INTRODUCTION

Among the negative impacts related to human activities, the mobilization of heavy metals from their natural reservoirs to the aquatic and terrestrial ecosystems has become a generalized problem in almost worldwide [Ran et al., 1992; Knopf et al., 2002; Kidley et al., 2005]. At the present, it is considered that a great proportion of soils in developed countries present concentrations of some elements and compounds higher than their expected natural concentration [Jones, 1994]. Nevertheless, in some areas, natural factors as parent material, climate, vegetation, volcanoes, etc., are highly influencing heavy metal contents in soils [Nigula, 1989; Nigula and Pacytka, 1988].

This problem is also recognized in the recent EU “Thematic Strategy for Soil Protection” [CSA, 2002], where contamination is identified as one of the main threats for soils in Europe. This Strategy constitutes the basis for maintaining and improving soil resources quality along Europe. The working group on “Contamination and Land Management” [Van-Camp et al., 2000] states the needs for measuring heavy metal concentrations in soils, determining the sources of pollution, establishing background values and critical loads of pollutants for each soil type and determining the risk of pollution as basis for the development of soil quality standards.

Decisions on the remediation of polluted soils are one of the most difficult management issues for environmental state agencies. The cost of the assessment of soil contamination status at regional or national level is high and, in most of the cases, this assessment is uncertain. The economic implications of different soil quality states are multiple thus understanding the spatial distribution of contaminants is a crucial point for policy making at the EU level.

This paper presents a general method to link pollutants to soil types that can be helpful to perform a quick analysis of the distribution of pollutants over soils. It can be used as a tool for decision makers to make a faster delineation of problematic areas and to analyze the probable sources of pollution in such areas.

STUDY AREA

The study was carried out in soils from Natura 2000 protected areas in the Italian Peninsula. We used a database containing 218 soil profiles, with a total amount of 664 soil horizons described. Their spatial distribution is shown in Figure 1.

Soil profile descriptions include geographic information (location, geology, vegetation type, aspect, slope, altitude), and pedological description as soil type, number and description of the horizons, soil texture. Total contents of heavy metals (Hg, Cd, Cr, Cu, Ni, Pb, Zn) were determined by atomic absorption spectroscopy. Threshold values for HM in agricultural soils coming from European legislation and descriptive statistics for these samples are reported in Table 1.

RESULTS

Heavy metal contents in this soil is heterogeneous. Since the soils include in this study are mainly derived from lime rocks, we observed that most of the samples have HM concentrations lower than the thresholds fixed in the European legislation for soil (ge-7). There are also many samples with high contents of heavy metals. This occurs in some samples for Cd (Lazio, Molise), Hg (Lazio) Cr (Basilicata, Toscana, Lazio and mainly Sardinia), Ni (Basilicata, Sardegna), Zn (Basilicata, Toscana, Lazio, Calabria and Sardegna). We must note that these thresholds were defined for agricultural soils, so they are not really applicable to natural soils as those presented in this study and they are merely presented just as a reference values.

PCA analyses reveals four groupings of heavy metals. The four-component model accounts for 83% of the data variation. The first factor well discriminates Ni, and Cr (Figure 2). It can be considered that the origin of these elements in soils is geogenic. The second factor separates Pb and Cu. These elements are usually related to human activities characterized by high concentration in soils is mainly anthropogenic. In the third axis is represented Zn, also controlled by lithogenic processes. The fourth axis represents Cr, in this case the origin of this element in soils is also anthropic. For Cd we found an ambiguous situation, it is represented equally in both the 2nd and 3rd axes. Seems that its presence in soils can be due to both human and natural inputs.

Hierarchical cluster analyses were performed for both heavy metals and soil types. These analyses were performed by administrative regions. Permuted data matrices on standardized data (Figure 3) show both the cluster trees for elements and soils and a colored matrix indicating the standard deviations of HM content for each soil type. Rows and columns are ordered according to the overall similarity to help interpretation.

In general, we observed the same pattern of associations between HM as those obtained in the PCA using the whole dataset. We observe that soils in regions like Basillica and Marche have a higher content in Cu, probably due to vine cultivation. In Lazio the most visible is the higher contents in Pb derived from the emissions of the road transport. In Molise, leptic soils tend to exhibit higher contents of Pb, Cd, Cr and Zn. These analyses also permit to identify special situations. In Sardinia, Cr and Ni contents in Phaeozems and in Mollic Cambisols/Leptosols can be related to the presence of vitric materials. Mining activities are reported in these areas. Vitric Andosols in Basillica presents very high contents in Cu.

Although these heavy metals are strongly influencing the diversity, distribution and specific vulnerability of soils across Europe. In this study we presented a method to perform a simple multi-evaluation on the status of pollution with heavy metal in soils. In this case we used natural soils coming from Natura 2000 as a way. The approach allows to identify areas at risk of contamination and to find links between heavy metal contents. On the other hand, soil types were ranked and clustered based on their heavy metal contents. It is first, the possibility to evaluate soils in order to protect specific areas minimizing the costs of evaluation in order to protect natural ecosystems and human health risks. Second, we obtained an idea of the spatial distribution of these elements in soils and also taking into account their spatial distribution in the study area. These results can be improved by adding information on land management practices, location of point sources of pollution, evaluation of deposition rates, etc. We must note that toxicity risk for heavy metals is not dependent only on the total metal content in soils but also in the speciation forms they are present and in their mobility. For more detailed studies, more surveys are needed.

CONCLUSIONS

Soil vulnerability to heavy metals is influenced by the diversity, distribution and specific vulnerability of soils across Europe. In this study we presented a method to perform a simple multi-evaluation on the status of pollution with heavy metal in soils. In this case we used natural soils coming from Natura 2000 as a way. The approach allows to identify areas at risk of contamination and to find links between heavy metal contents. On the other hand, soil types were ranked and clustered based on their heavy metal contents. It is first, the possibility to evaluate soils in order to protect specific areas minimizing the costs of evaluation in order to protect natural ecosystems and human health risks. Second, we obtained an idea of the spatial distribution of these elements in soils and also taking into account their spatial distribution in the study area. These results can be improved by adding information on land management practices, location of point sources of pollution, evaluation of deposition rates, etc. We must note that toxicity risk for heavy metals is not dependent only on the total metal content in soils but also in the speciation forms they are present and in their mobility. For more detailed studies, more surveys are needed.

Bibliography