

# Comparison of wastewater sludge drying processes: solar, thermal and reed beds

## Impact on organic matter characteristics

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*University of Poitiers, France*

*CNRS UMR 7285 (IC2MP), Water Geochemistry Health Team*

# Waste Production (per year / inhabitant)



354 kg



46 kg



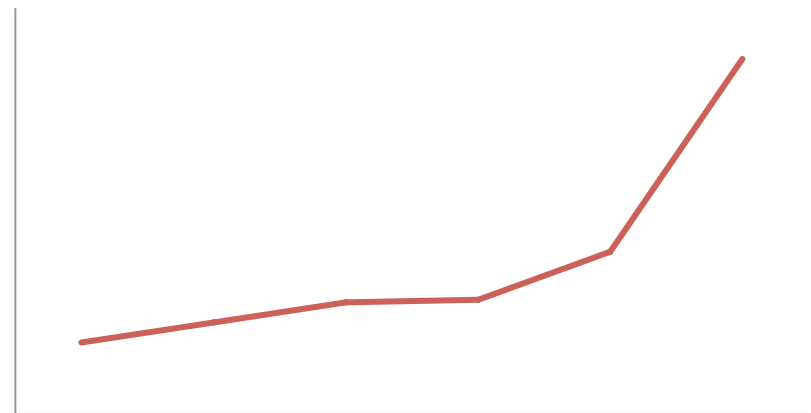
25 kg

### Sludge production in France

Mt

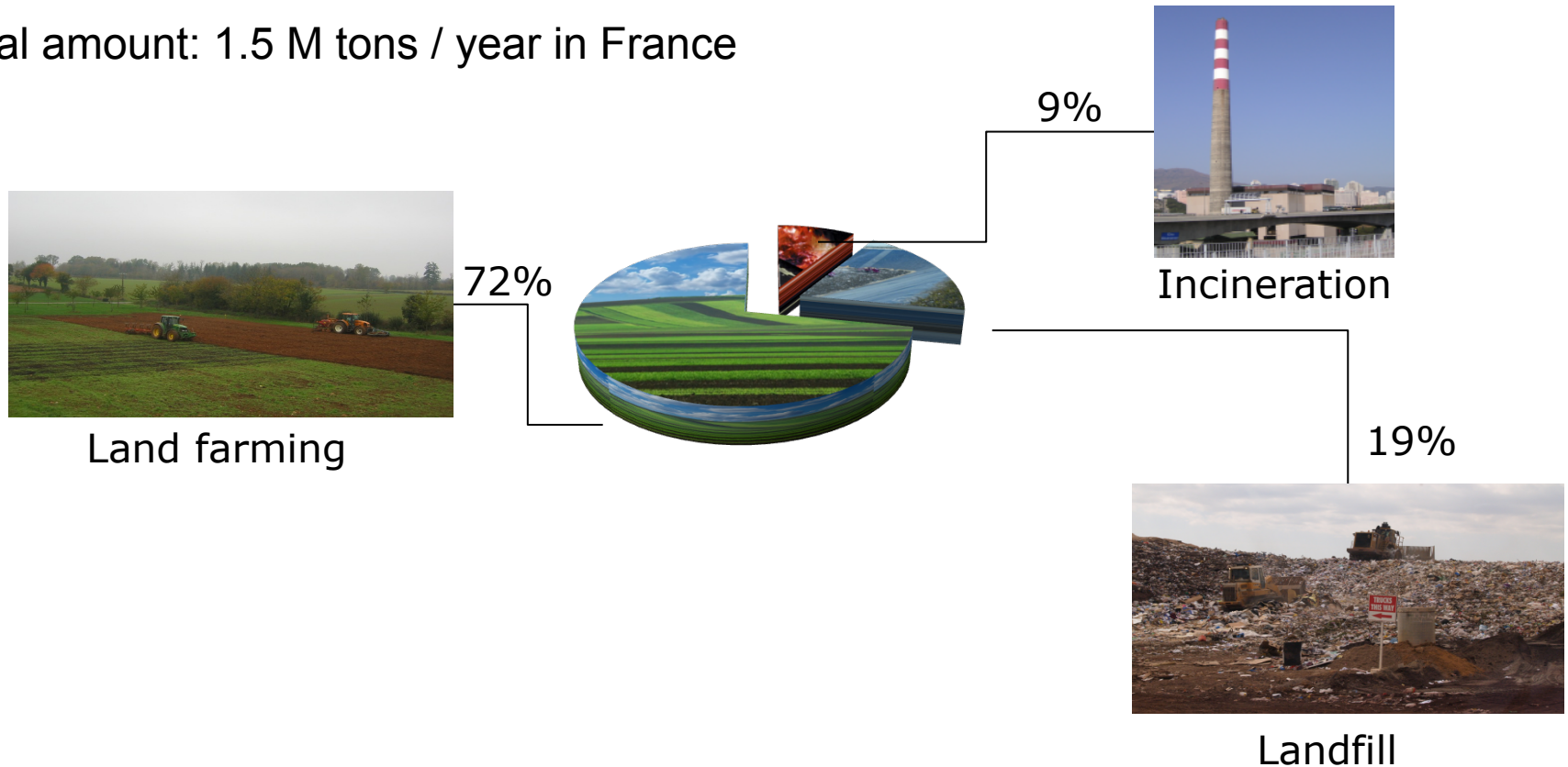
1,6  
1,5  
1,4  
1,3  
1,2  
1,1  
1,0  
0,9  
0,8

2003 2004 2005 2006 2007 2012



# Sewage sludge disposal

Annual amount: 1.5 M tons / year in France



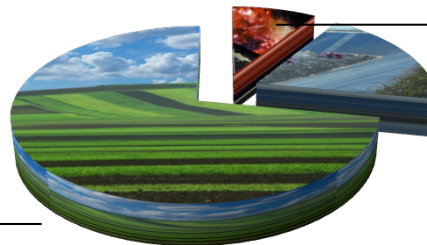
# Sewage sludge disposal

Annual amount: 1.5 M tons / year in France



Land farming

72%



9%



Incineration

19%



Landfill

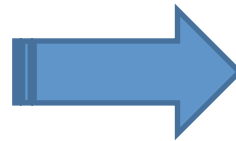
Changes in European law will induce :

1. Increase in production of sludge  
(13 M tons expected in Europe in 2020)
2. End to unsustainable recovery methods

If we don't want to be submerged ....



Drying process

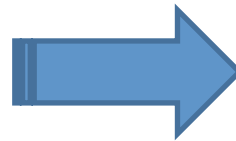


Reduce the volume

If we don't want to be submerged ....



Drying process



Reduce the volume

Aim of the study : Characterise the biomass

- > Understand impact of drying processes on sludge organic matter (OM) characteristics
- > Propose elements to optimise disposal and / or re-use of WWS

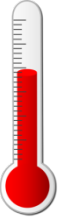








Thermal drying



Solar drying

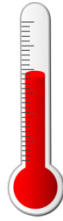


Reed beds drying





Thermal drying



Large WWTP : > 100,000 PE

LF-0

LF-85

pellets

LF-120

Fertilizer

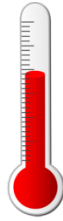


hours





Thermal drying



Large WWTP : > 100,000 PE

LF-0

LF-85

pellets

LF-120

Fertilizer



hours



Solar drying



Medium WWTP : > 2,000 PE

Solar-0

Solar-2w

Solar-4w

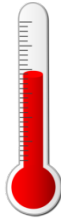
Amendment



month



Thermal drying



Large WWTP : > 100,000 PE

LF-0

LF-85

pellets

LF-120

Fertilizer



hours



Solar drying



Medium WWTP : > 2,000 PE

Solar-0

Solar-2w

Solar-4w

Amendment



month



Reed beds drying



Small WWTP

RB-0

RB-1

RB-2

RB-3

RB-4

Amendment



years

# OM characterisation

## Bulk scale

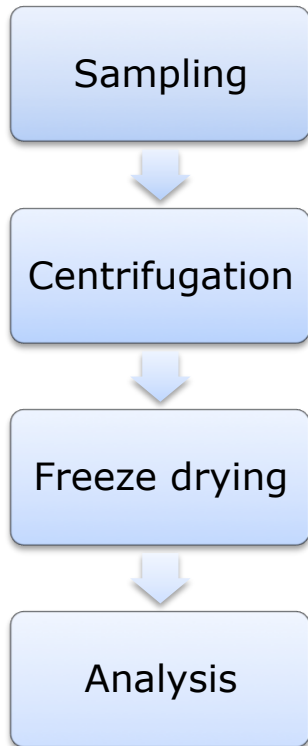
1. Elemental analysis (C, H, N)
2. Infra-red spectroscopy (ATR-FTIR)
3. Thermal differential analysis (TDA)

## OM fractionation

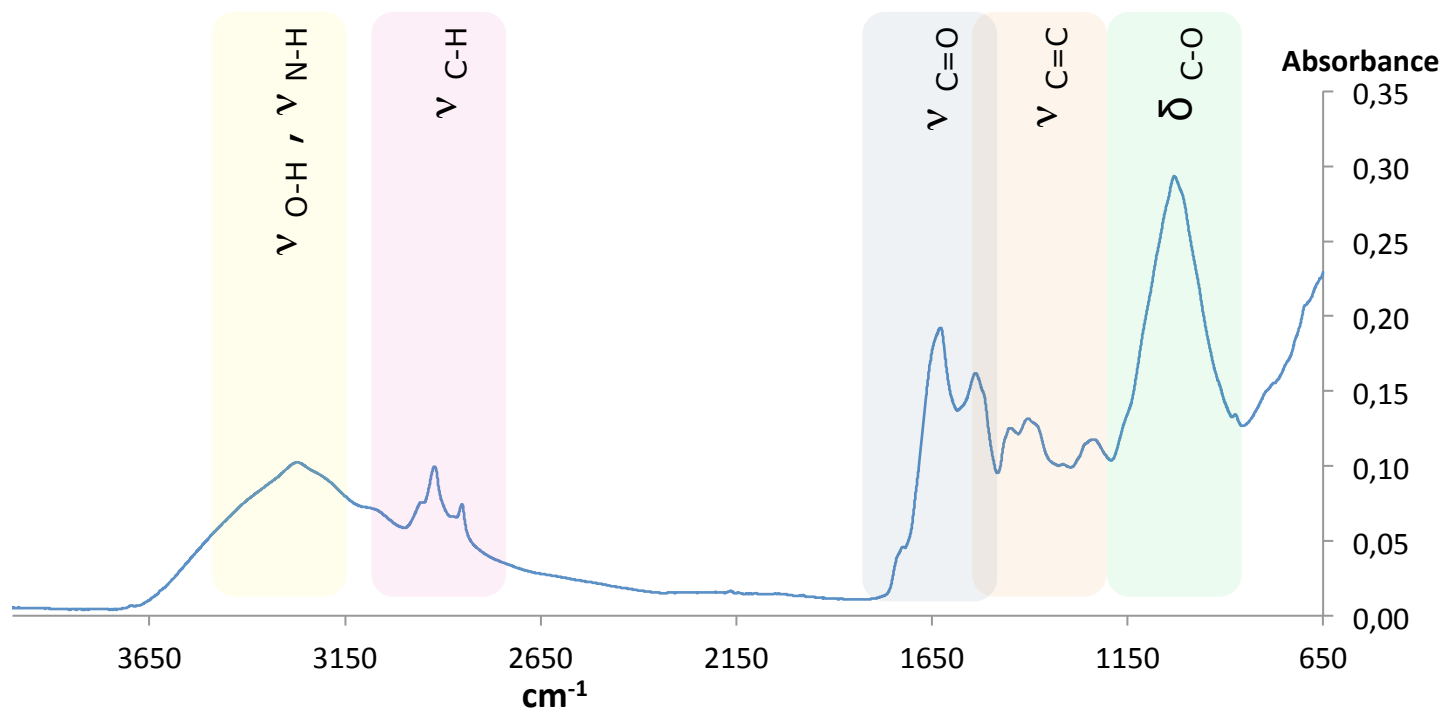
Lipids, Fulvic acids, Humic acids, Humin

## Molecular scale

1. Double shot pyrolysis (Py-GC/MS)



# ATR-FTIR

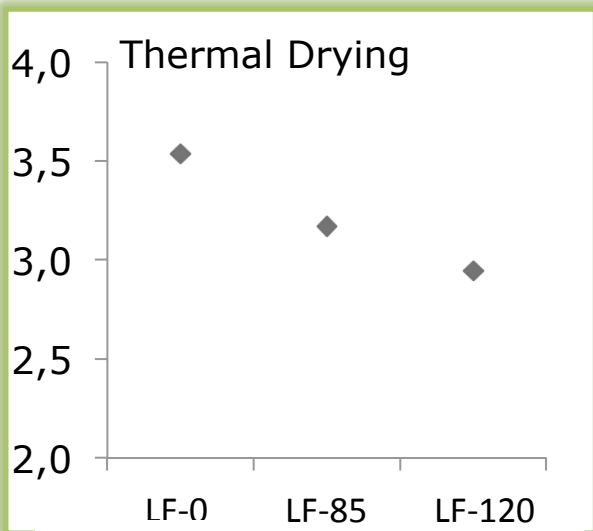


Identification of bands in OM as sample fingerprints

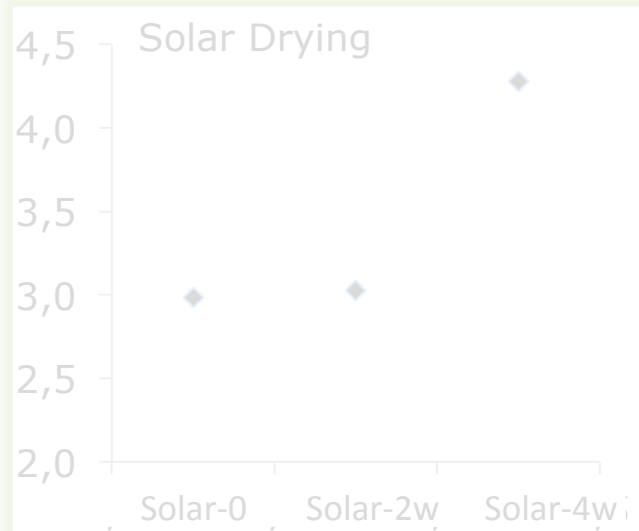
Monitoring of transformation of OM such as aromatisation (C=C), oxidation (C-O)

# ATR-FTIR

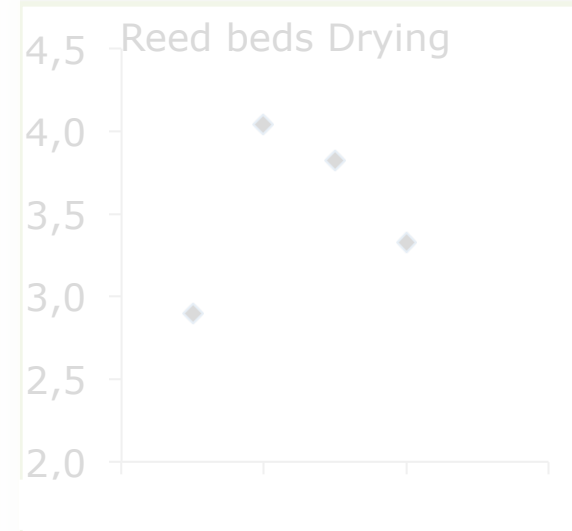
C-O/C-H ratio



Reduction process



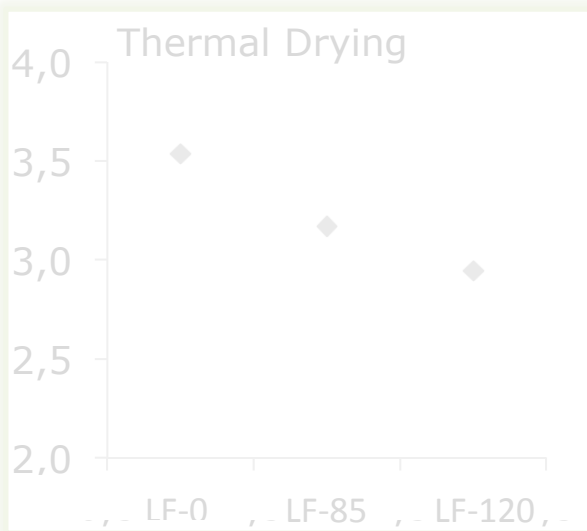
Biological oxidation



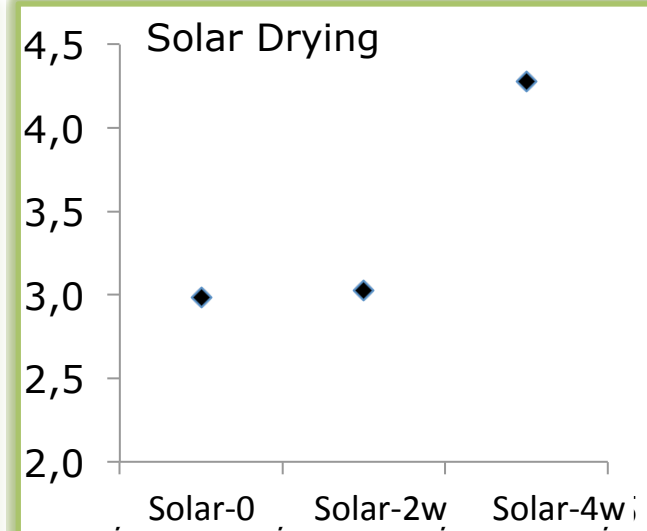
?

# ATR-FTIR

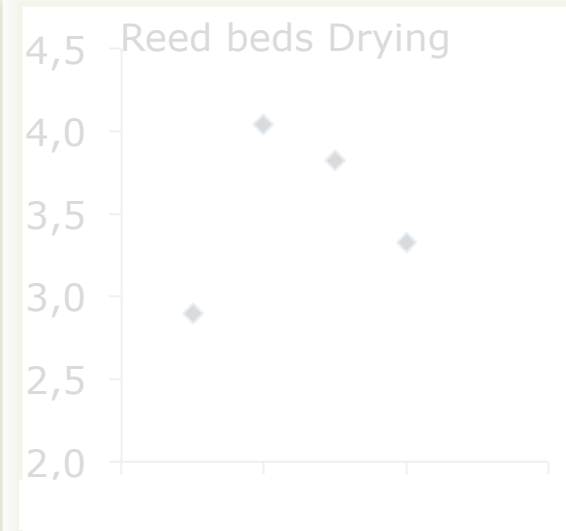
C-O/C-H ratio



Reduction process



Biological oxidation

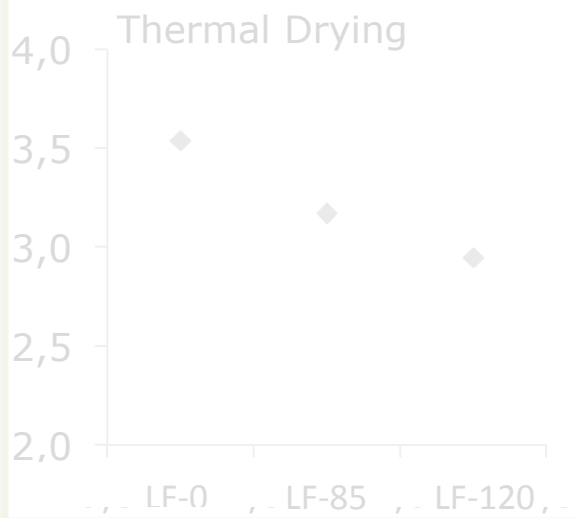


?

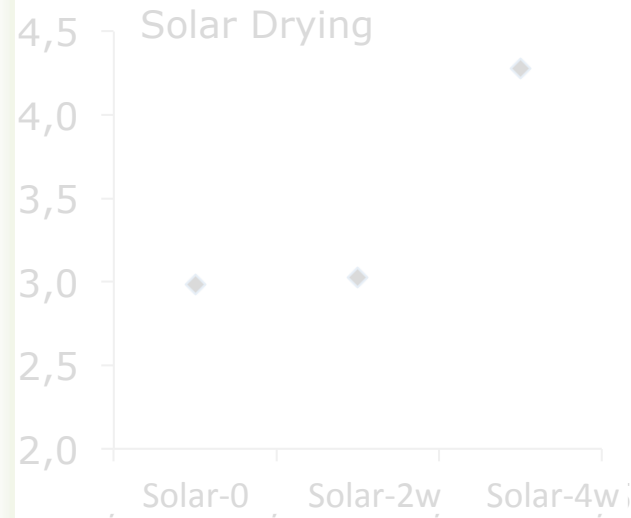


# ATR-FTIR

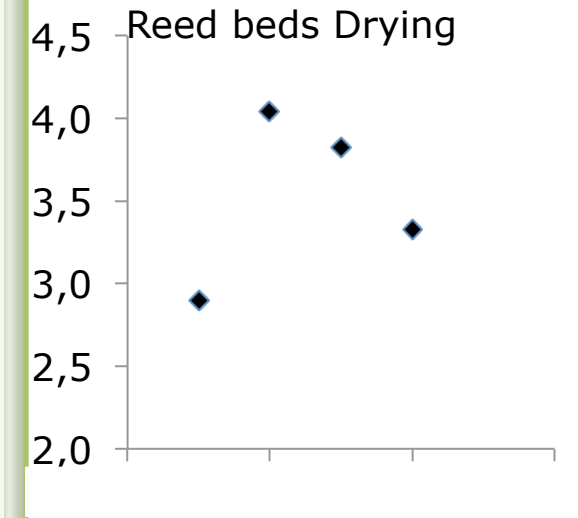
C-O/C-H ratio



Reduction process

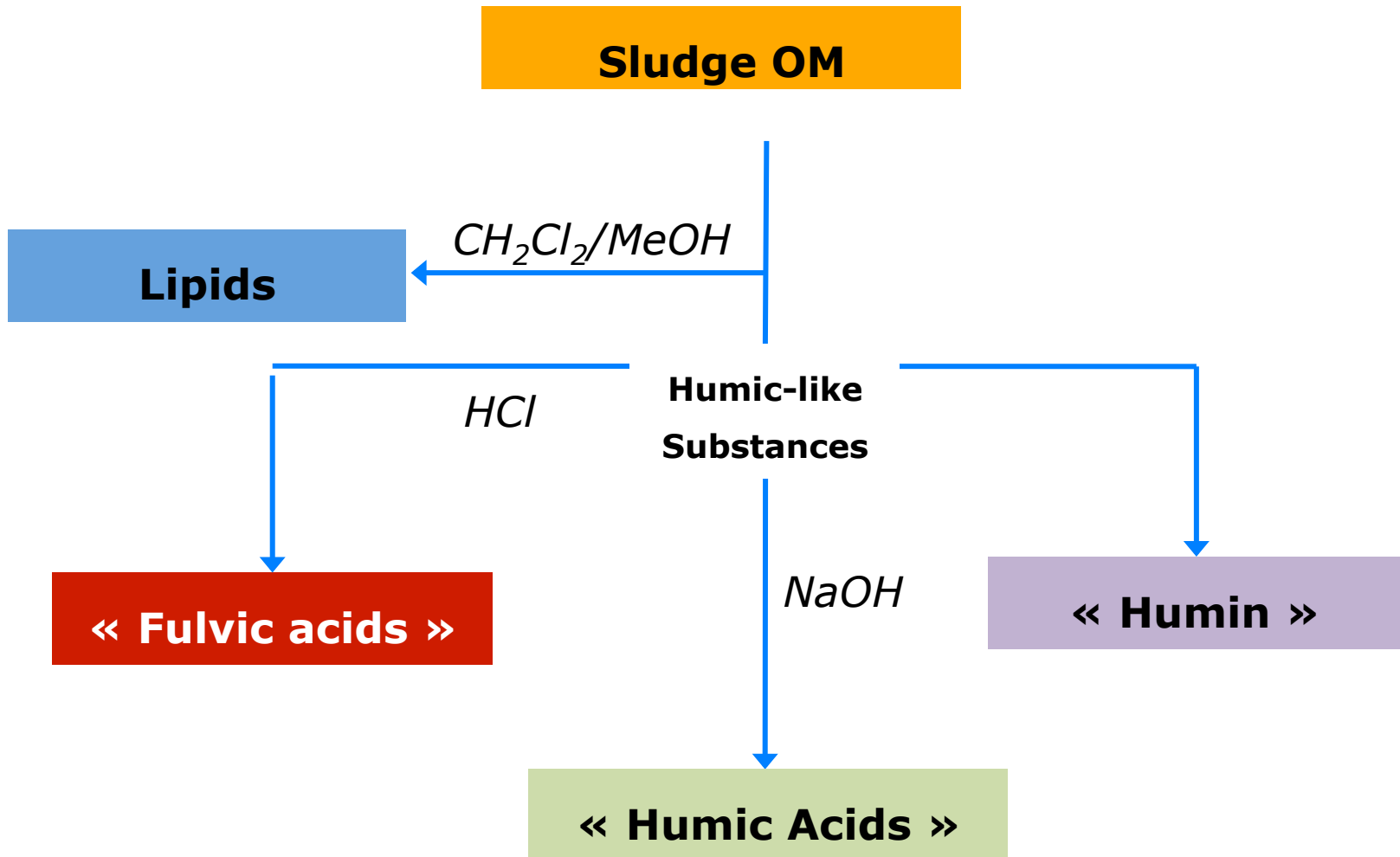


Biological oxidation

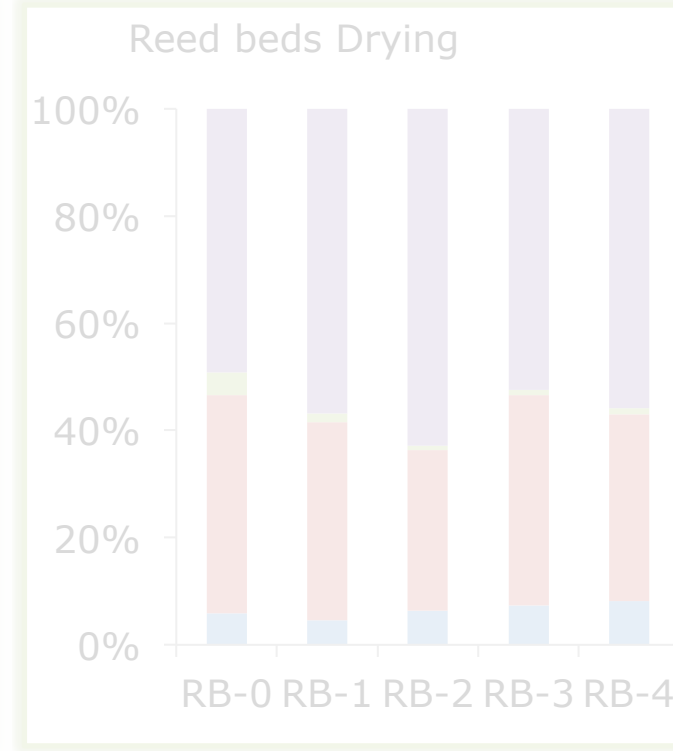
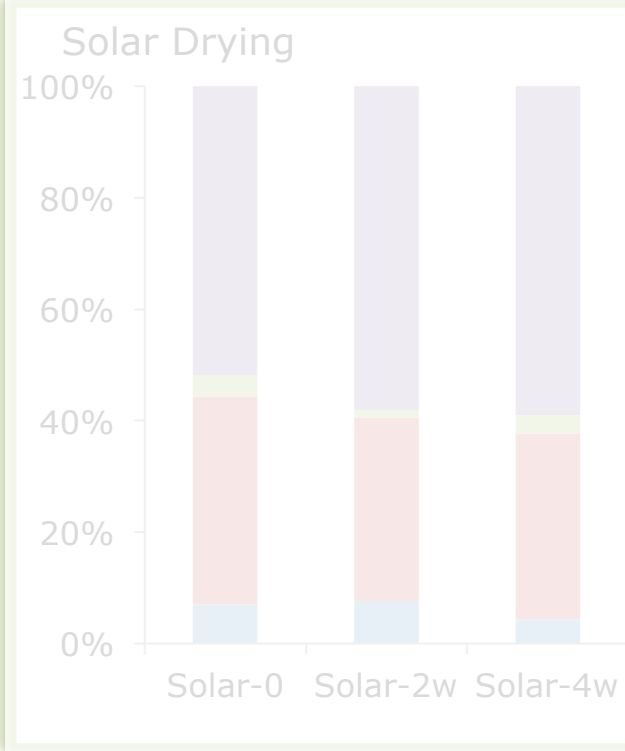
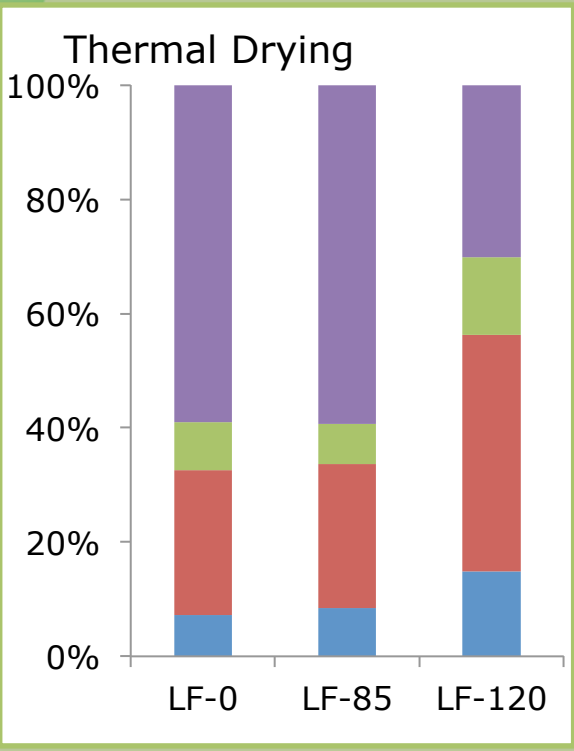


?

# Organic matter fractionation



# OM fractionation



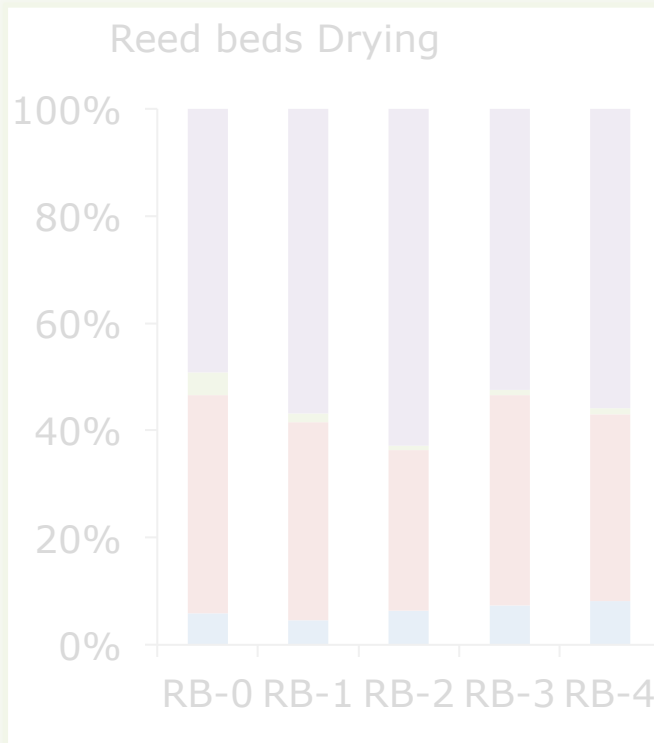
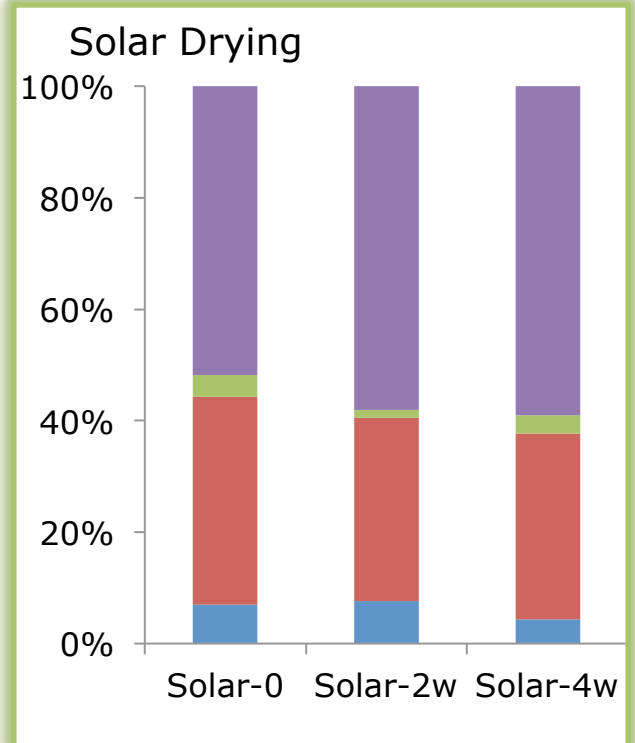
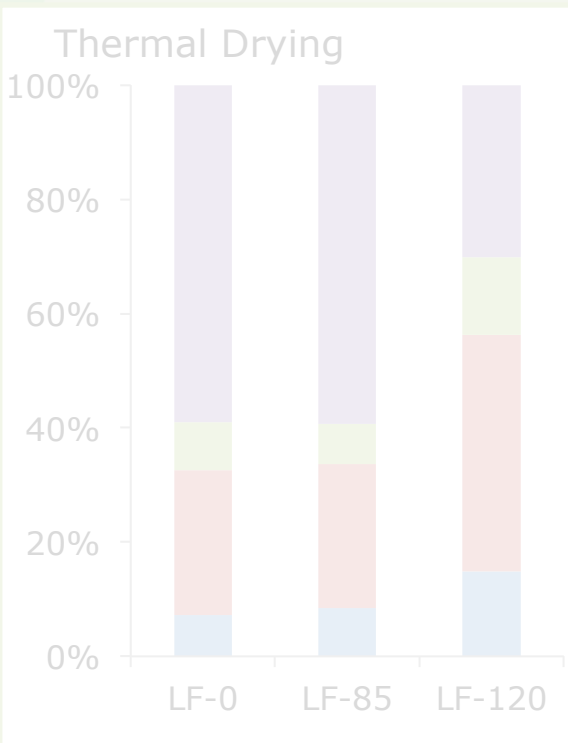
OM weakening

2w: OM complexification  
4w: biodegradation

?

- Humin
- Humic acids
- Fulvic acids
- Lipids

# OM fractionation



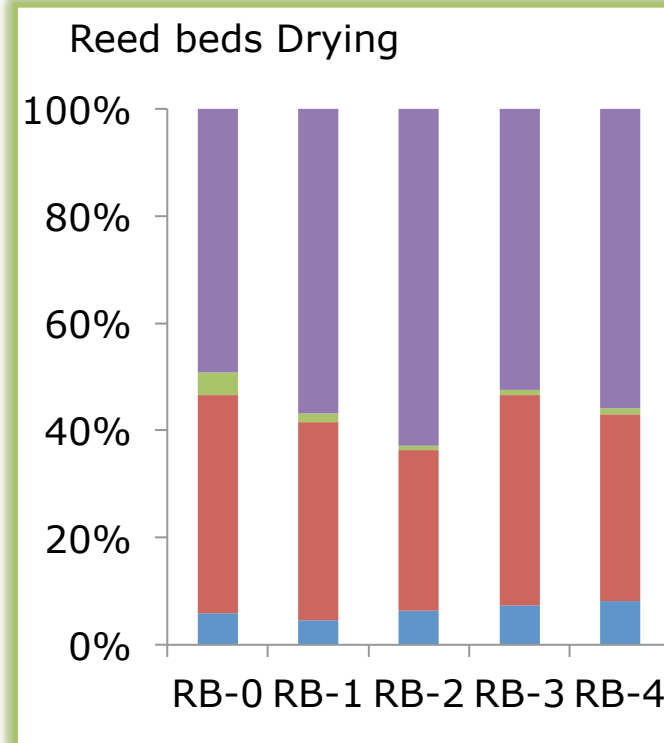
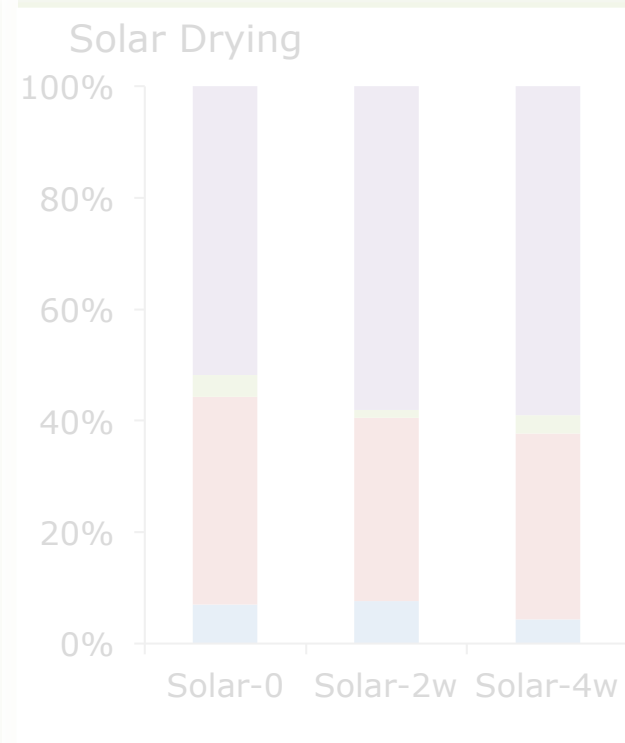
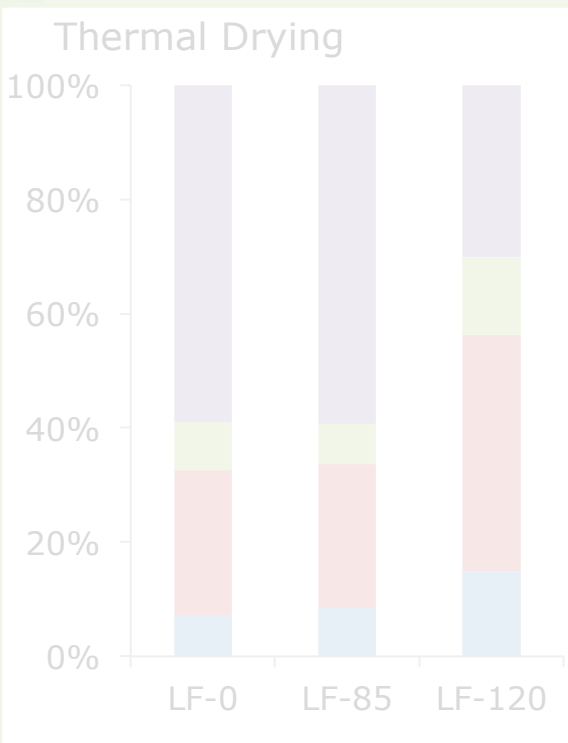
OM weakening

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# OM fractionation





OM weakening

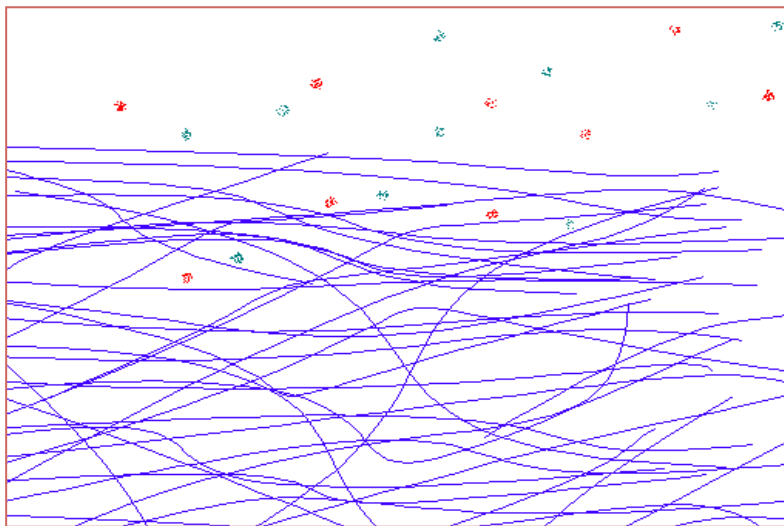
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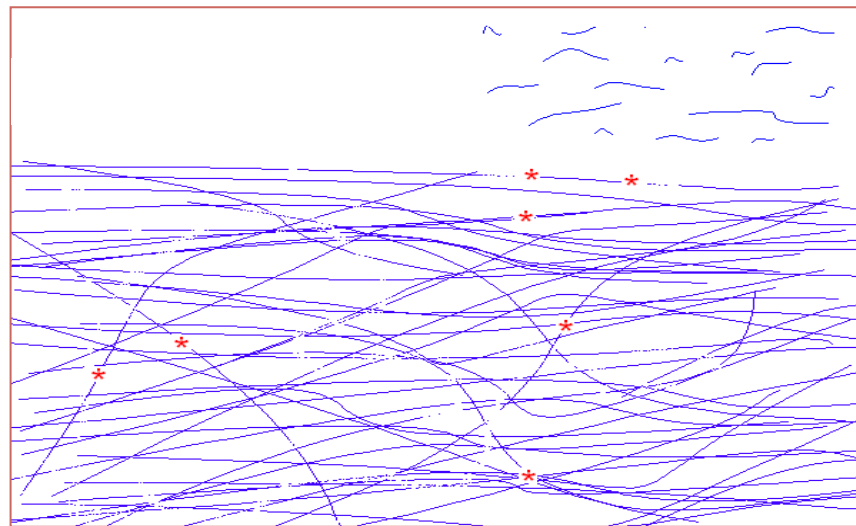
# Double Shot Thermochemolysis (Py-GC/MS)

Small Molecules   
Matrix 



1<sup>st</sup> shot : Warm

Trapped compounds are desorbed

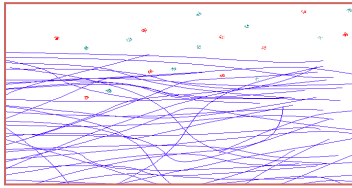


2<sup>nd</sup> shot : Hot

Polymers degrade into volatile molecules

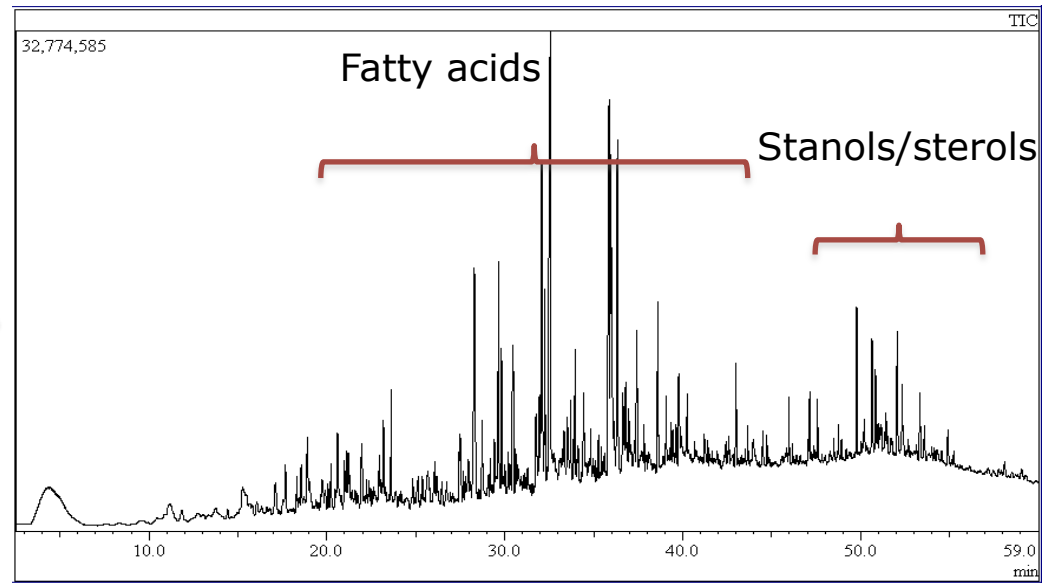
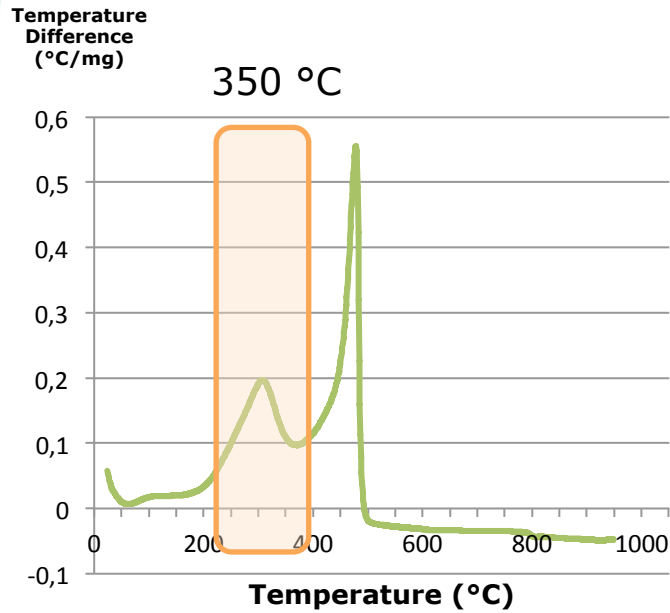
**GC-MS**

# First Shot



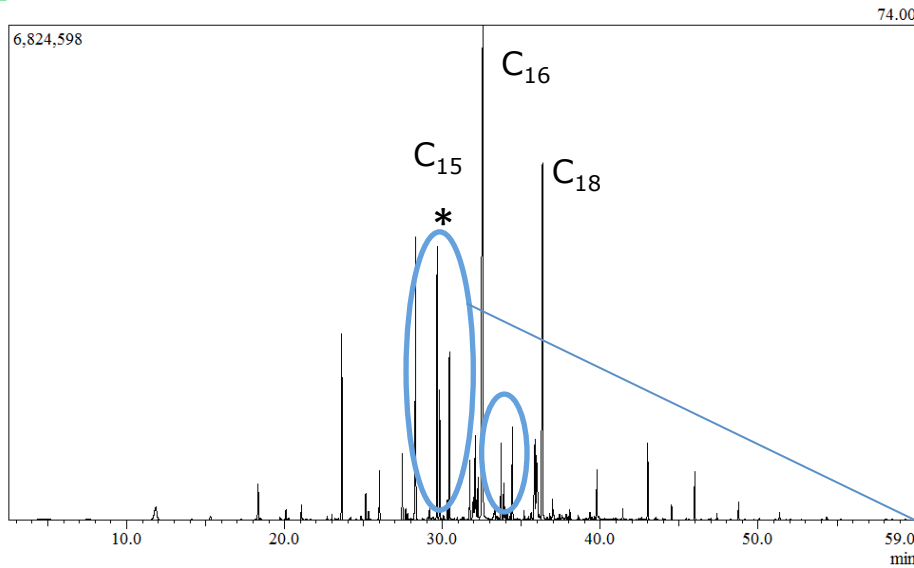
Warm

TDA

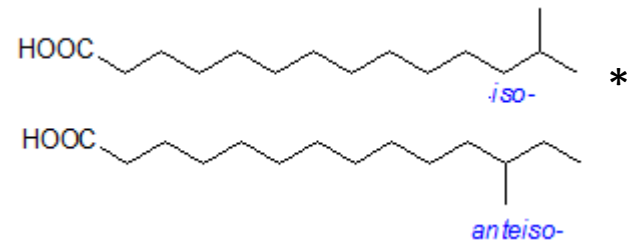


Pyrogram at 350°C of sludge

# Fatty acids



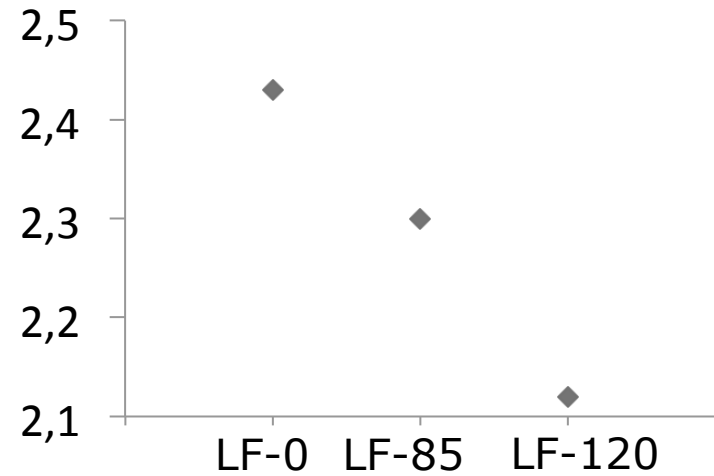
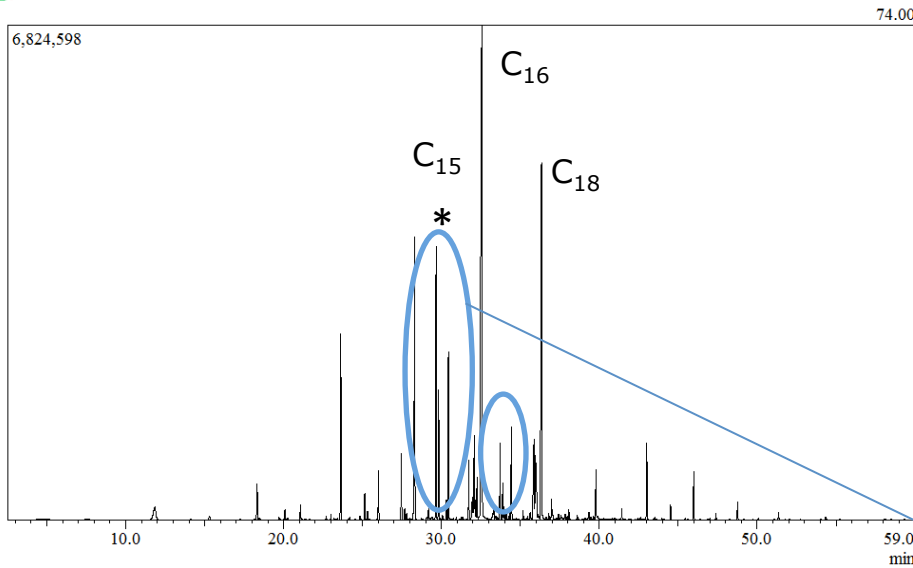
Plants



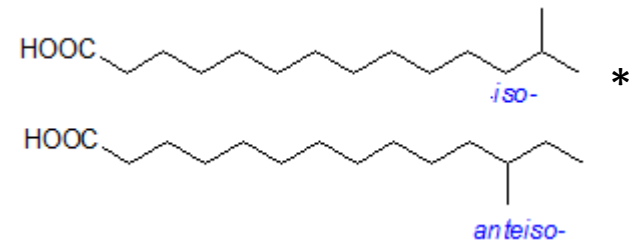
Bacterial origin



# Fatty acids

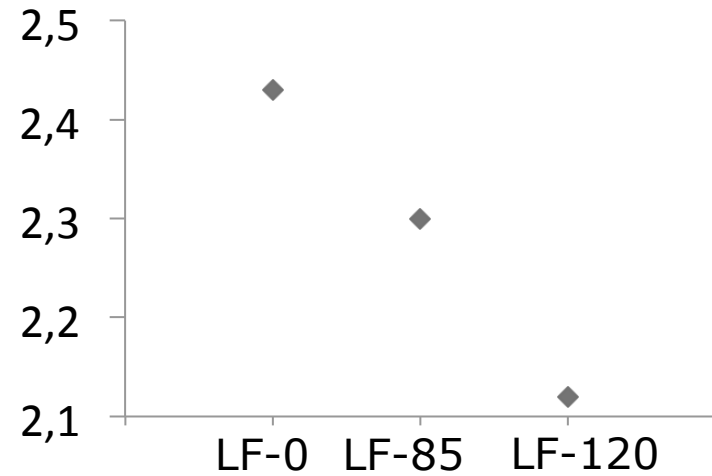
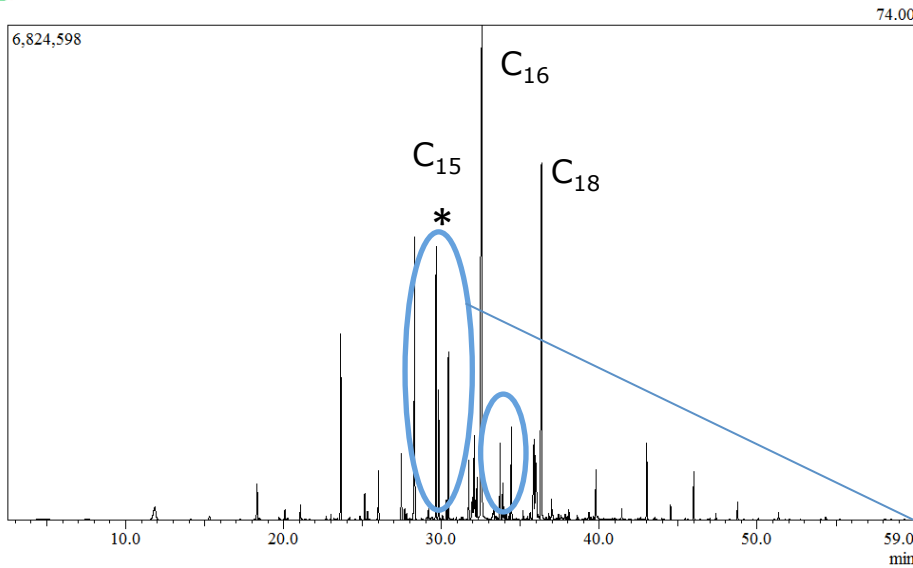


Thermal drying : decrease  
inhibition of bacterial activity



Bacterial origin

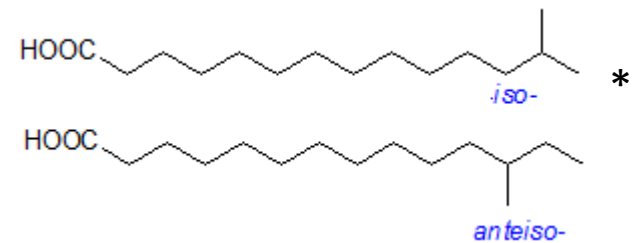
# Fatty acids



Thermal drying : decrease  
inhibition of bacterial activity

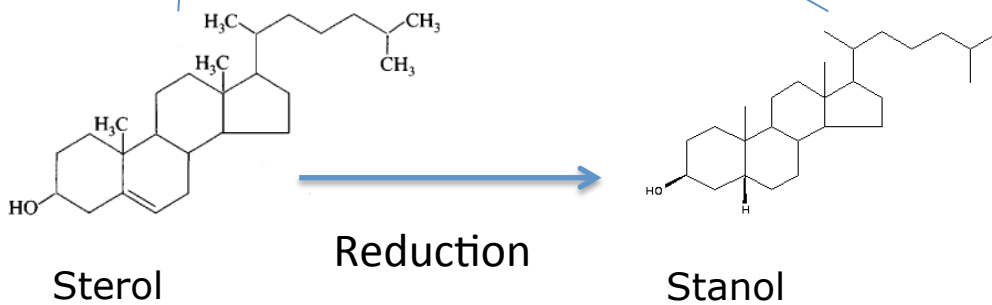
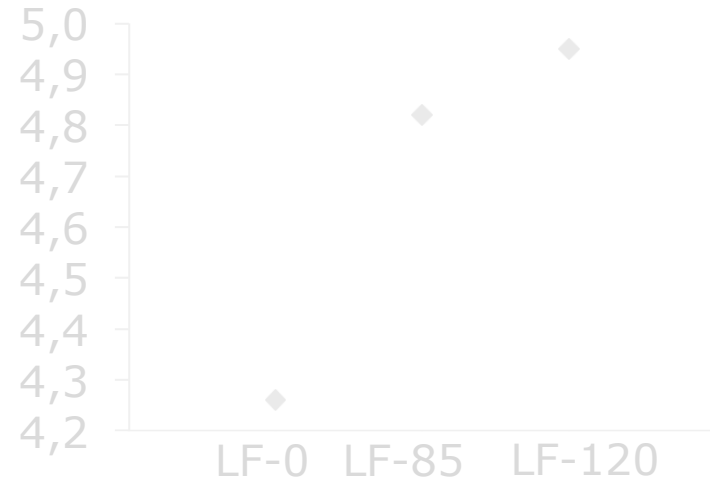
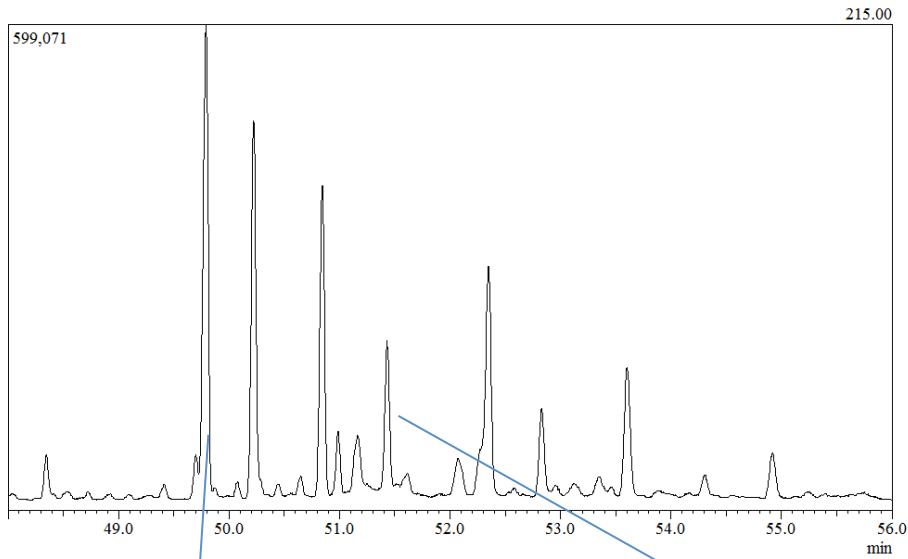
Solar drying : stable

Reed beds drying : stable

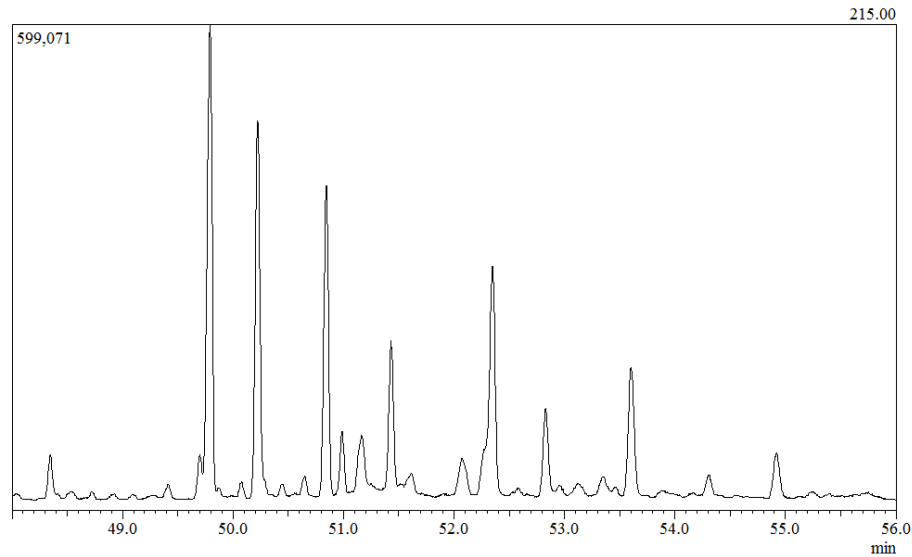


Bacterial origin

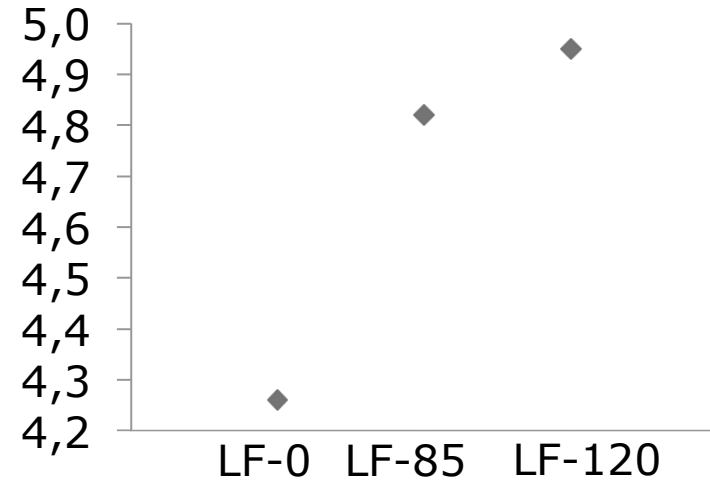
# Steroids



# Steroids



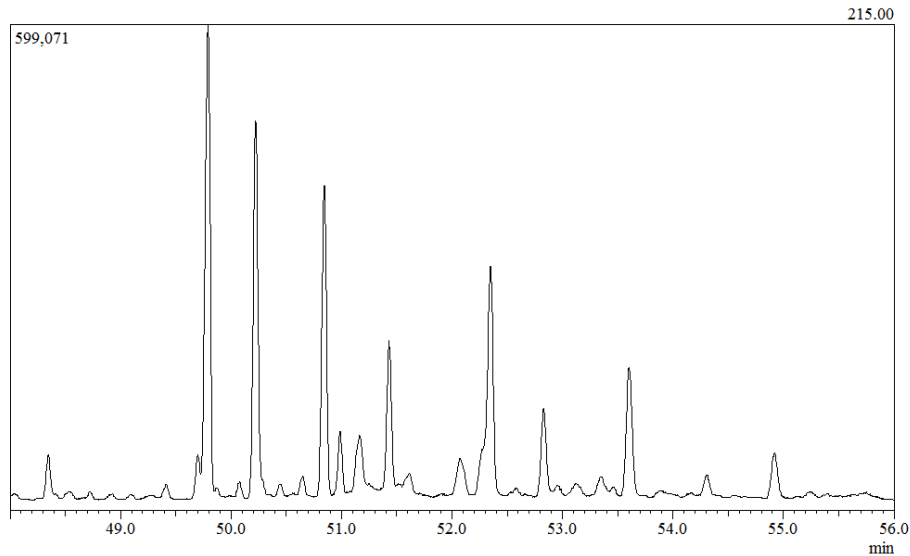
## Stanols/ Sterols



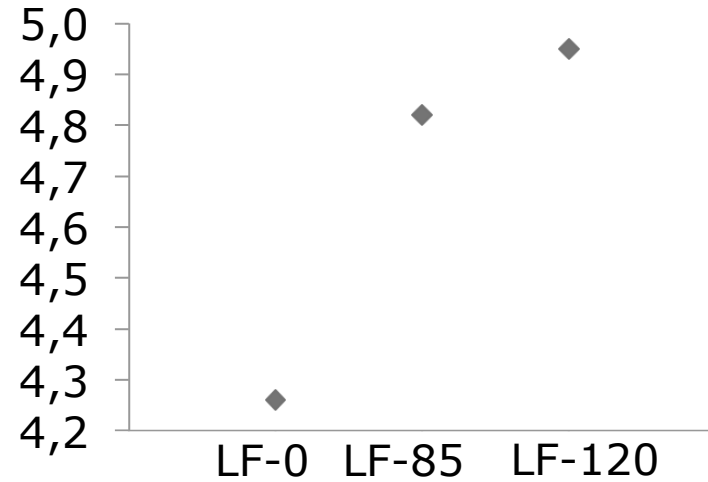
Thermal drying: increase

inhibition of bacterial activity

# Steroids



## Stanols/ Sterols



Thermal drying: increase

inhibition of bacterial activity

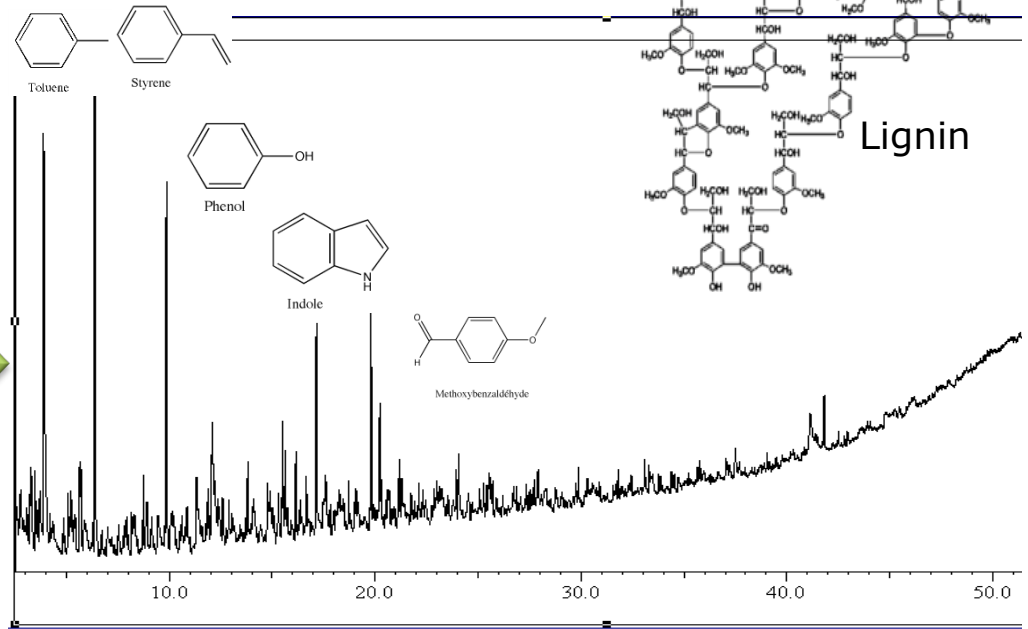
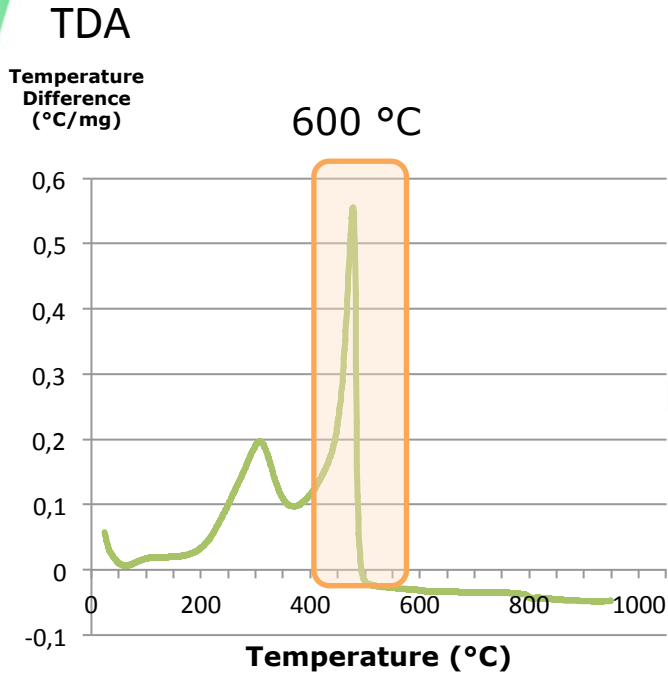
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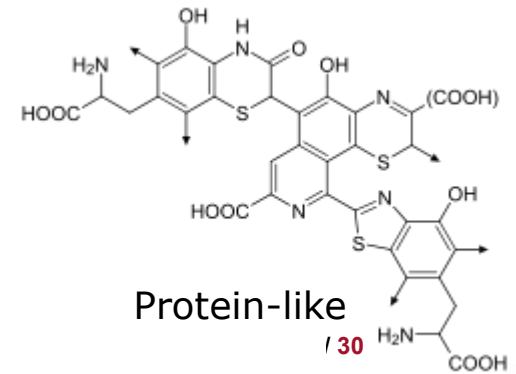


# Second Shot

Hot



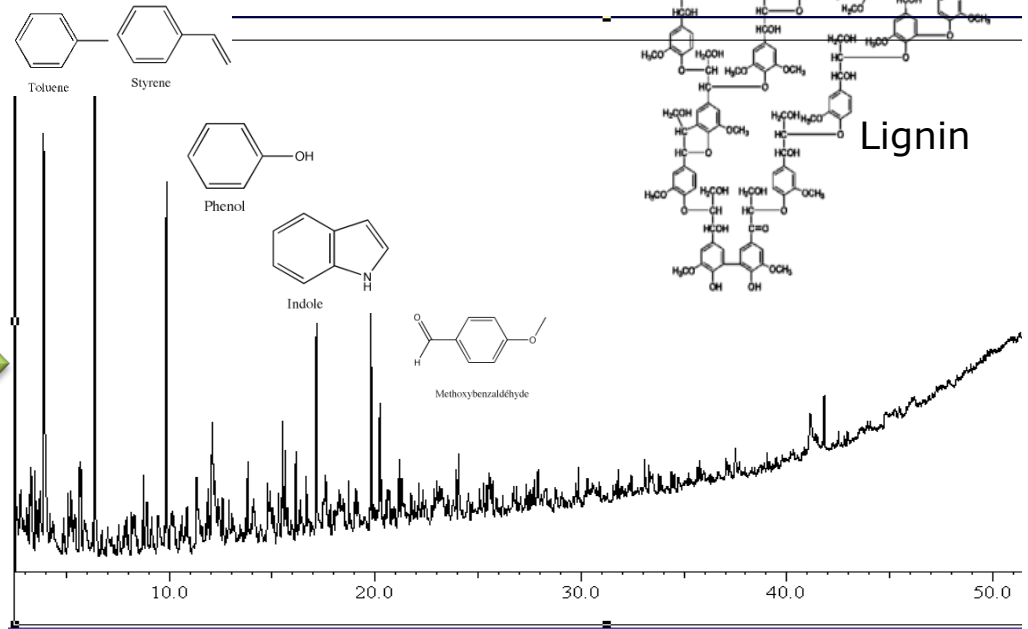
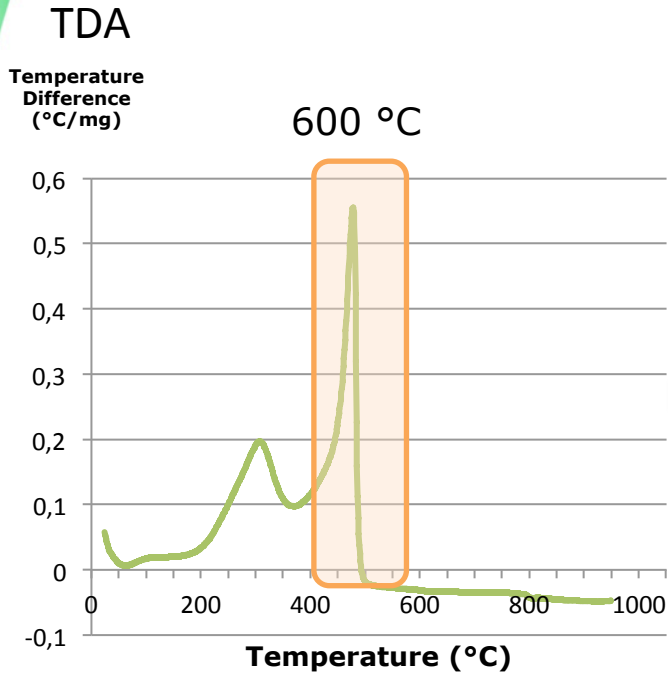
Monomers originating from biopolymers degradation





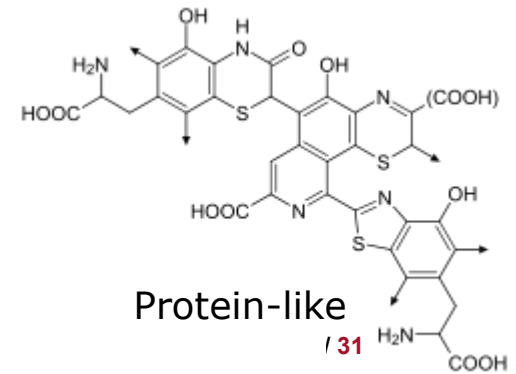
# Second Shot

Hot



Monomers originating from biopolymers degradation

No change induced by drying processes





# Conclusion

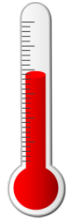






# Conclusion

## 1. Thermal drying : 4 hours heating process



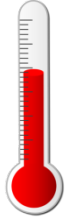
- weakening of organic matter
- inhibition of bacterial activity
- stable but biodegradable OM → better as fertilizer





# Conclusion

## 1. Thermal drying : 4 hours heating process



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- stable but biodegradable OM → better as fertilizer

## 2. Solar drying : 1 month in a greenhouse process



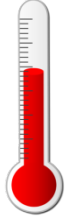
- 0-2w complexification of organic matter (Hu increased)
- 2-4w biodegradation (lipid decreased)
- humified OM → suitable for amendment





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## 3. Reed beds drying : years outdoor process

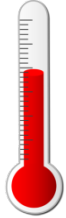


- surface sampling : characteristics close than of activated sludge
- perspectives : sample an older reed beds drying process



# Conclusion

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*Thank you for your attention*