On-site screening and monitoring of pollution by a field-portable X-ray fluorescence measuring device

Mária Tolner, Emese Vaszita and Katalin Gruiz

Budapest University of Technology and Economics, Department of Applied Biotechnology and Food Science

1111 Budapest, Gellért Sq. 4. HUNGARY; e-mail: mtolner@mail.bme.hu, www.ecorisk.hu

Introduction

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

Characterization of the reliability of the XRF measurements

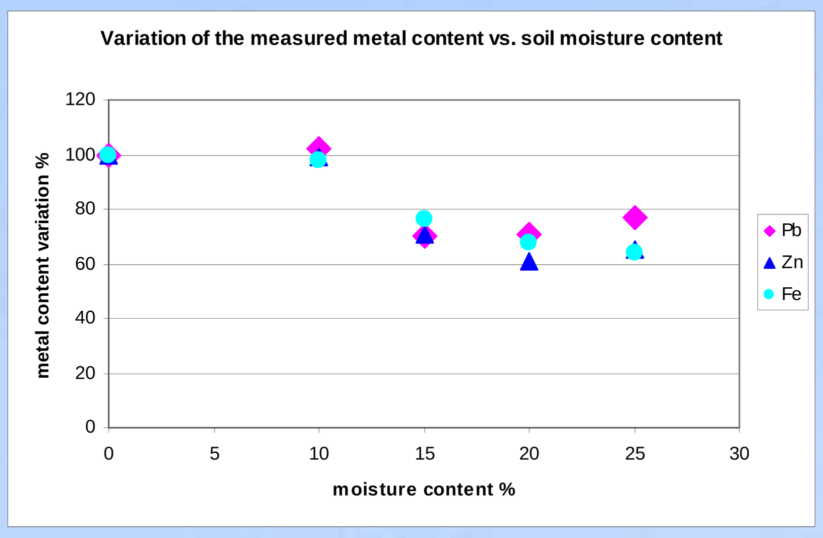

Fig 1: Variation of the measured metal content vs. soil moisture content

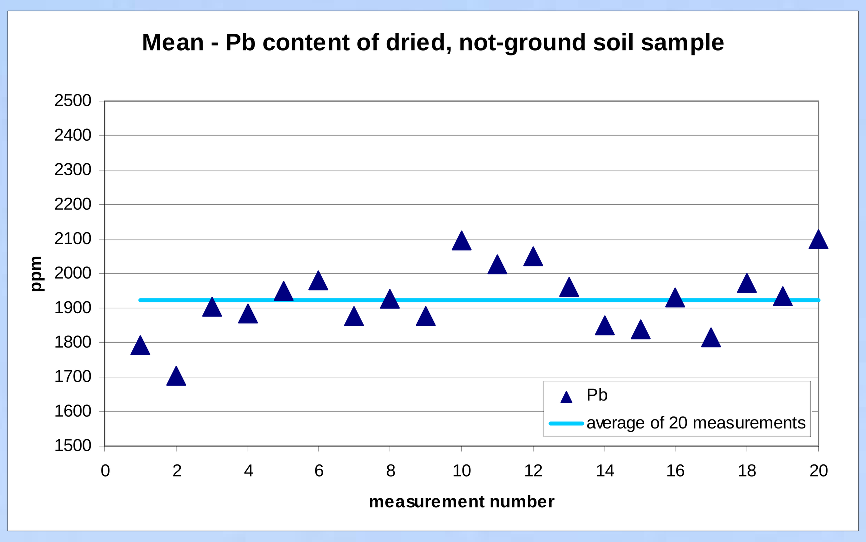

Fig 3: Mean of Pb content of ground and dried mine waste

Table 1: Descriptive statistics of dried and ground and of dried and non-ground mine waste sample

	Valid N	Mean	Confidence - -90,000%	Confidence - 90,000	Minimum	Maximum	Std.Dev.
Pb G	20	2 176	2 123	2 228	1 975	2 465	136
Zn G	20	250	236	263	198	322	36
Fe G	20	53 143	52 172	54 115	49 481	58 388	2 513
Pb NG	20	1 924	1 885	1 962	1 705	2 101	100
Zn NG	20	149	140	159	120	213	24
Fe NG	20	48 690	47 909	49 471	45 559	52 133	2 020

G – dried and ground mine waste
NG – dried, not ground mine waste

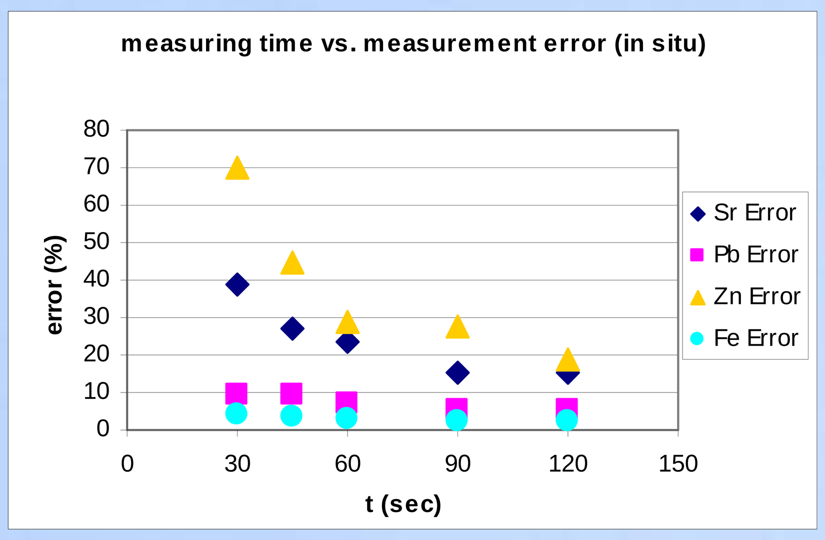

Fig 2: Variation of the measurement error vs. duration of the measurement

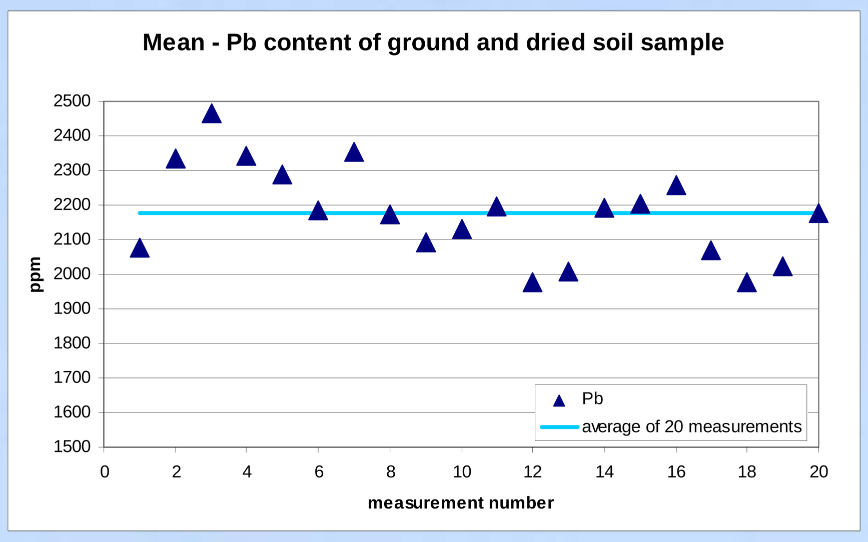

Fig 4: Mean of Pb content of dried and not ground mine waste

Objectives

To demonstrate the possibilities and advantages of in situ metal detection using field-portable XRF instrument through the following applications:

1) pollution transport pathway identification,

2) pollution mapping in a flooded allotment,

3) high resolution mapping,

4) preliminary assessment and selection of an experimental plot.

Distribution of the detected metal concentration within the assessed area was visualised on 3D charts using STATISTICA®6.0 and ArcView ArcGIS®9 software.

In situ applications of the field portable XRF instruments

Identification of pollution transport routes

Fig. 6: Mátraszentimre waste rock disposal site

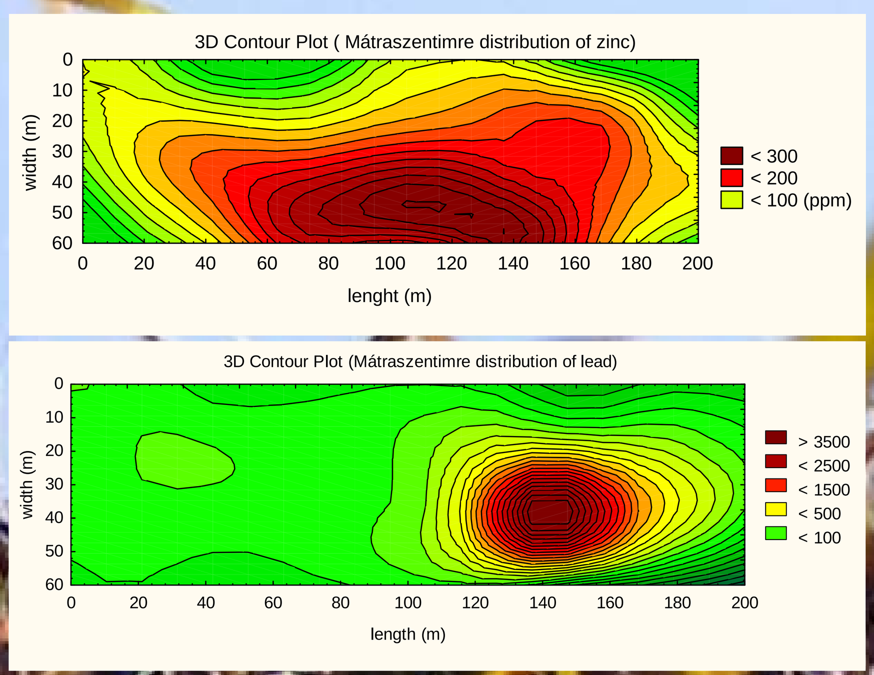

Fig. 7: Distribution of lead and zinc in Mátraszentimre waste disposal site

The pollution transport routes from the Mátraszentimre waste rock disposal site (Fig. 7) 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 photo above confirms the effect of erosion by water within the mine waste disposal site (Fig. 6).

High resolution mapping

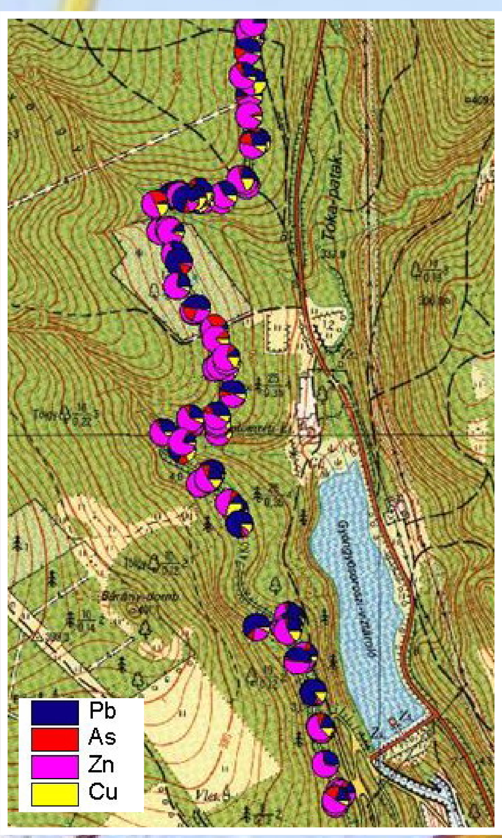

Fig. 8: Metal content along the run of mine transportation line

The run of mine ore transportation line section (Fig. 8) 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.

Preliminary assessment and selection of an experimental plot

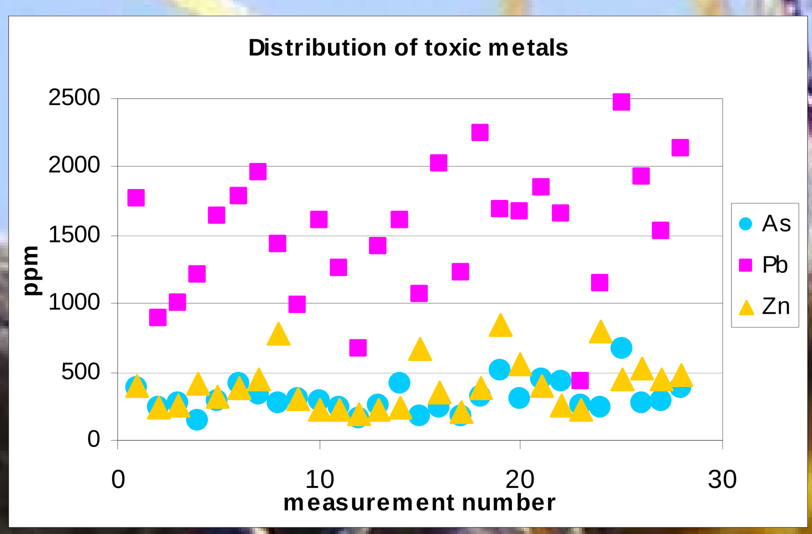

Fig. 5: Distribution of As, Pb and Zn

Figure 6. shows the As, Pb, and Zn concentration distribution based on 28 measurement points within the assessed 60m^2 area. The graph outlines the heterogeneity of the assessed site thus draws the attention on the advantages of the in situ XRF measurements able to outline in a relatively short time the most polluted sections of an area.

Pre-remediation mapping of toxic metal pollution

Some of the polluted allotments 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 (Fig. 9).

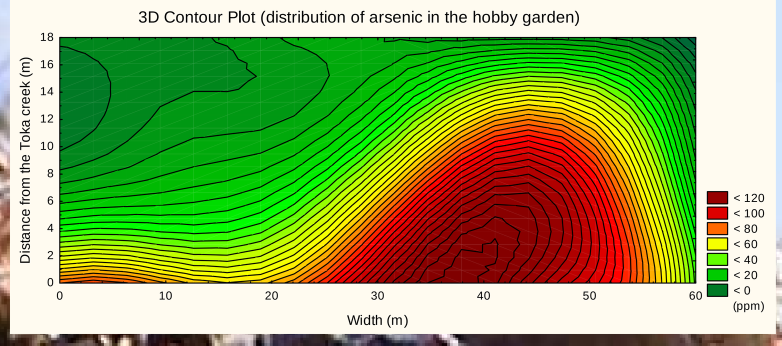

Fig. 9.: Distribution of arsenic along the Toka creek

Conclusion

The hand-portable XRF device is able to perform immediate, non-destructive, quick multi-element detection. It can be successfully applied to field pollution screening, delineation of point sources and mapping of diffuse toxic metal pollution on large areas. It is able to provide continuous and real time data, so that the assessment strategy can be modified during the assessment. It is suitable for source and transport route identification, source delineation and shortens the time of the preparatory works of risk reduction. The field-portable devices allow assessment of large sites, even whole catchments, on site monitoring of polluted sites and remediation technologies. The in situ metal detection methods have lower precision compared to the laboratory analysis, but the number of measurements have practically no limit, which is often more important. The field portable XRF methodology is cost-, and time effective for the in situ assessment of metal polluted sites.

The work was supported by the „Anyos Jedlik" (NKFP-3-020/2005) and „BANYAREM" (GVOP-3.1.1-2004-05-0261/3.0) Hungarian Research Programmes