BIOAVAILABILITY AS A TOOL IN SITE MANAGEMENT

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INTRODUCTION

It is now estimated that there are more than three million potentially contaminated sites worldwide. The risk at each site differs according to a variety of factors, and in certain cases remedial action will be needed in order to protect both human health and the environment. Most regulations and regulatory accepted assessment procedures are still based on total concentrations. Especially in developing countries the methods used to assess the risks of contaminated sites are often too theoretical, difficult to complete under local conditions, necessary laboratory facilities are lacking and resulting in a “wait and see” attitude. This “wait and see” attitude becomes exacerbated if the assessment procedure is followed by recommendations based on overly expensive or not realizable technology. The result is that no real actions to reduce risks are taken, nothing occurs till a new assessment is started in future; an infinite circle. Also in western countries this “wait and see” attitude is recognized, especially when removal of the contaminant is an expensive exercise and/or there are doubts on the risks posed by the contaminants.

From a risk-based point of view, contaminations are only a risk if they are or may become available. A risk-based approach can be more useful than a concentration standards-based approach. This widens the range of options and therefore can facilitate more tailor-made solutions for individual sites that address the problem and are more viable. In a risk based approach stimulation of biodegradation and/or immobilization and isolation of the contaminant may play a role. In particular bioavailability can be the underlying basis for the description of risks and for determining a solution and that can be used to break the infinite circle.

It is essential that bioavailability is used both in the assessment and in the actions to reduce the risks (remediation. This paper provides some concepts that have been used or can be developed into a suitable tool in future action to reduce the risks of contaminated sites.

BIOAVAILABILITY IN ASSESSMENT

Results of a method to measure bioavailability should be a help in solving the problem of a site. It should be more than a tool to conduct site assessment, it also has to be a tool to design an action plan to reduce the risk. Such a method should have an understandable physical base. ISO 17402 (ISO, 2008) is a guideline to select the proper methods and leads to methods that either measure the concentration present in the water phase (actual available) or the amount in soil that may move to the water phase in a certain period (potential available).

BIOAVAILABILITY IN REMEDIATION

Because bioavailable fraction poses risks this fraction should be as small as possible. This can be achieved in a number of ways including the removal of contaminants. It is not sufficient to remove the actual available fraction, because this will be replaced quickly by the reservoir of contaminants in the potential available fraction. So removal will mean removal of the potential available fraction. On the other hand, the contaminant in the water phase (actual available) is responsible for direct effects as accumulation in vegetation, effects on soil living organisms and leaching to groundwater. If this amount is reduced, risks are also reduced. Thus the key to managing contaminated sites could be via bioavailability reduction to a point that even the presence of residual contaminants does not result in release of available fraction.

CASE EXAMPLES

Biodegradation of organic contaminants

Fortunately a lot of organic contaminants are biodegradable. The biodegradable fraction can be estimated using a method that measures the potential available fraction. Tenax (Cornelissen, 1998) has been used and results of this methods can be used to predict the degradable amount. It is even possible to predict the degradation of the residual concentration, left after removal of the potential available fraction (Harmsen et al., 2007). Results shows that the potential available amount can be quickly removed, but that decades are necessary to biodegrade the residual amount. This has consequences for the use of biodegradation in remediation.

Reduction of the actual available fraction

If conditions are inadequate for biodegradation, the actual available concentration has to decrease. Strong adsorbent often summarized as black carbon (Koelmans et al., 2006) are suitable for this purpose and are applied to decrease the availability of PAH in sediment. This approach can also be used to reduce the risks of soil contamination with dieldrin in Africa by using local available char coal (Harmsen et al., 2009)..

Removal of heavy metals is mostly not an option. It is possible to explain the actual available fraction as extracted with 0.001M $CaCl_2$ with soil characteristics and/or thermodynamics (Groenenberg, 2011). The pH, redox and strong metal absorbing materials like clay and organic matter are important parameters, that also can be used in actions to reduce the actual bioavailability. Examples will be shown on reducing of bioavailability by 1) stimulation of the formation of sulfides, 2) control of pH and 3) maintaining organic matter content. Often bioavailability of metal contaminants are managed either via chemical immobilization process or via manipulating soil pH as is the case with Cd in farmed soils.

CONCLUSIONS

Bioavailability can be used as a tool to reduce the risks of contaminated sites. To do this it is essential that during the assessment, methods are used that give understandable results. The obtained knowledge on bioavailability is necessary to design the remediation.

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