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The Spread and Transformation of Contaminants in Ground Water

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The Körber Prize-winning researchers want to find out how contaminants spread in the ground and find their way into ground water. Mathematical models of these processes could provide the basis for the remediation of this irreplaceable reservoir of drinking water.

Transport processes of contaminants in ground water are examined and incorporated into a mathematical equation. (Photo: Peter Allert)

Just a few meters under our feet lies a treasure of immeasurable value: ground water which flows in the pores and fissures of gravel, grit, and sand and which forms the origin of around 70 percent of our drinking water. At the moment, the water works in many places can still mostly extract the life-giving liquid without the need for special purification, but more and more contaminants are endangering its quality. In Germany's eastern federal states alone, more than 60,000 sites with hazardous waste are known, of which at least 1,000 pose an acute threat to the ground water. It is therefore absolutely essential to understand the spread of toxic substances in the subsoil – not an easy undertaking, given the more than 70,000 man-made chemicals which are in daily use. Added to this is the large number of different soil types and the so far insufficiently understood interaction between the various contaminants and their environment. The objective of the Körber project "The Spread and Transformation of Contaminants in Ground Water" was therefore to develop models which track the chemical and biological processes in the subsoil as well as the physical transport of the substances.

The speed at which harmful substances make their way into the ground water depends mainly on whether they occur primarily in water or attach themselves to solid soil particles. The key factor for the behavior of metals is whether they form water-soluble complexes with other molecules known as ligands or complexing agents. Each of these reactions is in turn influenced by many chemical and physical factors. In a sub-project of the Körber project, some researchers studied, for example, the behavior of heavy metals such as cadmium, mercury, copper, or zinc. These contaminants enter the soil from polluted rivers, via seepage from landfill sites and from polluted rain. As an example of a complexing agent the scientists chose EDTA (ethylenediaminetetraacetate), a synthetically manufactured substance which frequently enters natural ground water due to widespread industrial use and interacts strongly with heavy metals. It emerged that whether EDTA / heavy metal complexes are taken up by the soil particles or dissolved depends decisively on the presence of other heavy metals, on the pH value (degree of acidity) of the water and on the presence and form of iron compounds in the soil. The researchers now want to implement their findings in a model for the sewage farms of Berlin-Spandau in order to track the migration of heavy metals into the ground water under the influence of EDTA and other complexing agents.

Furthermore, the prizewinners are examining nitroaromatic compounds, which are used as pesticides or as explosives like trinitrotoluene (TNT), which form important starting products and components of dyes and other chemicals and also occur through photochemical processes in the atmosphere. The chemists discovered that the degree to which these toxins are absorbed by the particles of clayey soil or dissolve in the water depends in particular on the cations (positively charged atoms) in the environment. In the next step, the researchers are concentrating on converting their results into mathematical equations and putting together models which track the complex transport processes of the contaminants through the soil into the ground water. Such models are likely to be used in practice soon. For example, the researchers simulated the spread of xylene which entered the subsoil following an accident on a refinery site in the Lower Rhine region, and are now planning a biological remediation. How oxygen, bacteria, and xylene spread in the soil and how they affect the decontamination process becomes predictable using the calculation – as does the success of the measures taken.

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