Theme B: Functions & Values of Soil-Water systems; Understanding of Processes

EXPERIENCES WITH SOIL CONTAMINATION MAPS IN AN EUROPEAN REGION - WHAT IMPLICATIONS DOES THAT HAVE FOR THE EUROPEAN SOIL STRATEGY?

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Keywords: soil contamination map, wide spread soil contamination, background-contamination, immission, heavy metal, PAH, dioxine, furane, German Soil Protection Law

1. Introduction and background of the NRW approach to soil contamination mapping

In Northrhine-Westphalia (NRW) a programm is currently carried out to acquire data of soil contamination with persistent contaminants and to produce soil contamination maps covering at present already an area of about 14.000 square kilometres or about 40 % of NRW.

The NRW-approach for mapping top soil contamination is based on the use of the following data basis [1]

- digital topographic land information (land use data),
- digital soil mapping data,
- existing soil sample data which are in accordance with defined quality standards.

Usually additional sampling is carried out. To achieve soil contamination maps for the non settled areas in acceptable quality in an 1 : 50.000 scale an average of about 0.2 to 1 sample per square kilometre is needed, however, the sampling points are not regularily distributed but distributed according to the (expected) variability and spatial distribution of the factors influencing the concentration of contaminants in the top soil.

Additionally in NRW a programme is carried out to map soil contamination in settled areas, though this is still in a more experimental stage. In this program about 13 cities / areas, mainly of the Rhein-Ruhr-area take part at present.

2. A „short course" to the german legal soil value system

The German Soil Protection Law [2] is the legal basis for the evaluation of soils in Germany. In this law different values are defined, in the German Soil Protection Ordinance [3] these values are figured.

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The following values are legally defined in Germany:

- prevention value: Values, when exceeded are indicating the anxiety, that detrimental changes of soil quality might develop. The values are derived from the „average“ natural background in top soil, but also taking into account health risks. Concentrations above the prevention value are referred to as „contamination“.
- trigger value: These are given for different transfer paths. When exceeded, risks cannot be excluded.
- action value: Values, where in the standard case actions have to be taken. With respect to the transfer paths soil – agricultural crop the values have been derived on the basis of german standards for agricultural crops. The respective European Directives (e. g. Directive 2002/32/EC of the European Parliament and of the Council on undesirable substances in animal feed) genereally are comparable, but with exception of some parametres.

3. Main results of the soil contamination mapping program in NRW

The major result of the soil contamination mapping in NRW is that this allows a better understanding of the spatial distribution of contaminants, the processes which drive or have driven soil contamination and, last but not least, that a realistic picture of the degree and extend of soil contamination in a region right in the centre of the new EU has been achieved.

3.1 Causes of contamination

According to the results of this program up to now the following main causes of wide spread soil contamination outside the settled areas can be distinguished:

3.1.1 Lithogenic and / or pedogenic contaminant accumulation

Natural factors strongly influence the distribution of (heavy) metals in soils. From geochemistry it is known that anomalies in the bed rocks can be detected by surveys of the soil [4, 5].

The studies in connection with the soil contamination maps show that even when metal concentrations are or have been below the level interesting for mining local or regional contaminations may occur in the top soil (e. g. Pb/Zn-anomalies in the Rhenish shield and adjoining areas [6]). Another example are soils which developed on basic volcanites. These rocks often contain high amounts of Cr and Ni causing anomalies with these metals in soil [7] (fig. 1).

3.1.2 Immission after short and long distance airborne contaminant transport

Both effects of short and long distance airborne contaminant transport can be observed in certain regions.

An example for a very distinct short distance airborne contaminant transport causing soil contamination is the area around the Lengerich cement factory, which had an accidental immission of Thallium in 1979. This caused up to the factor 100 increased concentrations of thallium in the upper soil horizons and caused determinal health effects within the population near the plant [8, 9].

Effects of long distance airborne contaminant transport can be observed especially in exposed (mainly forested) mountanious areas even more than 100 km away from the industrial centres of NRW [10]. Main contaminant to be found in the top soil of these areas is lead, while due to high acidication other heavy metals are already soluted and transported downward in the soil profile. Also PAH shows an immission controlled pattern of distribution in the top soils, with highest concentrations accuring in areas exposed to immission (fig. 2).

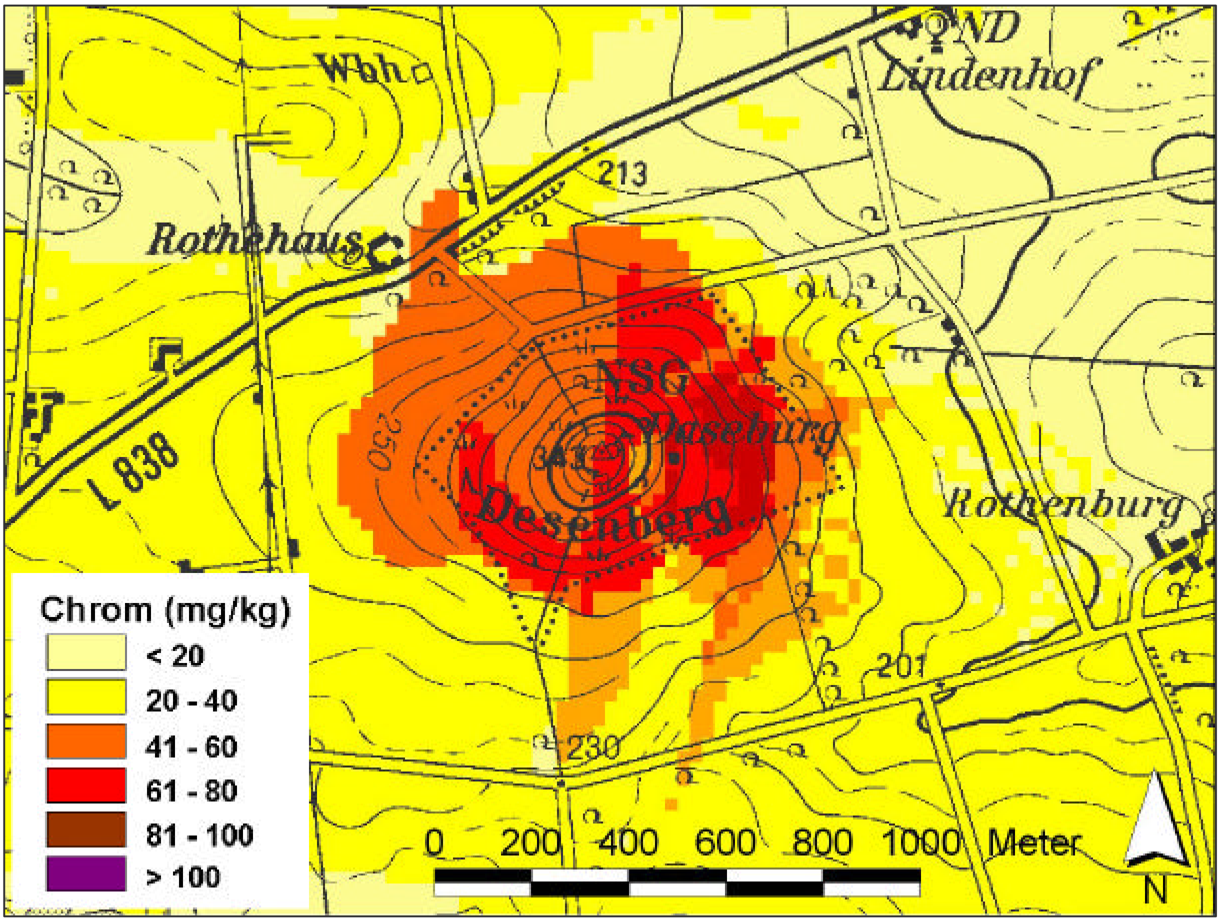

Fig. 1: Geogenic caused Cr-contents in the upper soil developed on a basic volcanic cone in Eastern NRW.

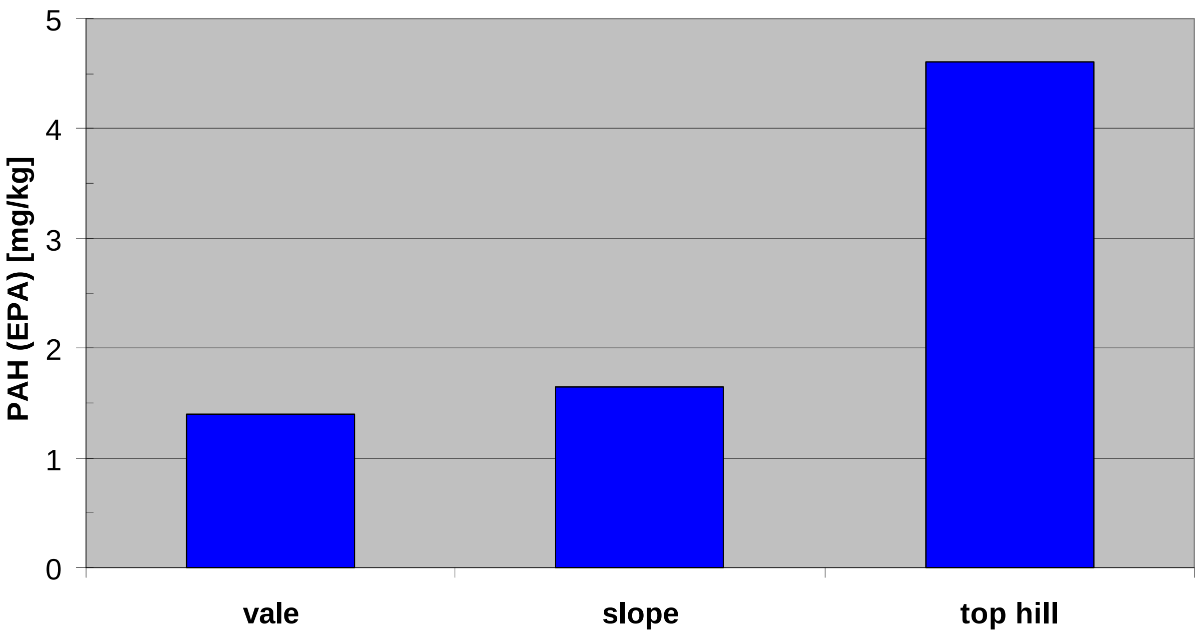

Fig. 2: Immission controlled PAH-contents (median) in the A-horizon of forest soils in a selected area of the Rhenish shield depending on exposure.

3.1.3 Inundation in contaminated river catchments

In soils of a number of river flood plains in NRW a strong accumulation of contaminants can be observed, being caused by deposition of contaminated river sediment. A major source for contamination in river catchments are (mostly former) ore mining and processing activities, especially in some places in the southern parts of Northrhine Westphalia, dating back to – at least – early medieval times (table 1).

Table 1: Median lead content (mg/kg) of current sediments of River Wupper [11].

spring (km 0)	**middle reaches**		**river mouth (km 113)**
Oberbergischer Kreis	Wuppertal / Solingen / Remscheid	Rheinisch-Bergischer Kreis	Leverkusen
119	579	263	264

Downriver of such sites sometimes a clear pattern of contamination can be observed. For example, even more than 15 km downriver of the historical copper mining and smelting town of Marsberg, both copper and the smelting related polychlorinated dioxines can be detected in significant concentration levels in the top soil of the flood plain (table 2).

Table 2: Copper- and PCDD / PCDF-concentrations within the upper soils outside and inside the flood plains of River Diemel about 15-25 km downstream of the historical copper mining site of marsberg [7].

	Unit	**Median**	**Minimum**	**Maximum**
Copper				
Outside flood plains	mg/kg	14	1	75
Inside flood plains	mg/kg	135	108	180
Dioxine + Furane (PCDD / PCDF)				
Outside flood plains	ng I-Teq/kg TM	3,1	1,4	11,2
Inside flood plains	ng I-Teq/kg TM	24,8	20,0	28,0

However, in the flood plains of the larger rivers up to the river Rhine a more diffuse contamination pattern can be observed, however partly reaching concentration levels which make actions to reduce contaminant intake of plants and animals necessary (fig. 3).

Within settled areas one major cause of soil contamination is the wide spread existence of depositions of anthropogenic materials, especially industrial mineral wastes and debris of the 2^{nd} World war in the heavily bombed cities of the Rhine-Ruhr-area. In addition local immission contributes to soil contamination in the industrialized areas [12].

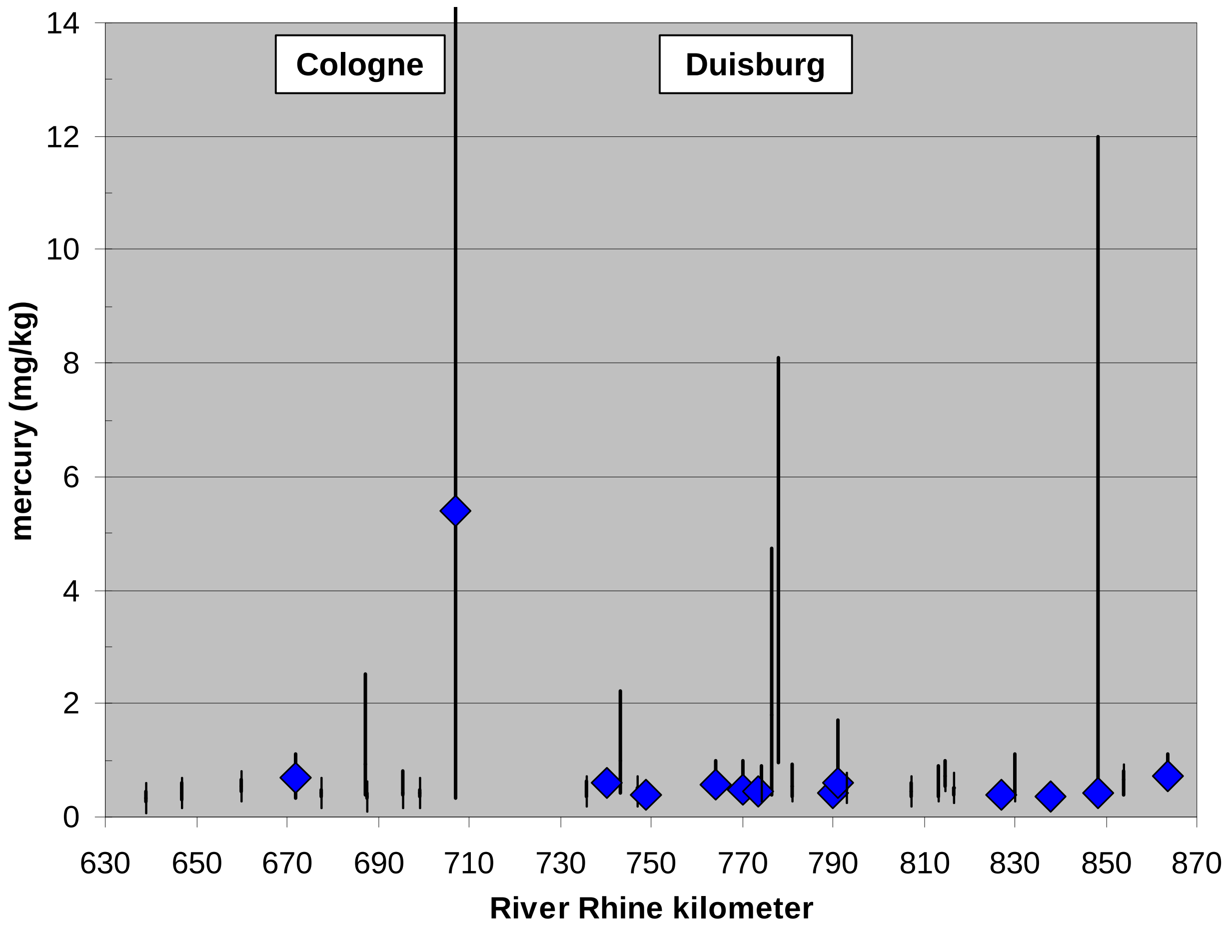

Fig. 3: Mercury content (median and range from 1984 – 2001) in the sediment of River Rhine in Northrhine-Westfalia [13].

3.2 Extent and level of contamination

The analysis of the acquired data and the map information show that in rural areas about 25 % of the area are regarded to be contaminated, e. g. contaminant concentrations lie above the german prevention values. The main factor for this is (historical) immission after long distance airborne transport of pollutants. Since the areas contaminated are usually forest land, besides possible effects on the forest ecosystem and – when the contaminants are dissolved and transported downward – the groundwater – generally no direct uses of land are effected.

Of some importance with respect to agricultural uses is the observation, that even only „moderately" contaminated soils can lead to high availability of contaminants for the agricultural crops if the soil acidity is not regulated according to agricultural standards.

One of the major problems of contamination both with respect to the potential effects on the prevailing land uses (agriculture, settlements) and the extent of the contaminated areas are contamination in some of the river flood plains in NRW. In some of these areas the level of contamination lies above the action values for the transfer paths soil – agricultural crops and soil – farm animals. Clean up of soils will not be feasible, so that restrictions to land use have to be discussed and / or implented. Additionally, improved agricultural practices can help to avoid contaminations of agricultural products.

Within the settled areas especially of the Rhein-Ruhr-area, a wide spread contamination of the mainly antropogenic soils occurs, quite frequently exceeding the trigger values for the relevant transfer paths and therefore making further investigations necessary.

4. Implications for the European soil strategy

4.1 Methodes for acquiring data on the spatial distribution of contaminants in soils

From the authors´ point of view the first step in an approach to acquire data on the spatial distribution of contaminants in soils should be an analysis of the area under concern. This analysis should lead to contamination hypotheses, which can be verified or falsified by a sampling scheme adapted to the specific hypothesis. For example to identify immissions in highly exposed montaineous areas sampling along transsects have lead to success. Similarily, transsects through river plains can be used to check on the existence and spatial distribution of contaminated soil due to deposition of river sediment.

Using available (digital) topographic information, especially land use data, and soil mapping data allows to develop an optimized sampling scheme, where each sample represents a certain soil type with a specific land use. Furthermore, in setting up of a sampling scheme other potential factors for soil contamination should be looked at, such as immission or inundation. Thus maximum information can be extracted from each sample. This offers the possibility of “extrapolation” to nearby areas with similiar factors, and, after some processing, the possibiltiy of interpolation using geostatistics.

4.2 Projection of the NRW-data to an European scale

Certainly NRW is not representative for the whole of Europe. However, the authors believe that the driving forces of wide spread soil contamination identified in NRW play an important role for soil contamination distribution in the whole Europe. Especially we believe that contaminant transport in rivers (while the contaminants will quite often stem from ore mining and processing) causing soil contamination in river flood plains is frequently occuring in European rivers. This contamination may have adverse effects on both agriculture and the multifunctionality of river systems, e. g. ecotoxicologial effects cannot be outruled.

4.3 Towards European management strategies for wide spread contaminated land

“Extrapolating” the NRW-data to the whole of Europe we have to expect that – variing from region to region – some percentages up to some tens of percentages of top soils are contaminated. The dimension of this contamination makes clear that new strategies, which are not only a magnification of the stratgies for contaminated sites, are needed. The authors believe, that restrictions to land use and / or adaption of specific agricultural practices on this land will be the most common and unavoidable strategy to deal with wide spread contaminated land in the future. Additionally measures to decrease contaminant mobility into the crop and / or into the groundwater might be feasible in a number of cases [14].

The authors expect that on European level typical “clusters” of wide spread contaminated land problems could be identified – such as heavy metal contamination in flood plains of rivers with historical or actual ore mining in the catchment area or soil contamination due to immissions after long distance airborne contaminant transport in exposed moutainous regions.

With this background the authors believe it is worthwhile to work on a common European strategy to manage and overcome wide spread contaminated land problems.

As a first step it would be desirable to collect existing and / or to gain information on (top) soil contamination in other regions in Europe and to establish an European practice of soil contamination mapping.

5. Literature

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