TNO Environmental and Energy Research

Sustainable soil use
a TNO-concept

TNO Environmental and Energy Research

Sustainable soil use a TNO-concept

A.J. Palsma (ed.), M.J. Diependaal (ed.),
F.G. Aelmans, E.J. Hoekstra, A.C. Leget, H.J. van Veen

May 1993

Photographs

Benelux Press, Voorburg (cover, p. 4)
F.P.J. Lamé, TNO Delft (p. 9)

Sustainable soil use

a TNO-concept

1. Introduction

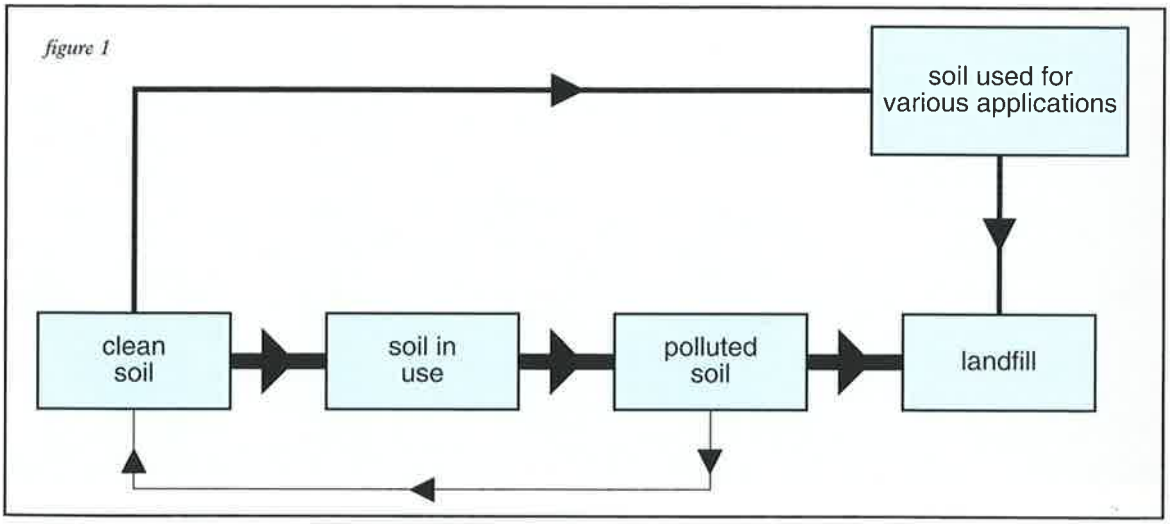
In the past few decades the authorities in many countries have been confronted with soil pollution. Most soil pollution originates in the past. Soil pollution was only recognized as an important environmental problem in the '80s. To deal with these problems soil clean-up policies were rapidly drawn up in several countries. A few years later these were followed by prevention policies.

The current soil use in various countries in the west is sketched in figure 1. Clean soil is used by man. The soil may be used either as a carrier or as a raw material. Part of the soil will be polluted by accidental or regular actions. In many cases this pollution is so serious that the soil has to be removed and stored in a landfill deposit as waste. The authorities are now trying to effect the clean-up of polluted soil through legislation. However, there is a major problem. The pollution of clean soil, its excavation and storage in landfill deposits, is much cheaper than remediation of polluted soil. As a consequence the flow sheet in figure 1 results in a reduction of the volume of clean soil and continued storage in landfill deposits of polluted soil. In other words, the flow from left to right in the figure exceeds that from right to left. Hence, clean soil is consumed and soil clean-up is delayed, i.e. such soil use is not sustainable.

Recent discussion within TNO has resulted in the development of a concept for the implementation of sustainable soil use. This concept is based on two premises:

- the availability of good quality soil is limited and the resources should be maintained;
- soil quality has an economic value.

The 'TNO concept', a proposal for sustainable soil use, was developed on the basis of these



Soil quality has an economic value.

premises. This concept will provide the direction to a discussion at a workshop during the TNO/KFK Soil Congress to be held in Berlin in May 1993.

2. Current situation

In the early 1980's a number of countries in the west were confronted with soil pollution. Policies to deal with this issue were drawn up in a relatively short time. At that time the Netherlands, one of the first countries confronted with the problems, set the direction for the clean-up policies.

Besides policies, clean-up technologies were developed rapidly. Initially the approach was to deal with the problem by removing all polluted soil and processing this on an industrial basis. Soon, however, it became clear that the scale of the soil pollution was far greater than first anticipated. At the international level the soil-pollution issue was also huge and the cases on the record are becoming more numerous.

Current remediation policies are largely based on the assumptions and estimates made in the early days. As available remediation technologies are often too expensive or unable to reduce the pollutants to the required level, polluted soil is often stored in a landfill deposit.

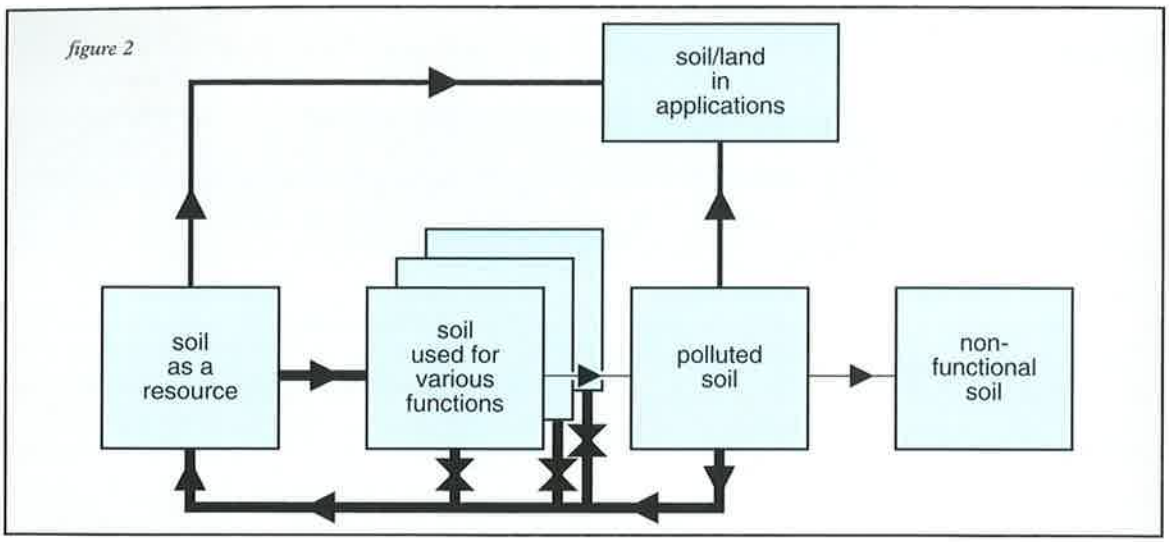
One can observe that in many countries the large-scale remediation of polluted soil is slowing down, while the development of remediation technology is also lagging behind. The prevention of new cases of soil pollution is also insufficient and the number of cases continues to increase.

The overall effect of this process is the consumption of clean soil.

3. TNO-concept

To implement the sustainable use of soil the use and quality of the soil will have to be integrated in an economic structure. In this way the prevention of soil pollution may be promoted and funds for remediation can be set aside. At present land prices are determined largely by the location and options for use within the existing planning framework. Soil quality and associated implications for use are less important. Furthermore, a functional use of the soil should be implemented. The proposed structure is outlined in Figure 2. Like Figure 1, this figure includes soil use and remediation of soil pollution. The TNO concept is characterised by:

Clean soil as a limited resource
Clean soil is a limited resource which has to be used and managed carefully. Different countries apply different standards to cleaned soil. In the Netherlands for example cleaned soil should be fit for all functions which were originally possible (multi-functionality).
A wide range of activities, associated with actual or potential pollution is often undertaken on the soil. In many cases the



resulting soil pollution is so great that it cannot be reinstated to multi-functional quality. Hence, the stock of clean soil is being reduced.

Functional application

Soil is used, now or in the future, to fulfil a function such as agriculture or residential area. An acceptable maximum pollution level for a given plot is determined, for the period of the functional use. Soil use is sustainable if a function can be maintained at a location for an indefinite period. Adequate prevention is an important element in this. Prevention can be promoted by putting a price on each function. These prices should depend on the potential pollution associated with the function. When the function is changed, the soil should be reinstated to a quality appropriate to the new function. Remediation costs can be set aside through the payments referred to above. When the level is exceeded, remediation activities will have to be carried out or the functional use should be changed.

Setting Standards

If function-dependent standards were introduced, soil quality could be defined as the fitness for use. Toxicological and ecotoxicological risks and effects could be evaluated for a given function or area which may be polluted. In this way a set of standards can be defined for each function, depending on the type of soil. When setting standards, the risk of pollution transport (through water or atmosphere) should be considered as well as the toxicological and ecotoxicological aspects. Protective measures, such as hydrological isolation, should be taken if the toxicological or ecotoxicological risk is acceptable but the risk of pollution transport through the groundwater is too high.

Such a quality criterion may introduce problems when the use of soil is changed. Soil suitable for agriculture may not be suitable for an area of natural interest or residential areas. To determine the suitability of soil when its function is changed, it is not enough just to set standards for potentially toxic substances. The standards will have to cover a wide range of chemical, (physico)chemical, hydrological, mineralogical and ecological variables. Standards will also have to be established for clean soil (good soil quality). In principle such standards will be independent of toxicological, ecotoxicological and hydrological risks. Even when dealing with clean soil, it is not enough to specify the levels of potentially toxic substances. In most parts of the Netherlands soil properties have changed as a result of the use made of it (e.g. agricultural soils enriched by human activity, areas where the groundwater level was lowered, sand brought on site for construction works). For soil whose properties have undergone major changes the question arises to what extent it is useful and practical to define a 'clean original situation'.

Remediation measures chosen on the basis of environmental yield

Remediation may be undertaken to reinstate a functional level of soil quality. Historical pollution is particularly relevant to remediation policies. The concept described here interprets sustainable use as an equilibrium situation. However, given the historical pollution, this equilibrium can only be obtained by making up for past problems. Environmental yield (return on investment) should be the main criterion for a choice from possible alternatives when considering remediation activities. Figure 3 defines 'environmental yield' as the 'cost effectiveness of a measure'. The environmental benefits or environmental effectiveness are subcriteria in which location, process and product aspects are combined.

In this context location aspects refer to the effects of the remediation operation on the site to be treated. This includes the environmental impact of the process to be used and the effects of the operation on the soil as a product. Other factors besides environmental efficiency affect the feasibility of the measures, for example administrative aspects and social desirability.

Technology

The concept presented here will affect the development of soil-remediation technology. Current techniques aim to reduce the level of contamination to the standard for clean soil in a short time. In view of the above considerations, future techniques should not only reduce the level of toxic substances, they should improve the overall quality of the soil. As a result the contamination level may be acceptable even if it exceeds the current reference values used in the Netherlands, provided that the soil is suitable for its function.

After the clean-up a risk analysis should be carried out to determine the purposes for which the soil (i.e. the product) can be used. This will make remediation techniques which do not affect the properties of the soil more feasible. In situ, non-intensive remediation techniques would appear to be particularly

PARAMETER	SUBCRITERION	CRITERION	MAIN CRITERION	
Actual risk Potential risk	Location aspects	Environmental benefit or Environmental effectiveness	Environmental yield	PRIORITIES
Waste disposal residues Energy, emissions	Process aspects			
Structure Organic C content pH Ecological recovery level of contaminants	Product aspects			
Costs/cost effectiveness				
Social desirability				
Administrative and legal aspects				

Figure 3

appropriate. However, such long-term remediation will only be acceptable if the risk of pollution transport during the process is monitored and remains within limits.

Soil remediation will not be limited to those cases where contamination levels are so high that the land cannot be used for any function. Non-intensive techniques may also be used at lower pollution levels as the economic structure proposed here guarantees that the value of the land will increase if the soil quality is closer to the standards for clean, good quality soil.

Soil use within the economic system

Sustainable soil use will only be feasible if the soil is part of an economic system. Although land is already included in the economic system, the price is largely determined by its location or the activities which are feasible or permitted. At present quality and scarcity of soil as a resource are less important.

Remediation of polluted soil can be encouraged by an 'economic drive'. Such an economic drive can be implemented in a variety of ways, for example, a fund could be established. Such a fund could be built up through annual contributions from those using the soil. The level of their contributions could depend on the use of the soil, its quality and the measures taken against soil pollution. For long-term responsible use a no-claim discount could be

At present quality and scarcity of soil as a resource are less important.

installed. Whatever its structure, the essence should be that a cost would be incurred in the event of pollution and that soil remediation should be rewarded. The reward should meet the costs required to obtain the result.

Figure 4 illustrates an estimate of the risks and relative costs of various functions. Naturally the costs per area unit for a given functional area correspond with the risk of pollution. The costs of a given function will depend on the risk and preventative measures taken. Figure 5 illustrates a possible differentiation scheme for landfill sites.

Transitional situation

As referred to above, the proposed concept is based on a steady state. However, at present the large number of soil pollution sites due to past activities amount to a considerable burden on the economy and the environment. Clearly sustainable soil use will require remediation of serious cases. Less serious cases can be incorporated in the system. The proposed criteria can then be applied to them. Those responsible for such problems created in the past will have to fund the remediation operations if they can be identified. Other cases could then be financed from the soil remediation fund.

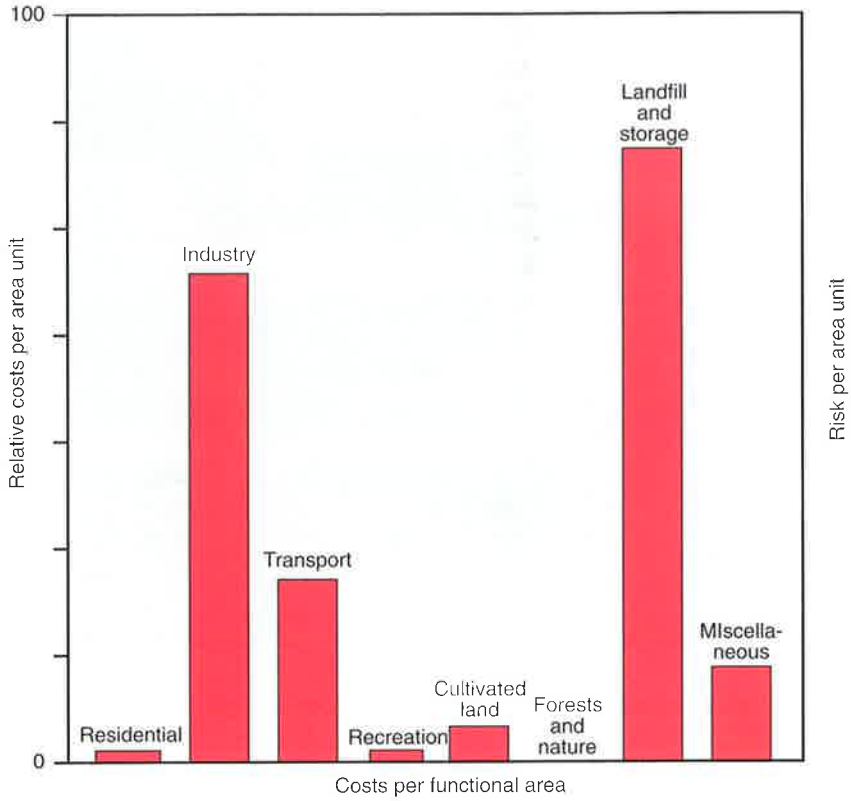


Figure 4

4. Comprehensive package

The idea presented here as the TNO concept is essentially simple. It not only provides soil users with the facility to implement functions but it also makes users financially responsible for any pollution associated with that use. The proposed system will only lead to the desired self-regulating, sustainable soil use if it is implemented completely, as a comprehensive package.

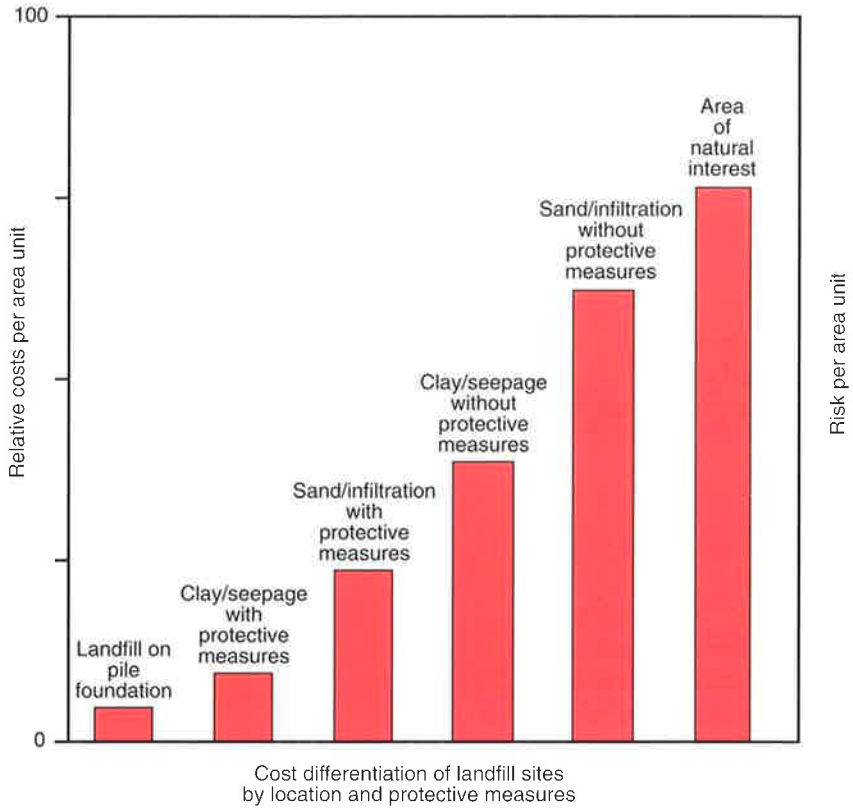


Figure 5

5. Recommendations

If the TNO concept is accepted as a feasible option, it will lead to a large-scale operation to develop certain aspects of the concept, for example:

- defining functions and the associated standards;
- developing standards to define the concept of 'good soil quality' in broader terms (chemical, physical, hydrological and ecological aspects);
- developing and implementing remediation techniques, including non-intensive techniques;
- selecting the most suitable form of 'economic drive';
- developing and implementing soil and groundwater quality monitoring systems.

6. Summary

Theses:
- Soil is a limited resource; soil pollution results in an irreversible reduction in the stock of high-quality soil.
- Soil quality should be associated with an economic value.

Conclusions:
- Soil is currently being consumed.
- Remediation of polluted soil is slowing down.
- There is extensive, and still increasing, soil pollution.

Solutions:
- The policies will continue to aim to protect clean, high-quality soil.
- Functional soil use associated with an acceptable pollution level, depending on the function (areas where pollution is acceptable).
- Remediation activities should be selected on the basis of environmental efficiency.
- Economic drive: a 'deposit' or 'insurance' for the use of soil.
- Creation of a national soil fund. This will have a preventative effect and set aside resources for remediation activities.

Sustainable soil use:
The TNO concept will lead to sustainable soil use if both the functional use and the economic engine are implemented.

Sustainable soil use - an aspect of sustainable development

There is a growing realization that, given the way the economy is developing, society will have to use the capacity of the environment, space available and natural resources carefully to offer future generations equal or better perspectives. TNO provides a valuable contribution to sustainable development.

TNO Environmental and Energy Research concentrates on research and consultancy on environmental management, responsible energy use and the efficient use and management of underground resources.

TNO Environmental and Energy Research has access to the expertise of other TNO institutes and is thus able to set up multi-disciplinary teams for special and complicated issues raised by the public and private sectors and other organizations. The division also co-operates with other organizations and universities in the Netherlands and abroad.

TNO Environmental and Energy Research has developed the 'TNO Concept for Sustainable Soil Use'. Other areas covered include:

- Environment and policy
- Integral chain management
- Sustainable aquatic systems
- Energy sources
- Energy conservation
- Process water and effluent
- Air pollution and climate change
- Waste substances
- Prevention of environmental hazards and disasters

For further information, please contact:
TNO Environmental and Energy Research
P.O. Box 6010
2600 JA Delft
The Netherlands
Fax +31 15 69 72 85
Phone +31 15 69 72 86