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Emissions of Heavy Metals and Lindane into River Basins of Germany

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Sumary

With the completion of this project a quantification of heavy metal and lindane emissions into surface waters is provided for the first time for Germany and for the years 1985, 1995 and 2000. Using the statistical and geographical basic data integrated in the MONERIS model system (**Mo**delling **N**utrient **E**missions in **R**iver **S**ystems), substance inputs were calculated by methods analogous to those used for the balancing of the nutrients. They were differentiated according to their sources and pathways and documented for the specific pathways. For this purpose, extensive studies and model adaptations were required to provide a most realistic representation of substance specific transport and retention processes. All quantification

approaches as well as the applied basic data were thoroughly documented. As a result an accessible overall model, always open to new perceptions, is now available.

As was to be expected, heavy metal inputs largely decreased in Germany. Depending on the metal observed, emission reductions amount to between 36 and 85 % within 1985 - 2000. The measures taken by industry and implemented within the scope of a more rigorous water legislation but most of all the massive decrease of industrial activities in the New Federal States (NFS former GDR) since 1990, have decisively contributed to an improvement of environmental conditions. Direct industrial discharges only play a secondary role in the year 2000. Municipal wastewater treatment plants remain important now as before. It can be observed, however, that in the year 2000 the water pollution load was mainly caused by diffuse inputs. The major pathways are sewer systems, erosion and groundwater inflow. Combined sewer systems and storm water runoff from separate systems cause, for instance, between 10 and 40 % of the total emissions. Especially high shares are reached for the metals zinc, lead and copper. Due to the fact that in combined systems a considerable share of the storm water runoff is transferred to wastewater treatment plants, the pollution load in regard to heavy metals is lower than in separate sewer systems. Erosion is the main cause for chromium and lead inputs into the surface waters. Arsenic and nickel are mainly emitted by groundwater impact. Significant load diversities resulting from both landuse and meteorological factors exist between the various river basins. In the year 2000 for instance, the highest specific loads were identified in the Rhine catchment. This is directly related to a more than average urbanisation intensity in this area. The comparison of the calculated inputs reduced by the retention in surface waters with the loads obtained by means of monitoring data, altogether shows good correspondence. The best results were obtained for metals featuring a good data base for emissions and immissions (e.g. copper, zinc and nickel) and for large catchment area units. For copper, zinc and nickel the total deviation for Germany was of < 30 %, for all further metals it was of < 50 %. In smaller subcatchments, regional and local peculiarities may lead to inputs ranging distinctly beyond or below the surface water loads.
Lindane emissions as well could be distinctly reduced between 1985 and 2000. This is due to the fact that lindane applications have been drastically limited in Germany since the mid-eighties and that they were prohibited in 1999. Despite of its production and application prohibition, lindane is still found in the atmosphere, the soil and the water as a result of its persistency. It is thus still emitted into surface waters in 2000. Inputs from urban sources represent the major share. Figure 1 shows the importance of the pathways for heavy metals and lindane in the years 1985, 1995 and 2000, as well as the loads discharged into the surface waters.

The results obtained prove that the model approaches and the data base used allow a plausible evaluation of inputs from point and diffuse sources in the large river basins of Germany. The model provides an instrument allowing to identify the major sources and impact regions and provide the basis for further analysis aiming at the formulation of successful pollution reducing measures.

Further improvements may be realised rather in the field of available and adequate basis data than in the field of calculation approaches. Both for heavy metals and for lindane it may be stated that in almost all environmental compartments valid measured data are only available to a limited extent. In the areas of municipal wastewater treatment plants, water quality and groundwater monitoring, i.e. in areas where many measurements have been taken, the quality of the measured values is affected by frequently implausible quantification limits. As a result, the major part of the data collected and filed with a great deal of energy, may not be used for quantification purposes. Both, an improved analytical technology and data base management may contribute to the solution of this problem in the future. A higher spatial resolution of quantification results may be obtained when regionally differentiated input data become available. First promising approaches are now available for atmospheric deposition from simulation results obtained by EMEP (Co-operative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe) and for input into the groundwater from the New Geochemical Atlas (Federal Institute for Geosciences and Natural Resources of Germany). However, for inputs originating from sewer systems, a regionalisation of the basic data for Germany is not possible in the light of present scientific knowledge. This, however, reveals to be urgently required given the importance of this pathway. Moreover, it turned out within the scope of this project that emissions via historic mining activities cause load shares that are not to be neglected. So far, merely inputs originating from point sources may be registered to some extent. On top of this, increased diffuse inputs for which no data is available so far, are to be expected from these areas.