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^{238}U, ^{232}Th, ^{40}K and ^{137}Cs activity concentrations along the southern coast of the Caspian Sea, Iran

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ABSTRACT

The determination of activity concentrations of the radioactive elements ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs was performed on grab samples taken from a polluted environment. The samples were sliced into strata from 5 cm depth, dried and ground to sieved through a 170 mesh size prior to the analysis. Activity concentration was quantified using gamma spectroscopy. The results showed that the concentrations of activity in the sediment samples are 177 ± 12.4, 117 ± 11.5, 1085 ± 101.6 and 131 ± 4.8 Bq kg^{-1} for ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs, respectively. In general, the distribution of activity concentrations along the southern coast of the Caspian Sea area exceeded international limits. The hazard index of the samples was 0.19–0.88, with an average of 0.49. The mean values of radium equivalent activity and dose rate are 176 Bq kg^{-1} and 63 nGy h^{-1}, respectively.

1. Introduction

There are many naturally occurring radionuclides in the environment, including isotopes of cesium, uranium and thorium. The average natural uranium abundance in the earth's crust is 2.7 μg g^{-1}, and 3×10^{-6} g L^{-1} in typical sea water (Mora et al., 2004). Interest in determining levels of these radionuclides mainly stems from their usefulness as environmental tracers. If environmental samples have a high concentration of uranium and thorium, determining the levels of radionuclides in sea water, soil and sediment is important for protection from radiation.

In addition to naturally occurring radionuclides, a large number of radionuclides have been produced and released into the environment by human nuclear activity, including nuclear weapons testing, the operation of nuclear power plants, research reactors, and nuclear fuel reprocessing. Nuclear accidents, such as the Chernobyl accident, have also released large amounts of radionuclides into the environment. Therefore, isotopic determinations of natural and anthropogenic radionuclides are required for environmental monitoring, nuclear safeguards, and nuclear forensic studies (Eisenbud and Gesell, 1997).

The Caspian Sea is surrounded by Azerbaijan, Russia, the Islamic Republic of Iran, Kazakhstan and Turkmenistan. With a surface area of 390,000 km^2, the Caspian Sea is the world's largest inland water body (Froehlich et al., 1999). The sea is 1200 km long and varies between 204 and 566 km in width, with an average width of 330 km. About 130 rivers of varying size drain into the Caspian Sea, providing an annual input on the order of 300 km^3 (Froehlich et al., 1999). Major river inputs include the Volga, Ural and Terek, with a combined annual flow account for 88% of the total flow (approximately 370 km^3 per year). The Sulak, Samur, Kora and a number of smaller rivers contribute approximately 7% of the flow, and the remainder comes from the rivers of the Iranian shore (Boulyga and Heumann, 2006). The dynamics of water circulation within the Caspian Sea were not previously known, but combined oceanographic and isotopic investigations carried out within the framework of the IAEA supported projects have brought new insights into these processes (Boulyga and Heumann, 2006). The nature and circulation of water masses in the Caspian Sea is shown in Fig. 1, with two types of cyclonic eddy currents present in the central and southeastern regions. In the southern coastal region of the Caspian Sea, currents are directed towards the northwest, north, southeast and south, with average speeds of 20–40 cm s^{-1} and a maximum speed of 50–80 cm s^{-1}. Therefore, this water flow drives pollutants from the central and northern coasts towards the south coast. Calculations by Vakulovsky and Chumichev (1998) show that from 1962 to 1976, the transfer of ^{90}Sr from the Volga and Kora rivers to the Caspian Sea amounted to 70 TBq (Vakulovsky and Chumichev, 1998).

Coastal sedimentary deposits are important indicators of climate change and sea-level fluctuations in the Caspian Sea area. Sedimentation is also one of the factors known to cause variation in the volume of the Caspian Sea basin over long periods of time

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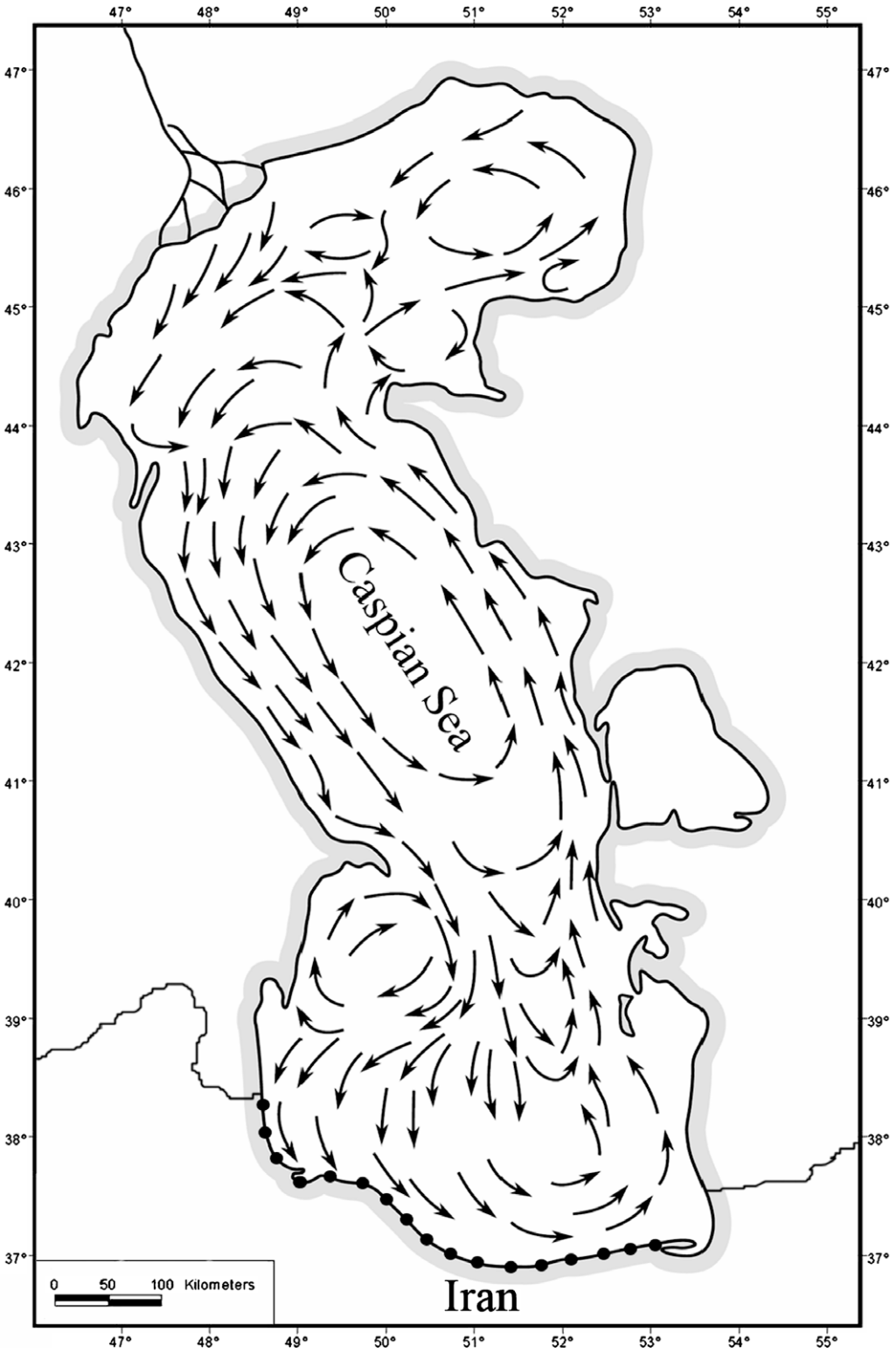

Fig. 1. Map of the Caspian Sea area indicating the location of sites mentioned in the text.

(Federov, 1995; Klige and Selivanov, 1995). Geological processes have influenced the water balance of the Caspian catchments basin by altering the watershed and thus diverting river courses to other basins (Varushchenko et al., 1987).

Research was conducted by the IAEA in August–September 1995 and in 1996 to measure anthropogenic radionuclides, oceanographic and isotopic investigations of ^{3}H and ^{3}H–^{3}He in order to study water balance and dynamics. Together with studies by the Iran Nuclear Regulatory Authority conducted to measure natural uranium concentrations in the Caspian Sea, results show that the measurement of radionuclides in sediments is necessary for the southern part of the Caspian Sea (Froehlich et al., 1999; Garshasbi et al., 2005; Oregioni et al., 2003).