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FRENCH FEEDBACK ON THE USE OF INERT WASTE LANDFILL CRITERIA FOR MANAGING EXCAVATED SOILS

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ABSTRACT: The management of excavated soils in the European Union suffers from a deficit of legislation and/or common methodology regarding the definition of soil quality objectives. As the project for a European "Soil Framework Directive" was postponed in 2014, member states that do not have national legislation regarding soil quality criteria generally refer to the inert-waste criteria defined in Annex II of the European Landfill Directive. But one difficulty with this approach is that these criteria were not derived for soil materials, but for waste materials (primarily construction and demolition; C&D waste). Their development relied on a number of working hypotheses; *e.g.* with respect to leaching behavior, based on the study of waste materials but not of excavated soils. This is a problem because, in France, many geological formations show natural enrichments in inorganic elements, even in areas that are not considered enriched in minerals. This is for example the case around Paris and its suburbs, where several geological formations may release natural concentrations of, *e.g.,* sulfate and selenium. A particular issue is that the earthworks of the "Grand Paris Express" project (a new subway) will generate over 40 million tons of excavated soils from such formations. Managing excavated soils based on the inert-waste criteria of the Landfill Directive would generate excessive costs due to the landfilling of a significant portion of these excavated soils in non-hazardous waste landfills, which would lead to a progressive saturation of landfills in the Paris area. An alternative, more sustainable regarding such earthwork projects, would be to consider excavated soils as a resource rather than as a waste. For this purpose, French administration has developed new criteria for the reuse of excavated soils, based on: (i) the preservation of soil quality, (ii) the preservation of water resources and (iii) compatibility with the future use of the target site, from a public health perspective.

Keywords: excavated soils, inert-waste criteria, landfill

1. INTRODUCTION

Infrastructure and development projects in France generate each year over 130 million tons of excavated soils. During the next ten years, the construction of a subway for the “Grand Paris Express” (creation of a new circular line and other lines around Paris) will generate over 40 million tons of excavated soils (SGP, 2019). The bulk of these excavated soils is typically landfilled because, in accordance with the Waste Framework Directive; WFD (OJEU, 2008), these soils are considered as waste materials if they are taken away from the site of their excavation. A certain proporition is reused, but very little in comparison with landfilling, mainly because of the liabilities associated with their waste status.

Such practice occurs because the management of excavated soils in the European Union suffers from a deficit of legislation regarding the definition of soil quality objectives. As the project for a European “Soil Framework Directive” was postponed in 2014, member states that do not have national legislation with respect to soil quality criteria, typically refer to the WFD which states that: “*The waste status of uncontaminated excavated soils and other naturally occurring material which are used on sites other than the one from which they were excavated should be considered in accordance with the definition of waste and the provisions on by-products or on the end of waste status under this Directive.*”. For the case of excavated soils that are not used on the site from which they were excavated, the demonstration of absence of contamination typically relies on reference to the inert-waste criteria of Annex II (OJEC, 2003) of the European Landfill Directive (OJEC, 1999). One obvious problem with this approach is that these criteria (leaching criteria for inorganic elements and total content criteria for certain organic compounds) were not derived for natural soil materials but for waste materials (primarily construction and demolition; C&D waste). Another issue is that common anthropic contaminant such as halogenated organic compounds are not included in Annex II.

This paper starts by reviewing the logic and methodology underlying the definition of the inert-waste criteria and then illustrates difficulties encountered in France regarding their application to the management of excavated soils. Finally, the paper proposes an alternative approach for the reuse of excavated soils, which does not rely on the inert-waste criteria. This approach is currently being applied in France.

2. WORKING HYPOTHESES UNDERLYING THE INERT-WASTE CRITERIA

The landfill acceptance criteria defined by Annex II of the Landfill Directive (OJEC, 2003 and 1999) were developed in the context of the Landfill Directive Technical Adaptation Comitee (TAC; Hjelmar and van der Sloot, 2003) and were based on a number of working hypotheses. As described in Hjelmar *et al.* (2001), the overall procedure consisted in assessing, for waste storage scenarios specific to each type of waste (inert, non-hazardous, hazardous), which waste leaching characteristics guaranteed compliance with water quality objectives in an aquifer, at some point located downgradient from the landfill (called a point of compliance; POC). The primary source of water quality objectives was the European drinking water Directive (OJEC, 1998).

With respect to waste leaching behavior, it was assumed that leached concentrations followed a decay function:

$$C = C_0 \, e^{-(L/S)^{K}} \qquad (1)$$

where:
C is leachate concentration as a function of L/S (mg/L);
C_0 is the initial peak leachate concentration (mg/L);
L/S is the liquid to solid ratio for concentration C (L/Kg);

κ is a kinetic constant describing the rate of concentration decrease (Kg/L).

By integrating equation (1), the cumulative release of contaminant mass E (in mg/Kg), over the period of time required to reach a specific value of L/S, is obtained from:

$$E = (C_0/\kappa)\,(1 - e^{-(L/S)\,\kappa}) \qquad (2)$$

From flow and transport model calculations, maximum values of C_0 were estimated such that water quality objectives at the POCs were always respected. Knowing C_0 and assuming κ is fixed, equation (2) yields the limit cumulative emission value for a given L/S ratio (in France a value of 10 L/Kg is generally used).

Values of the kinetic parameter κ, specific to each potential contaminant (As, Cr, Sb, etc.), were derived from experimental data measured on waste materials. For example, Hjelmar *et al.* (2001) provide examples of κ values for chloride (0.57 kg/l), antimony (0.11 kg/l) and lead (0.27 kg/l). The larger the value, the faster the release. It was assumed that these κ values controlled leaching at the scale of the landfill. However, the proposed κ values do not come from excavated soils data, whether or not contaminated.

3. DIFFICULTIES REGARDING THE MANAGEMENT OF EXCAVATED SOILS IN FRANCE

3.1 Sulfate and selenium leaching behavior in the excavated soils from Paris and its suburbs

The project of a subway for the “Grand Paris Express” will generate 45 million of tons of excavated soils in 10 years (SGP, 2019). The public contracting authority that manages this project decided in a first step, to base the management of these excavated soils on the landfill acceptance criteria. As a prerequisite, this authority built a detailed database gathering analytical results relative to over 4,000 samples, coming from various geological formations that will be drilled during the subway construction. This database shows that an important proportion of natural (*i.e.*, with no anthropic influence) geological materials exceed the inert-waste criteria for some soluble salts, metals and metalloids.

The example of sulfate and selenium in the natural formation of the Green Clays of the Paris Basin (of early Oligocene age) and of the *Sables de Beauchamp* [Beauchamp Sands] is shown in Figure 1. The boxplots show how naturally occurring geological formations may present leaching characteristics which do not comply with the inert-waste landfill criteria, thus illustrating difficulties in managing excavated soils on the basis of the Waste Directive and landfill criteria.

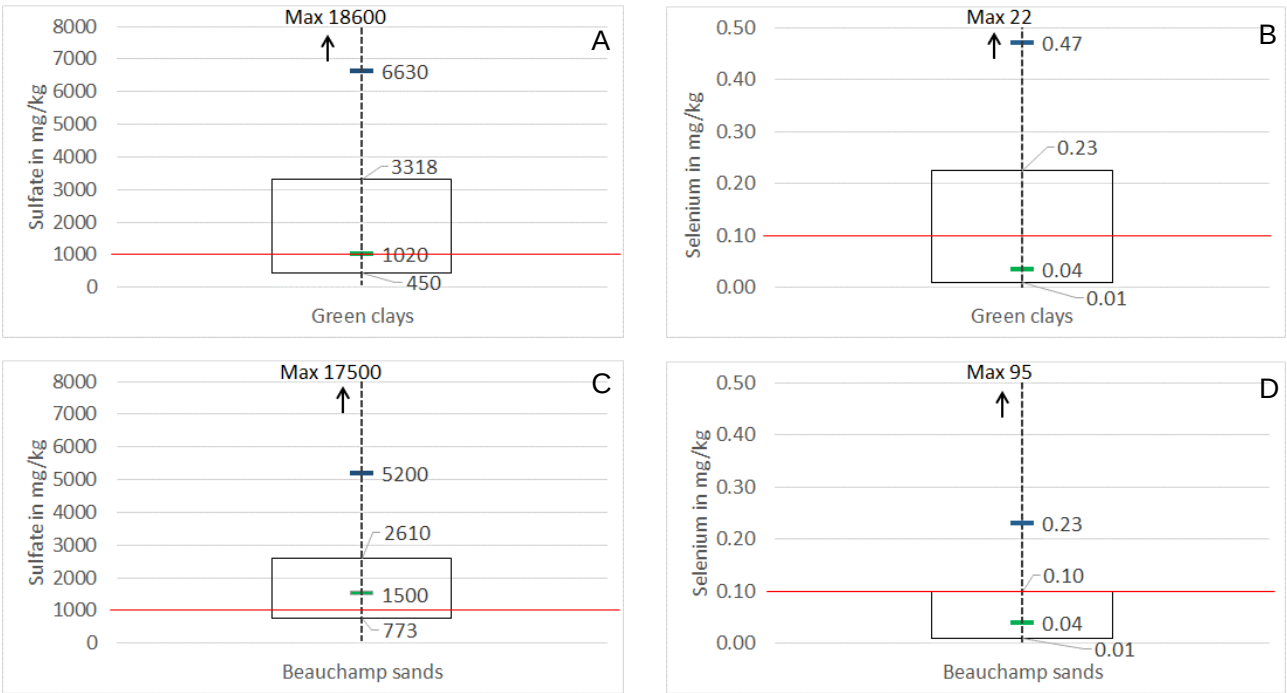

Figure 1. Boxplots of sulfate (A,C) and selenium (B,D) concentrations in leachates (in mg/kg) from the natural (*i.e.*, not influenced by anthropic activity) formation of the Green Clays (A,B) and Beauchamp Sands (C,D) of the Paris Basin (respectively 122 and 654 samples for each formation leached according to the standard NF EN 12457-2, with a L/S of 10 L/Kg). The blue and green dashes correspond respectively to the upper whisker and the median. The red line marks the inert-waste criteria for both sulfate and selenium. The data come from the Grand Paris Express database.

It was possible to plot the data of the Beauchamp sands formation on a map of Paris and its suburbs (Figure 2). This was not possible for the data of the Green Clays formation, due to a lack of geographical coordinates. The results indicates that many natural samples exceed the inert-waste criteria for sulfate in the Beauchamp sands formation. For selenium, the samples exceed the inert-waste criteria only in some specific locations in this formation. If we look at the same data in other geological formations of Paris and its suburbs (data not shown here), we can see the same trends, with high sulfate contents widespread all over the area, and local but sometime high enrichments in selenium.

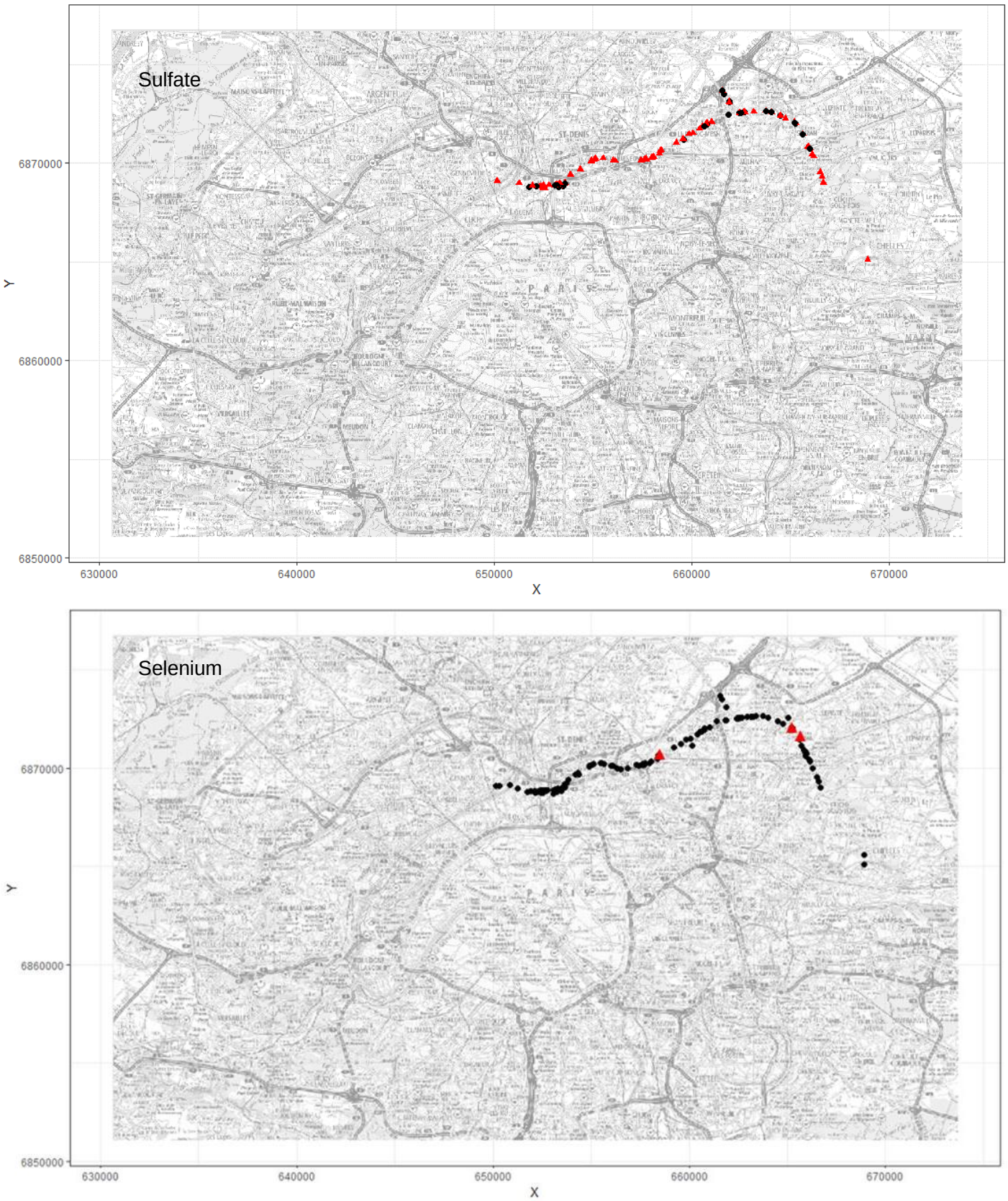

Figure 2. Maps of the data from the Beauchamp sands formation for sulfate and selenium. Red triangles indicate values above inert-waste criteria and black dots values below those criteria (1000 mg/kg for sulfate and 0.1 mg/kg for selenium).

3.2 Origin and nature of sulfate and selenium in the Paris Basin

The origin of sulfate is due to the presence of gypsum in a lot of geological formations under the city of Paris and its suburbs (*e.g.* Thierry *et al.*, 2009). This is particularly the case in the so-called pre-Ludian formations composed of the Bartonian (Late Eocene) *Calcaires de Saint Ouen* [Saint Ouen Limestone] and *Sables de Beauchamp* [Beauchamp Sands] and the Lutetian (Middle Eocene) so-called *"Marnes et Caillasses"* ["Brackish Marl and Limestone"] formation (Figure 3).

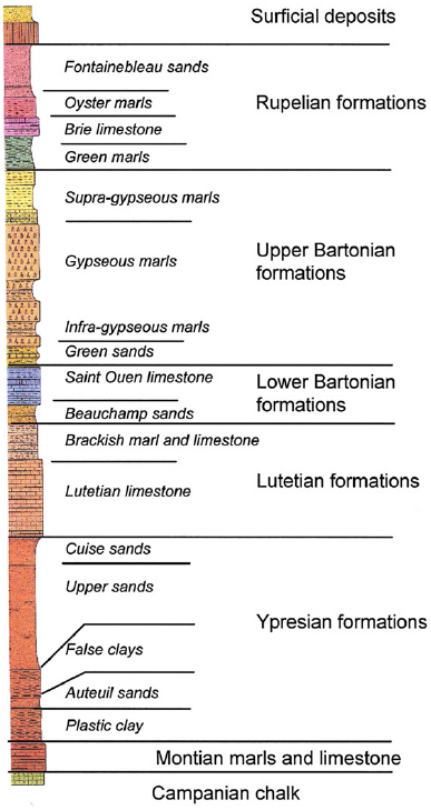

Figure 3. Simplified stratigraphic column of Paris (from Thierry *et al.*, 2009).

The origin of the high selenium content in the Paris Basin is natural (Gourcy *et al.*, 2011). Selenium is related mainly to the presence of Eocene, mainly Ypresian, and Oligocene formations (Chabart *et al.*, 2006, Gourcy *et al.*, 2011). The Ypresian formations were deposited during various marine transgressions and regressions and are made of limestones, clays, carbonate sands and fluvial deposits that are rich in organic matter. The Oligocene formations are essentially made of sands.

4. DISCUSSION

The use of inert-waste criteria for the management of excavated soils in France is not an option since (i) the inert-waste criteria were not derived for the types of materials encountered in this study and (ii) many geological formations show natural enrichments in inorganic elements, even in areas that are not considered as mineralized, as can be seen around Paris for sulfates and selenium. As an alternative, it is proposed to consider excavated soils as a resource and not as a waste destined to be landfilled. Indeed, the landfills in the Paris vicinity are becoming more and more saturated, while excavated soils can be useful in road infrastructures or development projects, with reference to the circular economy.

For this purpose, a national technical committee was implemented in France in 2009, in the framework of the transposition of the European directive on waste into French law, to set up a methodology for excavated soil management. Part of this work was dedicated to the drafting of a guideance document for the reuse of excavated soils coming from contaminated sites (Blanc *et al.*, 2012). This guide was updated in 2017 (Coussy *et al.*, 2017), and there are ongoing efforts to address natural excavated soils (*e.g.* not contaminated) in a similar fashion. The guide deals with the reuse of these materials for road engineering, city planning and landscaping purposes. The methodology proposed in this guide considers compliance with three important environmental criteria for the safe reuse of excavated soils on a target site:

- Maintaning soil quality of the target site;
- Protecting the water resource;
- Ensuring compatibility with the future use of the target site from a public health perspective.

To meet these criteria, a tiered 3-level approach (Table 1) was proposed to classify and evaluate excavated soils for reuse purposes, from a country-scale (based on generic guideline values) to a target site-scale (based on the target site background values). This approach is based on both the pseudo-total and leachate content of the potential harmful substances in excavated soils.

Table 1. Principles of the reuse of excavated soils according to a 3-level approach.

Reuse conditions	**A. Maintaining soil quality of the target site**	**B. Protection of the water resource**	**C. Compatibility with the future use of the target site (from a public health perspective)**
Level 1 : Country scale	Generic guideline values (from national natural background values)	Generic guideline values (from national natural background values)	Generic guideline values (from natural background values)
Level 2 : Local urban scale	Regional or urban guideline values (from regional or urban background values)	Generic guideline values on leachate or simplified hydrogeological study	Generic guideline values (from generic health risk assessment)
Level 3 : target site scale	Background values of the target site	Generic guideline values on leachate or simplified hydrogeological study	Generic guideline values (from generic health risk assessment) or specific health risk assessment

This approach is felt to be a viable alternative to the inert-waste criteria approach because:

- it takes into account all contaminants (natural and anthropic) potentially present in excavated soils. Contaminants are selected on the basis of a minimum list of substances and a historical and documentary study;
- it considers the natural background values of the target site, to allow excavated soils coming from geological formations enriched in specific inorganic elements to be reused in a target site of similar geochemical background;
- it includes guideline values based on health risk assessment;
- the protection of the water resource is ensured by using generic guideline values derived

from inert-waste criteria or by a simplified hydrogeological study.

This methodology will become mandatory in France because a new end-of-waste ordinance is in preparation for excavated soils. End-of-waste status will be acquired if the above methodology is applied.

5. CONCLUSIONS

The choice made in France to consider excavated soils as wastes, when they are brought outside their site of origin, have led over the years to absurd (and costly) consequences. The first one is that contractors often prefer to landfill huge amounts of (natural) excavated soils coming from earthwork projects, to be sure that they cannot be accused of causing any sort of environmental degradation (which is generally very unlikely for soils coming from natural geological formations without any sort of mineralization). The second one is that the inert-waste criteria are often used to assess the potential impact of excavated soils on the water resources, while these criteria were derived for waste materials and not for excavated soils. Consequently, many natural formations in France are not “inert” in the sense of Annex II of the European Landfill Directive (1999/31/EC), and are landfilled in non-hazardous waste landfills, which are not designed for receiving large amounts of excavated soils. The only way to tackle the problem and to change for a more sustainable approach regarding the management of earthwork projects is to consider excavated soils as a resource and not as a waste. For this purpose, the new methodology of reuse of excavated soils in France will be an important part of the solution.

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