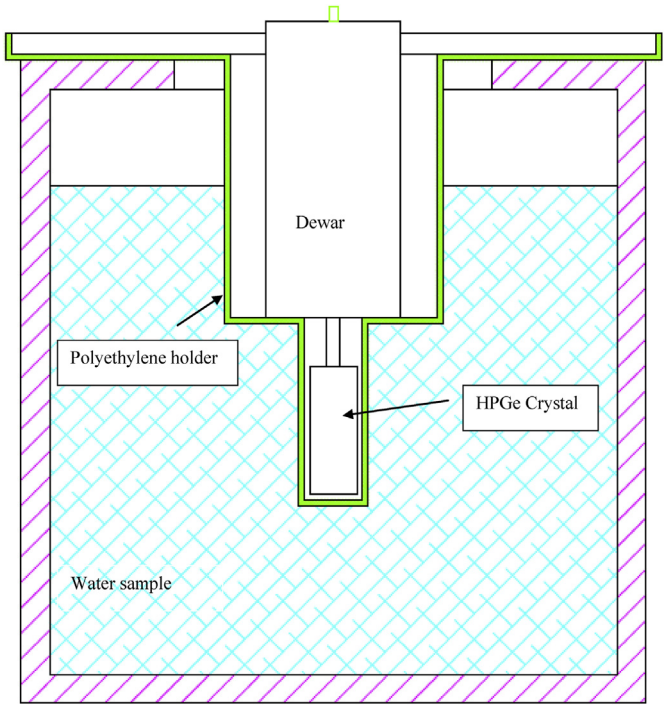

Fig. 2. Measurement setup for water sample analysis with portable HPGe.

is designed to keep the portable detector upright when lowered into the middle of water sample. The portable detector is fitted on the holder in such a way that the centre of the HPGe crystal coincided with the centre of the water sample.

2.3. Calibration and measurements by portable high-resolution gamma-ray spectrometry

The efficiency Calibration of the portable detector for the geometry was carried out using a portable coaxial P-type HPGe detector with energy resolution of 1.86 keV and relative efficiency of 41.3% for line of ^{60}Co. Spectrum acquisition was done using the computer software WinSPEC with a mini multi channel analyzer

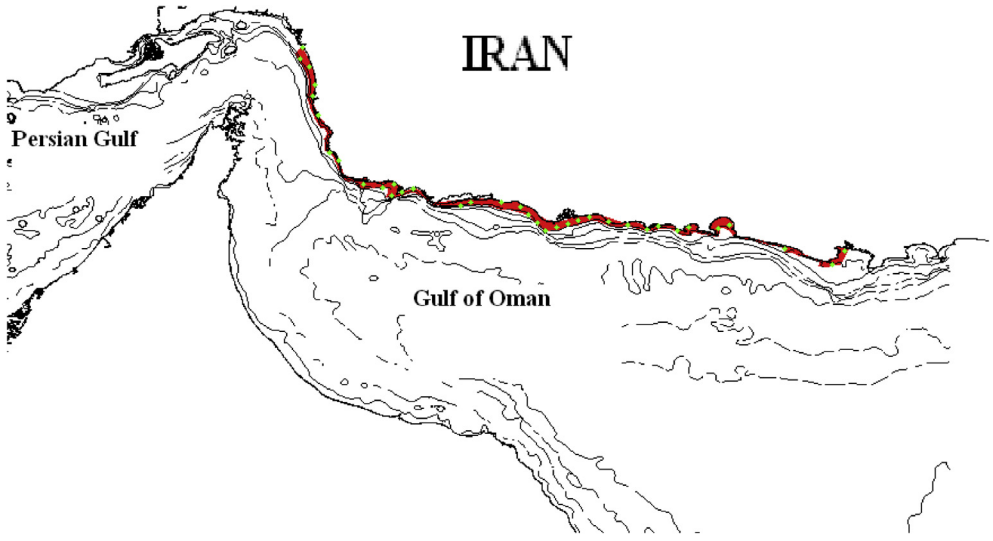

Fig. 1. Sampling spots in the northern coast of Oman Sea.