In situ delineation of point sources and high resolution mapping of polluted sites by field-portable X-ray Fluorescence measuring device

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Introduction

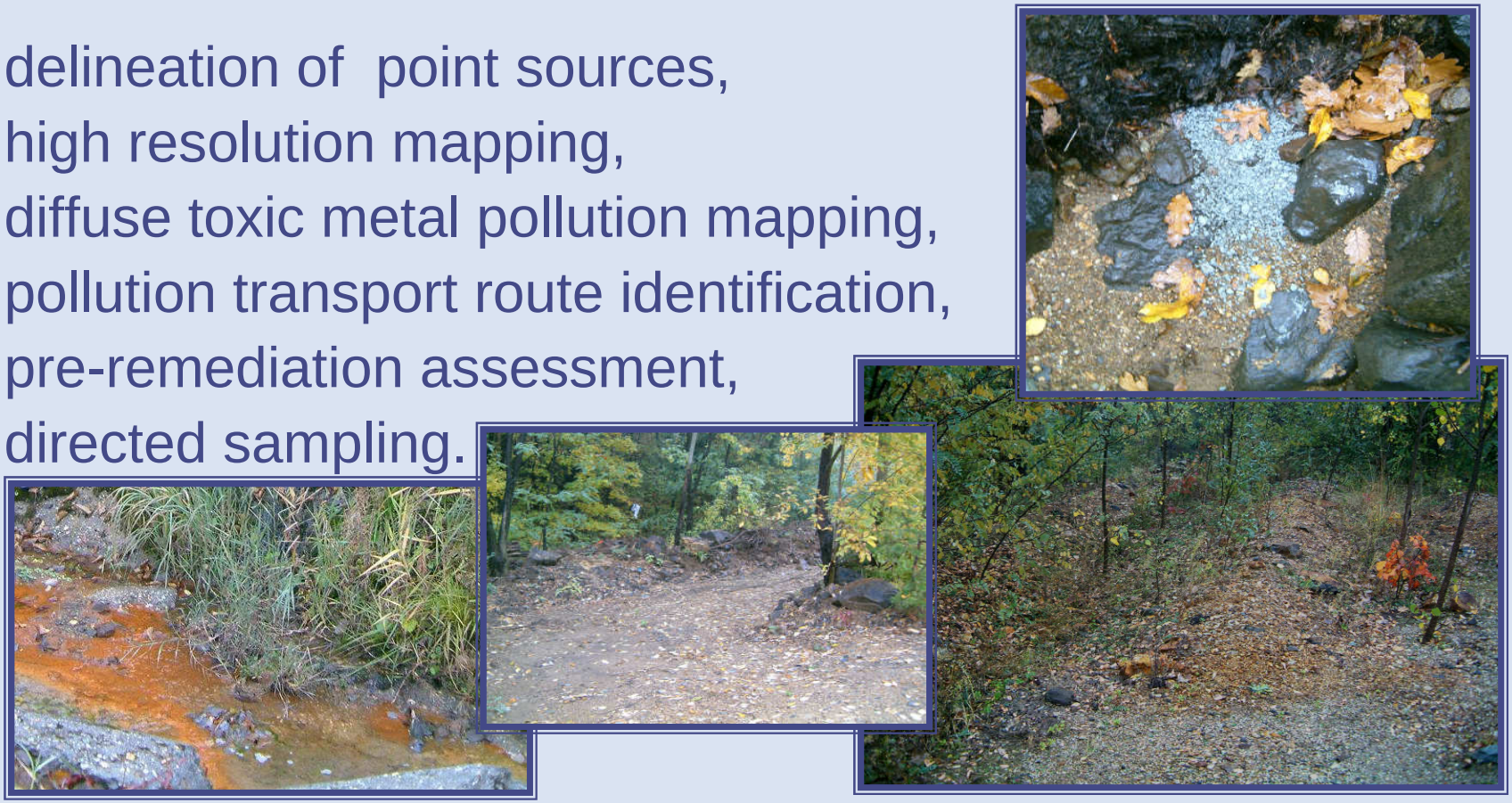
In situ or on site metal detection methods, able to spot the extent, the size and heterogeneity of the pollution, have gained an important role in site assessment, environmental monitoring and in the follow up of the effects of interventions.

The advantages of the field-portable, handheld XRF instrument and technique are demonstrated via case studies in the toxic metal polluted area of Gyöngyösoroszi, Toka watershed (North-East Hungary). As a result of the former mining activity, several million tonnes of mine waste material, flotation tailings, mud tails and precipitates from acid mine drainage treatment are disposed concentrated or diffusely in the Gyöngyösoroszi area. The toxic metal pollution is primarily delivered by the rain water reaching the Toka creek. During springtime due to the regular floods the hobby gardens along the creek are covered by the water transported sediment. Erosion is also typical due to the non-isolated disposal of the mine-waste.

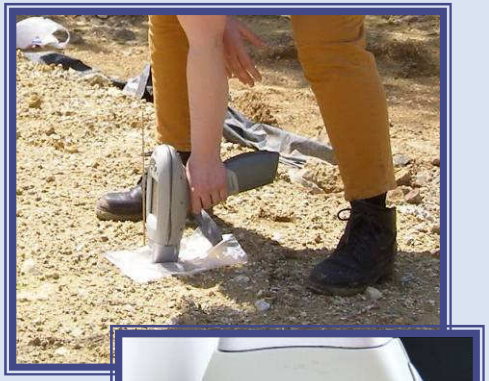
Objectives

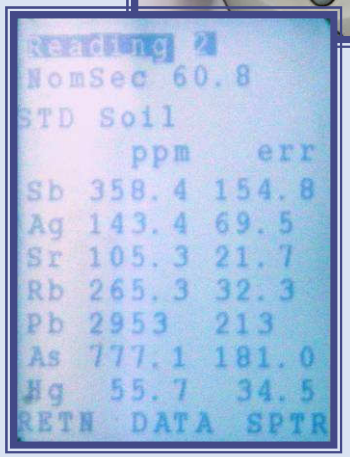
The possibilities and advantages of in situ metal detection using field-portable XRF instrument are demonstrated herein in various applications:

1) delineation of point sources,
2) high resolution mapping,
3) diffuse toxic metal pollution mapping,
4) pollution transport route identification,
5) pre-remediation assessment,
6) directed sampling.



XRF device

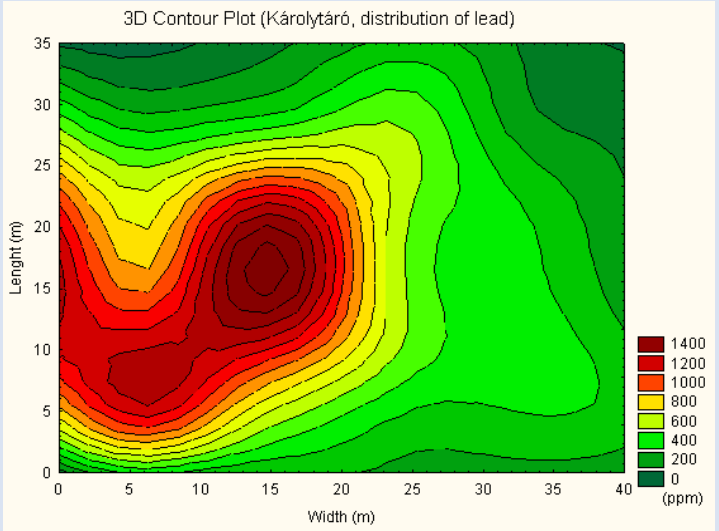


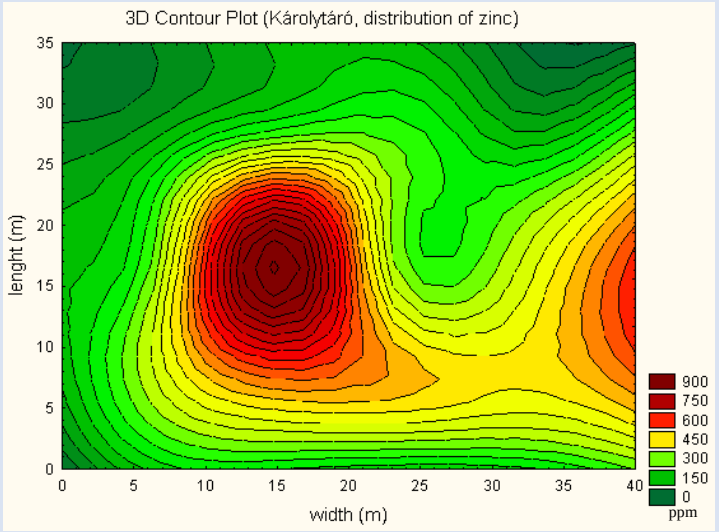


- The hand-portable XRF device is able to perform immediate, non-destructive, quick multi-element detection with built in calibration for soil.
- For environmental applications field-portable XRF results can be considered as quantitative when measurement precision is within 20%, and results are confirmed by an approved laboratory method. The accuracy of the in situ method is element and matrix dependent, it is influenced by site-specific conditions, particle size and distribution, sample moisture, sample preparation, analysis time (60–120 sec). The device can be used directly on soil or after on site sample preparation.

Delineation of point sources

- The point sources in the former mining site, for example the mine waste heaps left over in the forest were delineated by the hand portable XRF instrument.
- The 3D plots show the distribution of lead and zinc within a mine waste heap and its immediate vicinity.The toxic metal concentration vary with the distance from the pollution source. The lead is immobile, the zinc is leached out from the mine waste.

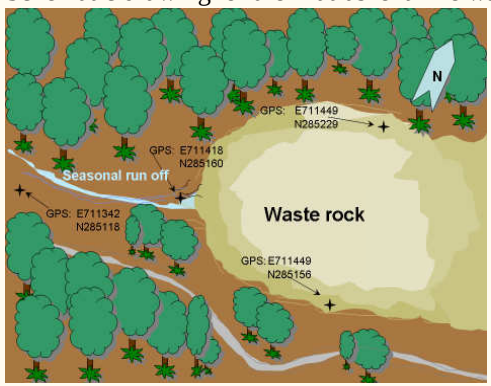


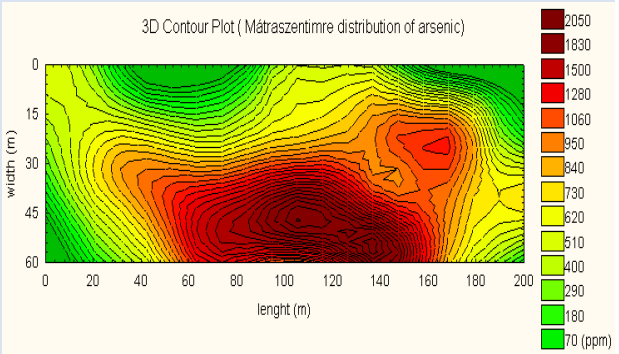


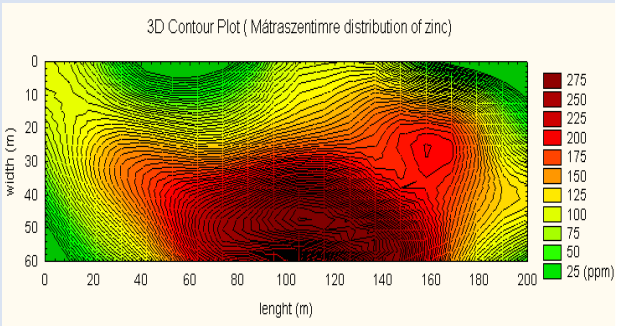
Identification of pollution transport routes

- The pollution transport routes from the Mátraszentimre waste rock disposal site were identified based on 55 XRF measurement points. The 3D Contour plots visualise the arsenic and zinc concentrations within the waste rock disposal site and along the seasonal runoff pathway. The pollution transportation route is clearly outlined on the pollution map: it agrees with the runoff path.
- The photos above confirm the effect of erosion by water within the mine waste disposal site.

Schematic drawing of the Mátraszentimre waste

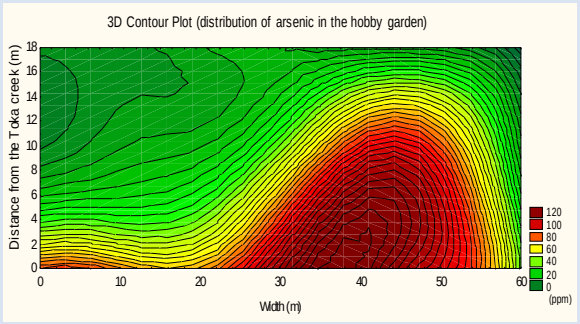


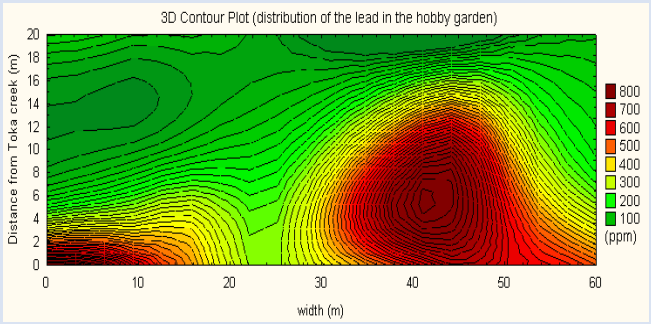


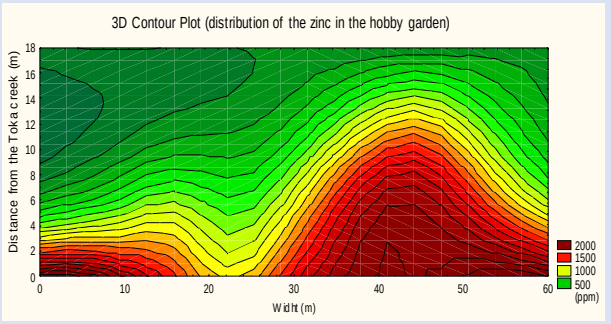


Pre-remediation mapping of toxic metal pollution

- Some of the polluted hobby gardens in the flooded area along the Toka creek have been assessed to identify remediation field plots. The maps prepared from 82 XRF measurement points show an increasing metal gradient in the Toka-direction.
- The effect of floods along the Toka creek becomes obvious: the low-lying land-strip near the creek shows extremely high metal concentrations.







High resolution mapping

- The run of mine ore transportation line section from the mine adit to the flotation plant was mapped to support decision making on the proper remediation measure. Metals distribution is shown on the GIS (Geographical Information System) map produced by ArcView ArcGIS®9 software.
- The metal concentration range at this site is: As 100–500 ppm, Cu 100–1200 ppm, Pb 2000–7000 ppm and Zn 1500–32000 ppm.