THE USE OF PORTABLE INSTRUMENTS FOR MAPPING CONTAMINANTS IN THE FLOODPLAIN OF THE PLOUCNICE RIVER (CZECH REPUBLIC)

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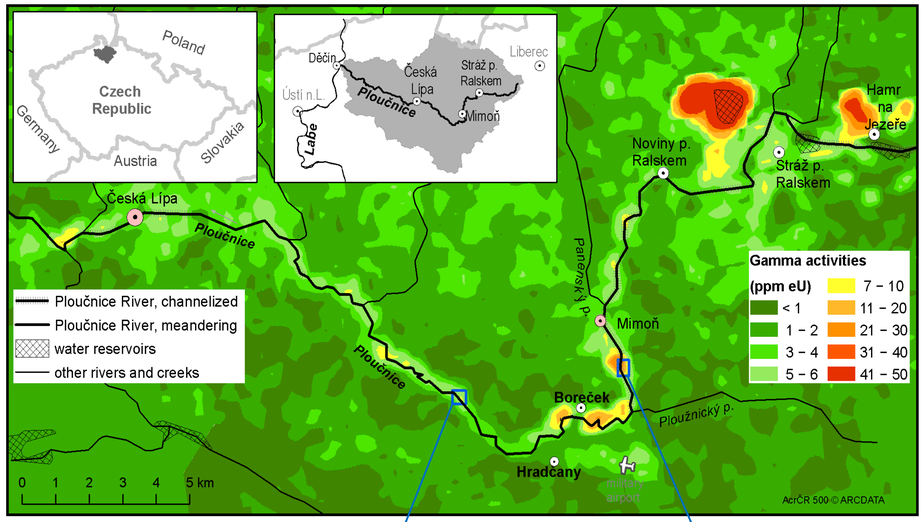
INTRODUCTION

The Ploučnice River (the Czech Republic) was contaminated by uranium mining in the areas of Hamr na Jezeře and Stráž pod Ralskem mainly in 1971–1987. The pollutants are now deposited all over the floodplain of the river. In the end of 1980s the primary pollution was terminated and since then less polluted sediments were deposited over the floodplain. In 2005 the aerial mapping of gamma activities in the floodplain of the Ploučnice River was performed at a height of 80 m above the ground in grid 250 x 250 m. That survey showed uneven, highly localised deposition of gamma-emitting nuclides (hotspots) along nearly the entire reach of the Ploučnice River.

We studied several of those hotspots 10–25 km downstream from the uranium mining area in aim to understand the reasons for that heterogeneity. These areas (ca. 100x400 m) studied in detail are located south of the city Mimoň and northwest of the village of Hradčany. The Ploučnice River has a meandering pattern in the floodplain, in parts practically not affected by engineering. The river channel is ca. 5 m wide in average.

SAMPLING METHODS

The contamination of the floodplain was analysed mainly by two portable (handheld) instruments. The gamma-spectrometer GT-30, which provides the concentrations of K, U and Th, was used for measuring the total surface gamma activity (main target nuclide was ^{226}Ra). Very effective was also the use of portable X-ray fluorescence spectrometer (XRF) Olympus Innov-X (DELTA Premium), which provides fast analysis of more than 30 elements, such as pollutants (Ba, Ni, Pb, U and Zn) and grain-size sensitive lithogenic elements (Al, Si, Zr, Rb). Besides pollution mapping, XRF also allows for mapping sediment lithology using Al/Si and Zr/Rb element ratios (proportional to the percentage of fine fraction and medium (fine sand) fraction, respectively).



DATA ANALYSIS

Datasets for GIS analysis were purchased from the Czech Office for Surveying, Mapping and Cadastre (© ČÚZK) and Military Geographic and Hydrometeorology Office (© MO ČR). The historical photographs from 1938 and 1975 were orthorectified using ERDAS 2013 software and shows land-use changes. The laser scanning dataset from 2010 (DMR 5G © ČÚZK) was used to create a detailed digital elevation model and based on the digital elevation model a detailed geomorphologic analysis of the area was performed. Data processing, analysis and visualisation were made in ArcGIS Desktop 10.2 with extension 3D Analyst.

Geostatistical analysis was performed for creation of a statistically valid prediction surface. The map of distribution of the surface gamma activity were interpolated. The surface trend in the data was removed using constant value or 1st order polynomial equation at first. The ordinary kriging method and J-Bessel function of the theoretical semivariogram was used for the final interpolation.

RESULTS

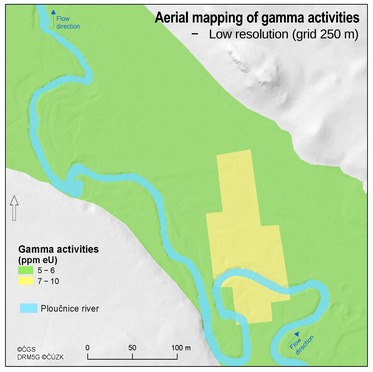
The field gamma spectrometry and XRF was performed with points spaced by 2–30 meters, which revealed that hotspots according to low resolution (in 250x250 m grid) aerial mapping is composed of one to several strongly polluted areas with sizes up to several tens of metres. Similarly heterogeneous was also the distribution of sediment lithology in the floodplain. In some cases, micromorphology of the floodplain, formed mainly by the past meander abandonments and channel shifts was responsible for the heterogeneity of the pollution. To understand the floodplain development we used old maps and aerial photographs. The Czech Republic has an extensive archive of historical aerial photos from 1938 and then from 1953 to the present with 5 or 10 years intervals. Additionally we used digital elevation model (DEM), created from a laser scanning (LIDAR) dataset DMR 5G obtained in 2010 with nominal altitudinal precision of 0.18 m in open terrain and 0.3 in forested terrain.

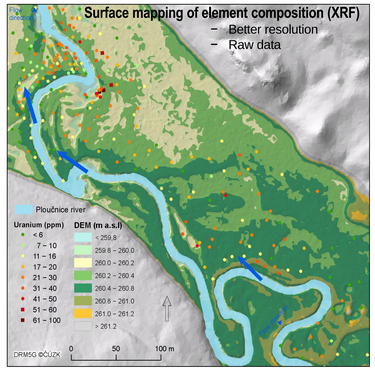
CONCLUSIONS

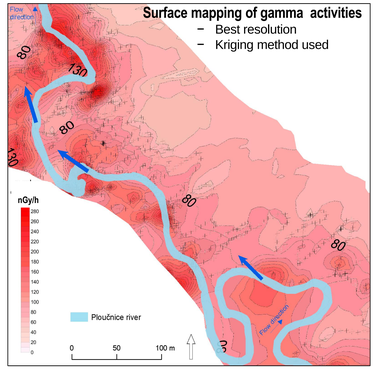
Our study demonstrated that very detailed, high-resolution analysis (mapping) of pollutant distribution in the floodplain can be achieved by portable analytical instruments. It can then be interpreted on the base of micro-geomorphology of the floodplain and fluvial deposition processes. Pollutant mapping can hence help to better understand the sedimentation patterns and sediment reworking in fluvial systems. The gamma spectrometry can visualise pollution even if it has been buried by several dm thick younger and less polluted strata, while XRF analysis has a penetration depth less than 1 mm and can reveal only pollutants on the very surface of the floodplain. Pollution mapping is very promising tool to analysis of polluted floodplains - it shows how unevenly are the pollutants distributed over the floodplain.

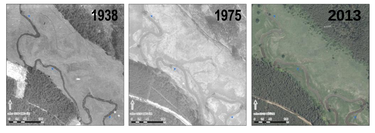
Heterogeneity of pollution in floodplain in Martin's Meadow

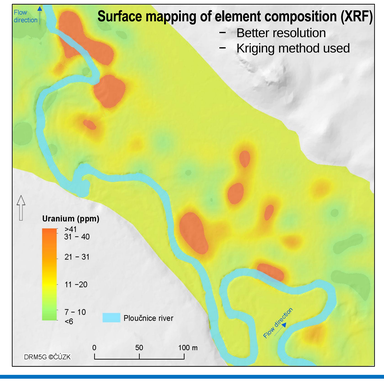
Improving resolution of mapping – visualizaion of more details

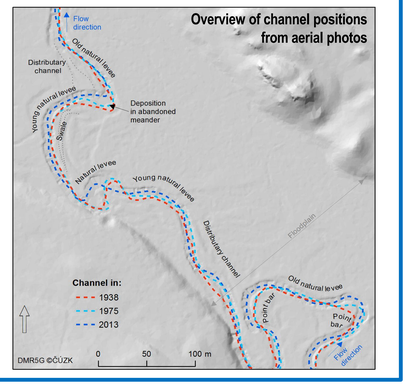












Most activity is in places of recent channel shifts – in point bars, abandoned meanders (visualised by gamma activity mapping, that is not hindered by younger sediments, integrating surface decimetres)

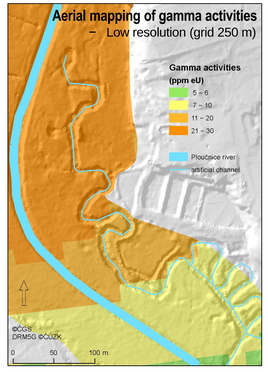
Increased activities/concentrations of pollutants are in old (fossil) natural levees (Gamma activity mapping, XRF mapping).

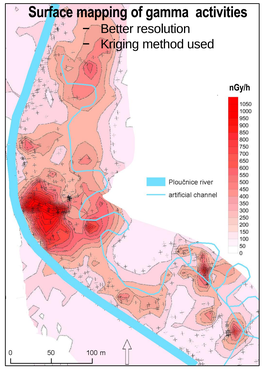
Low activities/concentrations in young natural levees, where younger and hence less polluted sediments cover the pollution (Gamma activity mapping, XRF mapping).

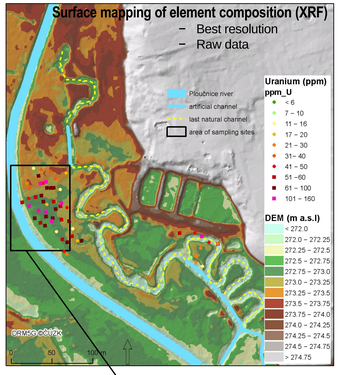
Low activities/concentrations in other places of active floodplain sedimentation (dark blue arrows).

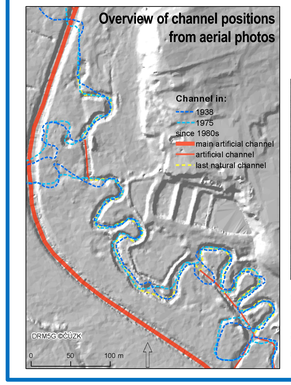
Heterogeneity of pollution in floodplain downstream from Mimoň

Improving resolution of mapping – visualizaion of more details









Surface mapping of element composition
– Better resolution
– Kriging method used

Gamma activity and XRF mapping revealed where the river engineering works were performed. High gamma activities are in remnants of former undisturbed channel belt Low gamma activities are in places where former channels were buried by sediment extracted from the novel artificial channel. Mapping clearly reveals where old floodplain was preserved.

The GT-30 Spectrometer is the state-of-the art in portable hand-held radiation survey search devices for the geophysical industry.

Portable XRF Analyzers DELTA Handheld X-ray Fluorescence provide decisive results to multiple industries with varied applications.

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