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Healthy soil

Testing for Life

Toward a factual analysis

Vision for data-driven soil management

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Author: Eurofins Agro Testing Wageningen B.V.

Contact: Marketing & communications department
communication-agro@eurofins.com

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Eurofins Agro Testing Wageningen B.V.
Binnenhaven 5
6709 PD Wageningen
The Netherlands
www.eurofins-agro.com
00 31 (0) 88 876 1010

Summary

Soil health is indispensable for existence on earth. Without a healthy soil there is no sustainable food production, no biodiversity, no water storage in the soil and no vital soil life. But not only that! A healthy soil fixes CO_2 in organic matter and thus contributes to reducing greenhouse gases in the atmosphere. A prerequisite for building soil organic matter levels is the availability of sufficient nutrients in the soil, such as nitrogen. Agricultural soils, especially permanent pasture, also contain large amounts of carbon.

Soil health and wildlife are under pressure in a number of places in the Netherlands due to excessive deposition of sulfur and nitrogen compounds. Soil is out of balance and nutrients have been released and washed out. The result is ongoing acidification, calcium deficiency and aluminum poisoning. This process has been going on for decades.

Soil health and nature will not recover on their own, even if efforts are made to reduce nitrogen emissions 100%. In the report 'What can be done' Johan Remkes formulates 25 recommendations for a broad transition of agriculture and rural areas. Remkes argues that the state of nature should be central when taking measures.

One of the report's recommendations concerns the long-term removal of critical deposition values (KDW) from the law. However, a different measurement tool must then be developed for granting permits, the report says. The proposal is to draw up a substance balance, which entrepreneurs can use to manage targets and emissions.

Eurofins studies soil health in both agricultural and natural areas and provides data on chemical, physical and biological properties of the soil, on carbon storage and on the possible presence of contaminants. Soil research can contribute to the proposed substance balance sheet.

Soil research deserves a place in the Agricultural Agreement between agricultural organizations and the government, which Johan Remkes is proposing to get out of the current impasse. Steering based on data from soil research provides insight and certainty about how soil health develops over time. Soil research is an instrument to monitor the effectiveness of the measures taken in order to achieve nature restoration step by step.

Together with agricultural entrepreneurs, nature managers, governments and researchers, Eurofins wants to work on a factual analysis of the state of nature and on improving soil health. In addition to nitrogen, water quality and climate also deserve attention in this approach.

Recommendations

Soil surveys provide an opportunity for factual analysis of soil health and the state of nature. Soil surveys are a practical tool for monitoring whether nitrogen reduction and nature improvement goals have been met at agreed upon calibration points.

Eurofins makes the following recommendations:

1. Measure and monitor soil health in natural and agricultural areas. Look at essential nutrients, moisture holding capacity, soil life and carbon fixation.

2. Expand the national monitoring network to include soil data and use the data obtained as a starting point for remedial actions and monitoring.

3. Provide insight into the relationship between what takes place in the soil and the effect on the growth process of plants (leaf/needle). Set target values for soil and nature on this basis.

4. Base restoration measures on the actual overall picture of soil health. Soil surveys provide concrete data on what is actually happening in the soil and are a valuable complement to deposition measurements.

5. Consider soil restoration as an essential component of climate policy. Recall that nitrogen is needed, among other things, for building up organic matter and sequestering CO2 in the soil.

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1. Introduction

The Netherlands faces a radical task when it comes to improving nature, preventing further climate change and optimizing water quality. Eurofins agrees that measures are needed to achieve this. These measures can only be effective if the initial situation and objectives for the soil are clearly defined and supported by all stakeholders.

Healthy soil

Achieving this task begins with ensuring healthy soil in agriculture and nature. A healthy soil is characterized, among other things, by sufficient calcium, sufficient organic matter for the climate (CO2 binding) and sufficient buffering and cleansing capacity to support water quality and prevent further soil acidification.

There are several conceivable paths along which the final goal can be reached. In each case, measuring and monitoring soil and water quality provides insight into the results of the measures taken. Thus, a factual analysis of soil health and the state of nature is possible.

Data and knowledge of the soil

Eurofins has an extensive database of data on Dutch agricultural soils and the coverage of this research is nationwide (see Appendix). Eurofins' soil experts have thorough knowledge in the field of soil health and cooperate nationally and internationally with renowned scientific institutions. Analyzing and interpreting soil data in relation to climate and water is part of their expertise.

A contribution

Eurofins therefore can and wants to make a contribution to addressing the nitrogen issue and improving the quality of nature. Soil research deserves a place in the Agricultural Agreement between the agricultural sector and the cabinet, which Johan Remkes is proposing to get out of the current impasse.

2. Why is healthy soil important?

Optimal soil health is the basis for sufficient and safe food production as well as for sufficient biodiversity in nature. Important characteristics that describe soil health are the organic matter and carbon storage, physical, chemical and biological properties and the presence of any contaminants. In a healthy soil, all the pieces of the puzzle need to fall in to place (see Figure 1).

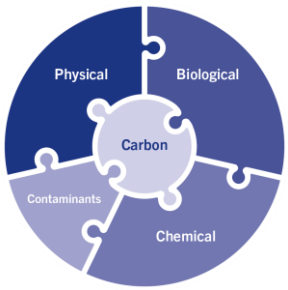

Figure 1: Soil health is a puzzle consisting of five parts. Source: Eurofins, 2022

Solving the soil puzzle takes time and attention, and is necessary to achieve government and society's sustainability goals:

- Healthy soil is the basis for a balanced natural ecosystem.
- A healthy soil limits further climate change by sequestering the greenhouse gas CO_2 in soil organic matter.
- A healthy soil has a high water-holding capacity and can better absorb heavy rainfall and is more resilient during periods of severe drought, due to good physical properties.
- Healthy soil contributes to food security because agricultural crops can absorb sufficient nutrients for optimal production and crop quality.
- Healthy soil in urban parks and borders improves the living environment in urban areas.
- A healthy soil is resilient to diseases and pests thanks to an active and diverse soil life and is able to restore the balance itself.
- Healthy soil is free of contaminants, providing the basis for healthy plant growth, productive agriculture and healthy food.

3. What is going on with the soil?

Soil health in the Netherlands is out of balance. This has been going on for decades. There are three causes for the poor soil quality and disturbance of nature.

1. **Acidification**
   High precipitation levels (deposition) of especially sulfur and nitrogen compounds (SO_4 and NO_3) in natural areas have caused acidification for several decades[1]). These sulfur and nitrogen compounds come roughly 50% from traffic and industry (S and NOx) and 50% from agriculture (NH_3).[2])

   Acidification occurs through the leaching of SO4 and NO3 to groundwater. In the process, these anions take cations such as calcium and/or magnesium with them. Acidification also reduces the soil's ability to bind essential plant nutrients to the clay-humus complex (called CEC). In addition, acidification releases aluminum ions that are harmful to plants. Acidification depletes and poisons the soil, so to speak.

2. **Eutrophication**
   In addition to acidification, fertilization (eutrophication) by nitrogen and other nutrients is also a concern. Excessive concentrations of nutrients reduce the competitiveness of vulnerable plant species in nature. The result is loss of biodiversity.

3. **Desiccation and salinization**
   Soil is drying out and salinizing due to climate change. Direct human actions such as dewatering and (more intensive) water extraction also have negative effects on the soil.

Soil will not naturally recover from acidification, eutrophication, desiccation and salinization. Not even if nitrogen emissions are completely reduced to zero. Measures to restore natural and forest soils were advocated as early as the 1980s. In subsequent years, this message has been repeated several times, but the proposed measures have never been fully implemented[3]).

Because poor soil quality has several causes, which vary from place to place, it is important that soil restoration measures be taken based on the locally measured condition of the soil.

4. What is the role of nitrogen in soil?

Nitrogen (N) is indispensable for life on earth. The element is essential for plant growth and development, for growing agricultural crops, and for building organic matter in the soil. Nitrogen is thus more than just a harmful substance that affects nature.

Through photosynthesis, plants build leaves, roots and stems. During this process, plants convert CO_2 from the air into various carbon compounds[4]). Nitrogen is one of the nutrients a plant needs for this, along with phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulfur (S). Plant residues and roots are food for soil life.

Carbon storage in soil

Plant residues and soil life together form the basis of organic matter and thus contribute to sequestering carbon in the soil. The level of CO_2 in the atmosphere decreases as a result. Thus, soil helps to counter global warming. The soil's capacity for carbon storage is enormous (see Figure 2).

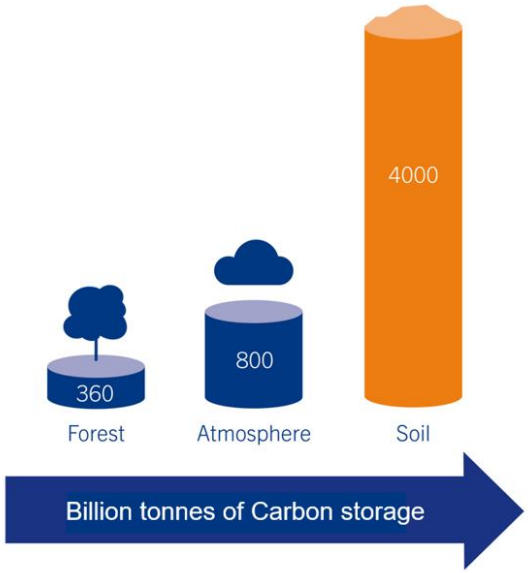

Figure 2: Soil has enormous potential to sequester CO_2[4]).
Figures in billion tons.

For organic matter accumulation, the more CO_2 that is stored, the more nitrogen is needed (see Figure 3). Nitrogen is also needed to maintain soil organic matter. In 2015, international agreements were made in the Paris Climate Agreement to aim to increase soil carbon content by 0.4% annually. Sufficient nitrogen is therefore indispensable (see box).

Research has shown that agricultural land in the Netherlands currently sequesters more CO_2 in organic matter than any other form of land use[5]). Being economical with the quality of agricultural plots and/or preserving these plots is therefore an absolute necessity for the Netherlands to meet international climate goals. Forest and natural lands also have great potential to contribute to carbon sequestration.

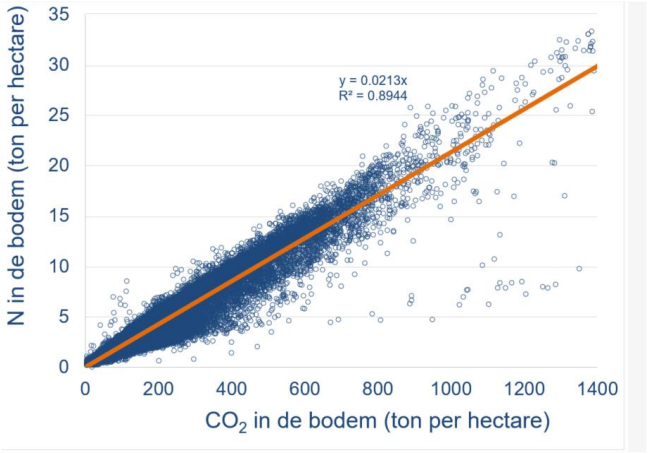

Figure 3: The relationship between soil CO_2-sequestration and nitrogen based on of 70,000 observations in the Netherlands. Source: Eurofins, 2022

CALCULATION EXAMPLE

Nitrogen needed to build up organic matter

Suppose the organic carbon content in the soil is 2%. That means that (in the 0-30 cm layer) 60,000 kg C per hectare has been fixed. If you increase this content in line with the Paris Climate Agreement by 0.4% through targeted measures, such as sowing a green manure crop or applying a soil improvement agent, 240 kg C per hectare will be fixed.

Nitrogen is needed to build up this organic matter. At a C/N ratio of 15:1 in the organic matter, this means that a minimum of 16 kg N per hectare per year is needed to build up this organic matter.

The storage of CO_2 in the 1,000,000 hectares of forest and nature in the Netherlands could total almost 900,000 tons of CO_2.

To build up this organic matter, 16,000 tons of nitrogen is then needed.

5. How do you measure and monitor nitrogen and soil health?

To measure is to know, an old wisdom that still holds true. Measuring and monitoring soil nitrogen and measuring and monitoring soil health provide data that make it possible to assess the effectiveness of nature restoration measures.

Nitrogen

When it comes to nitrogen, there are two methods of measurement:

1. **Deposition measurements**
   Deposition measurements concern the amount of ammonia (NH_4) and nitrogen oxides (NO_x) in the air (concentration) and the amount of these substances that end up in the ground (deposition).

   The RIVM has three monitoring networks for nitrogen deposition in the Netherlands. The data that the RIVM collects in this way are used, on the one hand, to gain insight into the development of the amount of ammonia and nitrogen oxide deposition in nature and, on the other, to check model calculations and adjust them where necessary.

2. **Soil testing**
   Soil testing provides data on mineral and organic nitrogen in the soil based on sampling and analysis in the lab. Soil testing takes place regularly and almost on all agricultural farms in the Netherlands. Natural land in the Netherlands, on the other hand, is sampled and analyzed relatively little. Soil testing is carried out by various companies. Eurofins has over 80 percent market share for soil testing in the agricultural sector (see appendix).

Soil health

Measuring soil health requires a complete analysis of a soil sample. This involves determining the organic matter (carbon), chemical, physical and biological properties of the soil and the presence or absence of any contaminants.

Healthy soil can be achieved with more control over the quality of applied animal manure and other soil conditioners, such as compost and Bokashi. Measuring and analyzing manure application rates is part of improving soil health.

6. Toward a factual analysis

Deposition measurements by RIVM and the associated critical deposition value (KDW) have so far guided nitrogen policy. However, it cannot be determined with certainty whether an exceedance of the KDW actually results in damage to nature. A new approach for a state of nature analysis is therefore necessary[7]).

Soil research is a valuable complement to deposition measurements because it provides concrete data on what is actually happening in the soil. For example, the same amount of nitrogen may leach into soil A while in soil B it is absorbed into organic matter. In the first case, the nitrogen acidifies the soil, while in the second case, that nitrogen contributes positively to soil carbon storage.

Measurement results from soil research show processes in the soil that deposition measurements ignore. Soil research allows a factual analysis of soil health and provides assurance about the effectiveness of measures to restore nature.

New understanding of nitrogen and soil life.

Understanding soil health provides concrete guidance for nature restoration. Organic matter, carbon and soil life are the basis for a healthy soil (see page 9).

In recent years, Eurofins has further innovated soil research precisely in this area[8]). Using innovative measuring methods (pyrolysis) it is possible, among other things, to distinguish between different fractions of organic matter. This gives more insight into the release of nitrogen in the soil and thus nitrogen inputs can be optimized. As nitrogen efficiency increases, the proportion of nitrogen in the cycle will decrease.

In addition, new measurement techniques have been developed for analyzing microbial soil life. The so-called PLFA method maps functional groups of microorganisms and provides a "fingerprint" of the soil life present.

Eurofins is working on establishing (unique) target values for agricultural soils and nature. An indicator for soil health is under development.

Comparing soils and measures

Analytical results from soil studies make it possible to compare and monitor different soils over time. This makes it clear what the effects of different measures are.

Eurofins has a database of soil research data from all over the Netherlands. This data can serve as a baseline for monitoring. Follow-up research provides insight into the actual change in soil health and the effectiveness of measures taken. Eurofins has a national network of samplers who can be deployed to sample the soil during set calibration times.

7. In conclusion

Agriculture and horticulture are essential for our food supply, our landscape, social cohesion and the livability of the countryside. This is also reflected in Remkes' recent report[7]). The demand for food will remain, even if the Netherlands scales down production. In the latter case, production will be partly taken over by other countries in Europe and/or beyond. For the Dutch economy, scaling down agricultural and horticultural production represents a serious loss.

Eurofins contributes to profitable and sustainable agriculture and horticulture and to a stable natural environment that fosters abundant biodiversity. The soil data Eurofins provides deserve a place within the package of measures in the Agricultural Agreement, which Johan Remkes proposes to get out of the current nitrogen impasse.

Concrete data on the condition of the soil form the basis for successful measures and sustainable soil management. Annual monitoring makes it possible to follow developments in soil health and adjust plans where necessary. Managing on the basis of concrete soil data creates room for precision agriculture and digitization, the cultivation of new (protein-rich) crops and a circular agricultural economy. This will create a vital rural area in which agricultural entrepreneurship and the development of valuable nature work together. Let the Netherlands be an example to the world!

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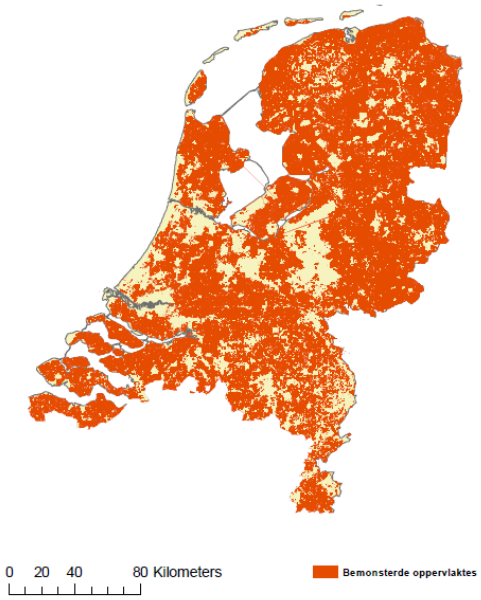
Figure 1

Soil testing by Eurofins

Eurofins and its predecessors have been performing soil testing in the Netherlands since 1928. Anno 2022, this soil testing by Eurofins has national coverage (see figure). Eurofins also has a solid knowledge base when it comes to soil health and works nationally and internationally with renowned scientific institutions. There is a lot of in-house knowledge about the interrelations in the soil and this knowledge is originally translated into practical advice towards the agricultural sector and, in recent years, increasingly towards nature management.



Areas sampled in 2022. Source: Eurofins Agro July 2022

Eurofins soil health solutions include research and consulting for five categories:

- Organic matter and carbon storage/carbon
- Physical properties
- Chemical properties
- Biological properties
- Possible contaminants

Regular soil testing thus provides tools for optimal soil management. This is important not only for agriculture, food security and quality, but also for forest and natural land management.

More about soil testing by Eurofins: www.eurofins-agro.com

Eurofins Agro is information supplier and knowledge partner for the arable and horticultural, dairy and greenhouse sectors. With a complete package of sampling, innovative analyses and clear advice, we provide entrepreneurs in the agricultural sector with tools for tools for production security and yield improvement. On an annual basis, more than 600,000 samples are analyzed. Eurofins Agro Netherlands has its headquarters in Wageningen and employs 300 people. Eurofins Agro is part of Eurofins Scientific, an international laboratory network with 900 affiliated laboratories in 55 countries worldwide.

Eurofins Agro Testing Wageningen B.V.
Binnenhaven 5
6709 PD Wageningen
The Netherlands

T +31 (0)88 876 10 10
E communication-agro@eurofins.com

eurofins-agro.com

eurofins