KD FUNCTIONS TO DEFINE RELATION BETWEEN INORGANIC POLLUTANT MOBILITY (SOIL TO WATER), THE MAIN BIOGEOCHEMICAL CHARACTERISTICS OF SOILS AND THE MAIN PARAMETERS OF GLOBAL CHANGE

RIVER BASIN MANAGEMENT ISSUE

Water Quality						Water Quantity		Alterations		Others
1	2	3	4	5	6	7	8	9	10	
		C, M, T	C, M, T							

(1) Diffuse pollution by agriculture
(2) Salinisation
(3) Contaminated sediment and floodplain soils
(4) Large scale pollution due to past mining / industries activities
(5) Pollution by organic matter
(6) Emerging compounds
(7) Water scarcity
(8) Floods and low flow
(9) Hydromorphological alterations
(10) Soil erosion

C = System Characterisation
M = System Monitoring
T = System Trend
R = System Remediation, Mitigation

RIVER BASIN

Danube	Ebro	Meuse	Elbe	Brévilles	Others
	✓.	✓			

Spec. : Results specific to selected River Basin

KEY FINDING TYPE

Understanding Processes (lab-scale)	Characterisation (field scale)	Modelling
✓	✓	

BENEFITS TO END-USERS

Technical		Management	Policy	
WFD Implementation	Research	River Basin	Compliance	Policy making
✓	✓	✓		

INTRODUCTION

BGC3 studied the transfer functions (Kd) for selected metals (As, Pb, Zn, Cd and Hg). Measurements of Kd were performed on soil and sediment samples collected in the Ebro and the Meuse basin. Soil samples were collected from the vadose zone and the saturated zone. Statistical analysis of measured Kd enabled to define Kd functions for each selected contaminant and for the vadose zone and the saturated zone. First Kd functions were defined. For the root zone, a modelling approach enabled to estimate the sorption coefficient that will integrate the relevant processes affecting the fate of heavy metal in the root zone. The Kd functions will be further developed over the next 2 years of AquaTerra project. In addition, BGC3 studied biogeochemical processes associated with the release of metals from soil in the vadose zone, the root zone and the saturated zone. Impact of bacterial activities on the transfer of metals in the vadose and saturated zone is characterised from studies of bacterial biodiversity using molecular techniques. Impact of climate change (different oxygen concentrations, temperature, pH, bacterial activity), different land use (nitrate concentrations), increasing pollution (varying sulphate concentrations) and environmental parameters on the behaviour of the considered inorganic pollutants in the vadose zone and the saturated zone are assessed.

KEY ISSUES

Kd functions determination enables to understand the transfer of inorganic contaminants from soil to water (and from water to soil). As a consequence, BGC3 enables to address river basin management issues associated with the presence of metal contamination in soil, water and sediment. Therefore, BGC3 addresses the issue of *Contaminated floods and floodplain soils* and *Large scale pollution due to past mining / industry activity*. Kd functions results will be assessed for these two issues.

Contaminated sediments and floodplain soils

Kd measurements of sediment samples in the Ebro and associated Kd function determination for mercury enabled to improve sediment samples characterisation and the understanding of the transfer of mercury in soil/water. It also enabled to give recommendations on monitoring parameters and predict evolution of release of mercury from soil to water with climate change.

- ***System characterisation***:
  - ***Knowledge***: Physico-chemical and mineralogical (anions, cations, carbon content, etc.) results of the Ebro soil / sediments showed that there was an evolution of the soil / sediment characteristics along the Gallego catchment. Downstream sediment samples contained more lime and were more polluted than upstream sediment samples. Moreover, the soil characteristics were connected with irrigation practices. Kd was measured for each sediment sample: interpretation of these value and their respective trend along the River was not within the scope of BGC3 work. Kd values enabled to determine Kd function for mercury applicable to the sediment of the Ebro. The analysis of the Kd with respect to environmental parameters and soil characteristics parameters enable to show that Kd for Hg (in the Ebro sediment) was more impacted by environmental parameters (different oxygen concentrations, temperature, pH, bacterial activity) than by soil characteristics parameters (mineralogical and chemical parameters) .
  - ***Key parameters***: The determination of Kd function (Hg/sediment) enables to define key parameters affecting the transfer of Hg from sediment to water. Key parameters include environmental parameters such as parameters of climate change (i.e. pH, temperature, Partial pressure of CO2) and biogeochemical parameters (i.e. bacterial activity).
- ***Monitoring***
  - ***Knowledge / Recommendations***: Kd analysis showed that Hg transfer function was highly dependent of bacterial activities. As a consequence, if impact of mercury release has to be assessed, it may be important to measure bacterial activity.
- ***Trend – Climate change***
  - ***Knowledge***: Increase in temperature and decrease in pH will increase bacterial reduction activity and as a consequence promote the mobilisation of mercury from sediment to water. As a consequence climate change may lead to an increased release of mercury from sediment to water. Kd function determination enables to evaluate impact of climate change on Kd.
  - ***Key parameters***: The key parameters to take into account are parameters of climate change (i.e. pH, temperature, Partial pressure of CO2) and biogeochemical parameters (mainly bacterial activity).

RECOMMENDATIONS

The research carried out on Kd function determination in the Ebro sediments samples enabled to draw the following recommendations:

- ***Monitoring***: If impact of mercury release has to be assessed, it may be important to measure bacterial activity and to follow the anoxic and reductive conditions in sediments. In order to enable easy measurements of bacterial activities, it is necessary to develop easy to use and affordable tools to measure bacterial activity.
- ***Trend***: Special attention should be taken to Hg concentration level in water (where sediments are contaminated with mercury), if temperature rise occurs.

These recommendations can be useful for the following **end-users:**

- **River basin managers of the Gallego catchment** or river basin managers who have an issue of mercury pollution in sediments or soils.
- **Researchers** – Bacterial activities measurement tools.

Large scale pollution due to past mining / industry activities

Kd measurements of soil samples in the Meuse (Flémalle and Dommel) and associated Kd function determination for Cadmium, Zinc, Lead and Arsenic enabled to improve soil samples characterisation and the understanding of partitioning of metals in soil/water. It also enabled to give recommendations on monitoring parameters and predict evolution of release of metals (Cd, Zn, Pb and As) from soil to water with climate change.

- ***System characterisation***:
    - ***Knowledge***: Physico-chemical and mineralogical (anions, cations, carbon content, etc.) properties of the soil from the Flémalle site and Dommel catchment were measured. This information enabled to improve existing database on soil characteristics for the Flémalle and the Dommel site. Some studies of bacterial biodiversity were performed in few selected incubations, using molecular techniques, to research a relation between the biodiversity and the metals and metalloids mobility on the unsaturated zone and the saturated zone. Kd was measured for each soil sample: interpretation of these value and their respective trend along the River was not within the scope of BGC3 work. Kd values enabled to determine Kd function for Cd, Zn, Pb and As for soil from different zones (vadose and saturated zones). The analysis of the Kd with respect to environmental parameters and soil characteristics parameters enable to show that
        - Kd for As was more impacted by environmental parameters (due to their influence on the bacterial activities) than by soil characteristics parameters.
        - Kd for Cd, Zn and Pb was more impacted by soil characteristics parameters than by environmental parameters
    - ***Key parameters***: The determination of Kd function enables to define key parameters affecting the transfer of As from soil to water. Key parameters include environmental parameters such as parameters of climate change (i.e. pH, temperature, Partial pressure of CO2) and biogeochemical parameters (mainly bacterial activity). The determination of Kd function enables to define key parameters

affecting the transfer of Cd, Zn and Pb from soil to water. Key parameters include soil characteristics parameters (such as Ca, Fe, Li..).

- ***Monitoring***
  - ***Knowledge / Recommendations***: Kd analysis showed that As transfer function was highly dependent of bacterial activities. As a consequence, if impact of arsenic release has to be assessed, it may be important to measure bacterial activity. Kd analysis showed that Cd, Zn and Pb transfer function depend on soil characteristics parameters. As a consequence, if impact of Cd, Zn and Pb release has to be assessed, it is not important to measure bacterial activity.
  - Identification of preferential flow impact on the mobility of Pb, in field-like conditions. The role of particulate-facilitated transport was also highlighted
- ***Trend – Climate change***
  - ***Knowledge***: Kd function determination enables to quantify impact of climate change on Kd. Increase in temperature and decrease in pH will increase bacterial reduction activity and as a consequence promote the mobilisation of arsenic from soil to water. As a consequence climate change may lead to an increased release of arsenic from soil to water. As Kd for Pb, Zn and Cd are not highly dependant on bacterial activities, climate change may not have any impact on Pb, Zn and Cd release.
  - ***Key parameters***: cf. system characterisation

RECOMMENDATIONS

The research carried out on Kd function determination of As, Cd, Zn and Pb from soils collected at the Flémalle and the Dommel site enabled to draw the following recommendations:

- ***Monitoring***: If impact of arsenic release has to be assessed, it may be important to measure bacterial activity. In order to enable easy measurements of bacterial activities, it is necessary to develop easy to use and affordable tools to measure bacterial activity. It is not recommended to measure bacterial activities to assess Cd, Zn and Pb mobility.
- ***Trend***: Special attention should be taken to Arsenic concentration level (in water), if temperature rise occurs.

These recommendations can be useful for the following **end-users:**

- **River basin managers of the Gallego catchment** or river basin managers who have an issue of mercury pollution in sediments or soils.
- **Researchers** – Bacterial activities measurement tools.