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FLUX-BASED RISK ASSESSMENT OF THE IMPACT OF CONTAMINANTS ON WATER RESOURCES AND ECOSYSTEMS

«FRAC-WECO»

D.Caterina, S.Brouyère, P.Jamin, J.Batlle-Aguilar,
A.Dassargues, W.Dejonghe, L.Diels, S.Crèvecoeur,
J.-P. Thomé, J. Dujardin, O.Batelaan, F.Canters, C.Hérivaux

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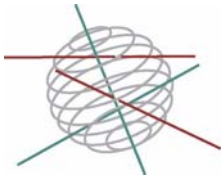

Terrestrial Ecosystems

FINAL REPORT PHASE 1
SUMMARY

FLUX-BASED RISK ASSESSMENT OF THE IMPACT OF CONTAMINANTS ON WATER RESOURCES AND ECOSYSTEMS

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SD/TE/02

Promotors

Serge Brouyère & Alain Dassargues
Université de Liège, Départment Argenco, Geo³-Hydrogeology (ULg-HG)
Jean-Pierre Thomé
Université de Liège, Laboratory of Animal Ecology and Ecotoxicology (ULg-LEAE)
Ludo Diels & Karolien Vanbroekhoven
Vlaamse Instelling voor Technologisch Onderzoek (VITO)
Okke Batelaan & Frank Canters
Vrije Universiteit Brussel, Department of Hydrology and Hydraulic Engineering / Department of Geography (VUB)
Cécile Hérivaux
Bureau de Recherches Géologiques et Minières (BRGM, France)

Authors

D.Caterina, S.Brouyère, P.Jamin, J.Batlle-Aguilar, A.Dassargues (ULg),
W.Dejonghe, L.Diels (VITO),
S.Crèvecoeur, J.-P. Thomé (ULg),
J. Dujardin, O.Batelaan, F.Canters (VUB),
C.Hérivaux (Brgm)

BELGIAN SCIENCE POLICY

Rue de la Science 8
Wetenschapsstraat 8
B-1000 Brussels
Belgium
Tel: +32 (0)2 238 34 11 – Fax: +32 (0)2 230 59 12
http://www.belspo.be

Contact person: Sophie Verheyden
+32 (0)2 238 36 12

D. Caterina, S. Brouyère, P. Jamin, J. Batlle-Aguilar, A. Dassargues, W. Dejonghe, L. Diels, S. Crèvecoeur, J.-P. Thomé, J. Dujardin, O. Batelaan, F. Canters, C. Hérivaux ***Flux-Based Risk Assessment of the Impact of Contaminants on Water Resources and Ecosystems «FRAC-WECO»***. Final Report Summary. Brussels : Belgian Science Policy 2009 – 5 p. (Research Programme Science for a Sustainable Development)

Summary of the project

In Belgium, as well as in many other European countries, many contaminated sites have been reported as resulting from a relatively anarchic economical and industrial development during the 19th and 20th centuries. Since the late 1980's, policy makers, stakeholders and the population in general have become more and more aware of the risk posed by these sites and that a sustainable economical development cannot be envisaged without optimizing land use and preserving or restoring natural resources and ecosystems. The promulgation of Directive 2005/35/EC on environmental liability has also reinforced stakeholders' perception of the economic dimension of environmental damages generated by contaminated sites. This directive, which has to be transposed into national legislation by the end of 2007, compels potential polluters to cover the cost of preventive or remediation actions required by the environmental damage they may generate. Other regulations and laws have appeared at various levels, from regional (Flemish Soil Decree, Walloon Region Soil Decree) to national and supra-national scale (EU Water Directive, coming EU Soil Directive…).

The objective of **the FRAC-WECO project** is to study the impact of contaminated sites on the receiving water bodies being the river basin or the groundwater body (serving as a drinking water body). At each phase of the process of soil and groundwater remediation, methodologies and indicators have to be proposed to site managers as a support to decision making associated with the contamination problem, the first decision being at each level to decide to go to the next step or not, based on the evaluated risk. From one step to the other, the complexity of the information and tools required increases together with the costs needed for making a "good" decision. At the same time, the risk of not tackling efficiently the problem is supposed to be reduced as the problem is better worked out.

In order to propose adequate, still economically feasible, remediation measures for contaminated sites, the first step is to evaluate and to quantify as accurately as possible the actual risk associated with these sites for the environment in general, for health (not directly considered here), for water resources and ecosystems in particular, and then to propose remediation measures that are adequate with respect to this evaluation. Based on the analysis performed during the first phase of the FRAC-WECO project, it has appeared that, in terms of policy relevance, it is necessary to manage these contaminated sites at the scale of the groundwater body which is relevant in the context of the Water Framework Directive (WFD). At such a scale, the cumulative effect related to the multiplication of contaminant sources and fluxes often dominates over local contamination problems taken one by one. Contaminated sites have thus to be considered altogether to evaluate the potential and actual damages for water resources and associated ecosystems, considering both their market and non-market functions. In this context, starting from the groundwater body scale risk assessment analysis, the project is developing a methodological framework that will allow to propose management plans and to design programmes of measures aiming at improving the status of water resources and ecosystems at the scale of the groundwater body, based on a cost-benefit analysis.

At the same time, a reliable characterization and remediation procedure relies on several key elements: **i)**water often being the main vector of the mobility of contaminants, an accurate description of surface and subsurface water fluxes is required, from site scale to (ground)water body scale, and from infiltration and runoff to discharge points such as groundwater abstraction points and surface water bodies, **ii)**because of the permanent competition between contaminant

migration and retardation, a sound and process-based description of biogeochemical processes occurring in the subsurface is needed, **iii)** contaminants being specific in terms of physico-chemical behaviour and (eco-)toxicity, detailed information on these aspects is required, and **iv)** risk assessment tools and indicators are required specific to various targets such as water resources or ecosystems.

In this context, the FRAC-WECO project develops an integrated methodology contributing to a multi-level risk assessment of contaminated sites on water resources and ecosystems. Specific objectives are: **i)** to develop a modelling approach for accurately calculating water and contaminant fluxes at various scales, from the contaminant plume to the catchment scale, **ii)** to quantify and to model biogeochemical processes affecting the mobility (speciation), retardation and reactivity of various specific contaminants (heavy metals, PAHs, organochlorinated compounds, emerging pollutants such as VOCls, or even toxic hydrophobic persistent contaminants with Kow >6 …) in the environment, through water resources, **iii)** to validate risk assessment methodologies using datasets coming from representative contaminated sites in Belgium and to develop a flux-based risk assessment indicator for evaluating the impact of contaminants on water resources (groundwater vulnerability) and on aquatic ecosystems (ecotoxicological risk) in relation with the management and cleaning of contaminated sites, **iv)** to evaluate uncertainty on contaminant transport of spatial variability in sub-surface and surface land characteristics and especially to evaluate impacts of uncertainty in the mapping of land-cover characteristics, and **v)** to develop and apply a decision support tool for planning and evaluating integrated management measures aiming at reducing short and long-term impacts of contaminants, inclusive costs and benefits that would result from an improvement of the status of water resources and associated ecosystems currently under pressure of brownfields.

Researches are developed through a strong collaboration of hydrogeologists, soil scientists, ecotoxicologists, remote sensing specialists and socio-economists. Pilot case studies selected in Belgium are used to apply and to evaluate the developed models and guidelines at various scales.

- Methodology

The DPSIR methodology will be considered as a general organizational framework for the project. The DPSIR framework, developed by the European Environmental Agency, has been widely adopted by policy makers, consultants and researchers. It helps in reporting, permits easier exchange and communication between policy-makers and other actors and it simplifies a complex reality. With a set of environmental indicators established by the EEA, DPSIR has three major purposes (Smeets and Weterings 1999): to provide information on environmental problems which allows estimation of their importance, to help in identifying key factors that create pressures on the environment and set priorities, to survey and follow-up the effects of policy responses.

The DPSIR methodology will be considered as a general organizational framework for the project as it presents a chain of causal links between Driving forces (economic sectors, human activities), Pressures (emissions, waste), States (physical, chemical and biological state of the resource) and Impacts on ecosystems, human health and natural resources. This leads to Responses such as prioritization, target setting and indicators (Kristensen 2004).

Following the DPSIR framework, the pressure (P) is the contamination source, more particularly its consequences on the state, i.e. the fluxes of contaminants migrating across the water system. The system ('State') is the water resource and associated ecosystems as affected by contaminants. In terms of water resource, the target can be the groundwater resource 'alone' or the groundwater resource + base flow to discharge points such as surface water or pumping wells (S2). Generally speaking, impacts (I) consist in increaded costs for site rehabilitation, in water treatment costs, in reduction in biodiversity and possibly in health problems fpor neighbouring communities (not the direct focus of this proposal). Based on the research efforts developed during Phase 1, the impacts can be described more accurately as follows. A change in groundwater quality (S) will in turn result in Impacts (I) related to a change in the level of services provided by groundwater to the society (i.e. damage in case of degradation/ benefits in case of improvement) [see D1.2]. Three main types of services and related values can be distinguished: (i) those related to groundwater 'as a resource' (direct use values that can generally be quantified with market based techniques); (ii) those related to groundwater 'itself' (indirect use values and non use values that are more difficult to quantify and require the implementation of valuation methods); (iii) those related to groundwater 'as a discharge into surface water' (indirect use values that can be quantified by methods directly applied to surface water).

The project combines on the one hand process studies contributing to a more comprehensive assessment and modelling of water and contaminant fluxes at various scales ranging from the local contaminated site to the (ground)water body, considering the specific biogeochemical properties (sorption, degradation…) and ecotoxicity of contaminants, on the other hand specific risk assessment indicators for ecotoxicological aspects (including the concomitant effects of contaminants) and for water resources management aspects (e.g. physically-based groundwater vulnerability assessment), which, based on conclusions drawn during phase 1, are two of the most policy relevant aspects related to contamination issues in the sense of the Water Framework Directive. One of the main objectives being to propose a methodological framework for the evaluation of damages related to the existence of multiple sources of contamination in the water body and of potential benefits of their remediation, a flux-based risk assessment framework is required, which allows considering the additive effect of these sources (cumulative fluxes). In the present context, research activities focus on the P-S-I chain and on possible responses formulated in terms of programmes of measures for sustainable redevelopment of contaminated sites, water resources and ecosystems in the groundwater body.