EuroGeoSurveys
European Geoscience for Society
The Geological Surveys of Europe

Geochemistry

Factsheet – Soil

What is Soil?

Soil can be looked at in two ways, based on its properties or related to its specific use[1]. Soil is the loose upper layer of the Earth's crust formed as the result of weathering of various rocks and sediments and their interaction with water, climate, topography, plants and living organisms. The pedological approach divides soil into horizons which are a result of interplay between underlying geological basement and climatic conditions over time and space[2,3].

What is Healthy Soil?

The concept of healthy soil has diverse interpretative meanings, depending on how soil is classified and used. In general, healthy soil should be defined as soil that is fertile and harmless to human, animal or plant health. For example, soil used for food and crop production needs sufficient amounts of macro- and micro-nutrients and low concentrations of toxic elements[4], and needs to fulfill many different conditions to be classified as suitable for agricultural use. Low concentrations of potentially toxic elements such as lead (Pb), cadmium (Cd), mercury (Hg), nickel (Ni) and arsenic (As) are required in urban environments, such as city gardens, playgrounds, preschool yards and residential areas. Natural soil can have high metal concentrations due to the occurrence of mineralisation or secondary enrichment through soil forming processes, weathering and precipitation of oxides and hydroxides rich in potentially harmful elements. Therefore, soil chemical quality and the need for remediation should always be assessed by taking into account the local (and/or regional) natural geochemical baseline variation.

How is Soil Relevant to Society?

Soil is the basis for food production, a crucial part of natural resource exploitation (e.g., forest, groundwater) and acts as a driver of resilience to climate change (including drought, floods and extreme weather events and even carbon dioxide capture). With an ever-increasing world population, more efficient food production is becoming a major challenge, as suitable soil is vital and must at the same time be protected from degradation[5,6].

How is Soil Relevant to Policy?

As part of the EU soil strategy for 2030, the European Commission has begun a process to establish laws on soil health. These laws aim to specify the conditions for healthy soil, to provide methodologies for soil monitoring and establish rules for sustainable soil use and restoration[5]. Establishing laws on soil health is particularly complex, as the qualification and quantification of healthy soil depends on the regional and local geochemical background parameters linked to the geographical and geological context, as well as on the use of soil (agriculture, industry, construction, etc.)[4].

EuroGeoSurveys Role in the Soil Surveys of Europe

EuroGeoSurveys (EGS) has been involved in two pan-European projects with a focus on soils.

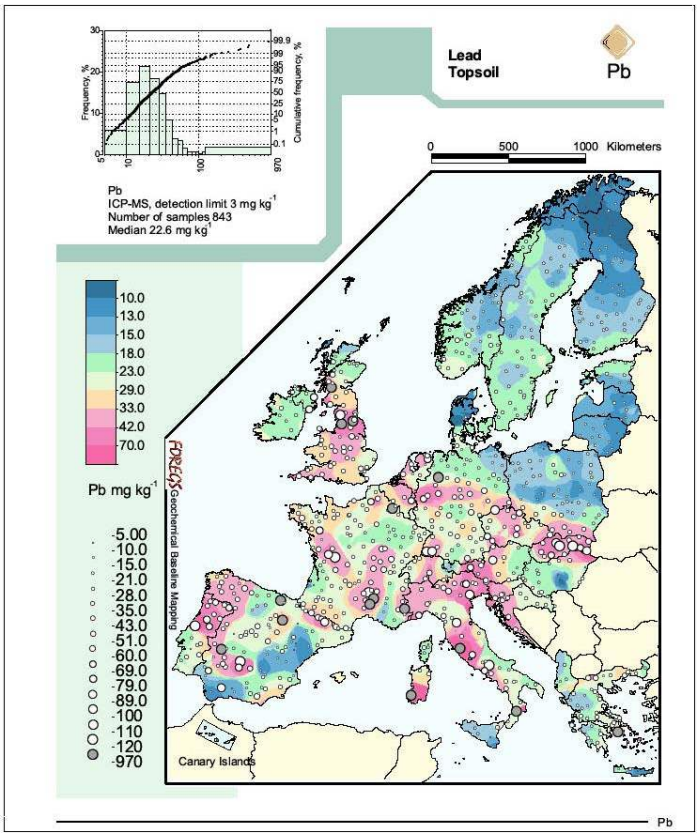
The FOREGS project[7] (Forum of the European Geological Surveys) was the first geochemical baseline mapping survey at the European continental scale, with the aim of providing high-quality, multi-purpose environmental geochemical baseline data for Europe (26 countries, 925 sample sites covering 4,250,000 km^2). This programme was completed with the publication of two-volume atlas. Following the **FOREGS** concept of the low density mapping of Europe, the **GEMAS** Project[4,8] (Geochemical Mapping of Agricultural and Grazing Land Soil) was conducted by the EuroGeoSurveys Geochemistry Expert Group in partnership with the European Association of Metals (Eurometaux), to carry out the geochemical mapping of agricultural and grazing land soil at the continental scale (33 countries, more than 2000 samples covering 5,600,000 km^2), and to produce a reference dataset for all kinds of environmental purposes.

Both projects produced high-quality harmonised data of chemical elements in European soil. Geochemical maps can be freely accessed via the European Geological Data Infrastructure (**EGDI**) platform and the websites of the Geological Survey of Finland (www.gtk.fi/publ/foregsatlas) and the Federal Institute for Geosciences and Natural Resources (https://geoportal.bgr.de/mapapps/resources/apps/geoportal/index.html?lang=en#/geoviewer).

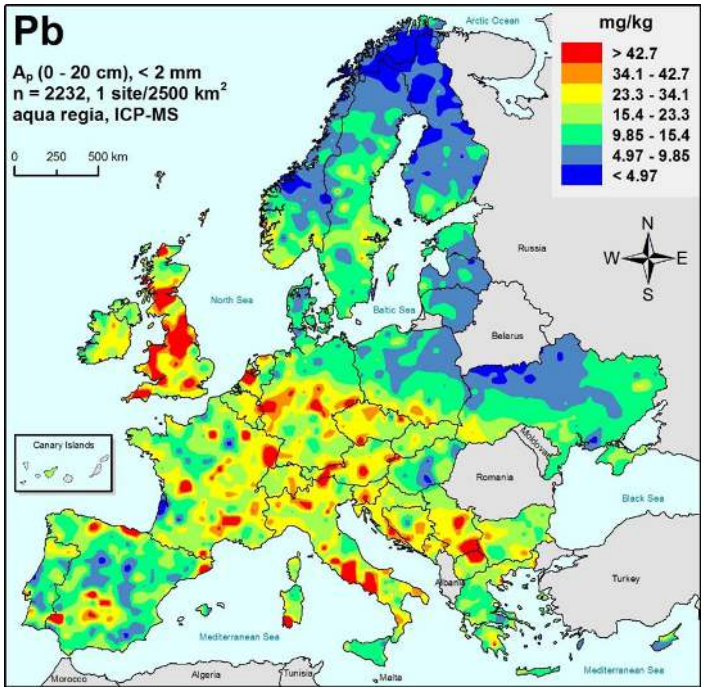
The main objectives of these two European surveys were: 1) to apply standardised methods of sampling, chemical analysis, and data management; 2) to present a geochemical baseline for soil across Europe; and 3) to deploy this reference network to level national baseline data sets.

The **FOREGS** and **GEMAS** Atlases of Europe have many applications, e.g., in agriculture, forestry, animal husbandry, in delineating metallogenic provinces, health-related research, environmental monitoring, spatial planning of infrastructure development in cities and policy-related initiatives.

Besides carrying out collaborative projects at the European scale, the EGS Geochemistry Expert Group provides broad expertise to the European Commission's legislative initiatives such as the Soil Monitoring Law and the European Soil Observation Platform.



Geochemical map of lead content in topsoil of Europe using aqua regia extraction and ICP-MS measurements (**FOREGS** project; samples collected from around 900 small catchment basins)



Geochemical map of lead content in agricultural soil (Ap) of Europe using aqua regia extraction and ICP-MS measurements (**GEMAS** project).

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