CONTROL OF A III-PHASE OLIVE POMACE COMPOSTING PROCESS USING THE CIELab COLORIMETRIC METHOD

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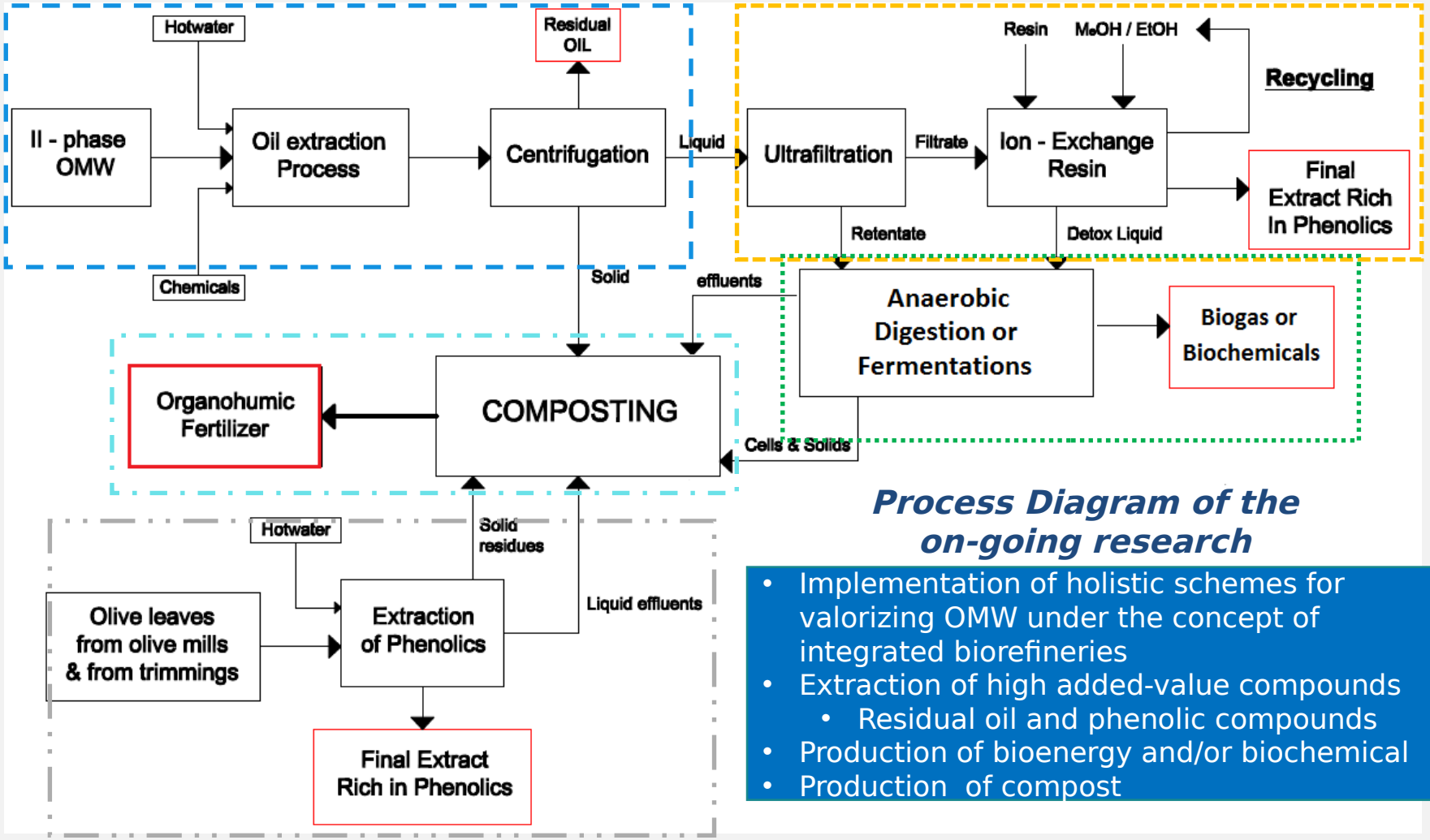
Development of an integrated OMW biorefinery

On going research of the Laboratory of Organic Chemical Technology, NTUA



Process Diagram of the on-going research

- Implementation of holistic schemes for valorizing OMW under the concept of integrated biorefineries
- Extraction of high added-value compounds
  - Residual oil and phenolic compounds
- Production of bioenergy and/or biochemical
- Production of compost

The scope of the study

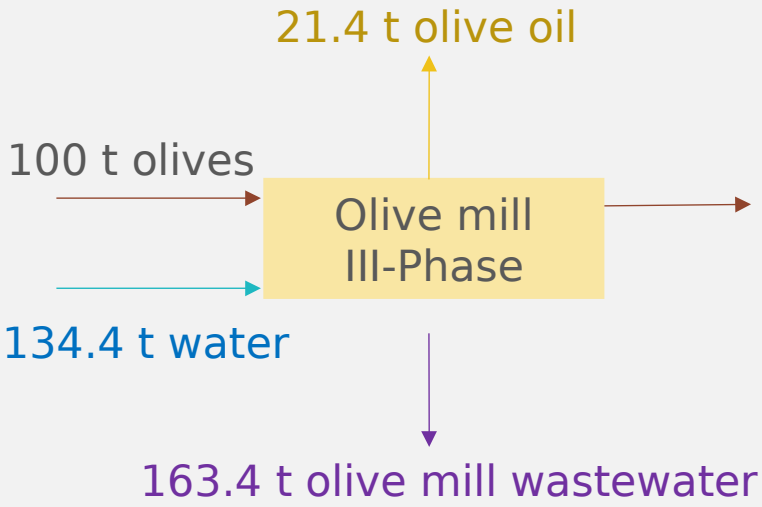
Objective

- Monitoring the composting process with a new colorimetric method
- Eliminate the need for complex maturity analyses during composting

Methodology

- Composting of three-phase olive pomace in an industrial scale facility
- Monitoring the most important physicochemical properties of the compost pile
- Measurement of the color variables using the CIELab color model
- Correlation between physicochemical parameters and color variables
- Compost maturity graphs using the CIELab color variables

Flow diagram of a III-phase olive mill facility



- Olive oil extraction: one of the most traditional agricultural industry in the Mediterranean Region
- Large amounts of two main by-products: solid residue and olive mill wastewater
  - Harmful to the environment
- A non-complex integrated utilization strategy is the co-composting of the two waste streams

Composting

Equation: $C_pH_qO_rN_s \cdot aH_2O + bO_2 = C_fH_uO_vN_w \cdot cH_2O + eH_2O + CO_2$

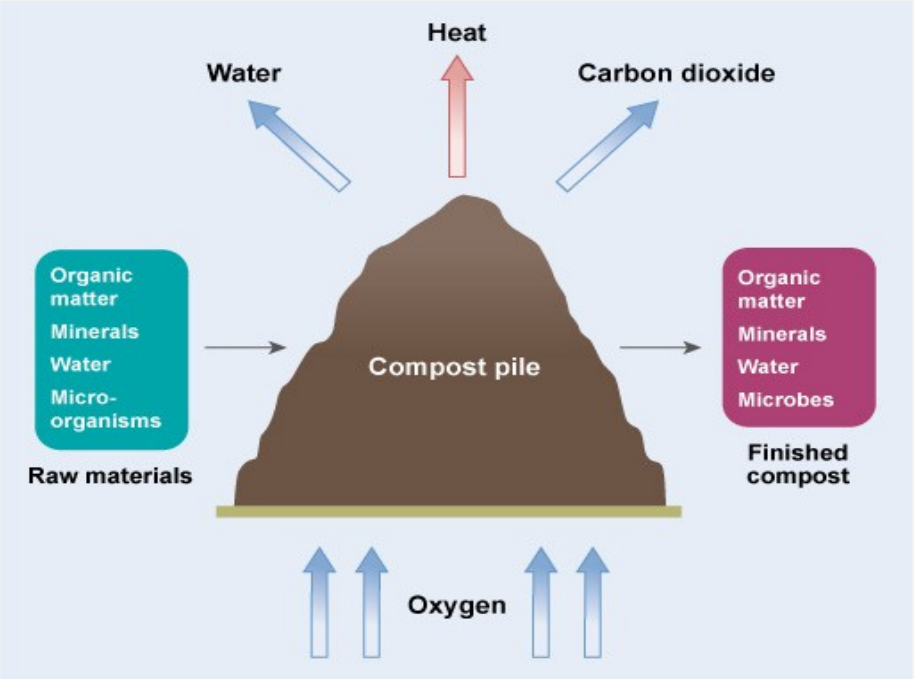
Organic matter | *Oxygen consumed* | *Compost* | *Water evap.* | *Water prod.* | *Carbon dioxide prod.*

Biological decomposition of organic ma
- *Heterogeneous-heterotrophic microorgan*
- *Controlled aerobic conditions*
- *Exothermic procedure*

Organic waste management:
- *Agricultural by-products*
- *Food industry waste*
- *Municipal solid waste*

The final product is Compost

Compost Maturity
- Degree of completeness of composting
- Stability of the final product



Measurement of at least 2 parameters *(maturity indexes)*

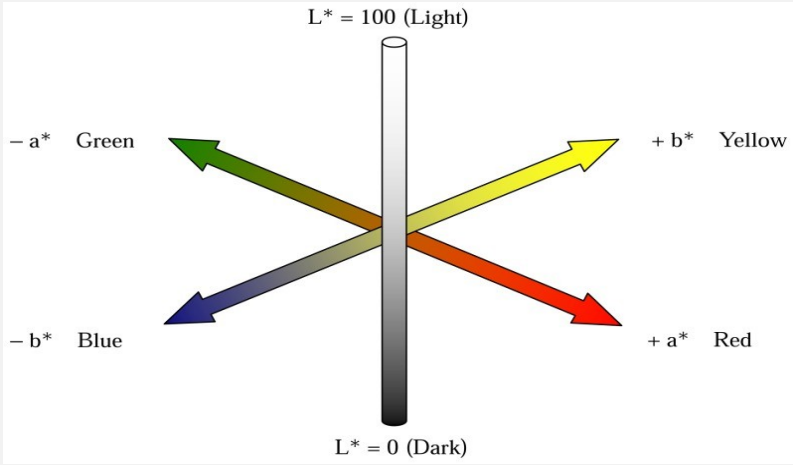
Colorimetry

Numeric calculation of color using *color models* and *spectrophotometers*

CIELab color model

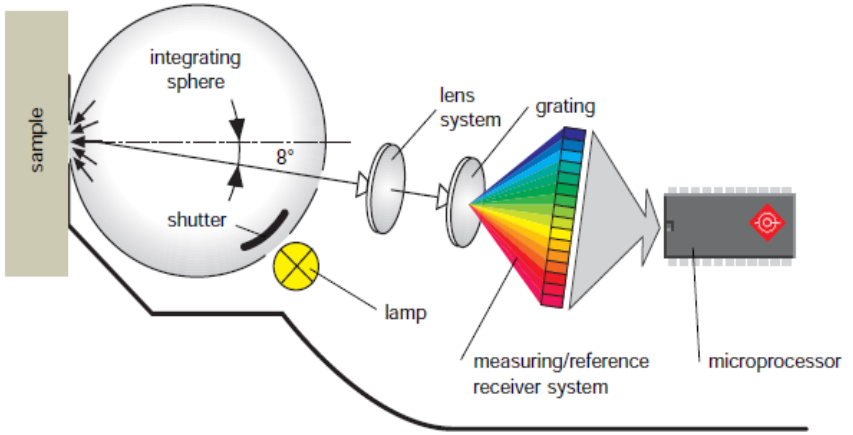
3D color space

- L (*lightness) from (0) dark to (100) light*
- a *from (-) green to (+) red*
- b *from (-) blue to (+) yellow*



Spectrophotometer:

- Portable device simulating the human
- Circular geometry of d/8^0
- Stable measuring conditions
- Rapid, inexpensive measurement



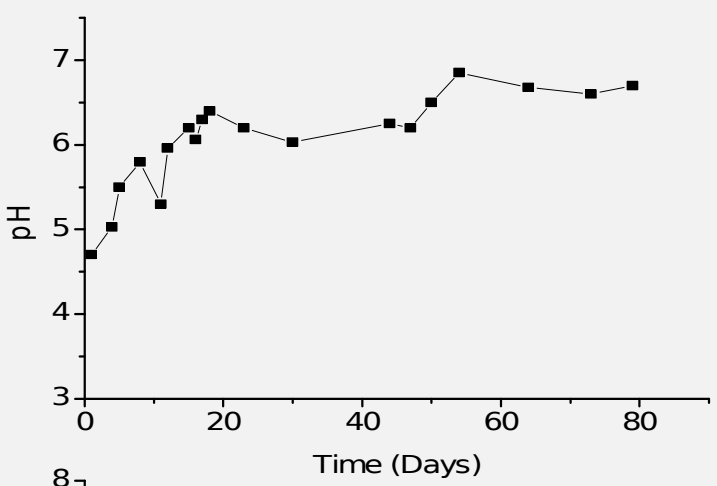
Composting process

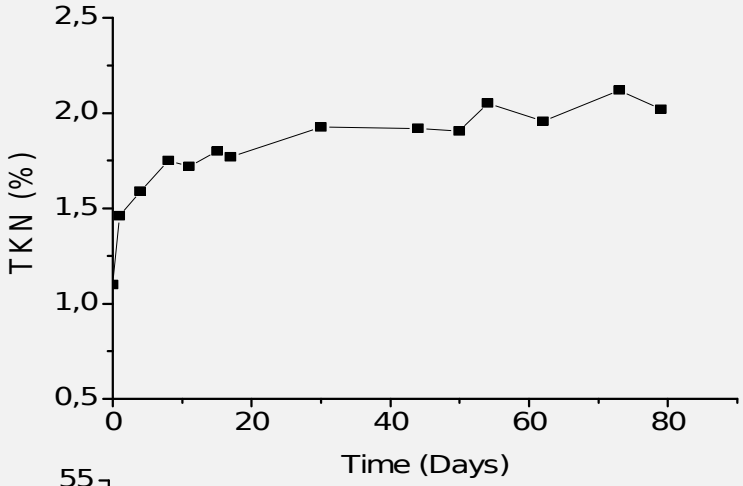
- Raw materials : *III-phase olive mill solid residue (olive pomace, olive leaves)*
- Open composting system : *dynamic aeration - windrows*
  - Aeration: turning of the compost pile using a tractor
- Industrial scale: 34.5 t *(first day of composting)*
- Sample collection: zigzag meth
- Composting duration: 80 days

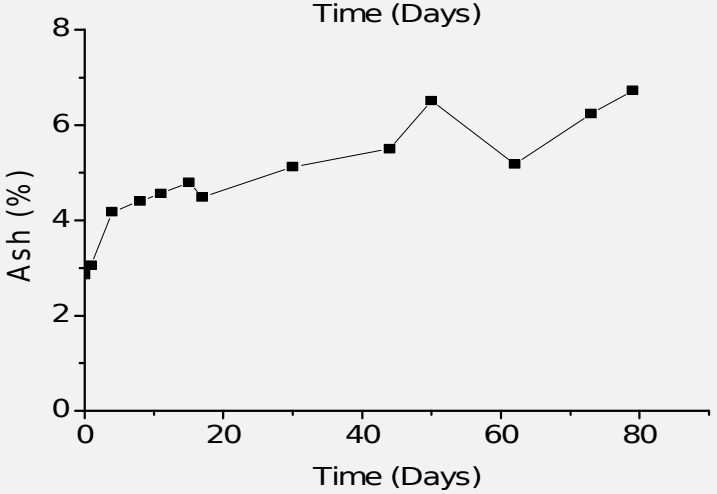
Measurement:

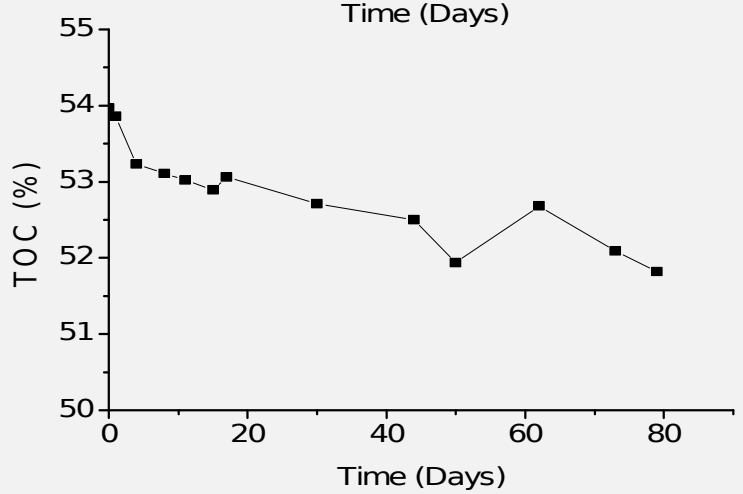
- pH, TKN, TOC, color

Results
Physicochemical parameters of compost



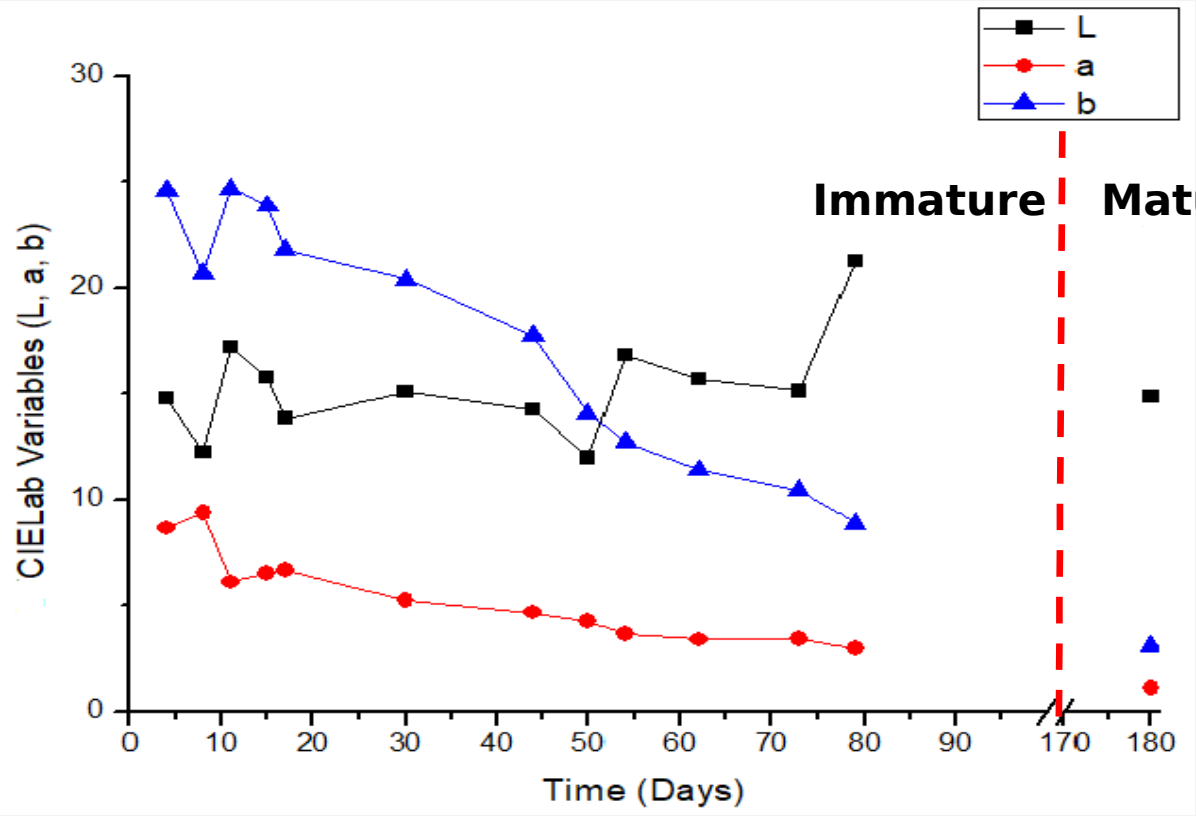






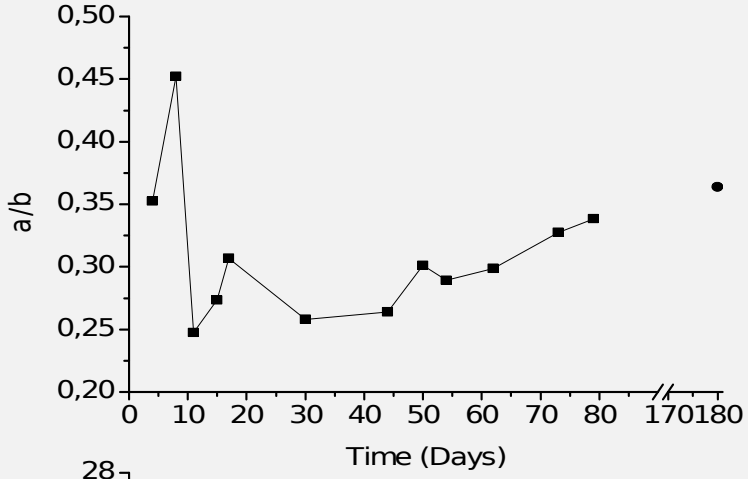
- Physicochemical parameters Maturity indexes

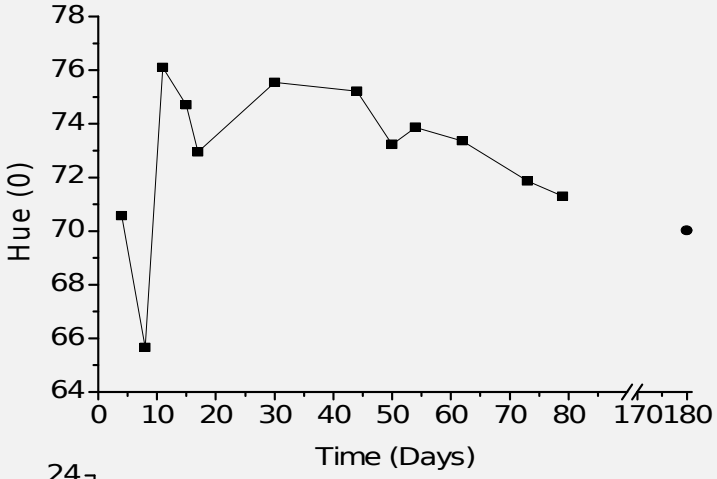
CIELab color variables



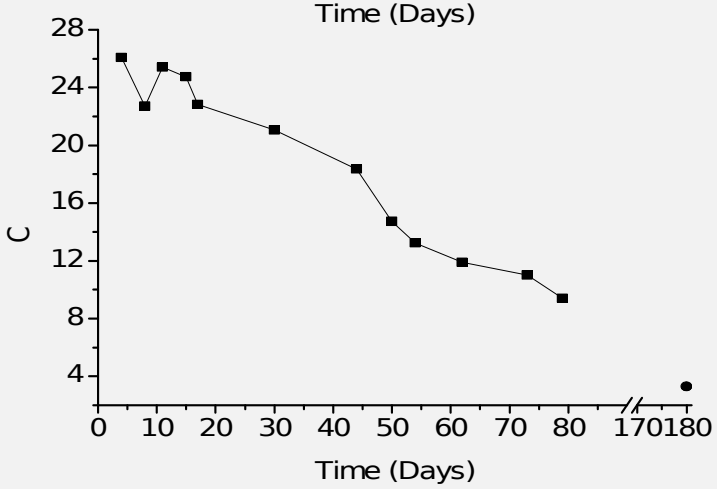
- Decreasing trend of a, b variables during the whole period of composting
- Evaluation of maturity using a, b variables

Color variables that derive from the CIELab model

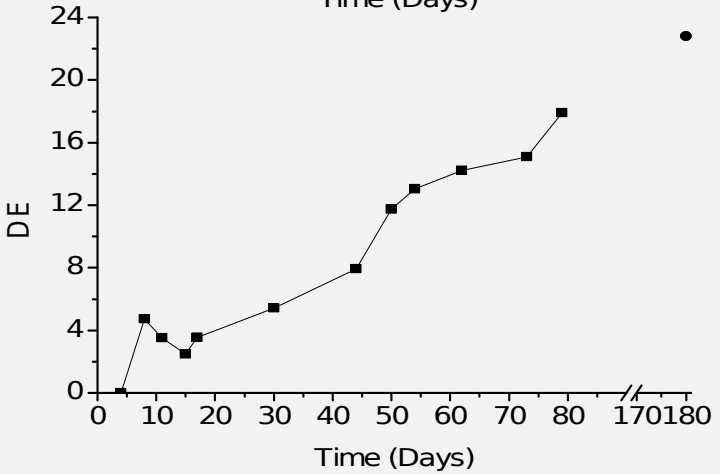




$$h = \tan^{-1}\left(\frac{b}{a}\right) \quad a > 0,\ b \geq 0$$



$$C = \sqrt{(a)^2 + (b)^2}$$



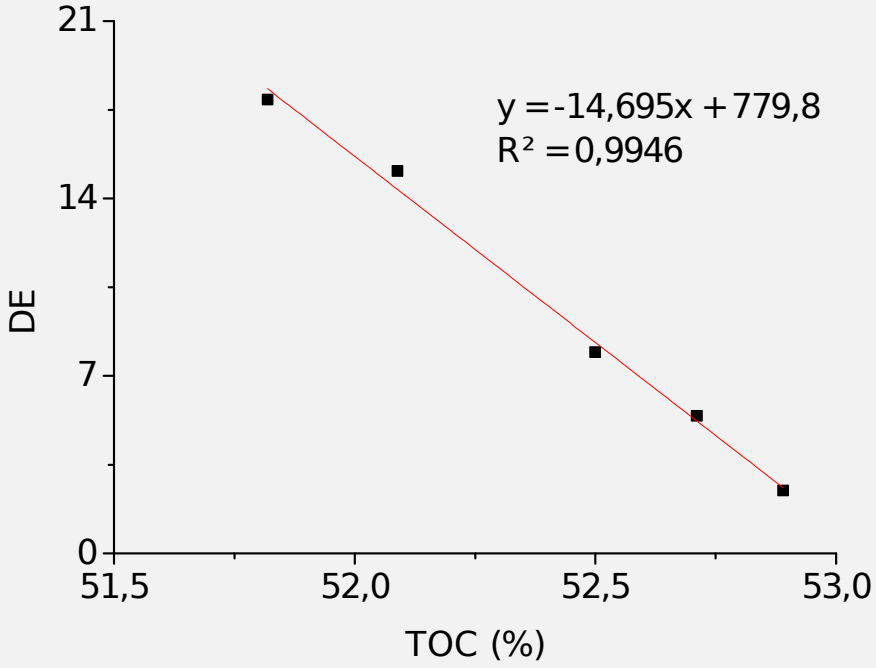
$$\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$$

- a/b and h Increasing and decreasing trend respectively after the 15th day of composting
- C and ΔE Decreasing and increasing trend respectively during the whole composting period

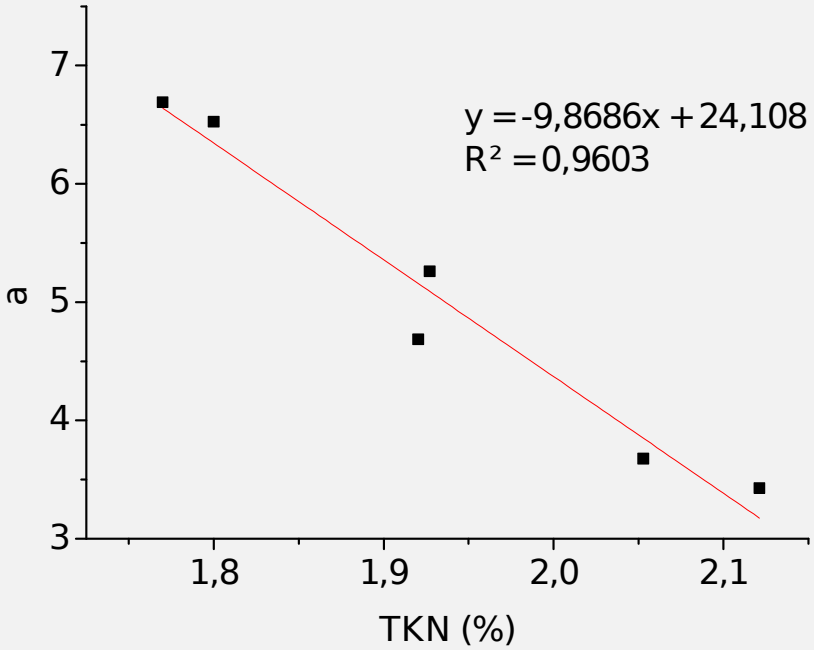
Linear correlation between CIELab color variables and physicochemical parameters – R^2

- Investigation of linear correlation between compost maturity indices and the CIELab color variables

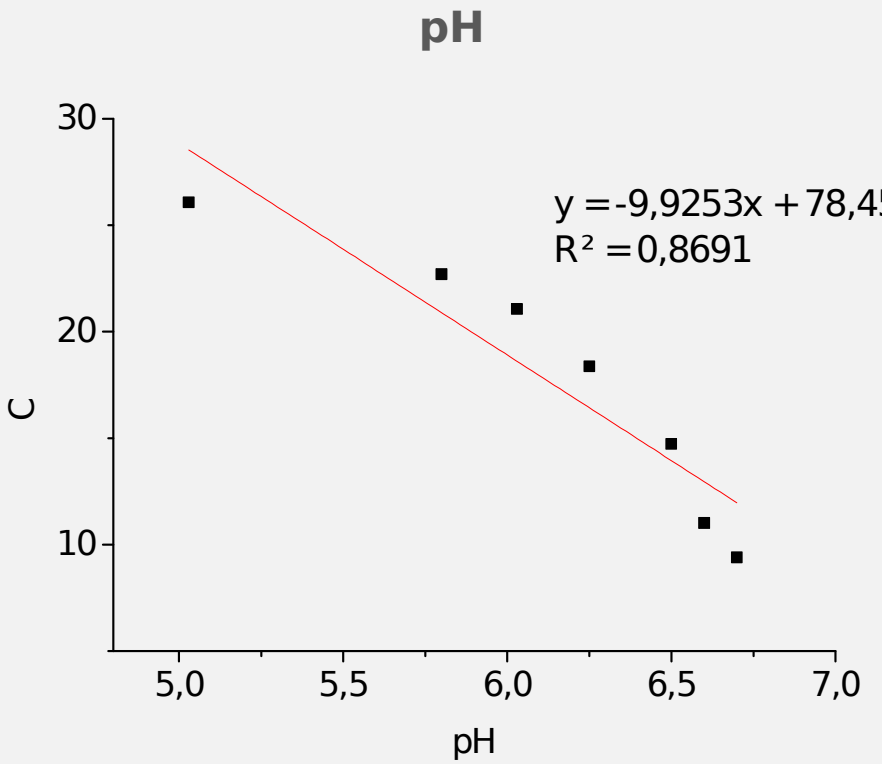
Total Organic Carbon (TOC%)

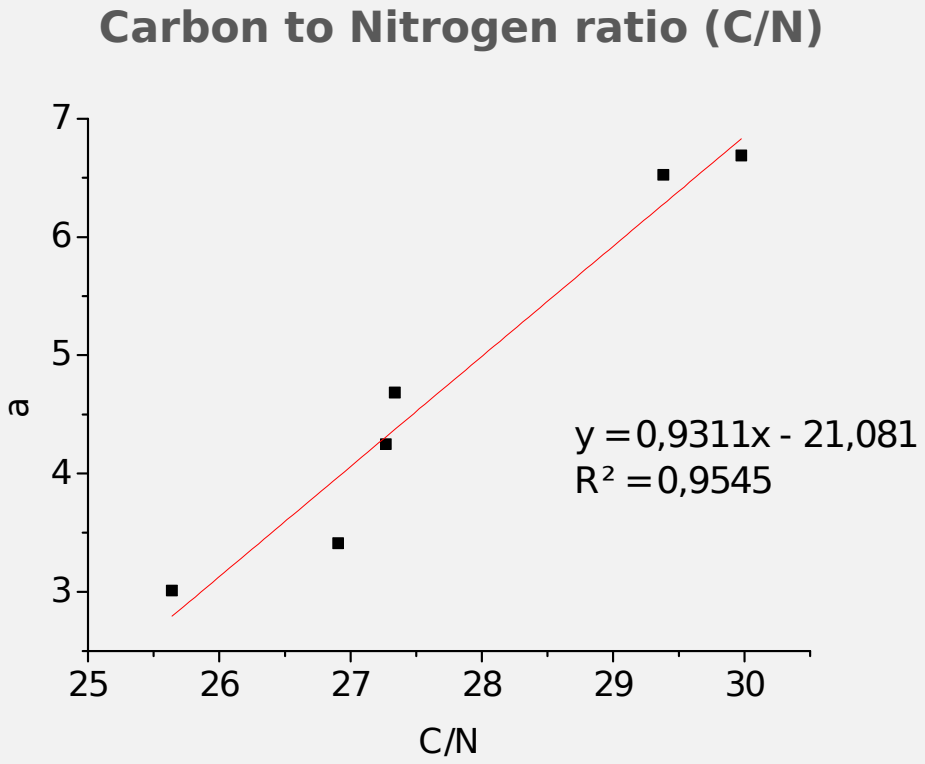


Total Kjeldahl Nitrogen (TKN%)



Linear correlation between CIELab color variables and physicochemical parameters – R^2





Very strong linear correlation between a, b, C, ΔE and TOC%, TKN%, C/N (R^2>0.93)
Strong linear correlation between a, b, C, ΔE and pH (R^2>0.85)
Strong linear correlation between a/b, h and TOC% during t=15-80 days (R^2>0.81)

Conclusions

- Determination of the stage/maturity of composting
  - Constant change trend of color variables a, b, C, DE during composting
  - Constant change trend of color variables a/b, h after the 15th day
  - Strong linear correlation between color and maturity indexes
- Determination of each individual physicochemical parameter of composting
  - Very strong linear correlation between parameters TOC%, TKN%, pH, C/N with color variables a, b, C, DE
  - Strong linear correlation between TOC% and color variables a/b, h after the 15th day
- Rapid and inexpensive compost maturity analysis

Suggestions for future research

- Complete composting study to locate the point of maturity
- Additional physicochemical parameters evaluation
  - Phytotoxicity, humic and fulvic acids, SOUR Test, Dewar Test etc.
- Multiple composting tests to determine the confidence levels of the color model
- Different substrate study
  - Anaerobic digestate, municipal solid waste, manure, etc.

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BIO AGRO OLIVA

Thank you for your attention