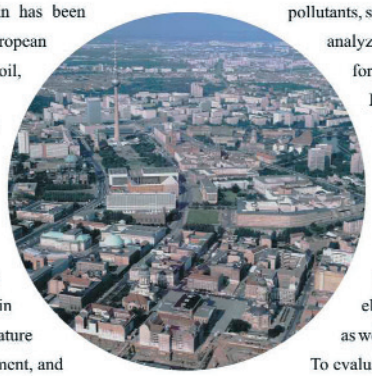
# Geochemical Investigations in the Berlin Metropolitan Area

**Manfred Birke, Uwe Rauch**

In Germany, ecological studies have been carried out in urban areas since 1970 but they were not accompanied by detailed geochemical surveys.

Since 1992, research on the environmental geochemistry in urban Berlin has been incorporated in the Natural Resources Monitoring. Berlin is the first European megacity to be covered in its entirety by a geochemical survey of the topsoil, including large areas of more or less rural environs.



Assessment of the regional or local extent of contamination of an industrial district or an urban area is possible only by comparison with less contaminated areas, in this case, comparison of urban Berlin with its rural surroundings.

Our studies are aimed at obtaining a differentiated picture of the complex geochemistry of soils in urban areas with respect to their natural composition and the secondary or anthropogenic contamination. The investigations in Berlin can provide a basis upon which to draw up general regulations for nature conservation and soil protection, conducting an environmental impact assessment, and estimating contamination of soils.

About 4000 soil samples (depth 0 - 0.2 m) were taken in suburban areas with little or no contamination as well as industrial areas in and around Berlin. The < 2 mm fraction was analyzed for 11 major elements and 41 trace elements, TOC, pH and electrical conductivity were also determined. Organic pollutants, such as hydrocarbons, aromatics, and volatile halogenated compounds were also analyzed in topsoils from the central part of Berlin and from locations currently or formerly occupied by chemical industries.

Densely populated areas and industrial areas were sampled at a density of 40 samples per km². Field observations provided additional information: geographical situation, geology, morphology, urbanization, land use, vegetation, soil type and horizon, and potential sources of contamination.

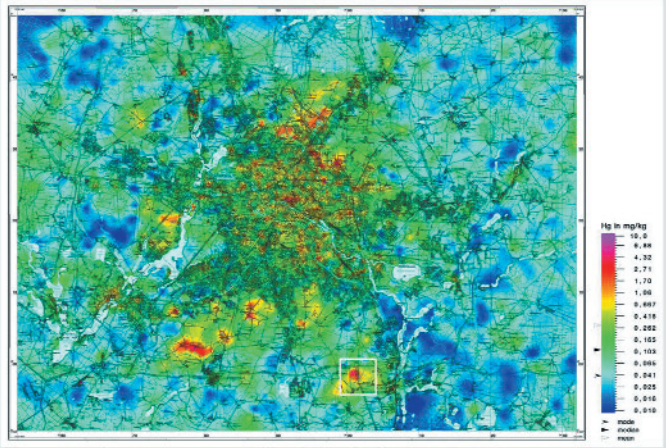
The distribution patterns of certain element associations in urban Berlin and its surroundings were determined by principal component analysis and cluster-Q analysis. They allow regional and local migration of the various elements in industrial emissions to be studied in the exogenic geochemical field, as well as the recognition of natural and anthropogenic element associations.

To evaluate and interpretate geochemistry data, we use both single-element and multi-element maps (cluster-Q analysis), maps of geochemical associations (component analysis), and maps showing the geochemical load index for various trace elements.

## Mercury

Certain types of industry are typically associated with mercury contamination of the ground (> 0.35 mg Hg/kg soil); these include the metal-working industry, non-ferrous smelters, sewage farms, the chemical industry and the wood processing industry. Anomalous concentrations of mercury also occur in association with solid-waste disposal sites and areas where building rubble has been dumped. In residential areas elevated concentrations (max. 4.4 mg Hg/kg soil) in city parks and gardens, allotments as well as in urban woodlands. Anthropogenic contamination in "green belts" and parklands is chiefly derived from the products of composting facilities and/or sewage farms, which are commonly applied for soil improvement.

*Areal view of sewage farm*

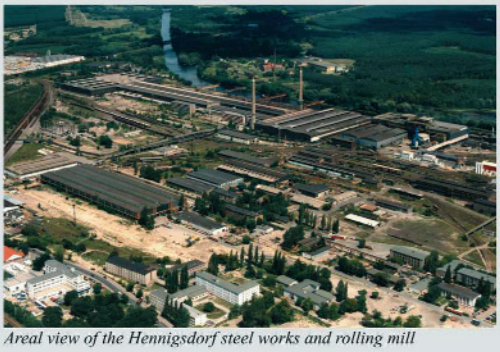



*Mercury distribution in topsoils in urban Berlin (☐ - location of areal view)*

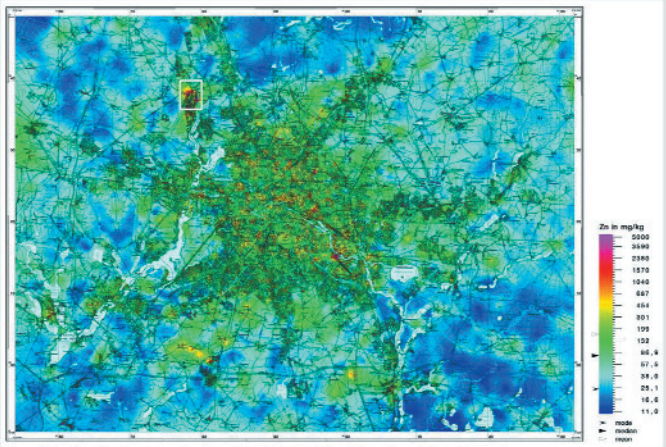
Local enrichments of mercury within urban Berlin are often detected near hospital complexes and outpatient departments, as well as in the areas downwind from power plants, which are usually associated with district heating and/or incineration plants. The area around Berlin is characterized by an unusually low mercury background of 0.04 mg Hg/kg. The geochemical background of sewage farm areas (1,0 mg Hg/kg) is seven times higher than the geochemical background of the urban area and about twentyfive times higher than the natural or geogene background. High-contrast and extensive Hg anomalies (max. 6,3 mg/kg Hg) caused by sewage farms are observed in the northern and southern environs of Berlin in traditional sewage farm areas.

## Zinc

The zinc distribution in Berlin is similar to those of mercury, copper and lead. The distribution pattern reflects that of industrial and residential areas. In contaminated soils, zinc is mainly bound to organic matter or is adsorbed onto oxides of Fe, Mn or Al. The geochemical background of urban centres is three times as high as that of the surroundings. The soils of the Barnim, Teltow, and Nauen flat upland areas, east, south, and northwest of Berlin, respectively, show a weakly elevated background. The Pleistocene urstromtal east of Berlin is characterized by zinc minima. Concentrations of up to 25 % Zn (Weissensee machine tool works), which exceed the limits allowed in Berlin, occur in the industrial districts of Berlin. The adjoining residential districts frequently display elevated zinc concentrations. Local maxima of up to 17 % Zn are found in landfill areas in the immediate vicinity of industrial sites. In the area around Berlin, the Hennigsdorf steel works and rolling mill, the AEG plant at Hennigsdorf, and the Gruenau shipyard show an anomaly of > 5000 mg Zn/kg.



*Areal view of the Hennigsdorf steel works and rolling mill*




*Zinc distribution in topsoils in urban Berlin (☐ - location of areal view)*



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## Geochemical results

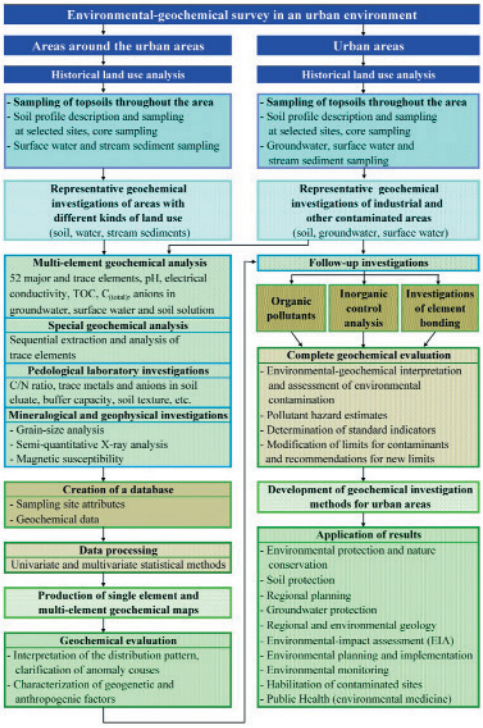
The element distribution in the topsoil shows a clear dependence on the type of urban land use and type of industry. The distribution of the elements Al, K, Na, Rb, Zr, Nb and Ti is mainly of natural origin, i.e., related to the composition of the parent material.

Industrial areas tend to be characterized by contamination of the subsoil with Cu, Zn, Pb, Hg, Sn, and/or Ni. Industrial and commercial areas often display considerably elevated Pb, Hg, Ca and electrical conductivity relative to the geogenic background.

The regional geochemical background in Berlin soils shows anthropogenic enrichment in Cd, Ni, Cu, Hg, Pb, Sn, Th and Tl, derived from high-temperature processing.

In agricultural areas, the background tends to show enrichment of Cd, Cr, V and P, caused by extensive use of fertilizers and sewage sludge. In the area around Berlin, strong, extensive anomalies occur near iron and steel industries and construction materials industries, as well as in the vicinity of sewage farms.

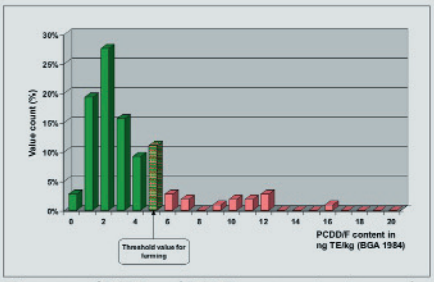
The element distribution maps are useful for locating anthropogenic geochemical halos, assessing environmental conditions, and making well based ecological decisions.



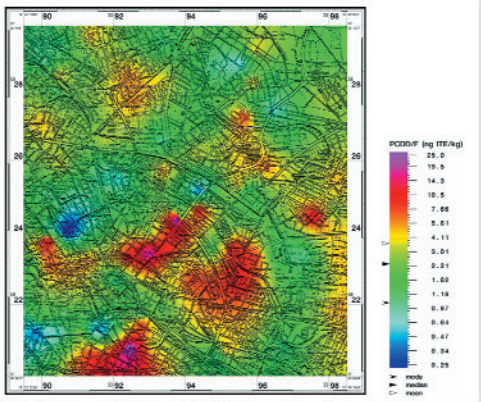

## Dioxins and Furanes

Polychlorinated dibenzodioxins and dibenzofurans (PCDD/PCDF) were analyzed only in topsoils from the central part of Berlin. To clarify the sources of PCDD/F contents the congener composition of the samples and the total sums of the PCDD/F and toxic equivalent concentrations were compared with the patterns of PCDD/F congeners that are typical for known sources.

The city-center is characterized by a geochemical background of 2.19 ng TE/kg. In the Berlin industrial districts of Friedrichshain and Weißensee the geochemical background is about three times higher than the geochemical background in the inner-city. The maximum toxicity equivalents were determined in the residential area of the Thälmann Park (34.4 ng TE/kg) and the former frontier region (31.3 ng TE/kg). They caused by sewage sludges (as fertilizer in green spaces) and dyeing effluents. The main sources of PCDD/F input were found to be flying ashes (waste incineration, heating plants) and waste from fire damages.




*Histogram of PCDD and PCDF concentrations in topsoils*



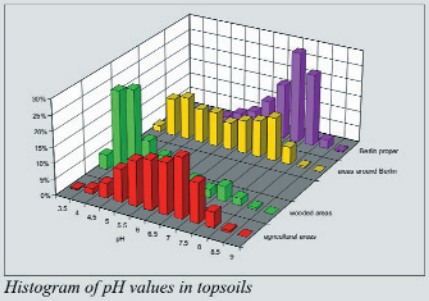

*Distribution of PCDD- and PCDF concentrations in topsoils in central part of Berlin*

*Areal view of the central part of Berlin*

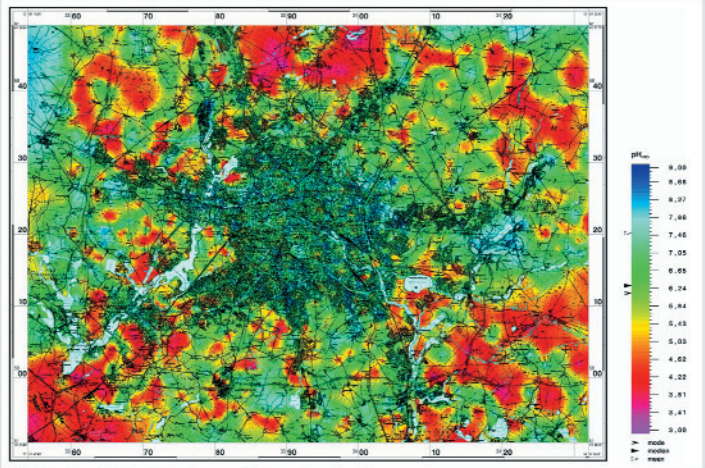
## Acidity of the soils

The urban soils are predominantly calcareous, with pH values of 6 to 8. However, the soils in the woodland areas in and around Berlin are acidic without exception, having pH values below 4.5. Wooded urban areas show a minimum pH of 3.5. This has been observed in several urban woodlands. The forest soils of the Tegel and Spandau districts, as well as those of the Mueggelheim and Mueggelberge nature reserves, show clear acidification with local minima of < 4.0. In this geochemical environment, the high solubility and mobility of the elements Cd, Zn, Ni, Co, Cu, Pb, Hg, Cr, As may pose a hazard to the groundwater.

The sewage farms, especially those southeast of Berlin, locally display pH values of < 5.0. This is very alarming, particularly in view of the extremely high heavy metal concentrations in these areas, as well as the high mobility of Cd at these low pH values.




*Histogram of pH values in topsoils*



*Distribution of pH values in topsoils in urban Berlin*



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