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Olive mill waste compost as organic fertilizer

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The problem of olive mill wastes in the Mediterranean area

Olive mill wastes (OMWs): residues produced during the extraction of olive oil.

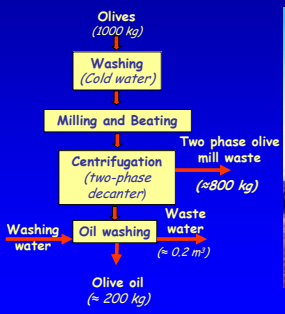
Spain
Italy
Greece
Turkey

High concentration of:
- Phenols,
- Lipids
- Organic acids

- Great quantities (millions of tons)
- Short periods of time

PHYTOTOXIC WASTES

Two phase extraction system



Available revaluation Options

- **Physical treatments**
  - a) Drying
  - b) Stone removal
  - c) Second extraction of oil
- **Physicochemical processes**
  - a) Combustion
  - b) Gasification
- **Biotechnological processes**
  - a) Anaerobic digestion
  - b) Solid fermentation
  - c) Composting

¿What is the best method to revalue TPOMW?

1. Amount of waste produced
2. Investment required to perform the treatment
3. Available land
4. Industrial or agronomic environment
5. Local laws, specific needs of the area, etc.

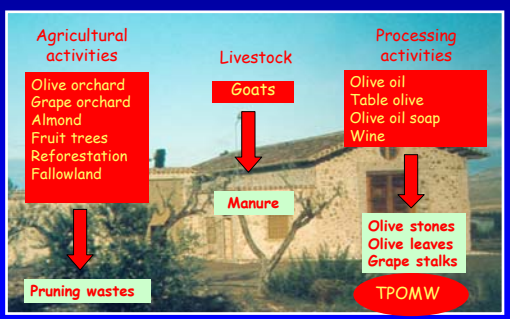
The majority of olive oil producer countries in Mediterranean area are exposed to desertification processes, so organic matter application would be beneficial to improve the soil fertility and control the erosion processes. Also in organic agriculture, the use of these by-products could represent an important source of nutrients, closing the cycle residues-resources.

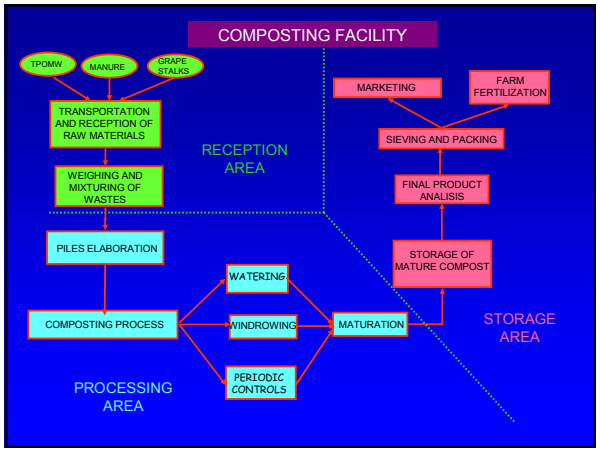
AIMS

Recycling of two-phase olive mill waste through composting for the production of a fertilizer that can be used in organic farming.

- Determining the composition and proportion of mixtures
- Establishing the best composting conditions in order to normalize the process
- Studying chemical and biological parameters that define the quality and maturation degree of the final composts
- Comparing the composts obtained with different current quality standards

Description of the farm (SAT 1870 Casa Pareja)





Main chemical characteristics of Two-Phase Olive mill waste

Parameters	Sample: 1	2	3	4	5	6	7
M (%)	64.4	63.5	63.1	65.8	57.8	67.8	68.8
OM (%)	92.1	95.1	95.5	94.1	96.4	94.0	93.0
TOC(%)	53.8	53.9	58.8	53.0	60.0	53.1	52.8
TN(g·kg^{-1})	12.7	10.7	11.5	12.9	9.7	10.6	11.0
TOC/TN	42.3	50.5	51.3	41.0	61.7	50.0	48.0
pH	5.23	5.28	5.53	5.31	5.03	5.26	4.99
EC (dS·m^{-1})	4.97	5.31	5.40	5.28	3.97	6.00	5.75
Lipids (%)	16.0	20.8	--	15.6	--	19.0	18.6
Lignin (%)	42.2	43.3	55.6	44.6	56.0	44.4	46.2
Hemicellulose (%)	32.2	33.2	44.0	38.1	48.9	35.4	39.4
Cellulose (%)	16.2	16.6	17.5	20.1	15.0	14.8	15.7
Polyphenols (%)	12.9	15.0	11.8	10.0	10.8	12.5	12.4
Carbohydrates (g·kg^{-1})	123.3	163.9	32.0	49.7	148.1	72.5	83.1
P (g·kg^{-1})	0.9	0.9	0.8	1.4	0.9	1.2	0.3
K (%)	2.7	2.9	2.2	2.4	1.7	2.7	--

HEAVY METALS IN TPOMW

(mg·kg^{-1})	1	2	3	4	5	6	7
Fe	462	171	331	429	177	570	1540
Cu	22	22	18	15	13	14	18
Mn	14	13	11	13	10	14	17
Zn	13	16	12	21	21	22	19
B	63	60	38	48	62	96	--
Pb	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Cd	n.d	n.d.	n.d	n.d.	n.d.	n.d.	n.d.
Ni	12	n.d.	8	9	n.d.	n.d.	9
Cr	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

Detection limits (mg·kg^{-1})
Pb: 5; Cd: 1; Ni: 4; Cr: 2

Main Chemical Characteristics of Conditioning Agents

	Grape stalks (GS)		Manures (M)				
Parameter	GS1	GS2	M1	M2	M3	M4	M5
M (%)	61.2	45.1	24.6	36.7	41.8	17.0	20.3
OM (%)	81.9	68.6	46.7	47.9	39.1	32.1	37.2
TOC(%)	42.7	40.9	25.5	32.3	21.6	17.3	18.9
TN(g·kg^{-1})	9.9	17.6	18.3	23.3	14.2	13.5	15.5
TOC/TN	43.1	23.2	14.0	13.9	15.4	12.8	12.2
pH	8.17	7.97	8.40	8.82	8.96	8.95	8.64
EC (dS·m^{-1})	1.60	3.32	3.90	10.61	9.94	5.43	4.76
Lipids (%)	0.7	0.4	1.1	--	0.4	0.5	0.5
Lignin (%)	41.8	43.2	24.8	--	--	--	18.4
Hemicellulose (%)	19.6	18.3	6.2	--	--	--	12.5
Cellulose (%)	39.0	22.6	16.2	--	--	--	8.7
Polyphenols (%)	2.4	0.18	2.6	--	0.21	0.13	0.16
Carbohydrates (g·kg^{-1})	7.0	9.0	7.3	--	7.8	5.7	7.0
P (g·kg^{-1})	0.7	1.8	3.3	2.4	3.1	2.1	2.1
K (%)	3.4	2.1	3.3	--	2.1	--	--

Heavy metals in conditioning agents

	Grape Stalks (GS)		Manures (M)				
Metals (mg·kg-1)	GS1	GS2	M1	M2	M3	M4	M5
Fe	957	4597	4108	4822	7500	7352	7467
Cu	23	28	45	28	37	35	30
Mn	42	80	127	148	151	150	153
Zn	15	46	72	102	102	91	82
B	54	119	83	--	--	--	233
Pb	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Cd	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Ni	16	30	51	68	40	39	87
Cr	13	--	36	--	50	56	79

Elaboration of Six Industrial Composting Piles by Windrow Turning

- TOC/TN ratio
- Texture
- Moisture
- Wastes availability
- Transportation costs
- Economic value

Mixture	Components	Proportion	Initial weight (tm)
1	TPOMW/M	60/40	40
2	TPOMW/M	40/60	45
3	TPOMW/M	50/50	45
4	TPOMW/M/GS	45/45/10	50
5	TPOMW/M/GS	70/15/15	35
6	TPOMW/M/GS	45/45/10	35

METHODOLOGIES USED FOR THE ELABORATION OF PILES

1. The appropriate amount of wastes was weighed. The bulking agents were spread on the composting pad making up a volcano shape.

2. TPOMW was collected in a truck from the storage tank

3. TPOMW was put into the bulking agent base

4. The wastes were mixed with a front loader tractor forming trapezoidal windrows.

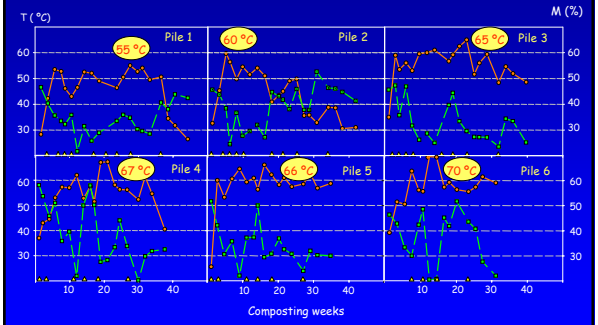
METHODOLOGIES USED FOR THE ELABORATION OF PILES

1. The TPOMW is directly collected from the storage tank into the mixer truck.

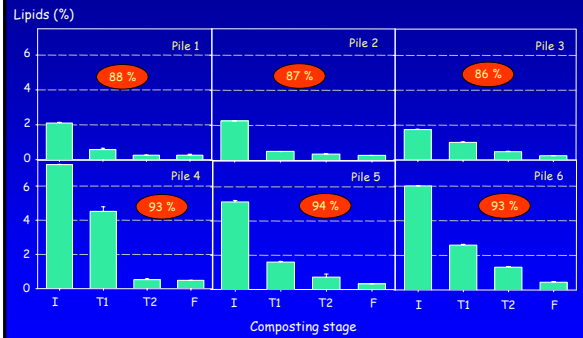
2. Manure and grape stalks are weighed and placed into the mixer truck by a conveyor belt.

INDUSTRIAL COMPOSTING PILES

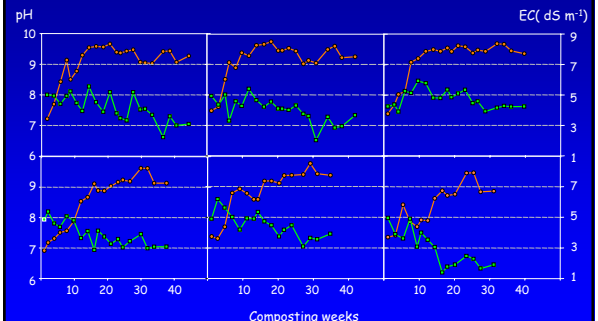
Temperature, moisture and turning frequency



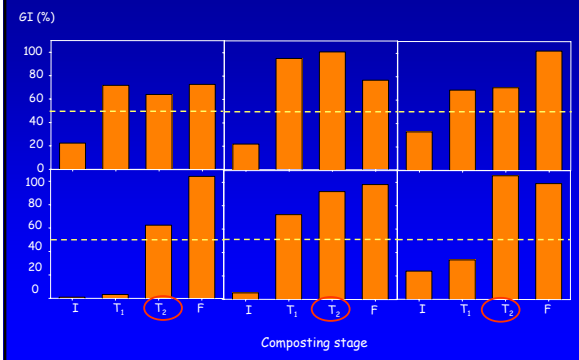
Evolution of Lipids concentration



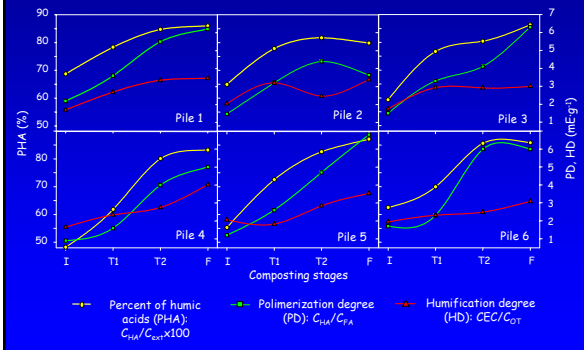
pH and electric conductivity



Germination index



Humification parameters



Main characteristics of composts

	C1	C2	C3	C4	C5	C6
OM (%)	34.9	38.9	46.6	48.6	40.8	46.7
TOC (%)	20.8	22.6	28.0	23.1	25.4	25.3
pH	9.27	9.25	9.35	9.13	9.37	8.86
EC (dS·m^{-1})	3.10	3.68	4.25	3.09	3.92	1.90
TN (%)	1.38	1.63	2.02	1.56	1.74	1.44
P_2O_5 (g·kg^{-1})	6.9	7.6	7.1	6.0	6.6	5.7
K_2O (%)	2.5	2.8	3.5	3.3	3.3	1.8
C_{HA} (%)	6.4	7.2	9.0	8.8	9.8	9.5
C_{FA} (%)	1.0	1.8	1.4	1.8	1.5	1.6
CEC (mE·100g^{-1})	67	70	76	76	78	72
Fe (g·kg^{-1})	7.9	8.0	6.7	6.5	7.7	7.3
Cu (mg·kg^{-1})	33	39	38	31	33	33
Mn (mg·kg-1)	36	42	33	29	34	32
Zn (mg·kg-1)	75	97	88	69	87	90
B (mg·kg-1)	72	87	82	74	76	77
F. coliforms (MPN/g)	<0.08	21.68	0.20	<0.08	<0.08	<0.16
F. streptococcus (MPN/g)	14.0	64.0	4.72	1.96	1.96	<0.8

Heavy metals in TPOMW composts

	TPOMW composts						Limits by some current standards						
mg·kg^{-1}	C1	C2	C3	C4	C5	C6	A	B	C	D	E	F	G
Cu	33	39	38	31	33	33	100	100	150	450	100	100	1500
Zn	75	97	88	69	87	90	300	200	400	1100	500	500	2800
Ni	79	107	80	81	66	103	50	50	75	120	62	62	420
Cr	89	120	78	68	51	77	100	100	150	270	210	210	1200
Cd	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1	0.7	1.5	3	3	3	39
Pb	8	7	7	7	7	4	100	100	150	150	150	150	300

A: European organic label.

B, C: Draft of the European directive on Biowastes.

D: Spanish Fertilizers Law.

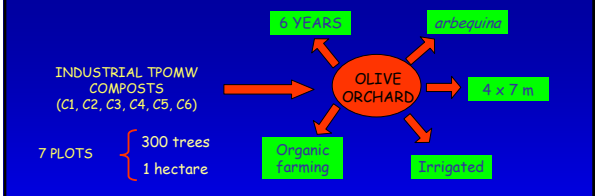
E: BNQ Canada (AA &A)

F: Australian compost standards

G: USA Biosolids

Special care when selecting manures as conditioning agents

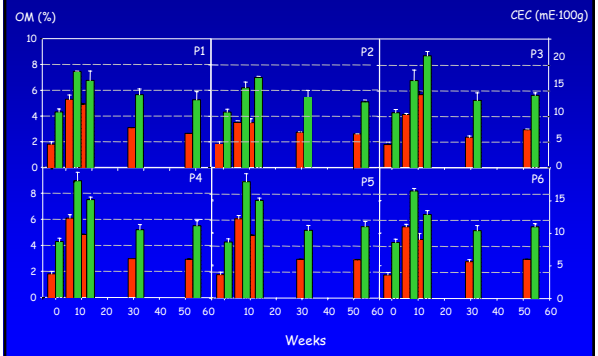
APPLICATION OF COMPOSTS TO OLIVE ORCHARD



1. View of the olive orchard when compost has just been added.

2. View of the olive orchard four months after compost application.

Evolution of OM and CEC



Foliar Nutrient status of olive orchard

	PRIOR TO COMPOST ADDITION	AFTER COMPOST ADDITION								
		1ST APPLICATION							2ND APPLICATION	
		CP	P1	P2	P3	P4	P5	P6	CP	P4
N (%)	1.6	2.0	1.9	2.0	2.0	2.0	1.9	1.9	1.7	1.7
P (%)	0.05	0.05	0.06	0.06	0.06	0.06	0.05	0.06	0.08	0.09
K (%)	0.8	1.0	1.0	1.0	1.1	1.0	1.0	1.0	0.7	0.9
Cu ($mg \cdot kg^{-1}$)	8	6	7	7	8	7	7	8	7	7
Mn ($mg \cdot kg^{-1}$)	36	43	40	39	40	40	42	41	34	36
Zn ($mg \cdot kg^{-1}$)	20	13	15	20	17	16	16	16	19	15
B ($mg \cdot kg^{-1}$)	78	76	67	57	69	54	53	83	44	45

Conclusions

- Composting is a feasible method of recycling TPOMW and of obtaining an agronomically acceptable product, free of heavy metals and phytotoxic substances. The process can be carried out at the processing facility, thus avoiding the high transportation costs associated with its disposal.
- The addition of a bulking agent such as grape stalks, improves considerably the aeration of the mixture, and therefore the composting process.
- In mature composts the TOC/TN ≤ 15, pH ≥ 9, GI ≥ 70%, PHA (CHA/Cextx100) ≥ 80%.
- The increase in OM and CEC in the soil was noticeable, even one year after the compost application. A higher phosphorus and potasium concentration was observed in the olive leaves of amended plots than in the control one.
- The product obtained can be used in accordance with organic farming regulations, contributing to the revalorisation of residues and the maintenance of the ecosystem. Nevertheless, olive tree responds slowly to fertilisation, so a long term research is currently being carried out in order to know the limitations and beneficial effects of a fertilization exclusively based in composts of TPOMW, GM and GS.

Thanks for your attention

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