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ORIGINAL RESEARCH PAPER

IMPORTANCE OF REPRESENTATIVE SEDIMENT SAMPLE FOR ENVIRONMENTAL INTERPRETATION: A CASE STUDY IN THE KRKA RIVER, CROATIA

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SYNOPSIS

To evaluate the representativeness of sediment cores in a lacustrine environment (Visovac Lake, Krka River National Park, Croatia), sampling was carried out in three small regular plots (1 m x 1 m). Sediment was sampled using a hand driven acrylic corer by scuba diver where undisturbed sediment and continuous sedimentation were expected. 14 sediment cores (15 cm) were analyzed for activities of natural radionuclides (^{40}K and ^{232}Th) which are known as a good tracer of terrigenic input of particulate matter.

Statistical analyzes of obtained results show good correlation (> 0.95) of ^{40}K and ^{232}Th activities in all three (0-5 cm, 5-10 cm, 10-15 cm) investigated layers. Activities of ^{40}K and ^{232}Th are decreasing downstream, indicating decreasing of terrigenic input. Spatial variations in small distances (1m) may be significant in upper part of the Lake. This is especially evident in the surface layer (0-5 cm) where may influence environmental interpretation.

INTRODUCTION

Sediments are a sink for environmental contaminants (Power and Chapman, 1992). Moreover, sediments may accumulate contaminants in concentrations higher than those observed in the water column, producing negative effect to the benthic biota and to the organisms that feed on the benthos or on the sediment (Shwartz et al., 1982).

Sediments can be used for historical reconstruction. Vertical pollutant species in sediment cores have been commonly used as “pollution records” (Valette-Silver, 1993). Over the last few decades, the study of sediment cores has shown to be an excellent tool for establishing the effects of anthropogenic and natural processes on depositional environments. A number of recent pieces of work have used sediment profiles to describe contamination history of different environments (Chatterjee et al., 2007).

For correct environmental interpretation, representative sediment sample is essential. Assessing sample representativeness is a critical component of any environmental investigation. If the samples are not representative, any conclusions or decisions may be incorrect (Ramsey & Hewitt, 2005).

The Lake Visovac is a lentic part of River Krka and is situated in the karst region of the NW Dinaric Mountains, near the Adriatic coast. The lake is formed by a tufa barrier (Skradinski buk), where undisturbed sedimentation and negligible anthropogenic impacts were expected (Cukrov et al., 2008). To check the representativeness of single point sediment samples, results of analyses of 14 sediment columns from the Visovac Lake, where activities of ^{40}K and ^{232}Th were determined, were evaluated using statistical methods.

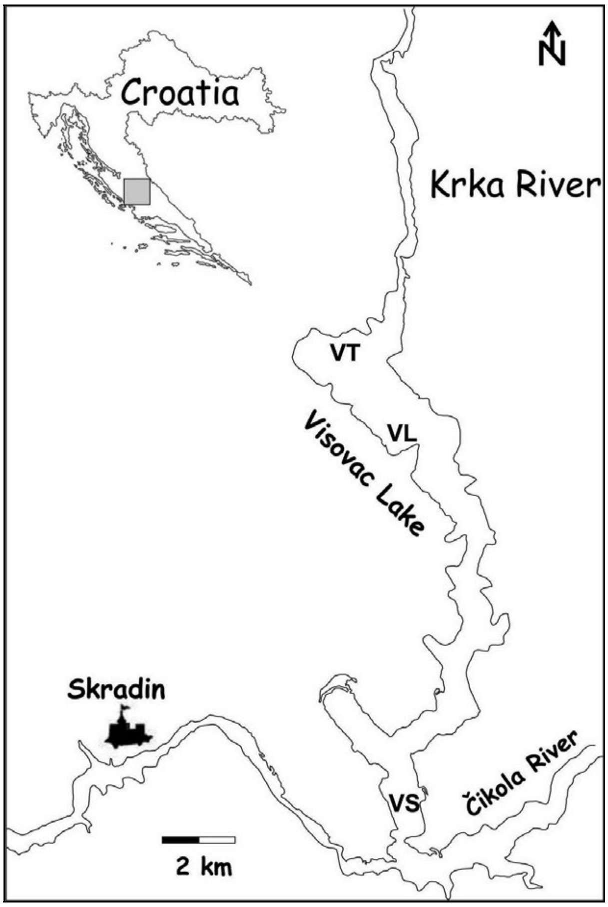

Figure 1:
Map of the sampling area.

SAMPLING SITES AND PROCEDURES

Sediment samples were collected during July, 2011 by scuba diving using hand-made and hand-driven Plexiglas corers. Sampling was performed at three locations in the Visovac Lake (Fig. 1), mapped using a GPS receiver (Garmin GPS Map 76 CSx; Kansas City, USA) with an accuracy of ± 5 m, in small 1 x 1 m plots. At sampling site VT three sediment columns (VT-1, VT-2 and VT-3) were taken in a shape of equilateral triangle (1 m) (Fig. 2). At site VL two samples were taken in a distance of 1 m (Fig. 3) and at the third site (VS) nine sediment columns were taken in a 2 x 2 m square the distance between each core being 1 m (Fig. 4).

At all locations, the upper 15 cm of the sediment were sampled. After sampling, sediment cores were separated in 3 layers (0-5 cm, 5-10 cm, 10-15 cm) and frozen at -18 ˚C until analysis.

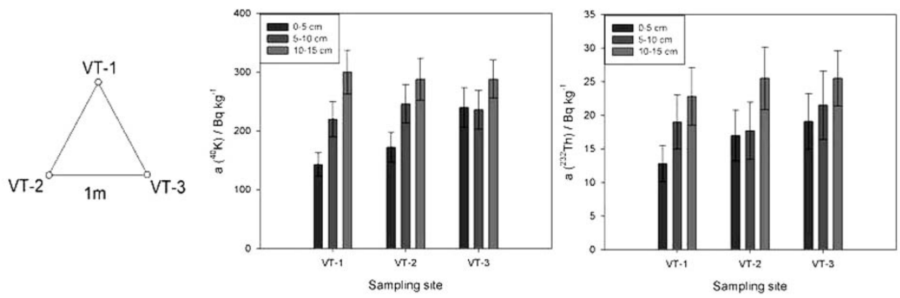

Figure 2: Activities of ^{40}K and ^{232}Th distribution in triangle pattern.

EQUIPMENT AND EXPERIMENTAL PROCEDURE

Prior to gamma-spectrometry measurements, sediment samples were thawed at room temperature and dried at 106°C for 24 hours until constant weight. Dried samples were placed into counting vessels of known geometry, sealed and stored for at least 4 weeks to allow ingrowth of gaseous ^{222}Rn (3.8 day half-life) and its short-lived decay products to equilibrate with long-lived ^{226}Ra precursor in the sample. At the end of the ingrowth period, the samples were counted on a multichannel gamma spectrometer (HPGe detector joined to an 8192 channel analyzer Canberra, Meriden, USA). The system was calibrated using standards supplied by Amersham International (Buckinghamshire, UK) and International Atomic Energy Agency reference materials (marine and stream sediments IAEA-306, IAEA-313 and IAEA-314). Counting time was 80,000 seconds and the recorded spectra were analyzed on a PC using the Canberra GENIE 2K software. Activities of ^{40}K were calculated from the 1460.75 keV-peak while ^{228}Ra activities were determined from the 911.1 keVpeak of its ^{228}Ac progeny Because of the relatively short half-life of ^{228}Ra (t1/2 = 5.75 years) and thorium conservative behavior, numerous authors equalize measured ^{228}Ra activities with ^{232}Th activities in natural samples (Carpenter et al., 1984; Murray and Aitken, 1988; Greeman et al., 1990), even in cases of possible radium migration in extreme conditions (Sheng, 1989). The 309.3 Bq kg^{-1} of 40K activity corresponds to 1 % total potassium while 4.06 Bq kg^{-1} of the ^{232}Th activities corresponds to a concentration of 1 mg/kg of thorium in the ground (Barišić, 1996).

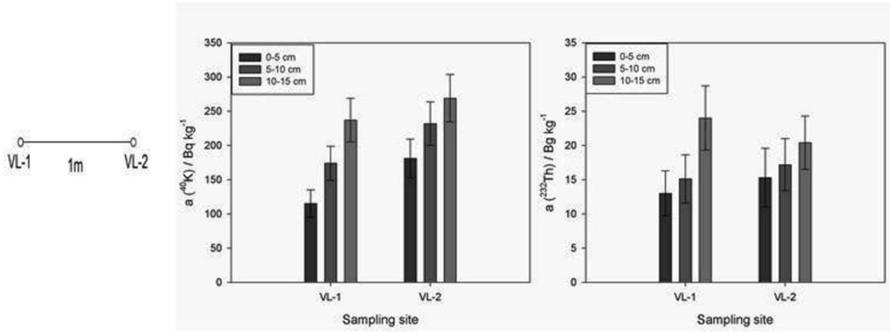

Figure 3: Activities of ^{40}K and ^{232}Th distribution in line pattern.

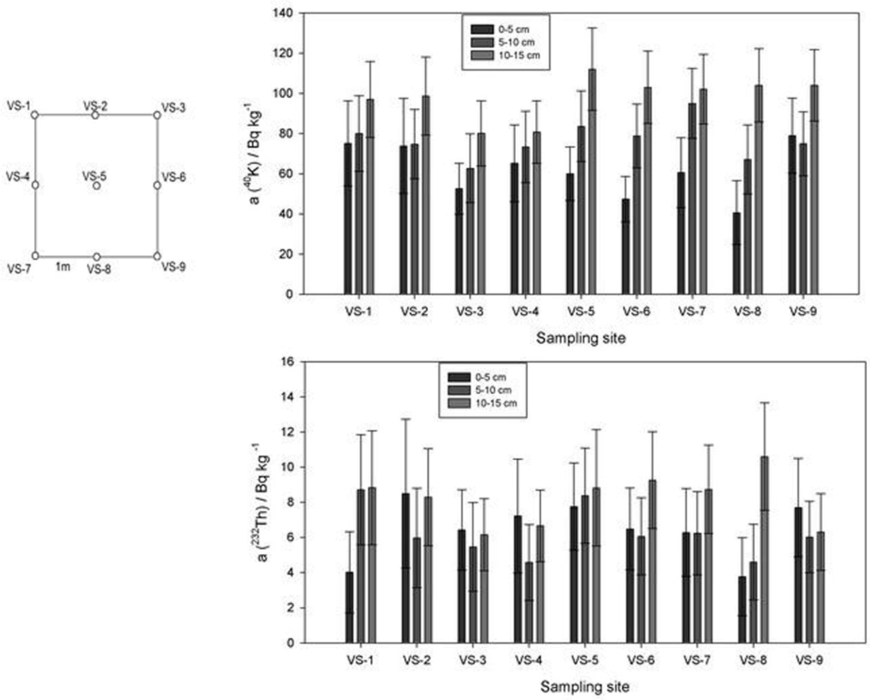

Figure 4: Activities of ^{40}K and ^{232}Th distribution in square pattern.

RESULTS WITH DISCUSSION

Sediments with the highest ^{40}K activity (300 ± 37,2 Bqkg^{-1}) were found in the upper part of the Lake Visovac (VT-1) in the sediment layer between 10 and 15 cm depth (Fig. 2), while the lowest ^{40}K activities (40,6 ± 15,9 Bqkg^{-1}) were found in lower part of the Lake (VS-8) in the surface sediment layer (0 - 5 cm) (Fig. 4).

The highest ^{232}Th activities (25,5 ± 4,64 Bqkg^{-1}) were also recorded in the upper part of the Lake Visovac (VT-2, Fig. 2), as well as the lowest ^{232}Th activities (3,77 ± 2,22 Bqkg^{-1}) in the lower part of the Lake (VS-8) (Fig. 4).

Activities of natural radionuclides are decreasing downstream, indicating that spatial distribution is under significant influence of terrigenous material input and could be a useful tool for recognizing the possible sources of material as well as for better locating of the areas where that material is predominantly deposited.

Regarding spatial differences of measured activities, results have shown that activities from sampling sites VT, VL and VS were significantly different. Spatial variations of activities in small distances (1m) also may be significant, especially in the upper part of the Lake.

At all sampling sites concentrations of ^{40}K slightly increased from the sediment surface to deeper layers. The same behavior shows concentrations of ^{232}Th at sampling sites VT and VL. This probably indicates a different sedimentation regime in the recent past.

In first investigated layer (0-5 cm) the correlation coefficient of the spatial distribution of ^{40}K activities with those of ^{232}Th was higher than 0.95. In all other sampled sediment layers (5-10, 10-15 cm) correlation coefficient was higher than 0.97. These results indicate very good correlation between ^{40}K and ^{232}Th concentrations.

CONCLUSION

Results have shown that spatial variations of measured ^{40}K and ^{232}Th activities can be significant, even at small distances (1 m). The spatial distribution is higher than measurement error. Previous papers (Cukrov & Barišić, 2006) indicated that spatial distribution of natural radionuclides is under influence of terrigenous material input. That can be seen on the example of the Visovac Lake. Higher values were recorded in upper part of the Lake, were terrigenic material is carried by Krka River. The most of the terrigenis material is settled in the Lake, causing decreasing of the activities in the lower part of the Lake.

Therefore, to assess representative sediment sample, it is necessary to make a reliable sampling strategy. For example, taking just one sediment sample in the study area can lead to incorrect environmental interpretation. Prior to sampling, it is necessary to consider which parameters can affect results. According to answers on these questions, sampling strategy should be designed.

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