Ecological Aspects of Soil Conditioning for EPB-TBM Projects

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ABSTRACT: Earth Pressure Balancing (EPB) TBMs with the use of soil conditioning products has become more and more frequent in the world of tunnelling. The toxicological & ecotoxicological aspects of these products belong to one of the important factors of a well prepared TBM drive.

The right and effective use of soil conditioning additives is not always obvious. An important point for the choice of soil conditioning additives is their possible impact on the surrounding environment. For a complete risk assessment, the emission into ground water during application, the working place concentrations and emissions from the landfilling of the treated soil have to be taken into consideration.

WHAT FACTORS AFFECT THE RISK FOR THE ENVIRONMENT AND FOR HUMANS?

The risk to human beings and the environment is mainly determined by the following four points:

a) The amount of substance entering the environment
b) The toxicity of a substance for the environment, respectively the toxicity towards aquatic organisms, and for humans
c) The chemical and physical properties of a substance which determine the distribution in the environment. In most cases this is the leachability into ground water. In addition, bioaccumulation has also to be taken into consideration.
d) The elimination process – known as degradation and / or immobilization – also determines the distribution in the environment. Organic substances can be degraded in two separate ways: Either by organisms which are already existing in the soil or added separately (→ Biodegradation) or by abiotic processes (→ Hydrolysis in presence of water; → Photolysis under influence of light).

In order to avoid misinterpretation regarding specific definitions, the following chapters give a short summary about Toxicity, Bioaccumulation and Biodegradation.

1.1 *Toxicity*

Toxicity is the intrinsic capacity of substances to cause negative effects to organisms. Toxic effects depend on the amount of a substance which is available to the organism.

Toxicity tests carried out in the laboratory are used to predict the so called 'safe concentrations' at which no negative impact on the organisms is expected.

In most cases the toxicity value is evaluated on a rat population. The lethal oral dose for 50% of the population (LD_{50}) is listed in mg substance per kg of organism weight.

1.2 *Bioaccumulation*

Bioaccumulation is a process by which organisms concentrate chemicals within themselves. This can result either from their food or directly from the surrounding environment.

1.3 *Biodegradation*

Biodegradation is the breakdown of an organic substance by the action of micro-organisms. Before degrading completely to water and CO_2, substances may degrade to smaller intermediates.
Persistence is the ability of substances to resist degradation.

2 SUITABLE SOIL CONDITIONING PRODUCTS

In the case of driving an EPB machine, which results in injecting substances like foaming agents or polymers in the front of the TBM and mixing them together with the soil, it is important to:

a) Choose products with minimum toxicity and ecotoxicity values

b) Choose products with high biodegradation or inert components (if the bioaccumulation risk is low).
c) Minimize the quantity of injection materials

In order to evaluate the general risk of the injected substances it is strongly recommended to carry out a general risk assessment prior to their intended use.

3 GENERAL RISK ASSESSMENT

The goal of the risk assessment is to summarize the technical data concerning the environmental hazards. Predicted environmental concentrations should be compared with predicted non-effect concentrations and recommended exposure limits.

3.1 *Product data*

A collection of various physicochemical, transformation and toxicological data as well as the product quantities which are typically used are required.

3.2 *Hazard identification*

The environmental risk assessment has to be carried out for each of the different ingredients of one product and the predicted environmental concentrations have to be compared individually to the respective predicted non-effect concentrations.

3.3 *Calculation of non-effect concentrations and maximum allowable concentrations*

For the predicted non-effect concentrations (PNEC) for surface water, the European 'Technical guidance document in support of commission directive 93/67/EEC and commission regulation (EC) No 1488/94' should be used.

3.4 *Exposure Assessment*

For the identification of the relevant emissions during application, loading and disposal, a relevance matrix should be prepared. For every specific emission the potential human exposures should be evaluated.

The calculation of the biodegradation rates and the predicted environmental concentrations (PEC) (based on the assumed infiltration into underground, groundwater width, depths and flow; also evaporation has to be considered) should be produced.

4 PREFERABLE RESULTS OF THE RISK ASSESSMENT

4.1 *Risk for workers*

The expected impact on the environment should generally be low if the substances are adequately handled and the recommendations of the Material Safety Data Sheets are implemented.

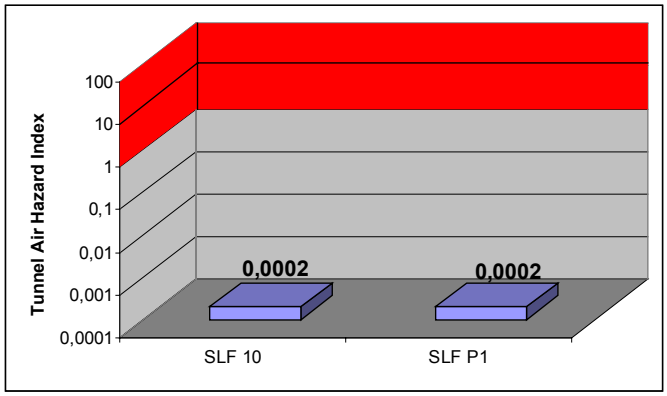

Figure 1: Example of Human Risk Assessment

Ideally the concentrations in the air are even under worst case assumptions more than 1'000 times below the respective occupational exposure limits (hazard index = 1) as shown in figure 1.

4.2 *Risk for the environment*

No risks to surface water from emission due to pumped tunnel water or run-off water should be expected, providing that the water is drained into the municipal sewage system for treatment.

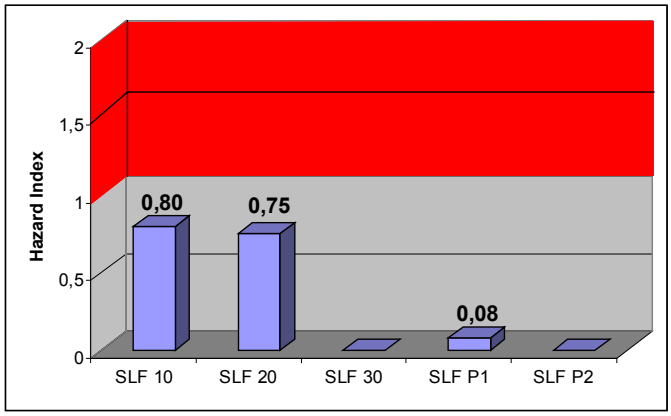

Figure 2: Example of worst case environmental assumptions for various soil conditioning polymers and foams

The potential infiltration of ingredients into the ground water during the product application should not cause any relevant risk for the environment. Based on the available information of the ingredient concentration in the treated soil, it should be able to be disposed on an appropriate landfill site without any special pre-treatment

5 REFERENCES

BMG Report, Environmental Risk Assessment: The use of MEYCO Fix SLF in tunnel constructions. May 2001, unpublished, BMG Engineering Ltd., Zürich

6 ACKNOWLEDGEMENTS

F. Kupferroth, MBT International UGC, Zürich