Copper contamination in vineyard soils of Bordeaux : spatial risk assessment for the replanting of vines and crops

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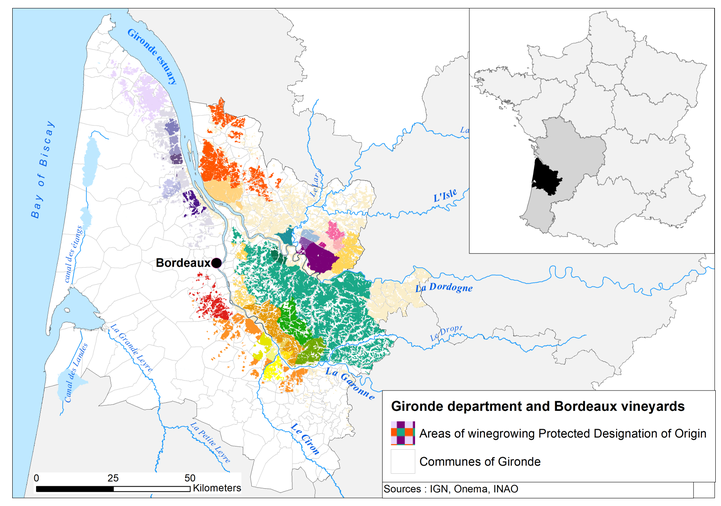


Introduction

Copper (Cu) is widely and historically used in viticulture as a fungicide against mildew. Cu has a strong affinity for soil organic matter and greatly accumulates in topsoil horizons of vineyards[1]. Excess of Cu in soils negatively affects soil organisms and young plants, consequently reducing soil fertility and productivity[2,3]. The Bordeaux vineyards have the largest vineyard surfaces (26%) within French protected designation of origin and a great proportion of French wine production (around 5 million hectolitres per year). The Bordeaux vineyards are also under heavy fungal pressure due to local climate. Considering the local context of vineyard surfaces decreasing (vine uprooting) and the possible new crop plantation, the issue of Cu potential toxicity rises. Therefore, our aims are to evaluate the Cu contamination in vineyard soils of Bordeaux, then to produce a risk assessment map for new vine or crop plantation.

Database of Cu contamination in vineyard soils

- 4496 soil horizons over 2424 study sites (soil pits), including 1757 georeferenced sites
- Data collected from various soil studies within the Gironde area (1984 - 2020)
- Analysis of Cu : total, EDTA, exchangeable (ammonium acetate)

4496 soil horizons collected
- 2191 horizons with Cu EDTA measured
- 2305 horizons without Cu EDTA measurements

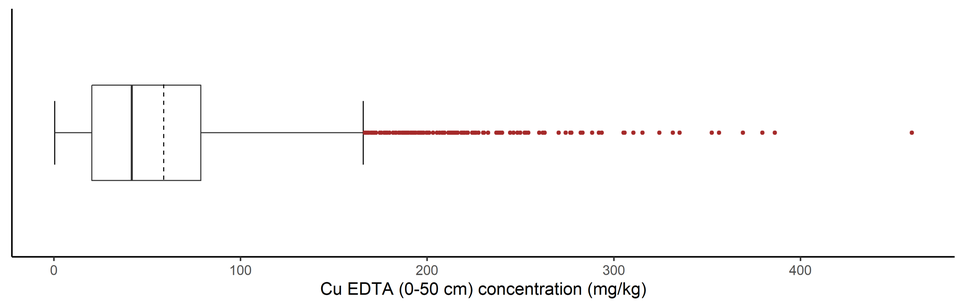
→ **Estimation of Cu EDTA** from modelling of pedotransfer functions
- Predictors :
  - Cu exchangeable
  - Total Cu
  - Zn EDTA
  - Organic matter
  - CEC
  - pH

→ **Estimation of Cu EDTA on 0-50 cm depth** for each study site (parcels)
- Ponderation of Cu EDTA according to soil horizon sequence
- 2424 samples with Cu EDTA 0-50cm including 1757 samples with georeferencing

→

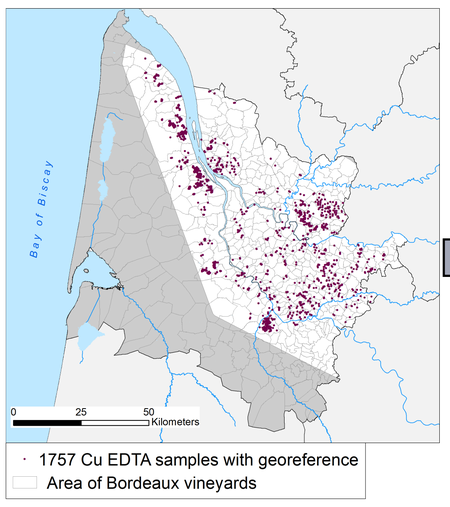
- Statistical summary of Cu-EDTA 0-50 cm (mg/kg)

Minimum	1st quartile	Median	Mean	3rd quartile	Upper whisker	Maximum
0.5	20.3	41.8	58.8	78.8	166.5	459.7

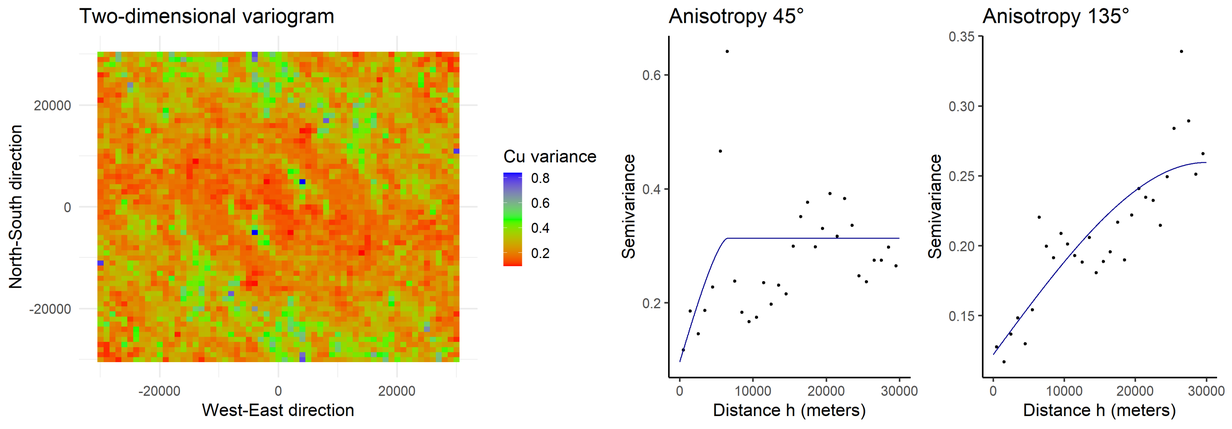


- French reference for soil pollution (Afnor) : 100 mg/kg total Cu

Spatial distribution of Cu contamination in vineyard soils and risk assessment

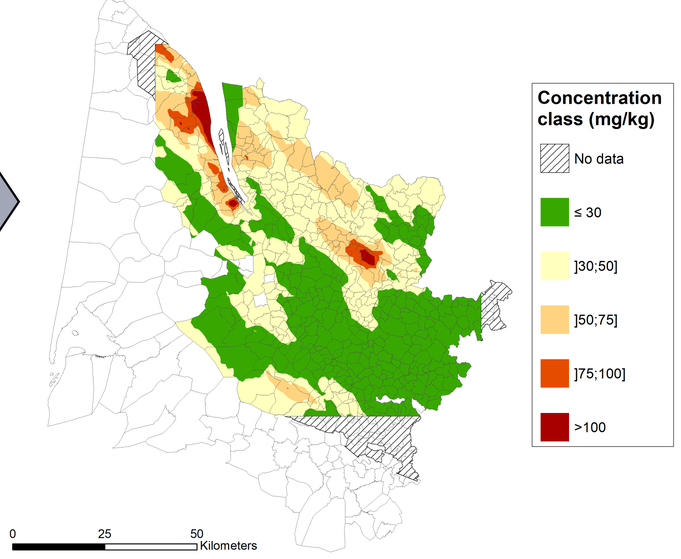


Geostatistical analysis



- Cu-EDTA spatial structure appears to be anisotropic (discrepancy between structures depending on direction).
- Anisotropy can be explained by the repartition of vineyards along the Gironde estuary system.

Kriging of Cu EDTA



Spatial risk considering vine soil use, uprooting and replanting

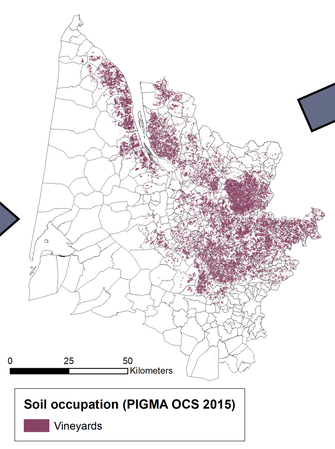
HAZARD: Cu contamination

Treshold	Sources
30 mg/kg	Given by laboratories
50 mg/kg	El Hadri et al. (2012) [4]
60 mg/kg	Baize et al. (2006) [5]
70 mg/kg	Darricau (2017) [6]

- Kriging results with thresholds of Cu-EDTA assumed toxicity for cultivation

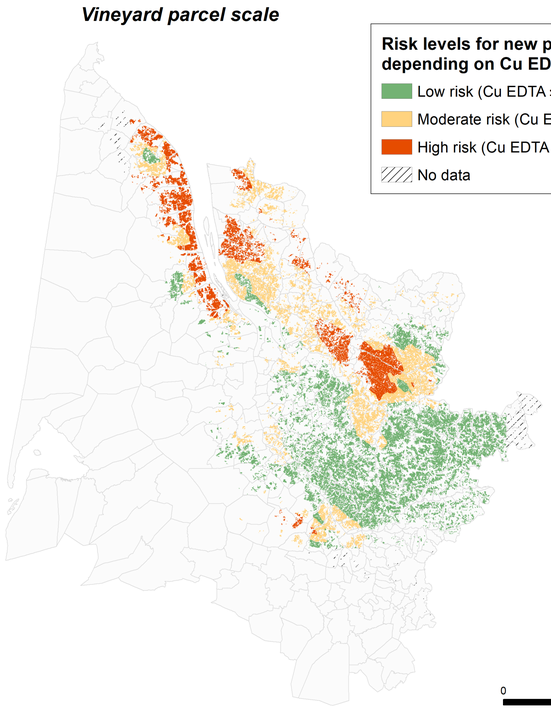
EVENT: uprooting of vine and replanting

- Evolution of vine soil occupation (PIGMA OCS 2000-2009-2015)

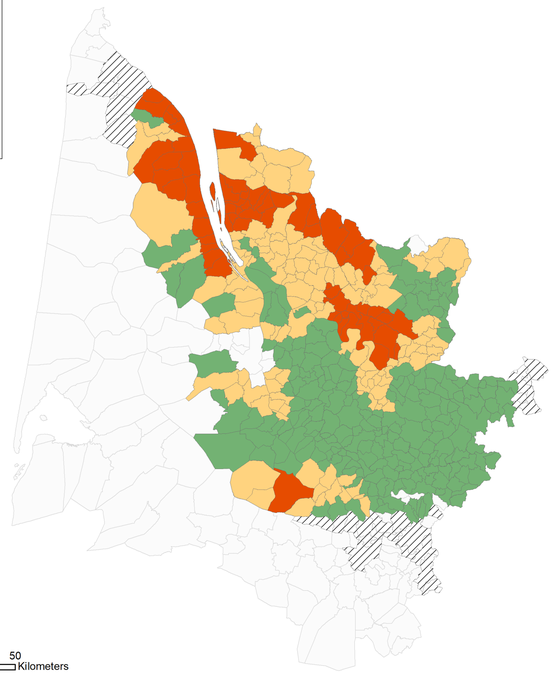


→ **RISK:** inhibition of growth and low yield for new crops or vine replanting →

Vineyard parcel scale



Administrative scale (commune)



Cu EDTA (mg/kg)	Risk	Vineyard area (ha)	% / total area	No. of communes
Uprooting		126998	100	424
No data	Unknown	4367	3	26
≤ 30	Low	60226	47	214
]30;50[	Moderate	36368	29	121
≥ 50	High	26037	21	63

Highlights

- Moderate or high risk for new plantation is estimated for 50% of Bordeaux vineyard soils (Cu-EDTA concentration superior to 30 mg/kg).
- Highest Cu contamination is found in the oldest and most prestigious appellations (Médoc, Saint-Emilion) which early used Cu as a fungicide.
- Results must be interpreted cautiously as they have limitations such as modelling errors, old data (in relation to Cu accumulation) and spatial missing data that may underestimate Cu-EDTA concentrations in vineyard soils.

References:

1. Brun, L. A., Maillet, J., Richarte, J., Herrmann, P. & Remy, J. C. Relationships between extractable copper, soil properties and copper uptake by wild plants in vineyard soils. Environ. Pollut. 102, 151–161 (1998). **2.** Michaud, A. M., Bravin, M. N., Galleguillos, M. & Hinsinger, P. Copper uptake and phytotoxicity as assessed in situ for durum wheat (Triticum turgidum durum L.) cultivated in Cu-contaminated, former vineyard soils. Plant Soil 298, 99–111 (2007). **3.** Mackie, K. A., Müller, T., Zikeli, S. & Kandeler, E. Long-term copper application in an organic vineyard modifies spatial distribution of soil micro-organisms. Soil Biol. Biochem. 65, 245–253 (2013). **4.** El Hadri, H. et al. Assessment of diffuse contamination of agricultural soil by copper in Aquitaine region by using French national databases. Sci. Total Environ. 441, 239–247 (2012). **5.** Baize, D., Saby, N. & Walter, C. Le cuivre extrait à l'EDTA dans les sols de France. Etude Gest. Sols 13, 259–268 (2006). **6.** Darricau, L. Impact du cuivre et de la typologie du sol sur la qualité biologique des sols viticoles du Nord de l'Italie: étude d'indicateurs de la qualité biologique des sols. (Bordeaux Sciences Agro, 2017).

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