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The toxicity of trace metal elements in Downy Oak in Gardanne Mining Basin

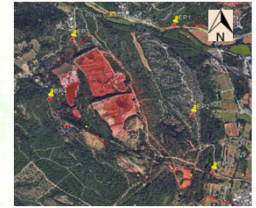
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Background : The Gardanne mining basin is undoubtedly one of the peri-urban territories of the Bouches-du-Rhône where air pollution is a major issue both in terms of public health and the preservation of natural environments. The various industrial activities, including the aluminum smelter, have contributed to exacerbating pollution with metallic trace elements [1,2]. Indeed, Bauxite manufacturing by the Bayer process in alumina production is associated with a by-product, bauxite residue (BR), also termed "red mud", a complex mixture of elemental constituents. Throughout the world, BR storage sites have been sources of adverse effects on the environment and the Mange Gary site is not an exception. The purpose of this work falls within the context of the environmental transition policy undertaken by the aluminum plant. We investigated the impact of the BR from Mange Garri on some populations of *Quercus pubescens*.

Material & Methods:

- Downy oak leaves and soil samples were collected in september 2022 from 5 populations around the site of Mange Garri : EP1-EP5 . The control samples were harvested in the vicinity of Cuge les Pins at about 30 km as the crow flies: TP1-TP4 . 9 leaf samples and 1 soil sample were collected for each population.
- Al, Cr, Ni, Zn, As, Cd and Pb were analysed by ICP-AES from soil, leaf (washed then dried), and leaf water leachates samples. Also, the ratio C/N from dry leaves was determined.
- Hyperspectral spectra of leaf samples were obtained with ASD FieldSpec 4 using the leaf contact probe.
- NIR spectra were obtained from leaf samples. The spectral data were coupled with the trace metal contents and C/N for chemometric analysis.



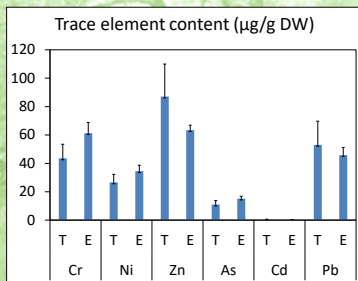
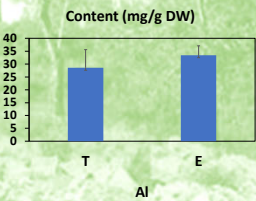
The BR site of Mange Garri



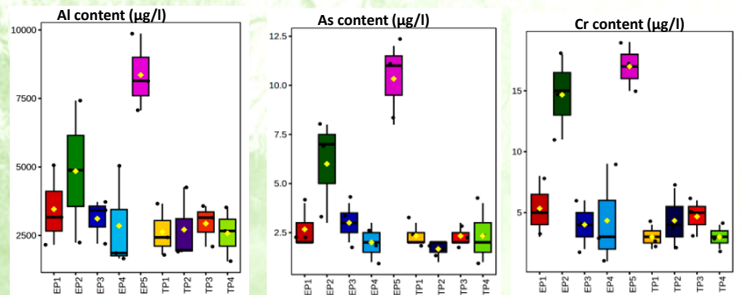
Control site in the vicinity of Cuge les Pins

Trace metal elements from soil samples?

The ANOVA carried out did not show any significant differences between the control sites (T) and the Mange Garri sites (Essay: E) regarding the content of the soil in metal trace elements.

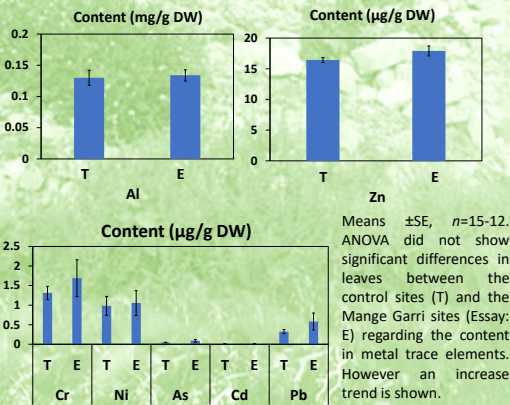


Trace metal elements from leaf water leachates samples?



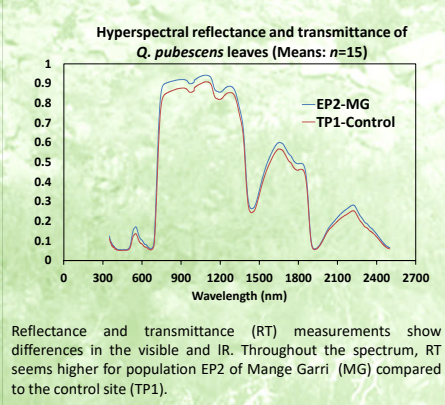
The populations EP2 and EP5 exhibited significant differences for Al, As and Cr. No difference was found for the other metals.

Trace metal elements from leaf samples?



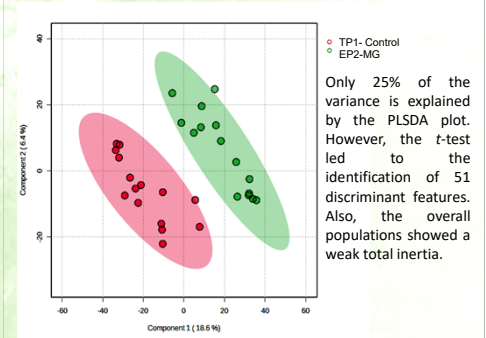
Means ±SE, n=15-12. ANOVA did not show significant differences in leaves between the control sites (T) and the Mange Garri sites (Essay: E) regarding the content in metal trace elements. However an increase trend is shown.

Leaves hyperspectral measurements?



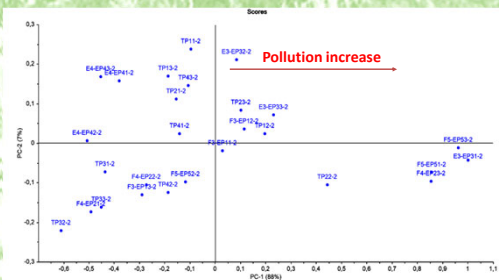
Reflectance and transmittance (RT) measurements show differences in the visible and IR. Throughout the spectrum, RT seems higher for population EP2 of Mange Garri (MG) compared to the control site (TP1).

Partial least squares-discriminant analysis (PLS-DA)?



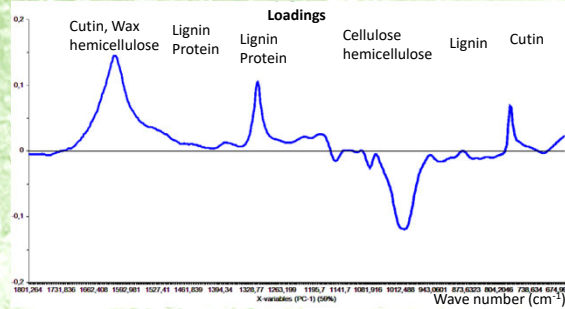
Only 25% of the variance is explained by the PLS-DA plot. However, the t-test led to the identification of 51 discriminant features. Also, the overall populations showed a weak total inertia.

Chemometry: NIR spectrometry of leaf



The PCA factorial plane of individuals shows a total inertia of 95% on axes 1 and 2. It is also characterized by a pollution gradient (fresh leaves).

Metabolic changes?



The increase of pollution from leaf samples results in a decrease of cellulose while the lignin and wax contents increase (leaves powder).

References:

1. R. Oral, G. Pagano, A. Siciliano, M. Toscanesi, M. Gravina, A. D. Nunzio, A. Palumbo, P. J. Thomas, F. Tommasi, P. Burić, D. M. Lyons, M. Guida, M. Trifuoggi, Soil pollution and toxicity in an area affected by emissions from a bauxite processing plant and a power plant in Gardanne (southern France), Ecotoxicology and Environmental Safety. **2019**, 170, 55-61.
2. R. Marion and V. Carrère. Mineral Mapping Using the Automated Gaussian Model (AGM)—Application to Two Industrial French Sites at Gardanne and Thann. *Remote Sens.* **2018**, 10, 146.

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Conclusion: This study showed that the storage activity of bauxite residues BR on the site of Mange Garri has a significant impact on the deposits of Al, As and Cr on the oak forests. These deposits are more important in the direction of the prevailing winds and near the transport routes of the BRs to the storage site. With the planned abandonment of the Bayer process one would expect a reduction in such pollution. No noticeable effect on the soil was shown, but this result should be qualified given the small sampling size. Nevertheless, the increase of pollution from leaf samples results in a decrease of cellulose while wax, lignin and or phenolic compounds contents increase. Further analyses are underway on both chemistry and genomics to try to understand the response of oak to metal pollution.