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Presentation : poster

The French National "Soil Quality Observatory"
L'Observatoire de la Qualité des Sols Français

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Many human activities result in soil degradations which, generally, remain insidious for a long time but are irreversible at human life scale. On the contrary, new sustainable agricultural land management methods are likely to protect and even to restore soil quality.

As a consequence, the "Ministère de l'Aménagement du Territoire et de l'Environnement" created the "Observatoire de la Qualité des Sols" (OQS) in France. The objectives of the OQS are to assess the present situation of soils, to early detect and to monitor soil evolutions.

The OQS is based on a network of sites, about one hectare large each. Firstly, OQS sites are described in detail (geographical context, pedological description, geochemical background assessment). Then, about every five years, classical soil characteristics and trace elements are monitored. Biological indicators are being developed.

The OQS needed to set up :
1. Sampling strategies allowing to assess soil evolutions which might be hidden by soil heterogeneity, by seasonal fluctuations or by analytical uncertainties.
2. A database fitted to future evolutions of scientific concepts.

Keywords : soil quality monitoring, pollutions, sustainable agricultural land management, sampling strategies, database.
Mots clés : suivi de la qualité du sol, pollution, agriculture durable, utilisation des terres, stratégies d'échantillonnage, base de données

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1. Introduction

Many human activities result in soil degradation which, generally, remains insidious for a long time but is irreversible at human life scale. On the contrary, new sustainable agricultural land management methods are likely to protect and even to restore the soil quality.

A relevant soil policy requires to know changes occurring in soil quality and to be able to foresee future trends according to different scenarios of land management.

This is why, in 1986, the "Ministère de l'Aménagement du Territoire et de l'Environnement" created the "Observatoire de la Qualité des Sols" (OQS) in France (Mamy, 1993; Martin, 1993; Legros and Martin, 1997).

2. The objectives of the OQS

The main objectives of the OQS are (1) to assess the present characteristics and properties of soils, (2) to early detect and to monitor changes in soil quality and (3), as far as possible, to identify their causes in order to get the capacity to control future trends.

Secondary objectives of the OQS are (4) to constitute a network of field laboratories in order to help integrated soil research and to provide modeling with data and (5) to inform agronomists and farmers about new approaches about soil quality.

Soil quality can be defined as the capacity of soil to function, within ecosystem and land-use boundaries, to sustain biological productivity, maintain environmental quality and promote plant, animal and human health (Doran and Parkin, 1994; Acton and Gregorich, 1995; Doran, 1996). This concept of soil quality can be completed by its resilience, i.e. the ability of a disturbed system to return after new disturbance to a new equilibrium (Blum and Aguilar Santelises, 1994; Chaussod, 1996).

3. The site location and characterization.

The OQS is based on a network of sites, about one hectare large each. Firstly, OQS sites are described in detail (geographical context, soil description, geochemical background assessment) (Baize, 1997). Then, about every five years, classical soil characteristics and trace elements are measured (Cf. table 1). Biological indicators are being developed (micro-organisms and macro-invertebrates) (Lavelle, 1988, 1993; Chaussod, 1996).

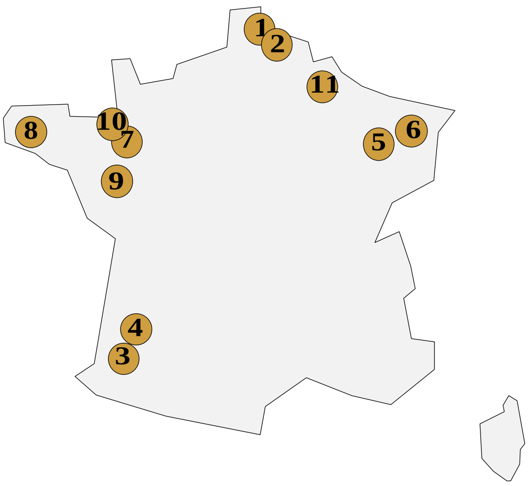
Most of the OQS sites have been investigated twice for the last ten years.

Site characteristics	Geographical context Soil description. Agricultural land use.
Classical soil analysis	- texture - bulk density - pH - organic carbon - nitrogen - cation exchange capacity - base cations exchangeable - phosphorus - calcium carbonate
Trace-elements	- cadmium - chromium - cobalt - copper - nickel - lead - zinc
Radionuclides (gamma emitters)	(For some sites only)

Table 1: Mandatory parameters on each OQS site.

Presently, the selection of the OQS site locations is based on four criteria (Baize, 1988):

- soil type,
- land use,
- type and intensity of presumed changes in soil quality,
- human context and land status.



<u>Table 2 :</u> the present sites of the OQS

	Department	Characteristics	Soil type
1	Nord	Agriculture	Clayey FLUVIOSOL BRUNIFIE
2	Pas de Calais	Agriculture.(pollution via atmospheric deposition)	Redoxic NEOLUVISOL
3	Landes	Forest.	PODZOSOL DURIQUE
4	Landes	Agriculture.	BRUNISOL RESATURE
5	Vosges	Agriculture.	PSEUDO - LUVISOL
6	Vosges	Forest	ALOCRISOL TYPIQUE
7	Ille et Vilaine	Forest	ALOCRISOL TYPIQUE
8	Finistère	Agriculture (pig slurry application)	BRUNISOL OLIGOSATURE
9	Loire Atl.	Agriculture	BRUNISOL MESOSATURE
10	Manche	Truck farming	Calcareous THALASSOSOL (polders)
11	Ardennes	Agriculture	Truncated NEOLUVISOL

4. The sampling strategies

A sampling strategy is a set of processes that yields a data set corresponding to the objectives of the study and to the characteristics of the terrain. It includes a sampling pattern but also analytical procedures, sample storage and data management in view of statistical analysis.

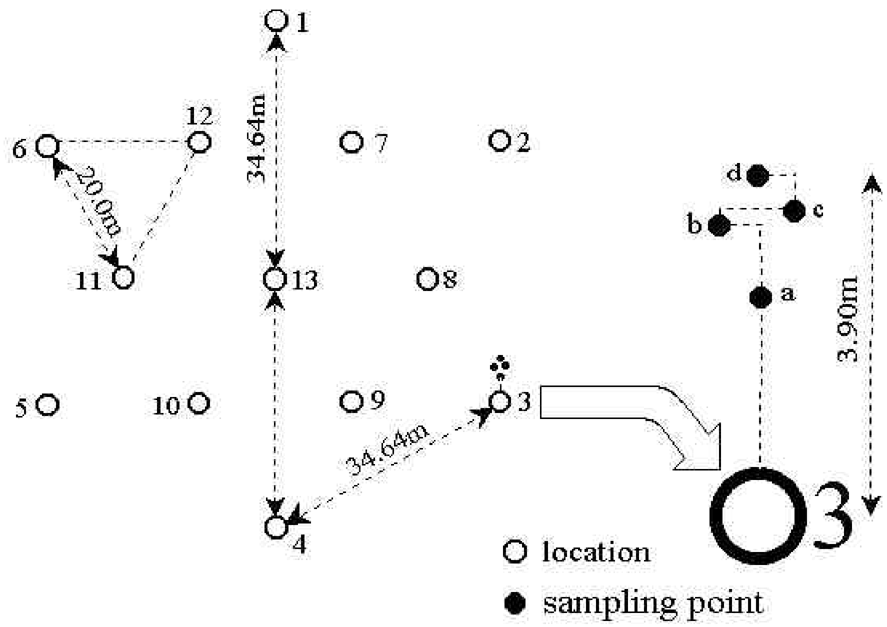
The OQS needed to set up sampling strategies allowing to assess changes in soil quality which might be hidden by soil heterogeneity, by seasonal fluctuations or by analytical uncertainties. After many trials and considerations, a sampling strategy was designed as follows.

In each OQS site, the sampling pattern is systematic at large scale with an hexagonal network of 13 locations. At each of these locations, a cluster of 4 sampling points is randomly selected (Cf. figure 1). This makes 52 samples per campaign. The sampling depth corresponds to the ploughed layer in cultivated lands and to pedogenetic horizons under forests. Every sample weighs about 2kg.

After analyses being done, samples are carefully stored.

Thus, for each parameter, means and variances are computed for global scale (on site) and local scale (from one to some meters). Furthermore, intra-laboratory variability is assessed by two ways : measurement *repeatability* (i.e. within one analytical series) by analyzing subsamples coming from the same sample, measurement *reproducibility* (i.e. between two analytical series corresponding to two successive sampling campaigns) by reanalyzing some samples belonging to the first set of samples. (Leprêtre and Martin, 1994; Cieselski *et al.*,1997).

Figure 1: sampling pattern in OQS sites (13 locations; 13x4=52 sampling points)



5 The data base

The OQS data base was designed by the way of the MERISE method which is based on the formulation "entity-association" (Tardieu *et al.*, 1984). The data base constitutes a representation (or a model) of the OQS. Thus, the conceptual model of the data base (Cf. figure 2) reproduces the concepts of site, of campaign, of set of samples (=cluster in the sampling pattern), of sample, of set of analyses and of analyzed parameter.

The OQS data base was developed and is managed with the ORACLE Relational Data Base Management System on Unix system. Queries and updates of data are done under client/server mode using the Microsoft RDBMS Access, ODBC and SQL*Net products.

Soil descriptions are separately stored in the existing DONESOL data base (Gaultier, *et al.*, 1993; Legros, 1996). Only the DONESOL keys, corresponding to these soil profiles, are stored in the OQS data base.

The specificity of a scientific data base lies in its capacity to be easily fitted to unforeseeable scientific concept changes. As a consequence, the OQS data base offers very few data treatment facilities. At present, its use is reserved to the scientific partners working for the OQS. External demands for information will be considered by the managing team in the next future.

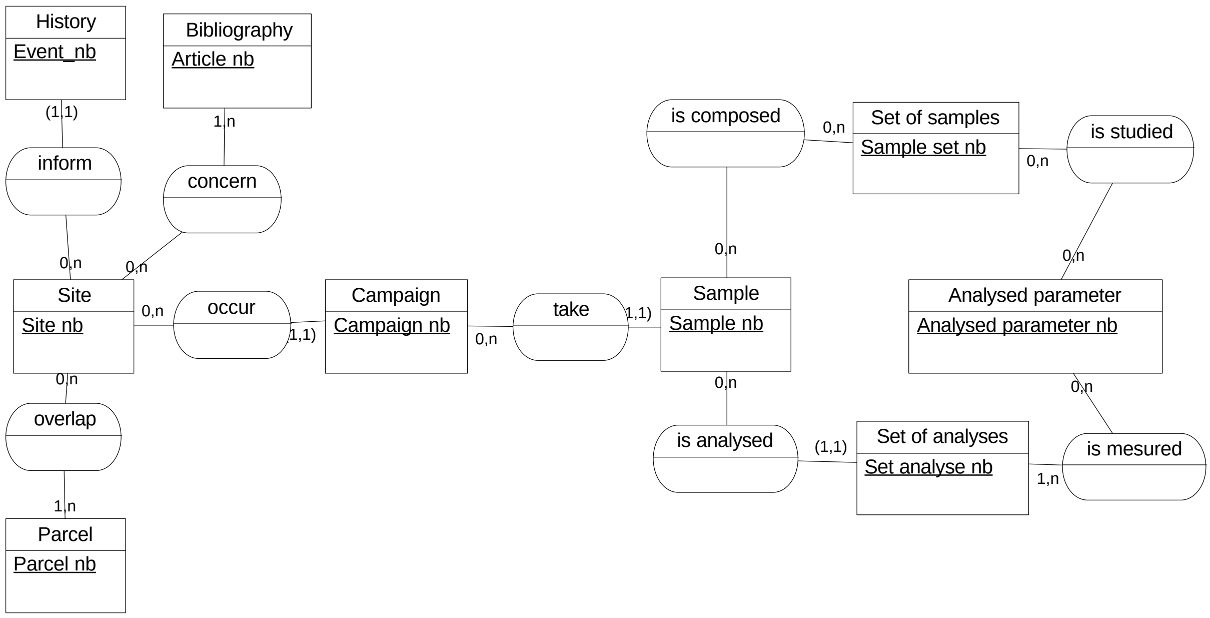


Figure 2: simplified conceptual data model of the OQS data base.

6 Example of results.

Table 3 shows several estimates of statistical parameters obtained for OQS site n°2 in northern France, which is highly polluted by trace elements. For cadmium and for lead, there is no significant difference between the three types of variance. It means that intra-laboratory variability might hide spatial variability of cadmium and of lead contents. For clay, global variance is statistically greater than local variance. This indicates a spatially dependent distribution of clay content.

Parameter estimates	Cadmium	Lead	Clay
Minimum value	7.6	490	174
Maximum value	9.5	584	192
Global mean (site)	8.8	530	181
Global variance	0.24	554	37
Local variance	0.26	376	8
Intra-laboratory var. (repeatability)	0.11	423	9

Table 3: some parameter estimates obtained with the OQS sampling strategy (cadmium and lead total contents in soil : $mg.kg^{-1}$; clay content in soil : $g.kg^{-1}$) for OQS site n°2.

7. Conclusion

At present, the OQS is organized to yield information about changes in soil quality in some well defined situations. It is planned to develop the system in two directions :

- Some well fitted out sites for process studies (for example: pollutant flow measurements)
- A network of numerous light control sites offering a much more extended geographical coverage to estimate spatial extent of changes in soil quality that have been studied in local situations and to detect new possible changes.

Furthermore, it is clear that harmonization and coordination between soil monitoring networks existing in different countries must be enhanced (Arrouays *et al*., 1998).

Conceiving and carrying out a soil monitoring network constitutes, by itself, a subject of pluri-disciplinary research. The problems are numerous and complex. It is necessary to attend to the long-term consistency of the methods of soil characterization and also to incorporate the advances in soil science. Thus, the OQS management requires a sound scientific and administrative staff.

Acknowledgments

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