

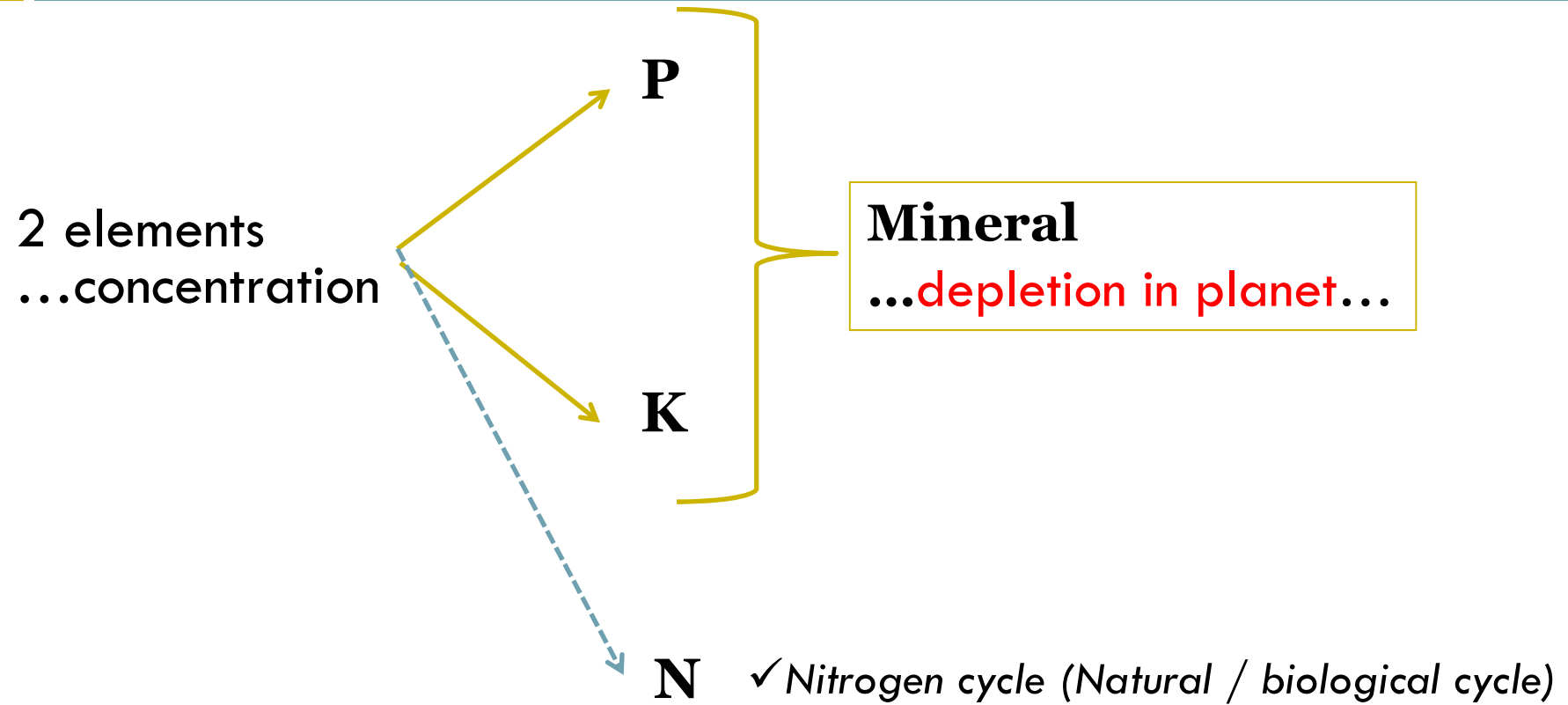


# SOLAR DRYING OF OLIVE MILL WASTEWATER WITH MANURE FOR THE PRODUCTION OF ORGANIC FERTILIZERS



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# The reason...



# Aim...



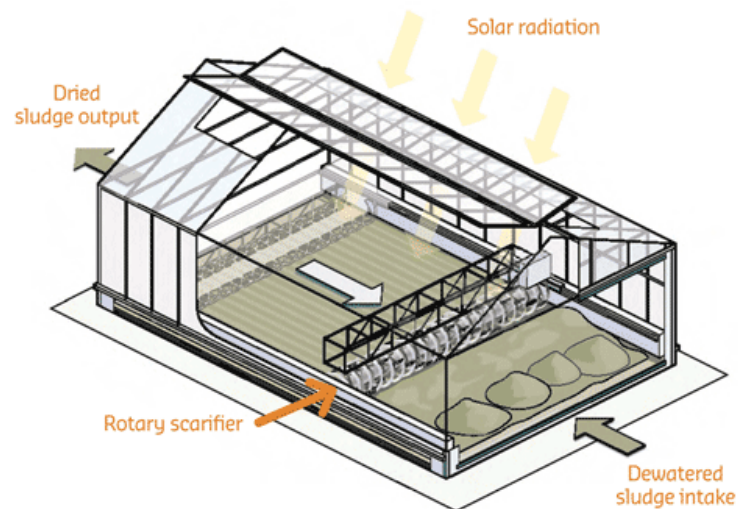
To determine if the condensation of manure, after composting and solar drying process, with addition of olive mill wastewater (OMW), for utilization of nutritive elements with low cost technologies can result or produce an alternative low cost ORGANIC FERTILIZER, rich in nutrients.

# Were used...

## 2 products



## 2 Technologies



# Process flow chart...



# 1<sup>st</sup> COMPOSTING... = COMPOSTING1

**Fresh manure**  
(pig, cow, poultry)



**Bulking Agents**  
(greens & brunches)

**Addition of OMW**



**Product**  
**COMPOST1**



# COMPOSTING1 – in windrows...



# COMPOSTING1 – in windrows...

## 3 windrows

### 1. COW manure windrow

- in 20m<sup>3</sup> product
- In 78 days
- Addition of 2.800lt

### 2. POULTRY manure windrow

- in 20m<sup>3</sup> product
- In 71 days
- Addition of 2.800lt

### 3. PIG manure windrow

- in 20m<sup>3</sup> product
- In 78 days
- Addition of 3.500lt



# 2nd COMPOSTING... = COMPOSTING2

**Fresh manure**  
(pig, cow, poultry)



**Bulking Agent**  
(COMPOST1)

**Addition of OMW**

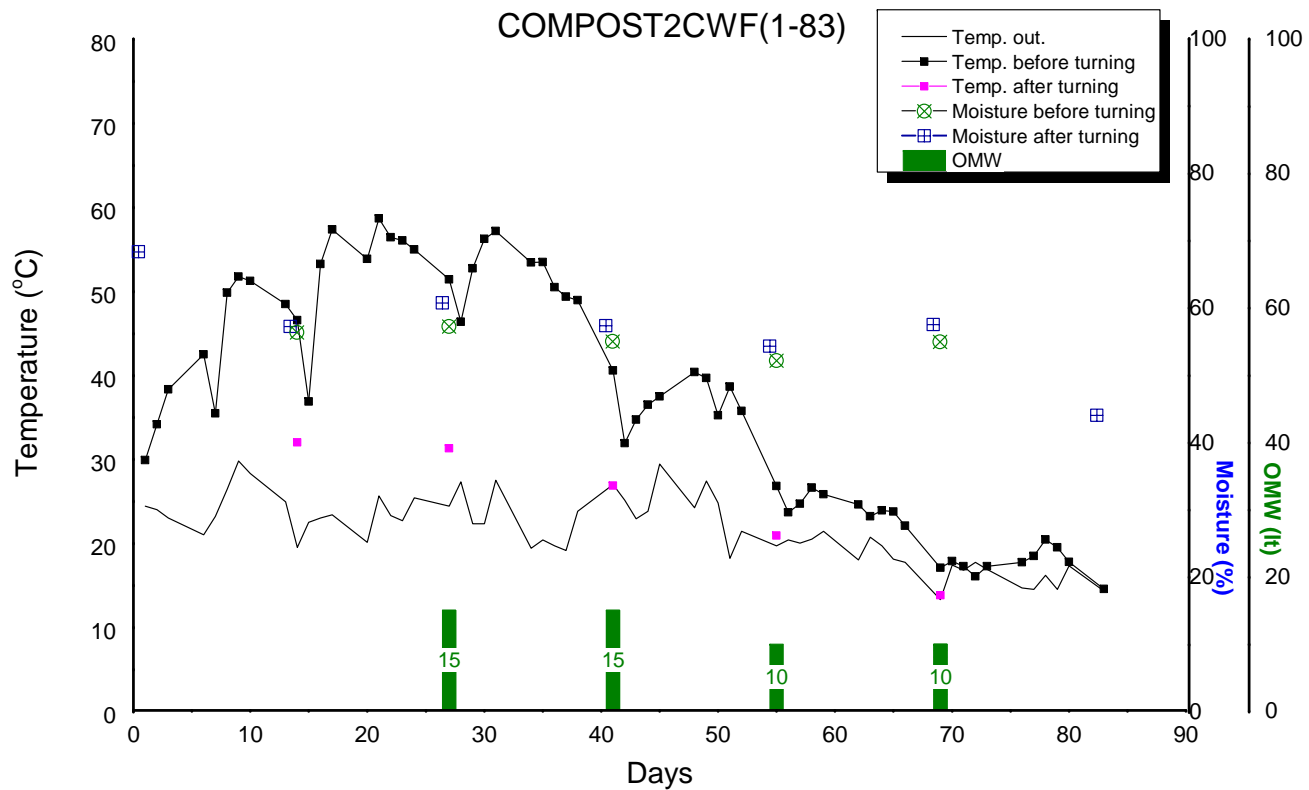


**Product**  
**COMPOST2**

# 2<sup>nd</sup> COMPOSTING - in composters



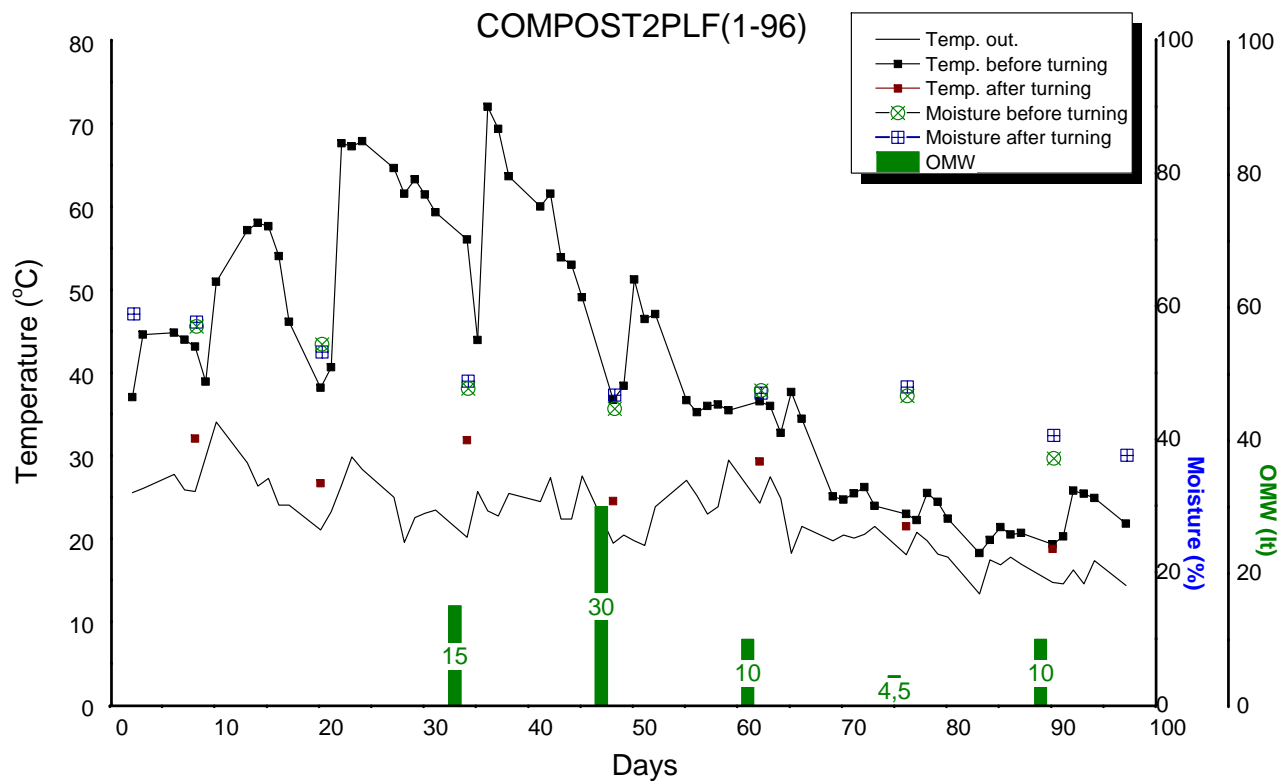
# Temperature profile in COMPOST2CW



## In COW manure

- ✓ 6 turnings
- ✓ 570lt compost
- ✓ 83 days
- ✓ 50lt OMW

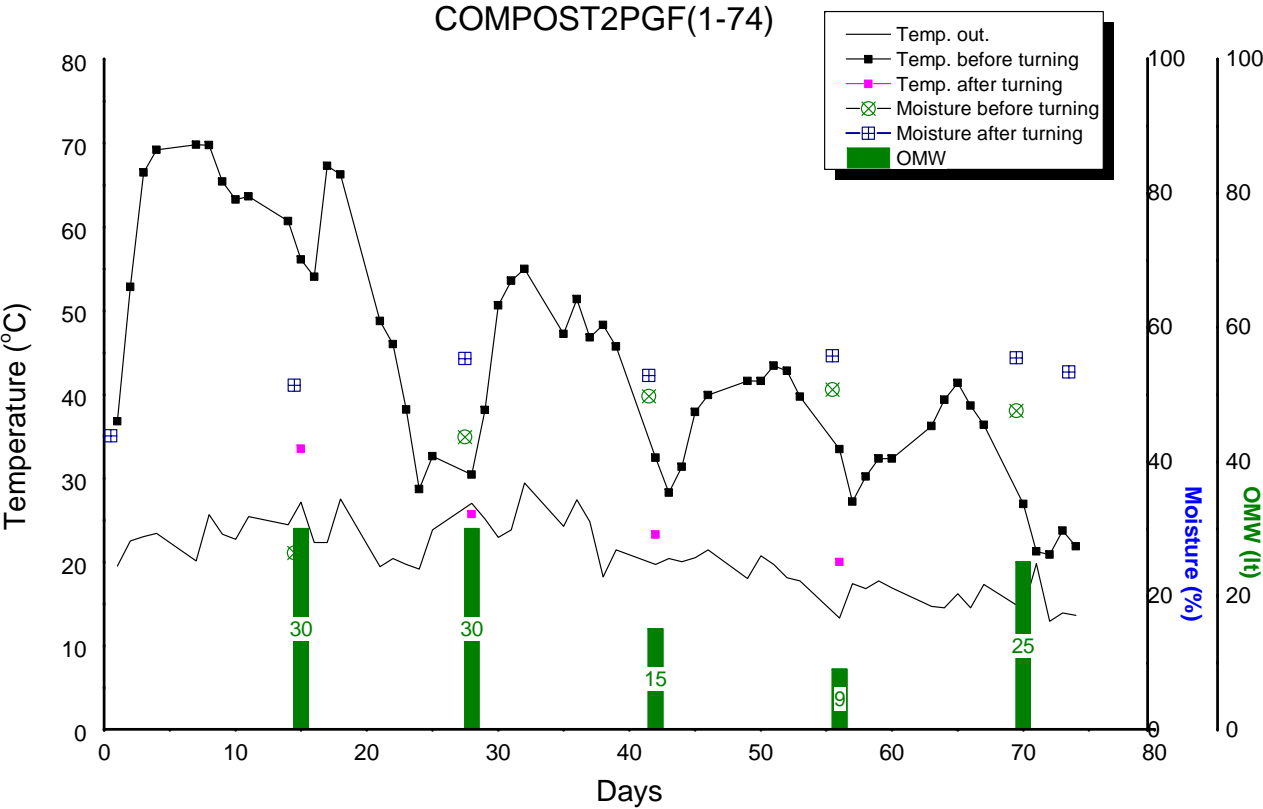
# Temperature profile in COMPOST2PL



## In POULTRY manure

- ✓ 8 turnings
- ✓ 51.5t compost
- ✓ 96 days
- ✓ 70t OMW

# Temperature profile in COMPOST2PG



## In PIG manure

- ✓ 6 turnings
- ✓ 510lt compost
- ✓ 74 days
- ✓ 110lt OMW

# DRYING COMPOST2...

Drying  
**COMPOST2**

Addition of OMW



**Final  
Product**



Drying for 55 days in thin layers... into the greenhouse...





Drying for 115 days in plastic tanks ... into the greenhouse...



# Physicochemical characteristics in fresh cow, poultry & pig manure...

## Fresh manure used in composting

Parameters	Cow manure	Poultry manure	Pig manure
pH	8,5	8,4	7,9
EC (mS/cm)	3,5	16,5	2,2
N (%)	<b>1,0</b>	<b>2,7</b>	<b>1,3</b>
K (%)	<b>2,1</b>	<b>4,3</b>	<b>0,3</b>
P (%)	<b>0,4</b>	<b>0,9</b>	<b>0,7</b>
TOC (%)	36,6	38,4	49,7
NO <sub>3</sub> <sup>-</sup> (mg/Kg)	81,7	<DL	84,0
NH <sub>4</sub> <sup>+</sup> (mg/Kg)	67,3	271,9	303,3
Mg (g/Kg)	17,3	12,8	3,4
Ca (g/Kg)	94,9	123,4	33,4
Phenols (g gallic acid/Kg)	0,9	0,5	0,6
Heavy metals			
Cu (mg/Kg)	31,6	89,4	50
Zn (mg/Kg)	254,9	1.574,1	926,2
Ni (mg/Kg)	121,2	3,2	3,7
Cr (mg/Kg)	58,5	1,4	<DL
Pb (mg/Kg)	5,4	<DL	<DL
Pathogens (CFU/gr)			
Total coliforms	3.333	4.620.000	3.800
Faecal coliforms	16.667	2.425.500	1.900
Faecal Streptococci	18.333	764.400	19.950

<DL = under detection limit

DL (NO<sub>3</sub><sup>-</sup>) = 0,31mg/l - DL (NH<sub>4</sub><sup>+</sup>) = 0,01mg/l - DL (P) = 0,0007mg/l

# Physicochemical characteristics in B.A. & OMW...

## Bulking agent = Green waste

Parameters	Values
pH	8,1
EC (mS/cm)	1,5
N (%)	1,8
K (%)	0,8
P (%)	0,3
TOC (%)	46,9
NO <sub>3</sub> <sup>-</sup> (mg/Kg)	84,0
NH <sub>4</sub> <sup>+</sup> (mg/Kg)	149,1
Mg (g/Kg)	6,3
Ca (g/Kg)	105,7
Phenols (g gallic acid/Kg)	0,1
Heavy metals	
Cu (mg/Kg)	27,1
Zn (mg/Kg)	207,5
Ni (mg/Kg)	24,8
Cr (mg/Kg)	15,6
Pb (mg/Kg)	4,2

## OMW

Parameters	Values
pH	5,0
EC (mS/cm)	2,3
N (mg/l)	1.169,3
K (mg/l)	3.274,6
P (mg/l)	100,5
TOC (%)	23,0
NO <sub>3</sub> <sup>-</sup> (mg/l)	<DL
NH <sub>4</sub> <sup>+</sup> (mg/l)	148,9
Mg (mg/l)	158,0
Ca (mg/l)	283,6
Phenols (g gallic acid/l)	3,0
Heavy metals	
Cu (μg/l)	229,4
Zn (μg/l)	4.347,6
Ni (μg/l)	283,8
Cr (μg/l)	5,3
Pb (μg/l)	<DL

<DL = Κάτω από το όριο ανίχνευσης

DL (NO<sub>3</sub><sup>-</sup>) = 0,31mg/l - DL (NH<sub>4</sub><sup>+</sup>) = 0,01mg/l - DL (P) = 0,0007mg/l

# 1<sup>st</sup> composting process ...

## 1<sup>st</sup> composting process (in windrows) - COMPOSTING1

Parameters	Cow manure COMPOST1CW		Poultry manure COMPOST1PL		Pig manure COMPOST1PG	
	Beginning	End	Beginning	End	Beginning	End
pH	8,5	9,1	8,8	8,7	8,1	8,9
EC (mS/cm)	3,7	6,8	13,0	8,4	1,9	4,2
N (%) *	<b>1,0</b>	<b>1,8</b>	<b>1,8</b>	<b>2,1</b>	<b>1,7</b>	<b>2,0</b>
K (%) *	<b>0,9</b>	<b>1,2</b>	<b>2,3</b>	<b>2,8</b>	<b>0,7</b>	<b>1,0</b>
P (%) *	<b>0,4</b>	<b>0,6</b>	<b>0,9</b>	<b>1,4</b>	<b>0,6</b>	<b>1,0</b>
TOC (%)	30,6	25,0	37,8	31,3	39,7	35,2
NO <sub>3</sub> <sup>-</sup> (mg/Kg)	<DL	463,4	47,9	196,9	88,5	7,2
NH <sub>4</sub> <sup>+</sup> (mg/Kg)	217,3	53,8	901,3	66,8	613,0	72,2
Mg (g/Kg)	n.m.	9,7	n.m.	11,3	n.m.	9,9
Ca (g/Kg)	n.m.	119,4	n.m.	212,3	n.m.	149,6
Phenols (g gallic acid/l)	<b>0,7</b>	<b>0,7</b>	<b>4,8</b>	<b>0,8</b>	<b>1,1</b>	<b>0,8</b>
Heavy metals						
Cu (mg/Kg)	n.m.	40,1	n.m.	77,9	n.m.	68,2
Zn (mg/Kg)	n.m.	402,4	n.m.	796,9	n.m.	698,3
Ni (mg/Kg)	n.m.	73,6	n.m.	35,5	n.m.	30,0
Cr (mg/Kg)	n.m.	44,3	n.m.	36,5	n.m.	15,2
Pb (mg/Kg)	n.m.	5,7	n.m.	11,3	n.m.	<DL
Pathogens (CFU/gr)						
Total coliforms	n.m.	8	n.m.	27	n.m.	0
Faecal coliforms	n.m.	0	n.m.	6	n.m.	0
Faecal Streptococci	2.561	0	30.913	4	6.254	0

✓ Increase in nutrients

✓ Reduction in phenols

\* (%) d.w.

n.m. = not measured  
<DL = under detection limit

## 2<sup>nd</sup> composting process ...

### 2nd composting process (in composters) –COMPOSTING2

Parameters	Cow manure COMPOST2CW		Poultry manure COMPOST2PL		Pig manure COMPOST2PG	
	Beginning	End	Beginning	End	Beginning	End
pH	8,6	8,1	8,7	8,0	8,3	8,1
EC (mS/cm)	2,3	5,9	13,8	8,9	2,5	4,1
N (%)*	<b>1,6</b>	<b>2,1</b>	<b>1,9</b>	<b>2,3</b>	<b>1,6</b>	<b>2,2</b>
K (%)*	<b>1,3</b>	<b>2,3</b>	<b>3,2</b>	<b>4,0</b>	<b>0,9</b>	<b>1,3</b>
P (%)*	<b>0,9</b>	<b>0,8</b>	<b>1,5</b>	<b>1,9</b>	<b>1,6</b>	<b>1,9</b>
TOC (%)	34,4	25,6	37,2	28,4	43,8	33,0
NO <sub>3</sub> <sup>-</sup> (mg/Kg)	<DL	440,8	114,4	1.195,0	42,5	576,2
NH <sub>4</sub> <sup>+</sup> (mg/Kg)	97,9	13,5	312,0	30,1	157,5	13,2
Mg (g/Kg)	10,2	9,4	12,1	10,2	8,4	6,9
Ca (g/Kg)	79,9	78,8	140,2	129,3	93,5	70,2
Phenols (g gallic acid/Kg)	<b>2,2</b>	<b>0,9</b>	<b>3,0</b>	<b>2,5</b>	<b>0,8</b>	<b>0,3</b>
Heavy metals						
Cu (mg/Kg)	30,4	36,0	63,3	66,2	53,4	46,6
Zn (mg/Kg)	63,7	309,4	157,4	337,4	93,8	234,4
Ni (mg/Kg)	45,8	54,9	17,4	18,3	24,6	20,8
Cr (mg/Kg)	28,6	30,4	10,5	12,9	13,9	13,0
Pb (mg/Kg)	<DL	2,2	<DL	<DL	<DL	1,2
Pathogens (CFU/gr)						
Total coliforms	343.750	0	TMTC	0	TMTC	0
Faecal coliforms	265.000	0	TMTC	0	TMTC	0
Faecal Streptococci	68.750	0	TMTC	0	1.045.000	0

✓ Increase in nutrients

✓ Reduction in phenols

# Drying process...

## Drying process

Parameters	Cow compost DRYINGCW	Poultry compost DRYINGPL	Pig compost DRYINGPG
pH	9,2	9,4	9,2
EC (mS/cm)	14,4	21,4	12,5
N (%)	<b>3,0</b>	<b>2,8</b>	<b>2,6</b>
K (%)	<b>3,8</b>	<b>12,3</b>	<b>12,4</b>
P (%)	<b>0,5</b>	<b>0,9</b>	<b>0,5</b>
TOC (%)	24,3	27,7	30,9
NO <sub>3</sub> <sup>-</sup> (mg/Kg)	<DL	<DL	<DL
NH <sub>4</sub> <sup>+</sup> (mg/Kg)	168,2	442,3	201,1
Mg (g/Kg)	8,0	7,0	5,0
Ca (g/Kg)	101,6	131,6	108,3
Phenols (g gallic acid/Kg)	<b>2,5</b>	<b>5,7</b>	<b>1,6</b>
Heavy metals			
Cu (mg/Kg)	28,0	46,9	37,1
Zn (mg/Kg)	647,6	347,6	247,3
Ni (mg/Kg)	45,8	12,6	15,1
Cr (mg/Kg)	21,5	5,2	4,9
Pb (mg/Kg)	<DL	<DL	<DL

✓ Increase in nutrients

✓ High increase in phenols

# In conclusion ...

## For Pig manure ...

Nutrients	After 1 <sup>ST</sup> composting	After 2 <sup>ND</sup> composting	After Drying
N%	2,0	2,2	2,6
K%	1,0	1,3	12,4
P%	1,0	1,9	0,5
Phenols (g gallic acid/Kg)	0,8	0,3	1,6

## For Poultry manure ...

Nutrients	After 1 <sup>ST</sup> composting	After 2 <sup>ND</sup> composting	After Drying
N%	2,1	2,3	2,8
K%	2,8	4,0	12,3
P%	1,4	1,9	0,9
Phenols (g gallic acid/Kg)	0,8	2,5	5,7

## For Cow manure ...

Nutrients	After 1 <sup>ST</sup> composting	After 2 <sup>ND</sup> composting	After Drying
N%	1,8	2,1	3,0
K%	1,2	2,3	3,8
P%	0,6	0,8	0,5
Phenols (g gallic acid/Kg)	0,7	0,9	2,5



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# THANK YOU FOR YOUR ATTENTION

