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A novel respirometer for determination of compost stability

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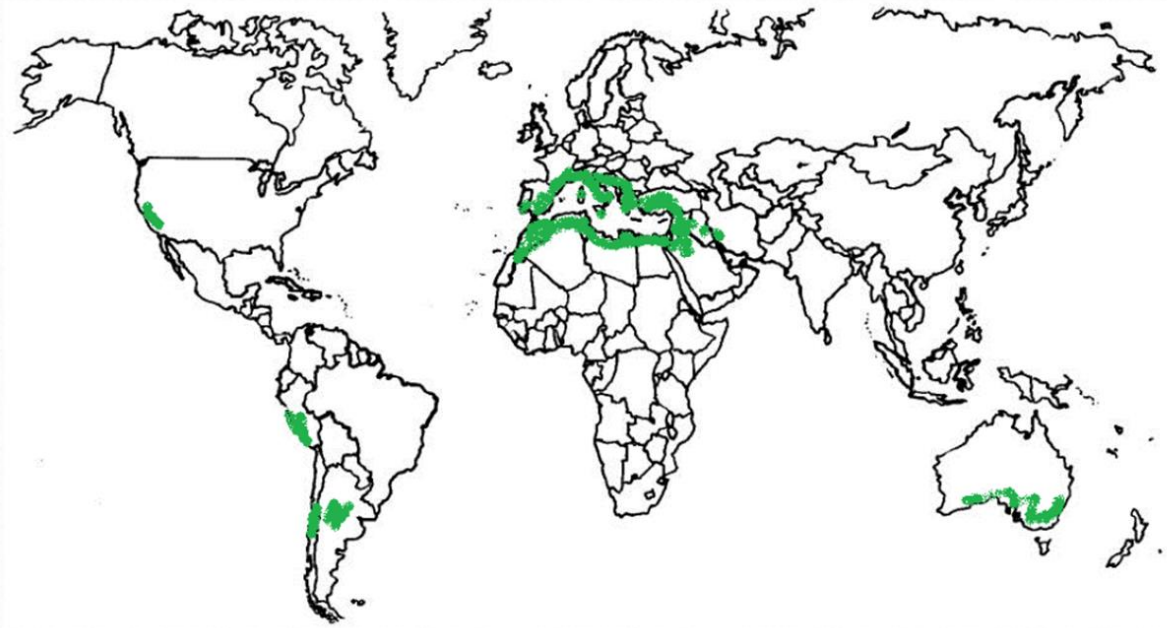
Aim of this work

A novel respirometric technique for composting process determination through

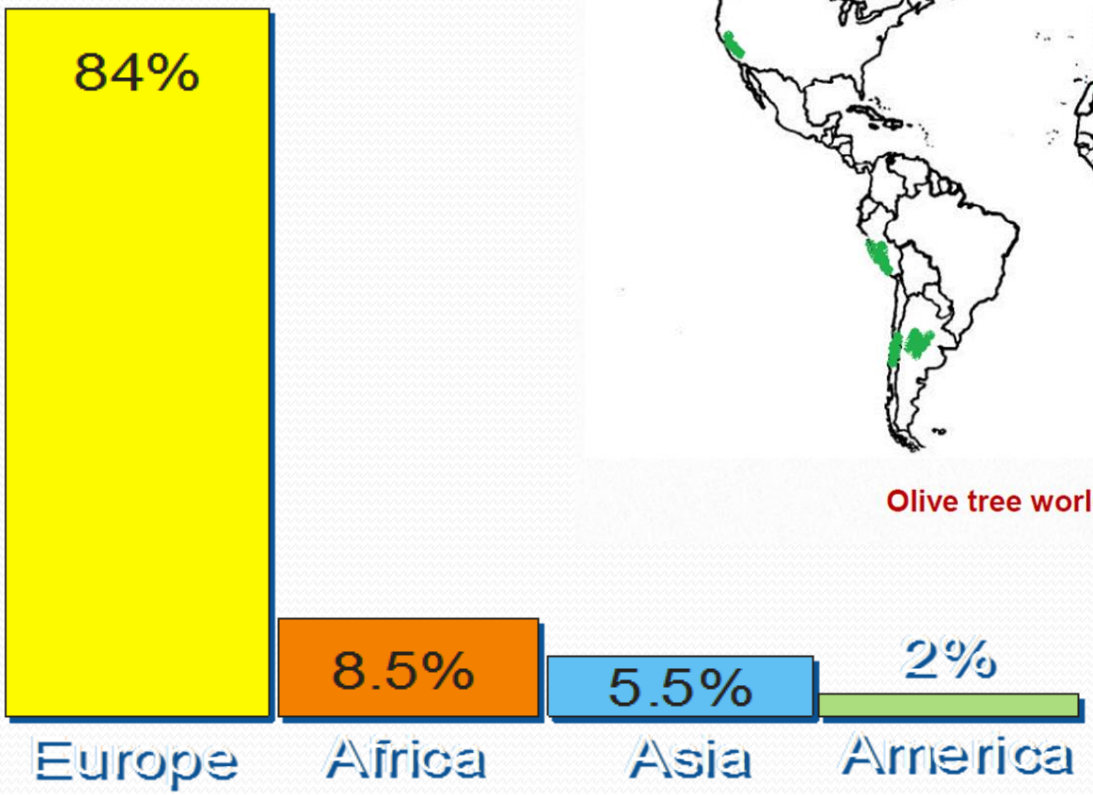
- Estimation of the maximum ***Oxygen Uptake Rate*** (or maximum CO_2 evolution)
- The biological kinetic rate k (day-1) of O_2 uptake
- The time required to complete the autotrophic and heterotrophic bio reactions

The current process has been tested on olive mill wastes.

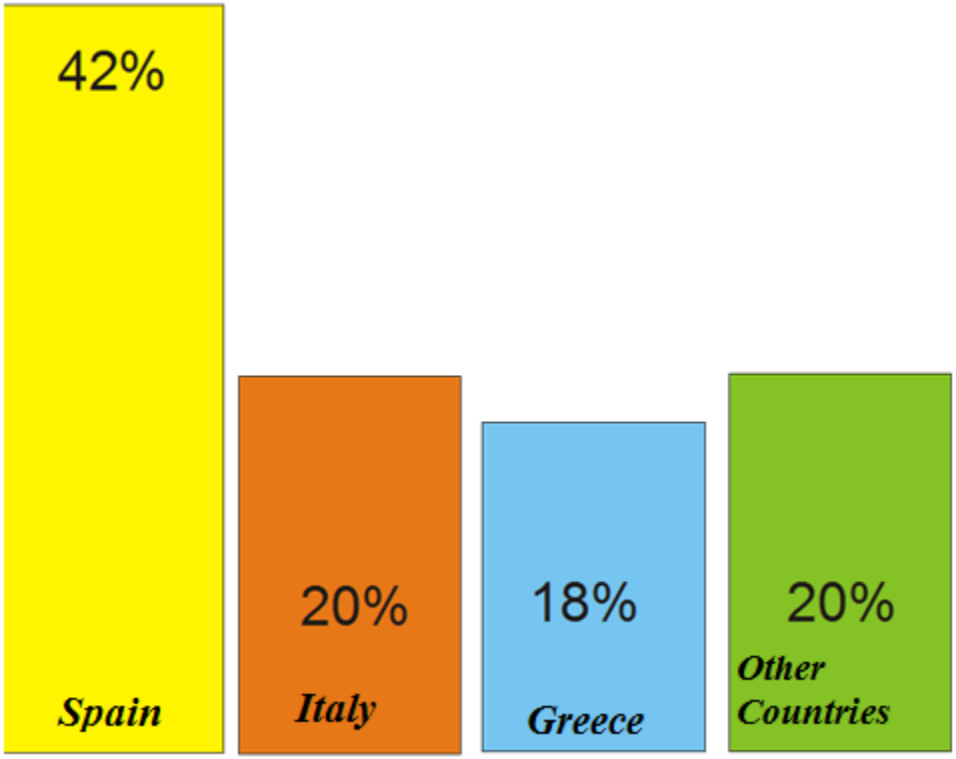
World wide Olive oil Production

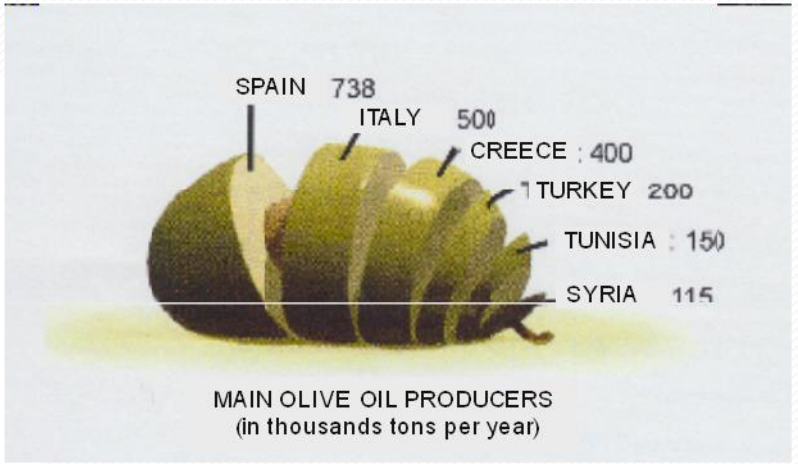


Olive tree world cultivation surface: >8 million ha



European Olive oil Production

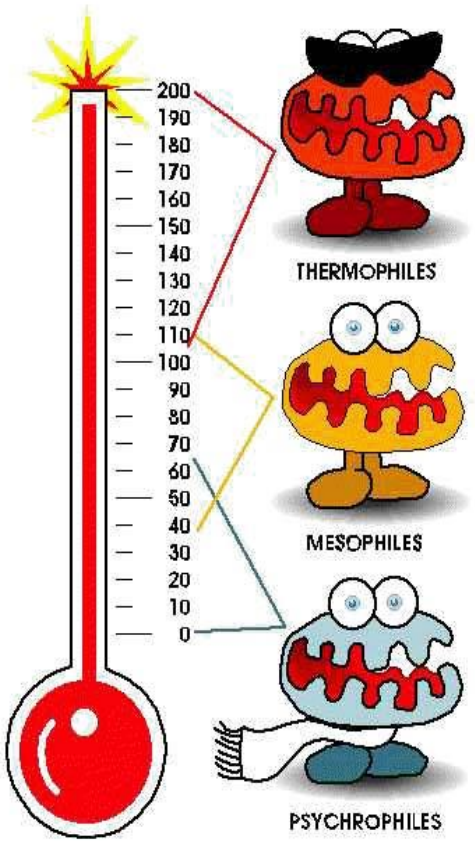




Composting

- *Integrated water treatment technology of mill waste (solid and liquid)*
- *Composting can be classified as an aerobic process that includes a series of chain reactions which have as main denominator, the oxygen consumption rate.*
- *Fertilizer or otherwise compost - product with added value*
- *The direct deposition to the ground gives:*
  - ❖ *increased water holding capacity*
  - ❖ *enhancing cation exchange*
  - ❖ *increased antimicrobial action.*

Phase of Composting



- Biodegradable organic carbon or stabilization phase dominating actinomycetes that deconstruct organic compounds increasing the temperature above 50°C
- Maturing phase: eukaryotic microorganisms take place in order to control the bio reactions and nitrification reactions are completed
- Humification phase organic products of previous phases transformed into fulvic and humic compounds giving the final product the properties of water holding capacity, the ion exchange and biological activity.

Compost Stability and Maturity

- ***Maturity*** is often assessed through sensory activity or the potential for plant growth. Maturity is best assessed with plant growth and a combination of several other assays.

- ***Stability*** can be determined by the rates of O_2 uptake, CO_2 produced or the heat released as a result of microbial activity. The chemical and physical stability of the compost determines the shelf-life and applicability of compost for various uses

  - The ***biological stability*** suggests the extent to which biodegradable organic matter has decomposed. The key point of this knowledge is the degree of biological stability of a compost due to fact that it is recognized because it affects the potential for odor generation, biomass re-heating, residual bio gas production, re-growth of pathogens, GI, plant disease suppression ability and process parameters such as airflow rate and retention time

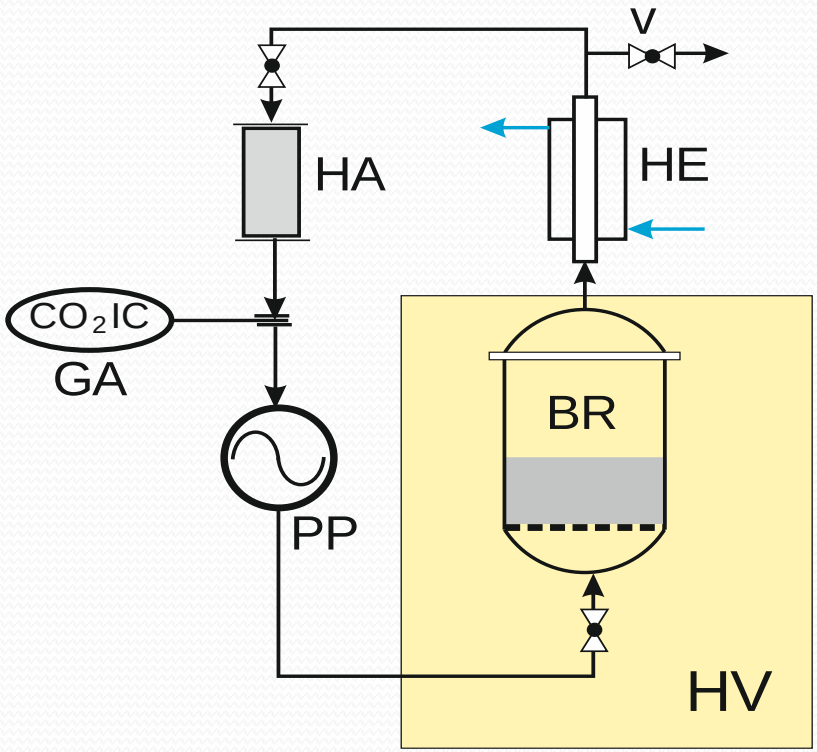
Oxygen Consumption rate

- The organic substrate stabilization achieved with low moisture content up to 50%.
- Although there are many direct process control parameters for adequate monitoring of compost such as temperature, pH and moisture
- More information considering the biological activity of the composting process can be obtained by monitoring the oxygen uptake rate (OUR) of the organic matter
  - ***Oxygen Uptake Rate (OUR) of the organic matter is assessed indirectly by measuring the CO_2 that is produced from the biological respiration of the organic material.***

Respirometric technique

- Organic materials from different composting phases were tested for their respirometric abilities.
- CO_2 evolution rates were measured during each cycle and obtained results were evaluated considering the composting progress.
- Usually maximum levels of OURs are reached approximately at 12-48 hours, depending on the temperature.

Respirometer Device



BR = Bioreactor Digestion

PP = Peristaltic Pump

HE = Water Conseder

HA = Moisture Removal

GA = Gas Analyzer

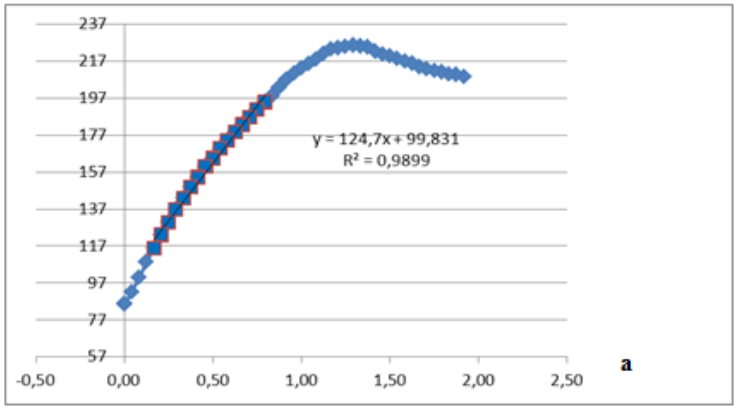
V = Venting Gas Line

HV = Temperature Control Area

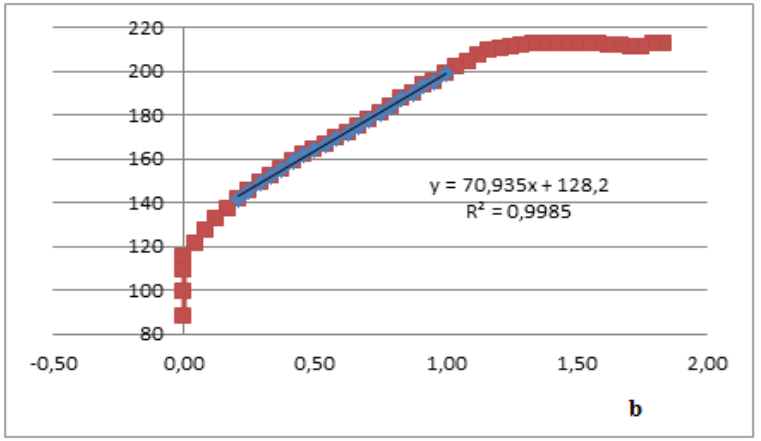
The indicative parameters at the stage of humification

PARAMETER	UNIT								
TIME	WEEKS	1	2	3	4	5	6	7	8
WHC	% d.b	162	151	140	120	124	149	125	118
pH		8,4	8,2	8,3	8,45	8,7	8,7	8,8	7,89
EC	mS/cm	1313	1403	1284	1323	1388	1061	1708	764
ORGANIC MATTER	% d.b	83,27	83,69	87,82	83,68	83,44	84,14	82,83	80
ORGANIC CARBON	% d.b	46,3	46,5	48,8	46,8	46,4	46,7	46	40
TOTAL ORGANIC NITROGEN	% d.b	1,24	1,54	1,35	3	2	2,5	2	3
CEC	meq./100g	29,9	30	28	32	39	45	55	59
GERMINATION INDEX	%	101,57	125	130	120	116	125	115	130
HUMIC ACIDS (HA)	gr/kg d.c	6	6	7	5,9	8	7	8	10,3
FULVIC ACIDS (FA)	gr/kg d.c	0,9	1	1	0,7	2,3	2	2,2	3,5
MAXIMUM OXYGEN RATE O2 rmax	mg/kg OM -d	697	611	519	361	196	219	164	29
C/N	% d.b	37,33	30,19	36,14	15,6	23,2	18,68	23	26,67

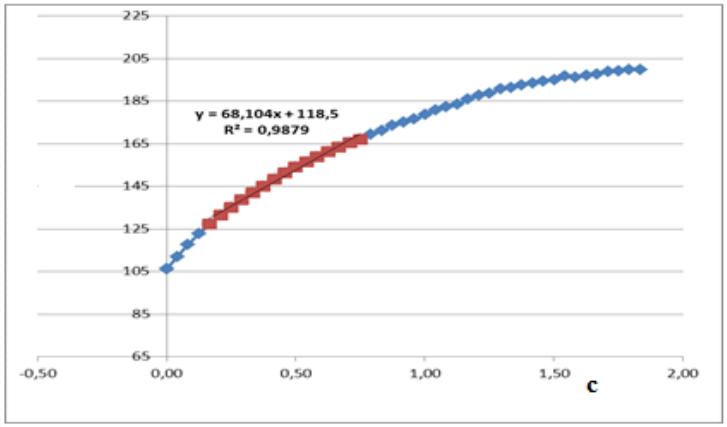
Rate of Oxygen Consumption (mgO2/kg. d. c/d)



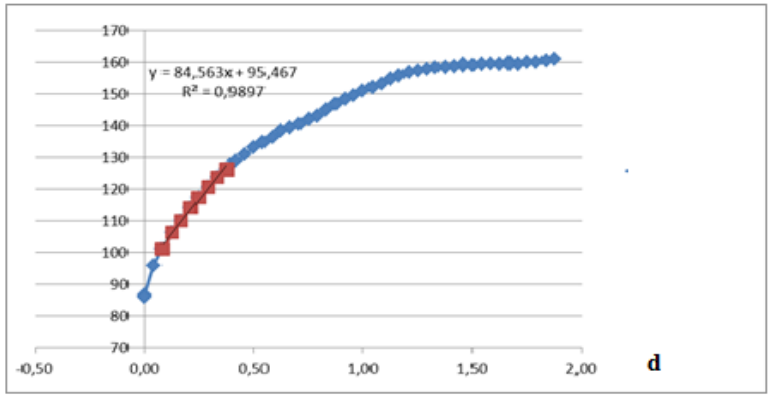
Days



Days

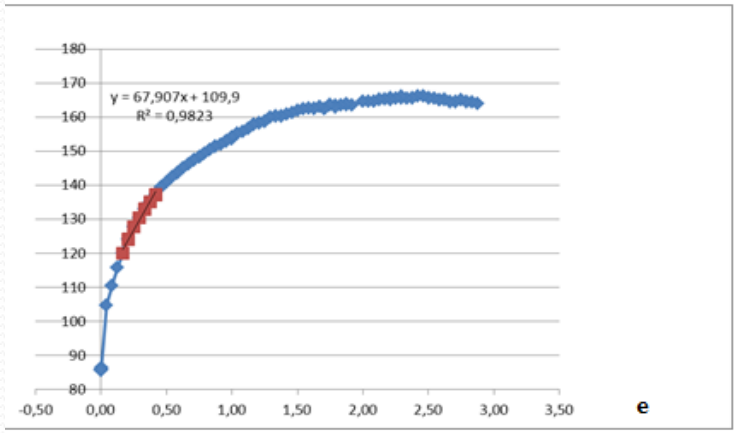


Days

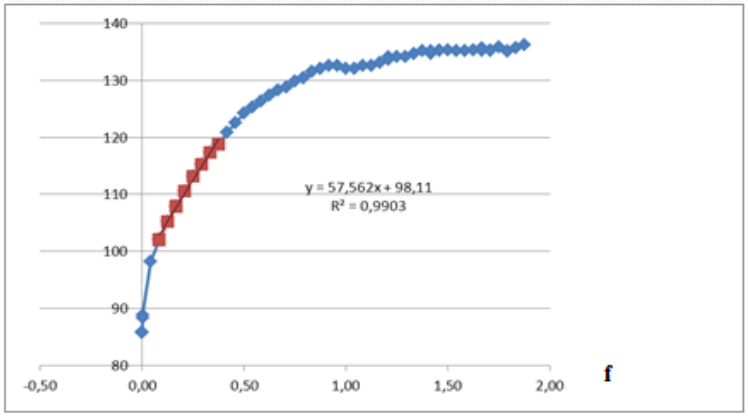


Days

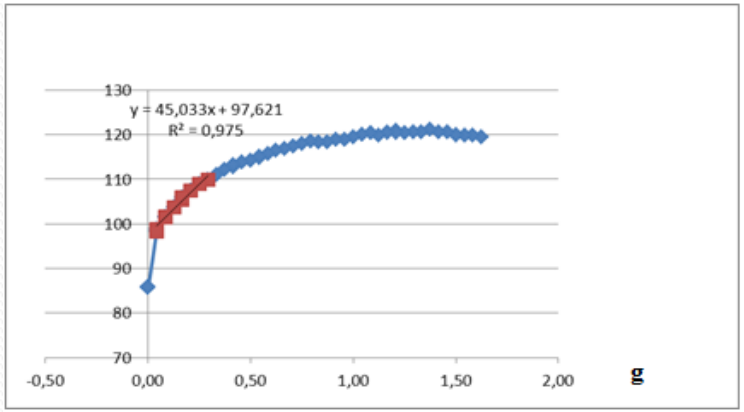
Results



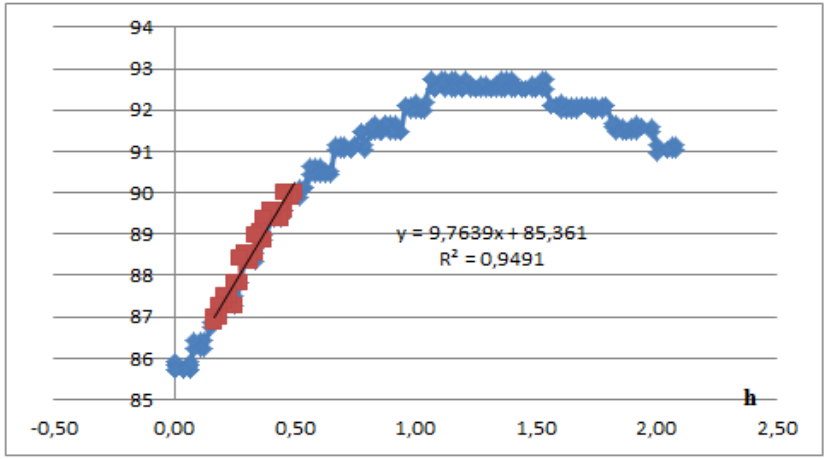
Days



Days

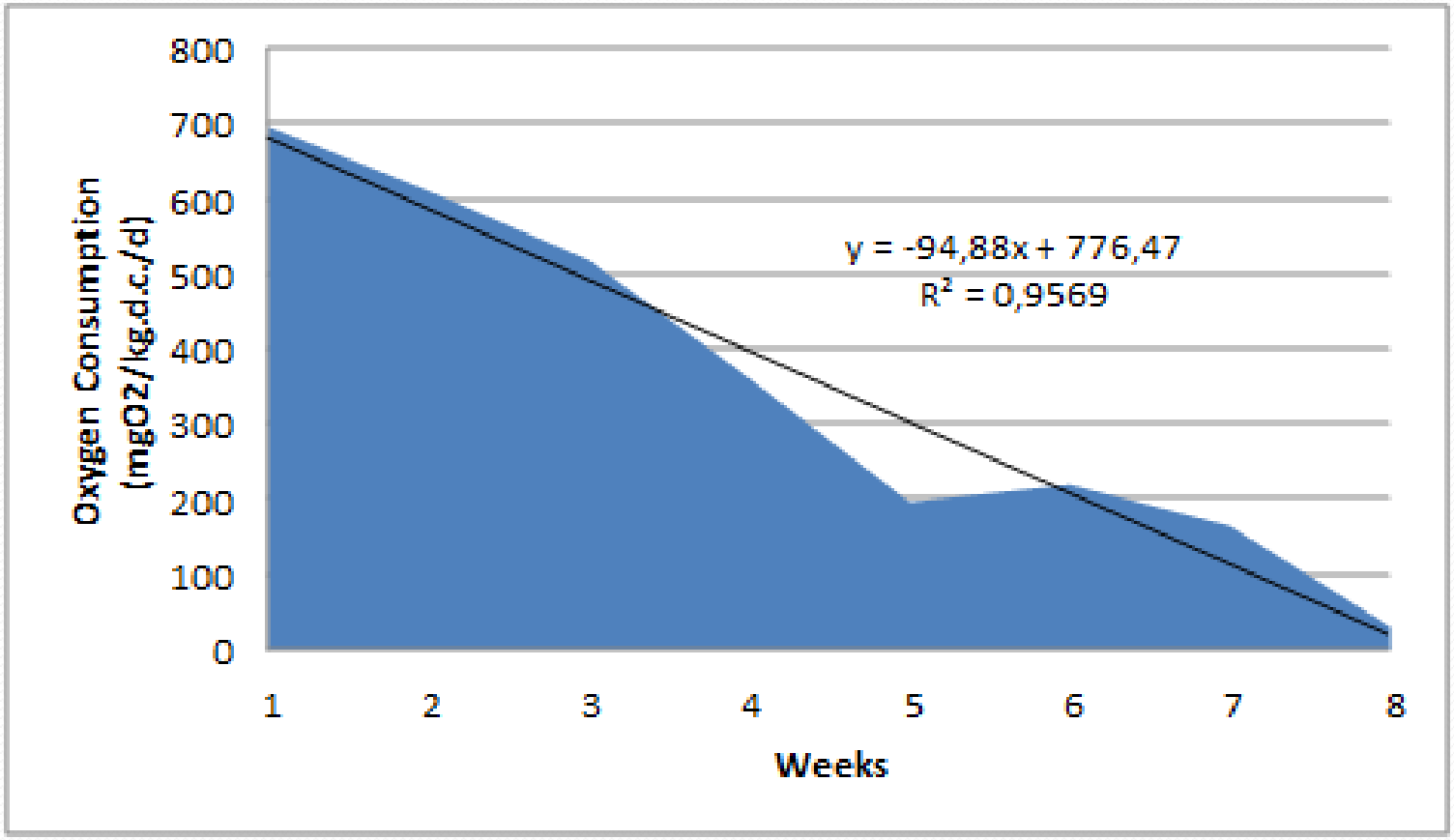


Days



Days

Total maximum oxygen consumption rate



Oxygen correlations

The characteristic oxygen absorption curves which were obtained are correlated with other parameters such as WCH, pH, HA and CEC.

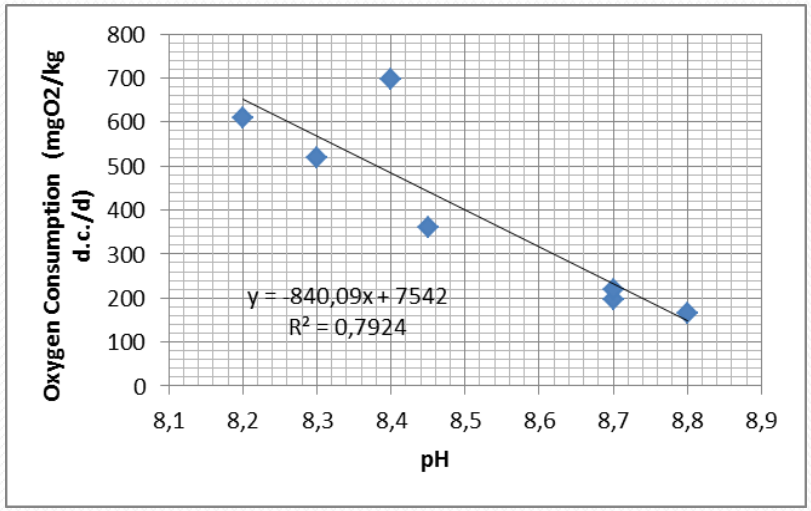
It is observed that there is a good correlation between the measured oxygen consumption in order to be used for the prediction of the compost evolution of any substrate. As the composting time is being the maximum oxygen uptake rate and the stabilization time are reduced.

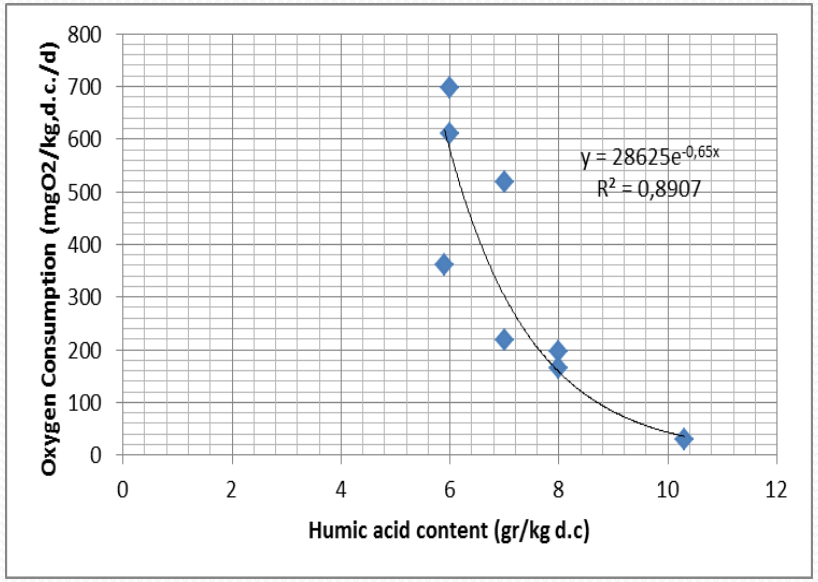
Oxygen Consumption and HA

Oxygen existent in structural component of the nucleus.

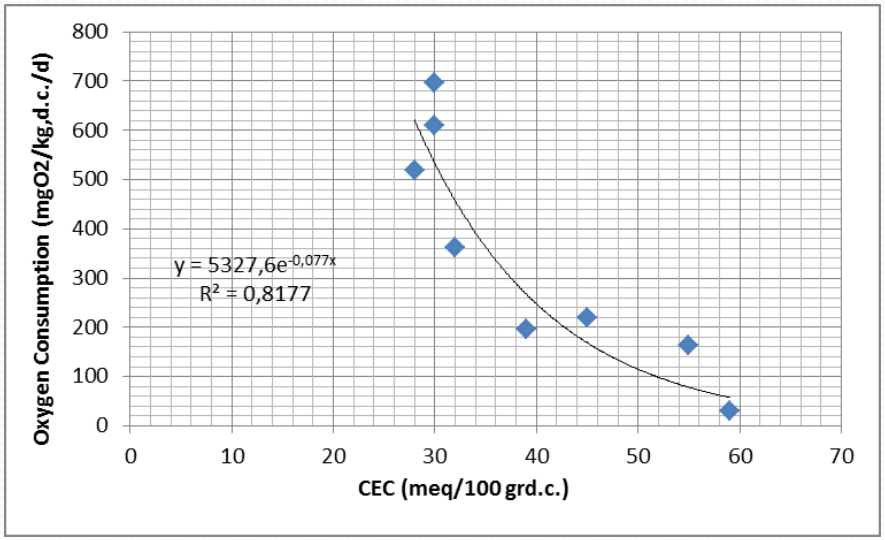
High concentration of humic compounds in a product can justify the high pH as well as the dark to black in color

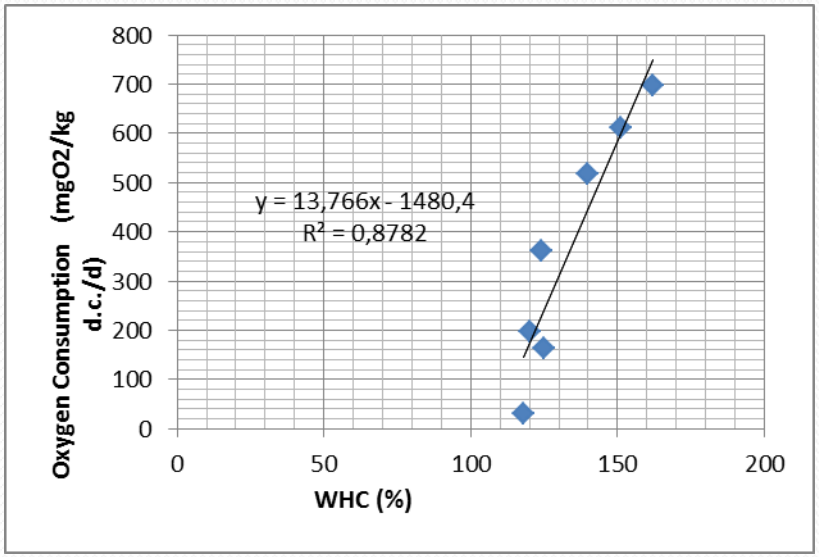
Correlation between oxygen consumption and other parameters





Correlation between oxygen consumption and other parameters





Conclusion

- Under an effort to measure the most significant biological parameter development factors based the whole process, a device created, giving the ability to measure the maximum oxygen adsorption rate in 2 days.
- Oxygen could be directly connected with all the other parameters
- Strong correlation between oxygen consumption HA,CEC, WHC and pH presented
- Though that correlations, is given the chance for a rough estimation of the parameters of a sample.

- *The maximum rate of oxygen consumption enables prediction and monitoring of composting evolution. This is so important due to fact that there is the ability to save time in analyzing the samples in industrial application.*

Thank you very much for your attention

Questions????

HAPPY SUMMER