From Sciences to Action : Feedback from two decades of soil bio-indicators development as agricultural soil management tool

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GLOBAL SYMPOSIUM ON SOIL BIODIVERSITY | 19-22 April 2021

Why study soil biodiversity?

« **Biodiversity Loss** and **climate changes** are two of the most pressing challenges of our time, and **soil biodiversity** is part of the solution to both », European *Commissioner for Environment Janez Potočnik* ***2010***

A healthy soil is a living soil

"A healthy soil is a living, dynamic ecosystem, teeming with microscopic and larger organisms that perform many vital functions […] A healthy soil also contributes to mitigating climate change by maintaining or increasing its carbon content.", *FAO International Year of Soil* ***2015***.

Caring for Soil is Caring for Life

"ensure that 75% of soils are healthy by 2030 and are able to provide essential ecosystem services", *Mission Board of the European Commission for Soil Health and food* ***2020***

How to diagnose healthy soils ?

Parallel with medical diagnosis :
Using set of indicators to determine symptoms & signs




Monitoring

Transfer : training

How to diagnose healthy soils ?

Parallel with medical diagnosis :
Using **set of indicators** to assess the **good ecological & functional state**


Biological indicators



Monitoring networks

Be **aware** and **familiar** with the indicators available

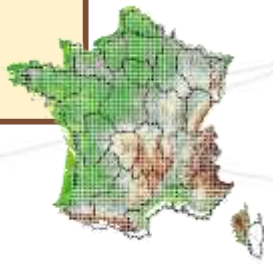
Transfer : training, standardisation & services offer

How to diagnose healthy soils ?

Since 1998, several initiatives were launched in France.

Biological indicators

Monitoring networks



Be **aware** and **familiar** with the indicators available

Transfer : training, standardisation & services offer

Soil biological indicators

- **Minimum set of indicators for monitoring agricultural soils** (ADEME, 2012)

Monitoring purpose	Indicators	Parameters
Management of soil organic matter	Microbial	Abundance: microbial and fungal biomasses Diversity of communities Activities: C and N mineralization, ergosterol measurement
	Fauna	Abundance and biomass of earthworms Functionnal diversity of nematodes
Management of agricultural practices	Microbial	Abundance: microbial and fungal biomasses Diversity of communities Activities: enzymatic measurements linked to C, N, S and P cycles
	Fauna	Functionnal diversity of earthworms and nematodes Diversity of collembola

Soil biological indicators

- **Organic matter & Soil Biodiversity : multi-performance of farms** (French Ministry of Agriculture, 2017)

Indicators of state :

Physico-chemical & biological indicators

- Classic methods : C, N, C/N, organic fractions
- Methods in development : infra-red
- Soil C and N

→ **Organic matter – Carbon**

→ **Soil organisms**

- Soil respiration, enzyme activities
- Microbial biomasse, Molecular biomasse, Taxonomic biomasse
- Earthworms, Nematofauna, Microarthropods

Additional indicators:
Spade test, structural stability, Litter-bag

Monitoring Indicators :

Physico-chemical & biological indicators

- Trends of organic fractions (quick changes), C storage (slow changes)
- Trend models of organic mat. storage : method AMG
- Carbon storage potential

→ **Organic matter – Carbon**

→ **Soil organisms**

- Trends of enzyme activities
- Trends of taxonomic diversity
- Trends of faunal composition Earthworms, Nematofauna, Microarthropods

Soil monitoring networks

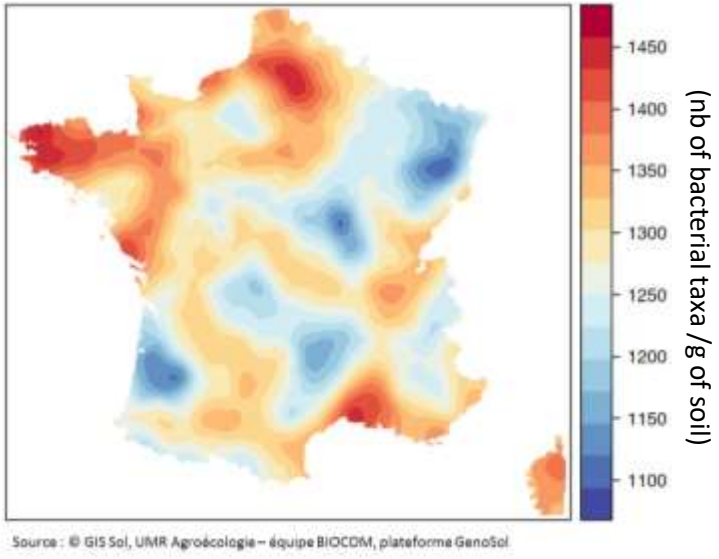
- Improving reference values and diagnostic interpretation by implementation of soil bio-indicators in national soil monitoring networks and databases

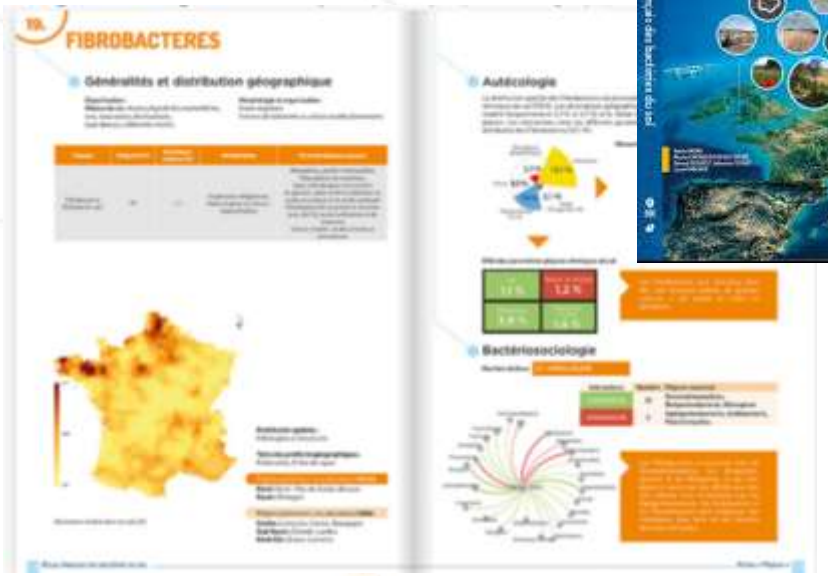
GisSol

Soil monitoring networks

- Inventories conducted at national level, on the soil microbial biomass *(Dequiedt et al. 2011)* and bacterial communities *(Karimi et al. 2018)*
- 2 200 sites / all major land uses

Bacterial diversity of soils – France





(Karimi et al. 2018)

Soil monitoring networks

- New initiative : Inventorying soil microflora and fauna as well as some functional measurements at national scale *(Imbert et al., 2020)*

Wednesday 21 April / Theme 1-session 3 | Mr Yusuf Yigini Moderator

"A soil biodiversity survey coupled with the National Soil Quality Monitoring Network?" - Camille Imbert, INRAE- France

Soil monitoring networks

- **Participatory observatory networks** :

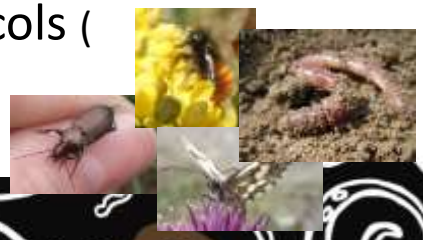
  - a large amount of collection data throughout the territory and repeatedly over time.

  - awareness and training tools

❖In France,

-observatory of earthworms (OPVT): earthworms diversity in urban and peri-urban area.(*https://ecobiosoil.univ-rennes1.fr/OPVT_accueil.php*)

-agricultural observatory of biodiversity : ordinary biodiversity in agricultural area, trends and link with practices; via 4 protocols (http://www.vigienature.fr/fr/agriculteurs)

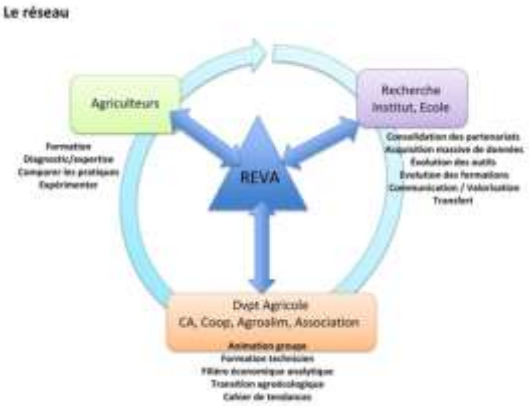


Transfer : training, standardisation & services offer

- Training is a key step to consider soil biodiversity.

Eg. AgrInnov project (2011-2015): development and transfer training and dashboard indicators of soil biological quality directly to farmers.

The Experimentation and Monitoring Network for Agricultural Innovation takes over from AgrInnov project to train farmers, with the aim of changing their farming systems towards environmental and economic sustainability.



https://www.ofsv.org/

Transfer : training, standardisation & services offer

- Standardisation : methods widely recognized, reliable, comparable…
  - Soil biological indicators standardised at the international level by the ISO-TC 190 committee (Bispo and Schnebellen, 2018).

Group	Indicators	Organisms and/or methods	Standards
Fauna	Diversity	Earthworms (sampling/extraction)	EN ISO 23611-1
		Collembola/mites (sampling/extraction)	EN ISO 23611-2
		Enchytreids (sampling/extraction)	EN ISO 23611-3
		Nematodes (sampling/extraction)	EN ISO 23611-4
		Total macrofauna (sampling/extraction)	EN ISO 23611-5
		Measurement of biostructures	-
	Activity	Bait lamina	EN ISO 18311
		Measurement of biostructures	-
Microorganisms	Microbial biomass	DNA extraction	EN ISO 11 063
	Diversity of microbes	PCR analyses based on DNA extraction	ISO 17 601
		PLFA analyses	CEN ISO/TS 29843-1 et -2
		Massive sequencing	-
	Global activity	Respiration	NF EN ISO 16072
	Enzymatic activities (eg : N, P, S)	Biogeochemical cycles	ISO 14238; ISO/TS 22939; ISO 23753-1 ; ISO 23753-2

Transfer : training, standardisation & services offer

Investment for the Future Program (since 2010)

- Finances innovative projects of all sizes to create and develop the French industrial sectors of the future.
- Topics includes ecological transition in agriculture, development of bioresources, soil and biodiversity conservation
- Since 2014, various projects considering soil biodiversity for farm advisory services, brownfield redevelopment or environmental monitoring.

Transfer : training, standardisation & services offer

- Soil functions and their links to ecosystem services :
  - a way to communicate with land managers and users (e.g farmers)
  - an increasing need for assessment of ecosystem services (e.g land planning; payment for environmental services, remediation, environmental labelling)
  - methods in development and/or already used by consultants

- ISO/TC 190/WG3 : a new ISO working group on the valuation of ecosystem services and functions provided by soils. 1st meeting, March 21, 2021.

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Conclusion

- **Biological tools that are becoming relevant and can be technically implemented** for the assessment of ecosystem functions and services of soils

- **Need to develop and standardize the interpretation frameworks** (e.g databases and reference values, links with agricultural practices, soil functions and ecosystem services).

- Keep on efforts in **raising awareness** and **training (e.g participatory approach)**.

Awareness rising (two examples)

GESSOL card games (in French, English, Portuguese, German)

On social networks
#plantetonslip

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Thank you for your attention