Comparative analysis of radionuclide and potentially toxic element accumulation in sediments from the Northern Bulgarian Black Sea coast

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Introduction: Receiving relevant information for radionuclide and toxic element concentrations in marine sediments is an important stage in realization of monitoring and control of marine ecosystem [1-3]. However, the type upper mentioned contemporary data for assessment of the ecological status of the Bulgarian Black Sea coast are quite few.

This article reports data on the content of toxic elements Mn, Ni, Zn, Cu, Pb, As, Cr, Cd and Co, technogenic (^{137}Cs, ^{134}Cs) and natural radionuclides of the ^{238}U and ^{232}Th series (^{234}Th, ^{226}Ra, ^{210}Pb, ^{232}Th) and ^{40}K in sediments collected from 10 pre-selected sampling stations along the northern Bulgarian Black Sea coastline for a period of more than twenty years.

Methods: Sediments (sand, clay and silt) were collected from the Black Sea shelf at depth 2 - 20 meters below the sea level and at distance up to 2000 m from the shore line. Sampling was done by specialists from IO-BAS, Varna and diving section of the National Club for Scientific Expeditions of UNESCO (NNEK), Sofia. Measurements were made by Gamma Spectrometry, Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Energy Dispersive X-ray Fluorescence Analysis (EDXRF).
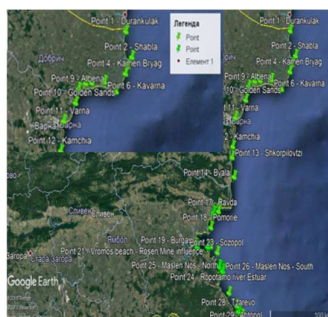

Fig. 1: Black Sea coast - North sampling stations.

Results: Cesium-137 is one of the most studied nuclides in the Black Sea environment after the Chernobyl accident. Our results show that all the measured activities of cesium isotopes vary between 1.1 and 92.0 Bq.kg^{-1} for ^{137}Cs and from 0.1 to 5.9 Bq.kg^{-1} for ^{134}Cs. The highest measured mean values were registered in the locations with clay type of sediments – Kaliakra (78 Bq.kg^{-1} for ^{137}Cs and 3.9 Bq.kg^{-1} for ^{134}Cs) and Kavarna (30 Bq.kg^{-1} for ^{137}Cs and 1.6 Bq.kg^{-1} for ^{134}Cs). The measured mean values in sediments from the other locations range from 1.1 to 14.6 Bq.kg^{-1} for ^{137}Cs and between 0.1 and 0.8 Bq.kg^{-1} for ^{134}Cs. The lowest measured values are in the locations with sand type of sediments - Durankulak and the main Bulgarian Black Sea resorts Albena and Golden Sands. The observed dependence is valid also for the natural nuclide contents. The highest values were registered in clay sediments from Kaliakra and Kavarna. The lowest concentrations were measured in the sand sediments from Durankulak, Tjulenovo and Kamen Bryag.

The sediments with the highest radionuclide content collected at Kaliakra (clay) and Byala (silt) were analyzed for determination of Mn, Ni, Zn, Cu, Pb, As, Cr, Cd and Co content by ICP-MS. The obtained data show that concentrations of all studied elements are higher in clay sediments from Kaliakra.

Discussion: All our results show that the radionuclides and toxic elements concentration in sediments strongly depend on the sediments nature. The data obtained for sand sediments are within a close range while those for silt and clay ones are higher and vary to a much greater extent. The increase in concentrations of some elements and radionuclides in clay sediments and sorption on fine particles leads to contaminants scavenging and occurrence at greater depths, which can be explained by physico-chemical interaction processes of the soluble forms with the surrounding media. Due to such a process, sea bottom sediments play a major role in potentially toxic pollutants redistribution between different components in the ecosystems.

References: [1] Saçan et al. (2010) *Environ Monit Assess* **161**:575–582; [2] Bezhenar et al. (2016) *Biogeosciences* **13**:3021-3034; [3] Wang et l. (2016) *Environ Sci Technol* **50**: 10448-10455