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Integrated soil and water protection against diffuse pollution (SOWA)

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Abstract: SOWA pulls together scientific knowledge from various disciplines such as soil science, soil chemistry, soil physics, hydrogeology, water resources, agriculture, atmospheric deposition of pollutants, environmental analysis and engineering as well as management and remediation of contaminated soil and groundwater. SOWA provides a multidisciplinary forum for the identification of research needs and strategies for integrated soil and water protection. The research needs and strategies are identified in five thematic working groups which focus on the different aspects of integrated soil and water protection: Inventory of priority compounds and trends, screening and monitoring tools at different scales, biogeochemical and physical processes, heterogeneity and scale issues in soil and groundwater, management options for large scale soil and water pollution incl. environmental economics / socio-economic issues.

0.0.1 1 Scope and original objectives

Soil and water pollution is a result of population growth and technological development. Industrial development has brought prosperity to millions of people, but has also left a legacy of environmental damage that continues to impact natural resources and ultimately the human well being. A wide range of man-made chemicals designed for use in industry, agriculture, pest control, consumer goods, and emissions from the combustion of fossil fuels are the main sources for diffuse pollution. Within the water cycle, soils act as the key zone for storage, filtration and transport of water and associated pollutants. Water sooner or later interacts with soil and / or sediments, and this interaction determines the quality of groundwater, surface waters and finally drinking water. If the accumulation of pollutants exceeds the buffer capacity, then soils or sediments can become the source of diffuse pollution of adjacent compartments such as for groundwater and surface waters..

In the EU Soil Thematic Strategy *Towards a Thematic Strategy for Soil Protection* (Commission of the European Communities, 2002), diffuse pollution is itemised as main threat to the soil by direct or either indirect pollution due to the disposal/use of sewage sludge, incineration sludge, compost and pesticides.

Experience shows that large scale remediation of diffuse pollution is economically not feasible and that soil contamination is not reversible at a reasonably time scale. The motivation of SOWA is the protection of soil as the most active resource in the hydro- and biosphere and as the essential environmental compartment for food production and finally human health.

The main goal of SOWA is to identify scientific questions which address the most relevant research needs for integrated protection of soil and water resources in future.

This includes the evaluation of especially large scale soil pollution which will potentially damage important soil functions (such as the buffering, filtering, transformation capacity) and the soil ecology.

In addition, SOWA identifies tools and procedures for low cost screening and contaminant analysis, soil characterisation methods, and management of soil/water contamination in Europe.

With workshops, publications, newsletters, conference presentations, and press releases SOWA increases the awareness of the risks of diffuse soil pollution, which pose a risk of long-term contamination of the water cycle.

2 Scientific approach

The approach of SOWA is to identify from a scientific point of view the risks arising from the continuous pressure of man onto soils leading to damage of crucial soil functions (Halm & Grathwohl, 2004) such as:

- Base for ecosystem quality, sustainable land use and safe food production
- Filter for drinking water
- Key compartment in global biogeochemical cycles (carbon, nitrogen, water. . .)
- Sink/source for anthropogenic and natural pollutants,

SOWA focuses on the physico-chemical multifunctionality of the soil, on long-term *vs.* short term issues, and on European/global and local dimensions.

SOWA is organised as a “think tank“ in five thematic working groups:

- Inventory: Identification of priority compound classes such as persistent organic pollutants and heavy metals
- Biogeochemical and physical processes
- Heterogeneity and scale issues in soil and groundwater
- Screening and monitoring tools at different scales
- Management options for large scale soil and water pollution including environmental economics and socio-economic issues.

The SOWA-partners come from nine different disciplines (hydrogeology, environmental chemistry, geophysics, soil physics, soil science, water resources, agriculture, environmental engineering, analytical chemistry). With this multidisciplinary thematic structure, the project is able to cover the different aspects of soil and water protection. In addition, SOWA invites internationally leading experts to meetings and workshops in order to integrate additional expertise.

3 Main results/output

Contamination of our natural resources, such as atmophere, water, and eventually soil have received much attention in the past decades. The awareness that contamination requires management and remediation has been a major incentive for several EU framework programmes. During the past decade, limits to the funds available for active remediation have become increasingly recognised and they steered environmental policies from remedial technologies into the direction of appropriate management and prevention of contamination. The latter approach - where key concepts in risk analysis are biological availability and mobility of contaminants - is not only a change in perception, but also a change in nuances to be considered. Both of these key concepts are to a large degree controlled by the concentration of contaminants in the gaseous and aqueous phases of soil and water resources and the atmosphere.

Inventory

During the last decades, large amounts of different chemicals were released to the environment through industrial waste, agricultural practice (including manure and sewage sludge applications) and via wastewater treatment plant effluent discharges.

This contamination can have a critical impact in the ecosystem due to their strong activity at low doses. According to an inventory of priority compound classes, persistent organic pollutants (POPs) have been identified to exhibit potentially harmful effects to man and the environment. In addition to being persistent, POPs are typically lipophilic and therefore bioaccumulative, and toxic (pbt: persistent, bioaccumulative and toxic). Actually, a second wave of pollutants, the so-called emerging contaminants are suspicious of causing adverse effects in both humans and wildlife. In addition, intermediates and end-products of the chemical and pharmaceutical (incl. veterinary) industry have to be mentioned. One of the key issues with emerging contaminants is that although few of them have been recently subject to legislation, many potential pollutants are not fully recognised and as a consequence no routine monitoring programmes exists. One of the key issues is the evaluation of risks of such non-regulated chemicals that are currently being detected in the environment.

Processes

Studies regarding biological availability and mobility have often resulted in different and apparently contradictory observations and conclusions. However, the underlying physico-chemical processes can not be in conflict and therefore such contradictions have to be due to limitations of our understanding of the involved factors and processes. The uncertainties due to apparent contradictions may be a major constraint to an accurate management and policy development for dealing with contamination. The awareness of the importance and complexity of these processes controlling the subsurface contaminant transport and the contaminant fate in soils increases. The complexity arises from several sources. First of all, the soil itself is a complicated disperse system made up of a microscopically heterogeneous mixture of solid, liquid and gaseous phases. The solid phase contains mineral and organic particles of varying sises, shapes and chemical composition ranging from the molecular sised and colloidal particles to coarse sand and gravel. The organic fraction of the solid phase includes diverse communities of living organisms, plant and animal residues in different stages of decomposition and humification as well as various types of coals and charred organic matter. How soil reacts to long-term changes in the hydrological cycle or by changes in land use is still not understood in its complexity (weathering, dissolution / precipitation of minerals, carbon turnover, release of DOC, wetting and drying properties, permeability. . .).

Scales

One of the major causes for uncertainty and erroneous understanding of causal relationships and the magnitude of parameters and trends has been identified as being the ‘scale problem’. Different levels of heterogeneity are encountered when passing from the microscopic to the macroscopic scale. With regard to complex soil and groundwater systems, the question of a conceptual basis for combining different sources is of concern. The scale problem is due to the spatiotemporal (i.e., in space and in time) variability of the systems of interest: statements that concern a particular scale may (and often will) not hold at other scales. Hence, extrapolation of understanding to a larger or to a smaller scale may require additional knowledge at these larger or smaller scales. If this need for additional knowledge is not recognised, the implicit assumption of 'scale invariance' is made and if this assumption is false, the interpretation of measurements or of model exercises may be erroneous.

Monitoring

During the last decade, the need for new, fast, and cost effective environmental screening and monitoring methods has grown significantly. Regional and larger scale screening and monitoring require balloon, aircraft or satellite based remote sensing. Research is needed to uniquely relate the measured quantity with type and levels of pollution and to resolve measurement uncertainty. This, of course, will require the identification of suitable and pollution specific proxies (e. g. magnetic proxies), which can be measured much easier but allow pollution pattern mapping as well as the monitoring of pollution dynamics and thus the early identification of long-term trends of increasing pollution.

Management

Presently diffuse pollution of soils and water is tackled by sectorial approaches. Water or soil protection usually focus on their specific domains and do not sufficiently coordinate their efforts. The sectorial focus is also reflected in the legislative basis of these activities. Different laws relate to soil and water protection. As chemicals are cycling in the environment between different compartments, problems in one compartment often are caused by activities in another compartment. The nitrate problem in groundwater is a perfect example. Even severe overfertilisation of agricultural land does create a serious problem for soil quality. Excessive nitrate loads can be quite rapidly removed through the uptake by plants which are subsequently harvested or via leaching. In waters on the other hand, as pointed out before, nitrate is a pollutant of prime concern. Even rather low fractions of the nitrogen fluxes which are turned over in agricultural cropping systems can already cause very serious pollution if they are exported into water bodies. Problems of this kind demonstrate that a holistic, integrative approach is desperately needed. Fig. 1 shows the interconnections between the environmental compartments, animals/cattle, and humans and the pressure pathways of pollutant inputs. The arrows and especially the crosspoints of arrows indicate the problem zones for ecosystem management, which have to be tackeled together in an integrative way.

Figure 1: Pollutant fluxes into and out of soil, groundwater and surface water compartments, as well as pathways to human, animal and crop plant receptors.

Literature:

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