ERMS: Task 1: Toxicity

Background

The goal of the ERMS program is to develop an integrated risk assessment model to enable the companies to quantify environmental risk from drilling discharges. The work is built on the present Environmental Impact Factor (EIF) being used for produced water (with DREAM) discharges that covers risk calculation in the water column. The new model development will also include risk assessment of the environmental compartment "bottom sediments". The EIF for produced water is based on the main principles of risk and hazard assessment as described in the EU-TGD, based upon the PEC/PNEC approach. This approach was also decided to be followed in development of the EIF for drilling discharges. A schematic presentation of the PEC/PNEC approach within the EIF produced water, is given in Figure 1.

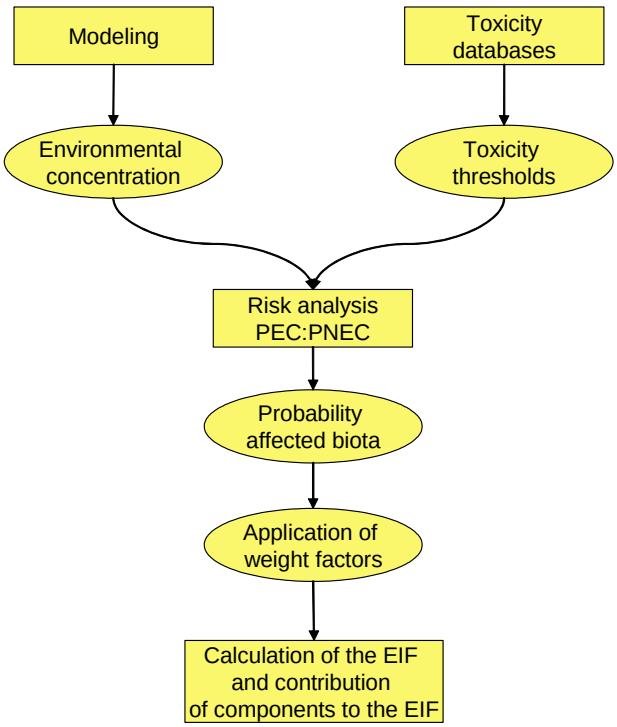

Figure 1. Schematic overview of the steps included in calculation of the EIF for produced water discharge.

The PEC (Predicted Environmental Concentration) is an estimate of the expected concentration of a chemical to which the biota will be exposed during and after the discharge of that chemical. The PNEC (Predicted No Effect Concentration) is the concentration below which it is not likely that adverse effects on the biota of a particular environmental compartment will occur. The ratio of the PEC and the PNEC indicates the likelihood of the occurrence of adverse effects. In this task toxicity contribution to the risk both in water column and in bottom sediments has been focused on.

For drilling discharges toxicity might not be the only important stressor. Therefore, different kinds of effects from additional stressors including burial and oxygen depletion are parts of an integrated measure of the overall probability of damage in the sediments. In the water column also risk from presence of suspended particulate matter (WBM particulates) also has to be taken into account.

Objectives
The aim of this study was to develop and decide upon a methodology on the basis of the PEC/PNEC approach for calculation of the risk of toxic substances present in drilling discharges. The approach should be in accordance to relevant environmental international regulations (EU-TGD, EC, 2003) for the water column and the sediments. For the sediment compartment also use of field derived effect data has been evaluated as basis for PNEC derivation for naturally occurring components. Sub activities within the present task were:

- Selection and scientific justification of components (metals, organics etc.) to be included in the risk assessment of drilling discharges
- Define which parameters should be used to estimate partitioning (partition coefficient – K_d) and bioavailability for calculation of PEC of metals in barite (weighing agent) for the water column by reviewing the literature.
- Derivation of PNEC for drilling chemicals for the water column for alternative TGD approaches (assessment factors, Sensitivity Species Distribution - SSD approach)
- Define which parameters should be used to estimate partitioning (partition coefficient – K_d) and bioavailability for calculation of PEC of metals in barite (weighing agent) for the sediment compartment by reviewing the literature.
- Derivation of PNEC for drilling chemicals for the sediment compartment for alternative TGD approaches (assessment factors and equilibrium partitioning method) by reviewing the literature for toxicity data and by use of the field-derived effect data collected over several years from monitoring surveys

Research needs
Based on the available knowledge and information from the literature, partitioning coefficients (K_d) for barite-water in the water column and barite-pore water in the sediments has been defined. The partitioning coefficients are being used for calculation of the bioavailable concentration (PEC) of metals from barite particles present in water based mud (WBM). There is a need for better understanding and verification of the behaviour (leakage) of metals for better mechanistic understanding of metal effects and also for verification of partition coefficients used in prediction of PEC_{metals} in the ERMS model. Relevant questions are therefore:

- Are metals becoming free available in the water column after discharges of barite, and what are relevant partition coefficients in the following scenarios:

a. Metals in barite-water as suspended particles in the water column
b. Metals in “whole mud” (used WBM) by use of barite as weighing agents in the water column

- Are metals becoming free available in the sediment from discharge of barite and what are relevant partition coefficients in the following scenarios:

a. Metals in “normal” sediment (at different pH-levels)
b. Metals in barite-pore water in the sediments at different pH- levels
c. Metals in bulk drilling discharges by use of barite as weighing agents in the sediments at different pH-levels

Ilminite is considered as an environmentally friendlier alternative for barite. Experiments with used drilling mud with ilminite should be carried out to compare the results with similar experiments carried out on barite.

These activities need to be coordinated with the results from the ongoing PROOF project "Impacts of drilling mud discharges on water column organisms and filter feeding organisms" run by RF-Akvamiljø (project No. 159183).

Experiments carried out through the PROOF program indicated that metals in barite are taken up in body tissue of aquatic biota and therefore potentially harmful. The exposure route of these metals to the biological targets is not fully understood. It is unclear whether metals become free available in the water first or that they are taken up directly with the barite particles. For the ERMS model it is important to know this exposure route in order to estimate the exposure concentration and consequential risks. In that concern relevant questions are:

- Will metals attached to barite/ilmenite particles and taken up by biota become free available (released into the gut) and cause effects?

- What will the accumulation of metals in biota mean for accumulation in the food chain?

Different components of muds (i.e. chemicals and metals) should be tested in a similar way in comparison with the corresponding whole used mud (WBM). This will serve both as input data and validation data, as well as contribute to the objectives of pointed out above.

- Different metal content in weight compounds is also a variable input factor, and also combinations of weight compounds (providing different properties), which is interesting to test. This will also contribute to the understanding of the metal vs. particle effects of the muds in the organisms.

In ERMS the presence of suspended matter in the water column is indicated as a stressor to aquatic biota. The stress function included in the EIF for drilling discharges is based on direct effects on mainly filter feeders. Secondary effects (e.g. caused by a reduction of light penetration) might as well lead to effects on phytoplankton development. These effects might have consequences higher in the food chain. Studies to assess the importance of these secondary effects could be of interest especially for arctic systems.