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Possibilities of implementation of bioavailability methods for organic contaminants in the Dutch Soil Quality Assessment Framework

Ellen Brand*, Johannes Lijzen, Willie Peijnenburg, Frank Swartjes

National Institute for Public Health and the Environment (RIVM), P.O. Box 1, Bilthoven, 3720 BA, The Netherlands

HIGHLIGHTS

- Currently SQS are determined based on total concentrations in soil.
- Including bioavailability gives a more effect based risk assessment for soils.
- We advise on implementing the use of bioavailability in regulatory frameworks.
- Actually bioavailable soil concentrations can be related to aquatic toxicity data.
- Potentially bioavailable soil concentrations can be related to soil toxicity data.

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ABSTRACT

In the Netherlands, risk assessment of contaminated soils is based on determining the total contaminant concentration. If this measured soil concentration exceeds the Soil Quality Standards (SQS) a higher tier risk evaluation must be performed. Experiences from the field have given rise to the perception that performing risk evaluations based on (measured) total concentrations may lead to an inaccurate assessment of the actual risks. Assuming that only the bioavailable fraction is capable of exerting adverse effects in the soil ecosystem, it is suggested, that by taking bioavailability into account in a (higher tier) risk evaluation, a more effect-based risk assessment can be performed. Bioavailability has been a subject of research for several decades. However up to now bioavailability has not been implemented in the Dutch Soil Quality Assessment Framework. First actions were taken in the Netherlands to determine whether the concept of bioavailability could be implemented in the risk assessment of contaminated soils and to find out how bioavailability can become part of the Dutch Soil Quality Assessment Framework. These actions have led to a concrete proposal for implementation of bioavailability methods in the risk assessment of organic contaminants in soils. This paper focuses on the chemical prediction of bioavailability for ecological risk assessment of contaminated soils.

1. Introduction

This paper aims to combine scientific knowledge on measuring bioavailability and using bioavailability in a policy framework of contaminated soils. To do so it uses the results of a review of methods [1] that can be used to chemically measure bioavailability and by presenting a concrete advice on how these methods can be used in the practice of ecological risk assessment. In order to better understand the outcome of this work, first a small overview of the Dutch regulation is presented in which bioavailability should be implemented.

1.1. History

The formalization of contaminated site management in the Netherlands goes back to 1983 when the first Interim Soil Remediation Act was established. No further consideration with regard to the appearance and availability of contaminants in soil was included at that time [2].

Currently, the Dutch Soil Quality Standards (SQS) are called Target values, Background Values and Intervention Values (see Fig. 1) [3,4].

The SQS are derived for a so-called standard soil including 10% organic matter and 25% clay. Since the introduction of risk-based SQS in the Netherlands, the Target and Intervention Values are corrected for organic matter content for organic compounds and clay content for inorganic compounds [5]. This could be considered as an indicative correction for bioavailability, although the scientific basis of the soil properties correction formulae is poor.

* Corresponding author. Tel.: +31 30 274 26 89; fax: +31 30 274 44 13.
E-mail addresses: ellen.brand@rivm.nl (E. Brand), johannes.lijzen@rivm.nl (J. Lijzen), willie.peijnenburg@rivm.nl (W. Peijnenburg), frank.swartjes@rivm.nl (F. Swartjes).

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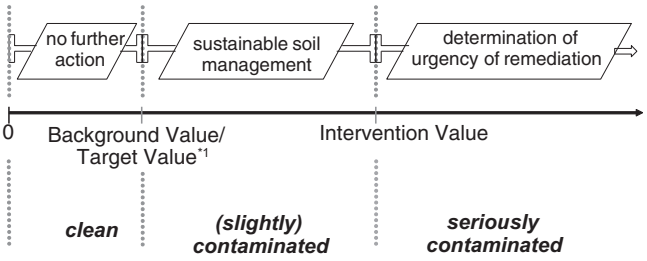

Fig. 1. The contaminated sites management framework in the Netherlands *1: Background Values are used for the unsaturated soil compartment ('soil'); Target Values Groundwater are used for the saturated soil (groundwater) compartment only. Taken with permission from [3].

1.2. Risk assessment of contaminated sites

The current regulatory framework on contaminated soils in the Netherlands includes three tiers for human and ecological risk assessment (see Fig. 2). This paper will focus on ecological risk assessment only.

The tiers are as follows:

1. Identification of a possible case of serious soil contamination;
2. Standard risk assessment;
3. Site specific risk assessment.

The first two tiers are obligatory. Tier 3 can be carried out if deemed necessary by the initiator or by the competent authority pursuant to the Soil Protection Act (1987). Fig. 2 shows the flow diagram used within the regulatory framework for contaminated soils, including the steps of risk assessment, remediation and management.

1.2.1. Tier 1

In the first tier the total soil concentration is measured to determine if there is a case of serious soil contamination. If this concentration exceeds the Intervention Value for soil in a volume of at least 25 m^3 soil or the Intervention Value for groundwater in more than 100 m^3 of water-saturated soil, there is a case of serious soil contamination and a standard risk assessment has to be carried out [5].

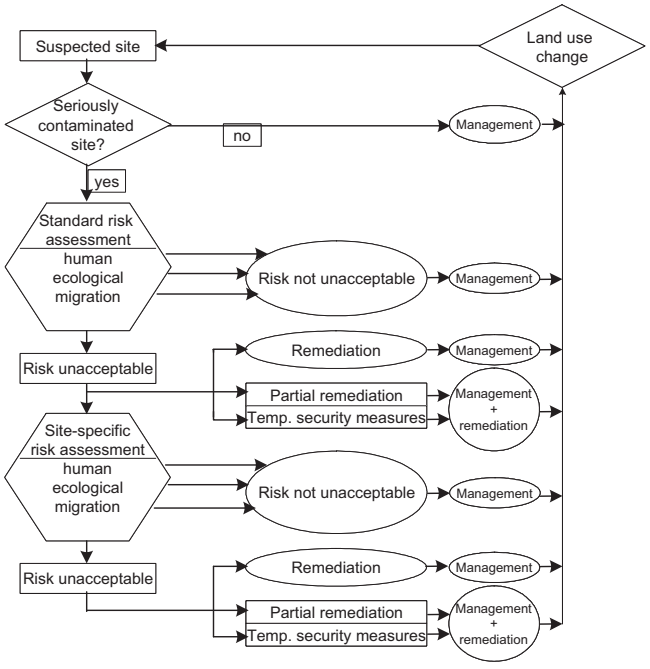

Fig. 2. Flow diagram, including three tiers, related to the current regulatory framework for contaminated site management in the Netherlands [5].

1.2.2. Tier 2

The standard risk assessment of a site is done with help of the Sanscrit web application [6,7]. By use of default user scenarios of the contaminated site (e.g. nature areas) and relevant exposure pathways, ecological risks are determined. If ecological risks cannot be excluded, a more detailed site specific risk assessment can be carried out [5].

1.2.3. Tier 3

In tier 3 it is possible to use more site specific information as input for the Sanscrit web application. This higher tier evaluation can be both of chemical and/or biological nature. If, based on this site specific risk assessment there still is an indication for risks, remediation is obligatory and a remediation plan needs to be established.

Performing a Triad assessment to determine ecological risks is one option to use more site specific information [5]. The Triad approach combines three areas of ecotoxicological research – chemistry (e.g. extractions), toxicity (e.g. bioassays) and ecology (e.g. field surveys) – to construct a final judgement on ecological risks of contaminated sites. The Triad approach provides a procedure to use and combine knowledge on for example, bioassays and the chemical measurement of bioavailability (chemical availability).

Performing a Triad approach can be costly and time consuming. However it is not obligatory to perform a Traid approach to assess ecological risks. For more information on the Triad we refer to [8–10].

1.3. Sustainable land management

1.3.1. Generic Maximal Values

Besides risk assessment of contaminated soils, the Dutch framework also includes sustainable land management. The principle behind sustainable land management is that a soil is fit for current or future land use.

In order to manage slightly contaminated soils, so called generic 'Maximal Values' (residential and industrial) and 'Background Values' have been derived. Together with the Dutch Intervention Values they divide contaminated soils in four quality classes. If the concentrations in soil are below the Background Values, it is possible to reuse this soil material everywhere. This quality is equal to the quality common in relatively undisturbed agricultural areas and nature reserves. If the concentration in soil is above the Maximal Value 'Industrial', the soil is not suitable for reuse. Soil with a concentration below the Maximal Value 'Residential' (between the Background Value and the Maximal Value 'Industrial') can be reused in residential areas. Excavated soil can only be reused on soils that belong to the same land use class or to less sensitive land use classes (see Fig. 3) [11].

In addition to these generic Maximal Values, local authorities are allowed to derive area-specific standards when there is a diffuse contamination over larger areas with slightly or moderately contaminated soils or if the natural background is higher than the level on a national scale (after correction for soil properties, see Fig. 3) [11].