EUROPEAN UNION
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Interreg
Central Baltic
INSURE
Innovative Sustainable Remediation

COMMON SUMMARY REPORT ON MODELLING ACTIVITY

Activity A.T 3.16.2.

Contents

Background

In many countries contaminated sites impact the quality of surface water and/or groundwater. The concentrations and also content of pollutants vary a lot depending on site characteristics, contamination type, historical activity, chemical characteristics of substances and many additional aspects. To identify and assess the impact of contaminated sites on water quality, different approaches are being used, two of them are expert estimation and geo-chemical/physical modelling.

First of all is necessary to identify potential contamination area and pollutants, their fate and concentrations. After making initial characterization of contaminated site and pollutants, experts can make next steps – assessment of impact.

In Sweden, there is a lack of knowledge and data to assess the impact of polluting substances from contaminated sites on water resources. The contaminated sites in Sweden are divided into four risk classes due to the risk of contaminating the environment and possible impact on human health. In total in Östergötland there are 4078 registered contaminated sites, 55 of them are set as class 1 (highest risk). Better analyses and prediction of the dispersion of contaminants to the water resources would improve the risk classification of the contaminated sites and also show where action needs to be taken.

In Latvia exist contaminated and potentially contaminated sites data base (CPC), where are included more than 3500 sites. Most of them (more than 2600) are identified as potentially contaminated sites because the information on pollution and its possible dispersion is insufficient. Usually in site description are included only general data on its previous usage, type of activity, working time etc., and only in very rare cases there are some real monitoring data on contamination available. Currently the contaminated sites aren’t classified by risk classes as it is in Sweden, however, some risk assessment can be made anyway.

Available information on contaminated sites and related data is not enough to assess influence on water resources, thus is needed to find other more effective solutions. Models are considered a promising tool for evaluation of risk and calculate dispersion of polluting substances from contaminated sites to groundwater and surface waters. During the INSURE project existing models was used to calculate transport of polluting substances to water bodies. Analytical survey in pilot sites in Latvia and Sweden was done focusing on relevant substances addressed in the Water Framework Directive 2000/60/EC. In Sweden usually, models are not being used to observe how contaminants will disperse since this is a very new area and way of thinking. However, for the project INSURE a dispersion model made by SMHI; NET was used. The NET model works by using water flow data from the S-HYPE model, and can model different polluting substances such as metals in surface waters. In combination with the NET model a conceptual model was made for the pilot area of Åtvidaberg. In Latvia for modelling of polluting substances in groundwater the LAMO/Groundwater Vista model was applied which also served as conceptual local model. The results from modelling can be used as background for prioritization of remediation of contaminated sites.

Summary of modelling results

Latvia

In Latvia a pilot site was selected to implement the goals set in the INSURE project - former Valmiera city fuel storage facility (Figure 1), that initially was not included in the list of contaminated and potentially contaminated sites (in CPC data base) due to lack of data.

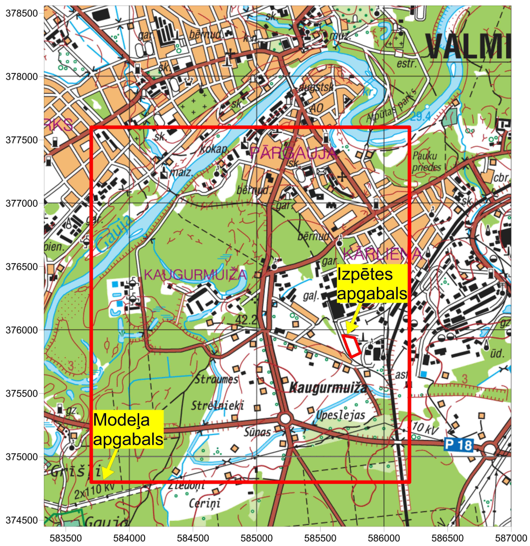

Figure 1. The location and pilot area in Valmiera city, in Latvia.

To create local hydrogeological model Ltd. “Environment consultation bureau” carried out research in 25 boreholes (including 14 boreholes for groundwater monitoring) and soil probes. Also, mazut (heavy black oil) analyses were carried out and different series of mazut physical properties were evaluated. Using research data, database “WELLS” data maintained by State Ltd. “Latvian Environment, Geology and Meteorology Centre” and State geology funds data the local hydrogeological model in the size of 2500m×2800m, with plain step size 10 m and 11 layers, was created for Valmiera city territory.

Contamination modeling was calculated for three scenarios: a) if contamination source is not liquidated; b) if contamination source is liquidated after 25 years; c) if contamination is degraded. In worst case scenario - a) contamination source is not liquidated; the modeling results indicated gradual increase of the amount of contamination in the environment after 60 years and then stabilization (blue line, Figure 2.).

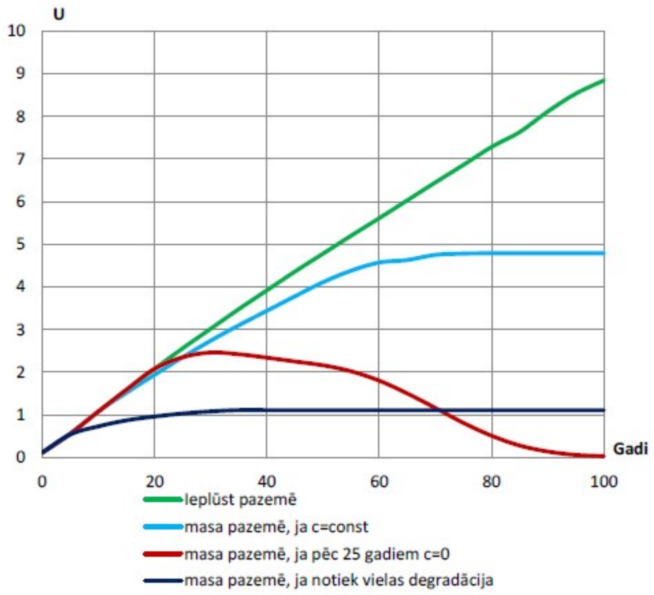

Figure 2. Change in relative mass of contamination over time for three scenarios.

It was modeled the trajectory of water particles to assess where the pollution will be moved together with water molecules, as well as forecasted the potential range and time for such movement (example of water particle movement is illustrated in Figure 3) (Spalviņš A. et al., 2017).

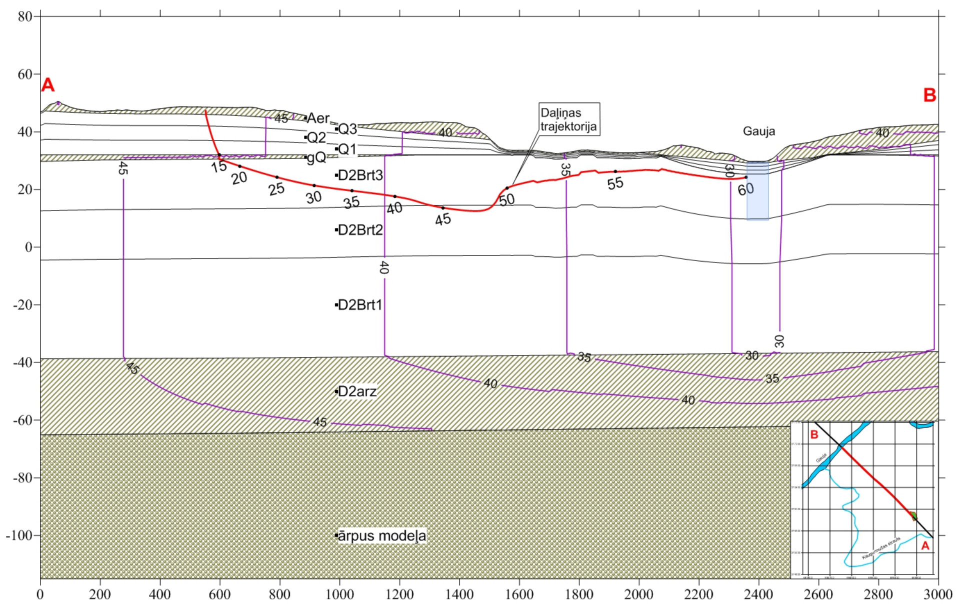

Figure 3. Vertical section of water particle movement into the LAMO model (MODPATH tool).

The obtained results indicate that the contaminated groundwater will reach the Gauja river after 60 years. The pollution reaching Gauja river is 0,1 % or 0.04432 µg/l of pollution concentrations found (BTEX) in the former fuel storage facility area and is much smaller than limit values set by Latvian legislation (Cabinet of Ministers regulation No 118). Above mentioned suggests that contamination distribution is local and in the long-term will not lead to deterioration of water quality of the Gauja river. The area's ongoing remediation works will reduce the concentration of locally distributed pollutants and reduce the risk of water pollution in the Gauja river, as well as groundwaters.

Sweden

In Sweden two different pilot areas were selected within the INSURE project, Finspång and Åtvidaberg (Figure 4).

Figure 4. The location of the Swedish pilot sites of Åtvidaberg and Finspång.

These areas are parts of the Motala Ström and the Storån basin and have a long history of industrial activities. Since the industrial activities has been going on for so long in both sites, there are basically contaminants all over the area, which makes it hard to find the hot spots where the source of the pollutants can be found. To get a better overview of the contaminant problem the Åtvidaberg pilot site was selected and a conceptual model was created based on previous and current sampling in the area combined with groundwater data and topography. By creating this map (Figure 5) the municipality of Åtvidaberg gets a better overview of the contaminants and where they may origin from.

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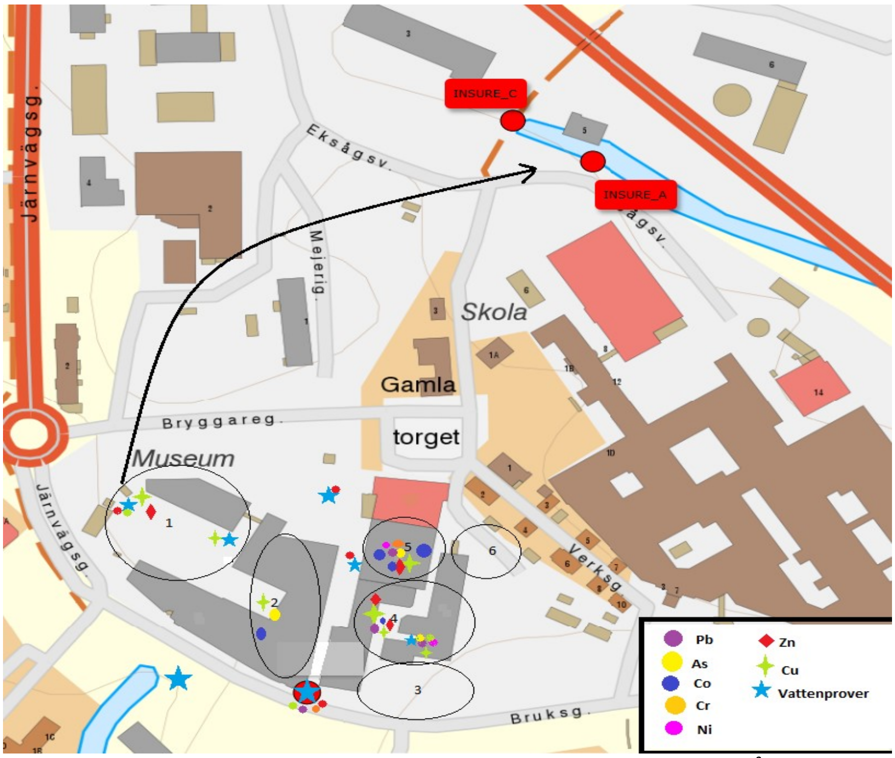

Figure 5. Displaying the contaminant mapping that was done for the Åtvidaberg pilot site in the INSURE project.

To get a better idea of how the contaminants flow around and from the both selected pilotsites the NET model was used. This model is a general tool for upscaling water quality information. The NET model was developed by Lindström et al. (2017) and calculate substance fluxes using information collected for the S-HYPE hydrological model for Sweden (Strömqvist et al., 2012). S-HYPE describes the hydrology of Sweden in high temporal and spatial resolution. In the set-up which was used for this project, Sweden is divided into about 37000 sub-basins, modelled dynamically with a daily time step. NET only estimates average flow weighted concentrations and loads, but this is often what is desired for a first screening of the status of a large drainage basin. The NET model is independent from S-HYPE for retention rates and is general for many substances transported by water.

NET can also be used to find contaminants that has not been known of before by displaying how much e.g. copper should be in one point and by combining this info with measurements it can be observed if the differ (Figure 6).

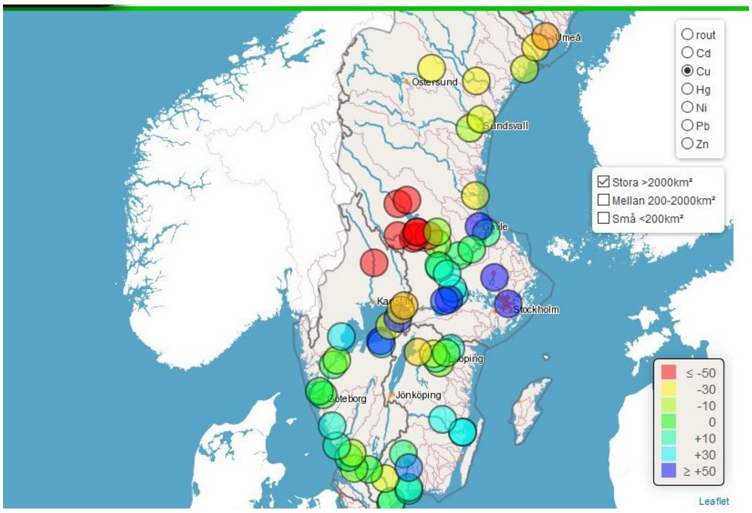

Figure 6. Displaying how the results from the NET model can look like. Here copper concentrations are depicted, and the red color represents an underestimation by the model, e.g. there is an unknown source of copper in this area that has not been compensated for in the model.

In Figure 6 the results from the NET model concerning copper in the south of Sweden is depicted. Here the difference between what the model thinks the concentrations should be and what they have been measured are shown. This makes it easy to see where unknown sources of contaminants, in this case copper, could be and based on this more investigations could be made.

Guideline for implementation of dispersion model in risk assessment

Some very important issues to keep in mind when implementing any dispersion models in risk assessment, are the availability of experts, the quality of the data available and also the total costs for implementation of the model. In many cases available information is insufficient and not qualitative to assess potential impact of contamination on environment, water resources as well as on human health.

First step is to analyze the contaminated site area and all available information on it, including its economic activity type, working time, used materials and chemicals, industrial processes etc. Also, the environment is important – is its surface water, soil, buildings or groundwaters that should be investigated. Taking into account this issue, correct model can be selected and necessary data can be identified.

Second step: survey of existing situation, including data sampling (soil, surface water, groundwater, buildings), collection of information from different data sources (including, archives for historical information, as well as different data bases and locally available documents) and data analysis. Usually this task can be implemented with help of outsourced environmental experts or companies.

Third step: practical modelling using selected modelling tool. According to information available and necessary input data in models, the results can identify problem areas, as well as forecast potential problem zones in close or wider area.

Conclusions

The pilot areas of Finspång and Åtvidaberg (in Sweden) has had large metal industries for many years, affecting the surrounding environment and making the pollution in these areas from metals widespread. Here the NET model can be a good first step to examine how far the contaminants from the pilot areas can spread and thereby get a field of impact from the contaminants. When this first step has been achieved a relatively simple conceptual model as the one made for the Åtvidaberg area can be done, using sampling and the knowledge of the area. In this project when sampling, several high concentrations were found that needs to be addressed by the municipalities. Even though there were samples taken and a model made of the Åtvidaberg area the same should be done for the Finspång pilot area. The usage of a relatively simple conceptual model can prove both economically and time worth to gain a better understanding of the area in question as it has proven difficult to pin down where all the metal pollution is originating from. Also, there seems to be some unaccounted contaminant sources of copper in Finspång, that was seen both in the sampling as well as in the modelling.

The NET model is based on large quantities of data entries and as such can be considered a rather robust model. However, it cannot be considered user-friendly and for the greater mass to be able to use it the model should be worked into an easier framework. Summarizing the modelling in the pilot areas with the NET model there are some advantages as being able to detect unknown sources of contamination. However, the model needs to be worked into a more user-friendly framework to be helpful when working with metal polluted areas.

Pilot area – former fuel storage site in Valmiera city – is a widespread contaminated site type in Latvia, however, in most cases there are no survey data on pollution available either in soil nor in groundwater. Usually there was two options how to deal with these sites – either to leave them as it is (to do nothing) or to start remediation works, based on results on few samples. The most important doubts occurred due to potential impact and pollution to surface and/or groundwater due to leaching of pollutants. Usage of LAMO model indicated that this risk assessment can be made, however, similar to NET model usage, it also takes a lot of time from initial “construction” of pilot site model till the achievable results.

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