C. Schulze: Modelling and evaluating the aquatic fate of detergents

Within this thesis an environmental assessment and evaluation method for analysing aquatic ecotoxicological impacts of household laundry is developed. The methodology allows comparative assessments of different product alternatives, washing habits, and wastewater treatment techniques in order to identify their relevance with respect to waterborne discharges. Elements from both analytical tools Life Cycle Assessment (LCA) and Environmental Risk Assessment of chemicals (ERA) are combined in this methodology. The core consists of the Geography-referenced Regional Exposure Assessment Tool for European Rivers (GREAT-ER), which calculates concentrations of 'down-the-drain' chemicals in surface waters due to point releases. In order to simulate the aquatic fate of detergents, a new GREAT-ER emission model is developed, called GREAT-ER product mode, which calculates calculates concentration increases of detergent ingredients in surface waters based on product formulations and assumptions concerning washing habits. Two evaluation methods, the Critical Length (CL) and the Product Risk Ratio (PRR_x), are defined for evaluating the results. CL is the sum of mean concentration increases, divided by substance-specific no effect concentrations (NECs), over all river stretches and all ingredients weighted by the lengths of the stretches. PRR_x is the (percentual) number of river stretches in a region, in which the x-percentiles of the predicted concentration increases of at least one ingredient exceed a substance-specific NEC. The emission model requires input data that can be derived from the functional unit of an LCA, which allows an assessment of other impact categories by using any existing LCA method.

The methodology is applied to a case study which is based on scenarios given in the comprehensive product assessment 'Washing and washing agents' (*'Produktlinienanalyse'*, PLA). In order to apply the GREAT-ER product mode, the Rur river basin in Western North-Rhine Westphalia is chosen as study area. The catchment integration includes the development of a simple hydrological model that combines a nonlinear regression analysis with a local refinement procedure. The quality of the integration of the Rur catchment data is analysed by a comparison of monitoring data and predicted concentrations of detergent and cleaning agent ingredients using actual consumption data of the two years 1993 and 2000. The product mode results show that use habits have a larger influence on the results than product formulations. However, the largest influence is caused by varying wastewater treatment techniques. Boron and the surfactants are the most relevant detergent ingredients. Furthermore, using different detergents for white and coloured laundry lowers the predicted emissions significantly.

Based on this methodology, sustainable development indicators (SDIs) for describing the aquatic aspects of household laundry are defined. CL is proposed as pressure indicator and PRR_x as state indicator for describing aquatic aspects of the sustainability of household laundry in a region. Different regions can be compared by normalising the CL by the region's population and expressing the PRR_x as a percentage of stretches in a region. Annually evaluating regional CLs and PRR_xs allows the assessment whether a region is moving towards a more sustainable state.