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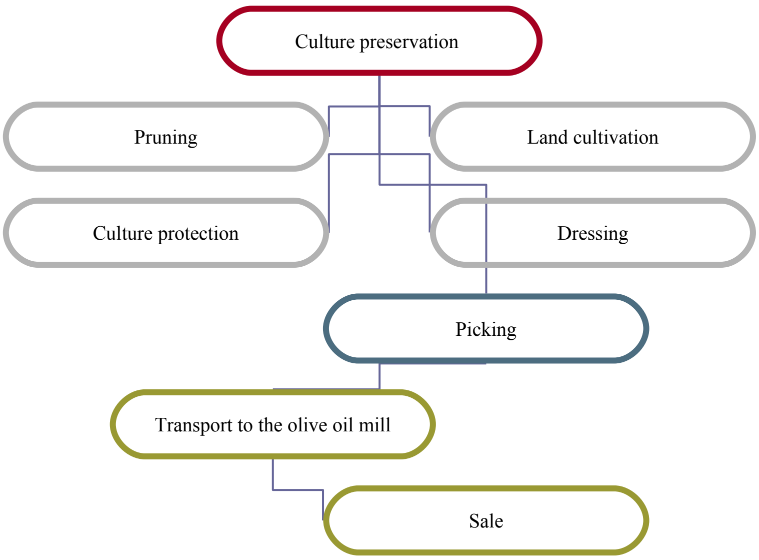
RES –HUI PROJECT

NUM. C3 -03

SUMMARY

1. Olive tree cultivation and olive oil mill

Olive oil production includes two different phases: the first one consists of olive tree cultivation and olives pressing, the second one is composed of refining, mixing and manufacturing steps.
The first phase is structured in hand made way and it's linked to the territory; on the contrary, the second one is characterized by considerable presence of big farms. Therefore oil present in the market can be introduced directly from oil mill or it can be sold to big farms for mixing and trasformation steps. In the last case oil can be refined or mixed with other different oils, also no italian, to obtain a product more suitable for large-scale retail trade. But in the last years in Italy, due to the consumers attention, there has been a diffusion of great quality products (extra vergine olive oil with protection geographic mark (IGP), denomination of protection origin (DOP)) also from big farms that work on large scale manufacturing.
In this study the first part of oil production (olive tree cultivation and pressing step) will be characterized. This is the phase where are produced the most relevant quantities of wastes.

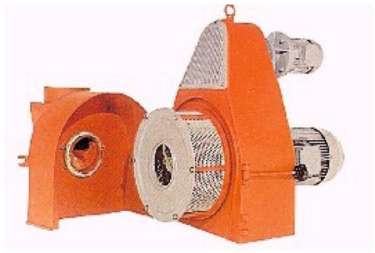


Oil production farms: phases management

Oil extraction process can be separed in different phases:

1. *Pressing:* the aim of this phase is to grind olives producing husk made up of its vegetal parts. There are two methods to carry out this phase:

– traditional system with pressure: it makes use of stone mullers;
– system with continuos cycle: it uses cylinder oil mill with hammers.



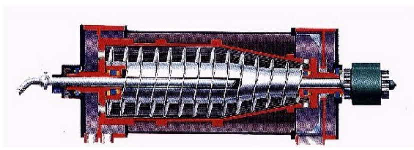
Cilinder oil mill with hammers and mullers

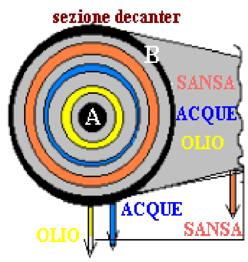
2. *kneading:* this phase prepares olive husk to next phases (extraction and separation) reducing oil emulsions with other fractions and assembling oil drops in agglomerates more dense. In the traditional system this phase is carried out by the same muller used for the pressing step; in the system with continuous cycle on the contrary this phase is carried out using a kneading machine (steel tank with sides at 25° C where oily compost is mixed)

Particular of a kneading machine

3. *Extraction:* in this phase oil is separed by oily compound coming from the kneading machine. Actually extraction methods are:

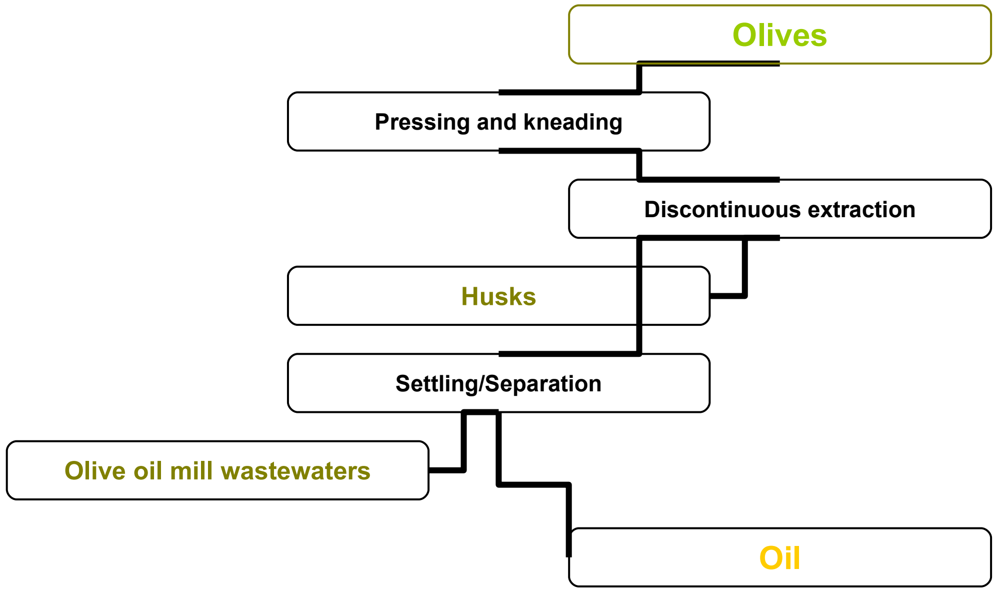
- with pressure;
- with centrifuge;
- with seepage ("Sinolea") present in some productive contest but not diffused.





Traditional system presses and continuous centrigue machine (longitudinal and frontal section)

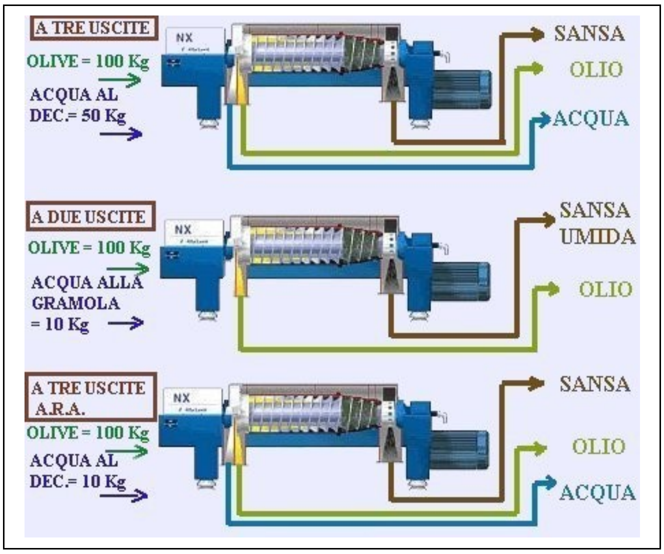
Methods with pressure (traditional) and with centrifuge (continuous) are the greater part of oil extraction systems in the world and they determine the whole transformation line name.
The advantage of the traditonal method is essentially that during the process it's not necessary to add water allowing to produce smaller quantity of wastewaters. Nevertheless this kind of process allows to work smaller quantities of olives in the same time and a greater possibility of product deterioration (extension of the contact time between watewater and oil).



Traditional method scheme

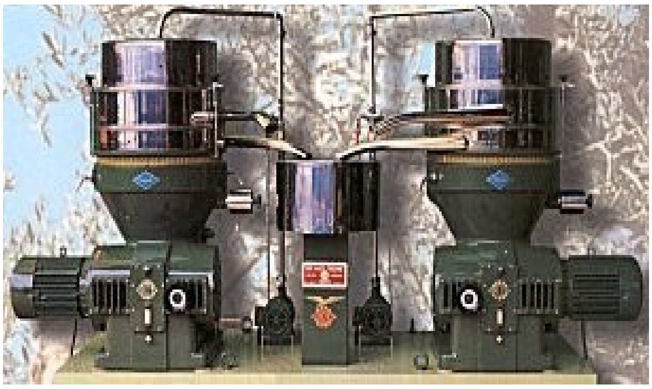
Extraction process with continuous cycle can be separed in:

- continuous with two phases: we will obtain in this case oil and husks from centrifuge;
- continuous with three phases: in this case it will be oil, olive mill wastewaters and husks separation;
- continuous with three phases but with water saving: in this case it will be necessary during the process a smaller water quantity.

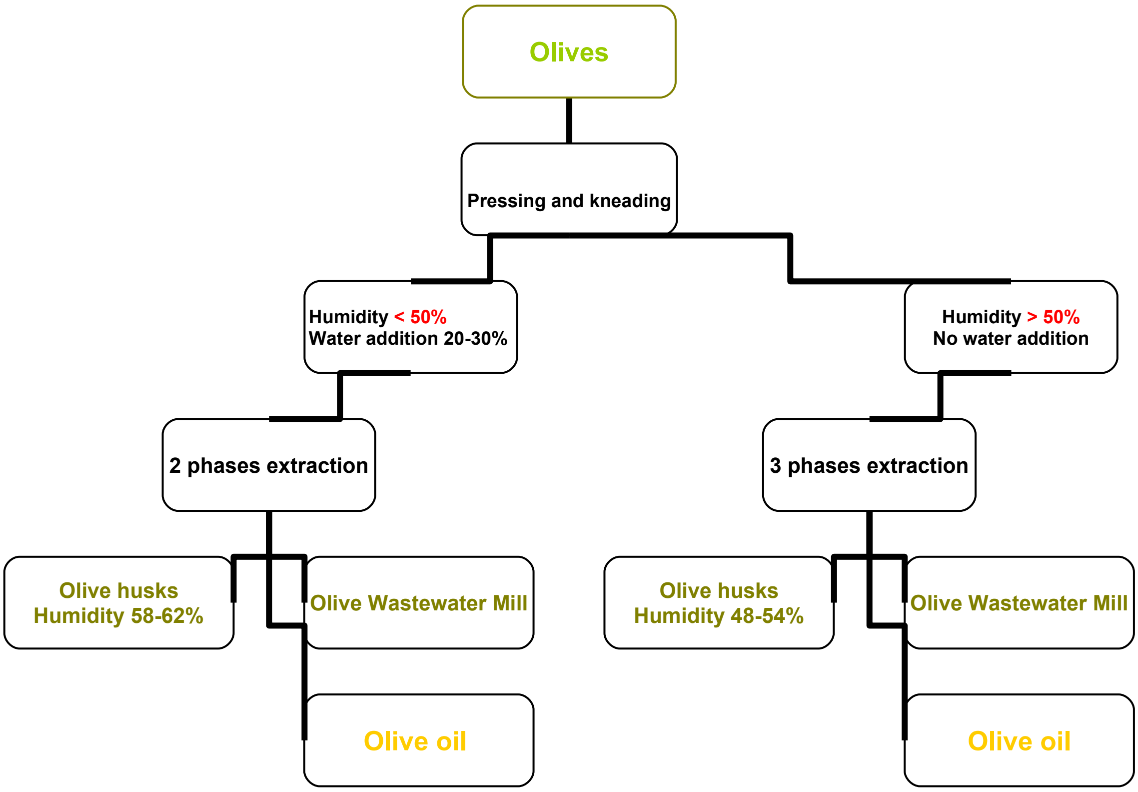


Input and output scheme for three kinds of continuous centrifuge machine

4. *Separation:* this phase in the traditional system is carried out with a centrifuge that separates oil mill wastewaters; in the continuous process this pahse is realized with two vertical centrifuges:
   - in the first one water present in oil is extracted;
   - in the second one oil present in the wastewater fraction is extraced.



Vertical centrifugal machines (in parallel) for OMW by olive oil separation



Process scheme for continous method

1.1 Agricultural surface and production

The olive tree cultivation in Italy is spreading out along one milion of hectares and it covers about 7,5% of the arable national territory.

Total surface (10^3 ha)	30133	(*)
Agricultural surface (10^3 ha)	15484	(*)
Olive soil cultivated (10^3 ha)	1161	(**)

Olive tree cultivated land in Italy; 2001
(*) INEA "L'agricoltura Italiana conta 2004"
(**)AgeControl e ISTAT, 2000 - 2005.

In Tuscany, olive tree cultivated hectares are about 6% of the total agricultural surface.

Total surface (10^3 ha)	2300
Agricultural surface (10^3 ha)	1627
Olive soil cultivated (10^3 ha)	101

Olive tree cultivated land in Tuscany; mean 2000 - 2005
Regione Toscana

Even if there is a olive tree survey, it's not possible to define the mean number of trees existing on the natonal territory because a lot of this cultivation is intensive and there is a big difference concerning cultivation kinds in different regions. The following table reports the number of tree extimeted in Italy and Tuscany.

	Italy	Tuscany
n° olive tree (million)	150	13

Olive tree number in Italy and Tuscany
Agecontrol

It's possible to point out that in Tuscany the hectare olive yield is lower than the italian production.

	Italy	Tuscany
Yeald (q/ha)	36.3 (*)	14 (**)

Yield in Italy and Tuscany
(*)ISTAT, 2005
(**)Regione Toscana, 2000 - 2005

Olives produced in Tuscany are only 3,4% of the national production even if the olive tree cultivated surface in this region is 8,7% of the italian total olive tree cultivated surface.

1.2 Agricultural farms

The distintive parameter to characterize agricultural farms is called SAU "Used Agricultural Surface" that is defined as "the whole lands intended for sowables, agricultural and woody cultivations, domestic gardens, persistent meadows, pastures and chesnut wood. It's the surface intended for agricultural cultivation and it not includes the areas intended for mushroooms cultivation"(ISTAT).

	SAU classes (ha)								
	< 1	**01-feb**	**02-mag**	**05-ott**	**ott-20**	**20-50**	**50-100**	**≥100**	**Totale Aziende**
	FARMS								
Tuscany	34.064	13.117	13.798	7.277	5.157	3.712	1.181	755	79.061
	43,1%	**16,6%**	**17,5%**	**9,2%**	**6,5%**	**4,7%**	**1,5%**	**1,0%**	**100,0%**
Italy	594.296	231.624	205.780	84.294	43.664	25.113	6.551	3.214	1.194.536
	49,8%	**19,4%**	**17,2%**	**7,1%**	**3,7%**	**2,1%**	**0,5%**	**0,3%**	**100,0%**

Farms, olive tree cultivated surfaces and SAU classes

It's possible to point out that the agricultural total farms (excluded zoothecnics and forestal farms) that are intended for olive production are both in Italy and in Tuscany about the 40%.

	Italy	**Tuscany**
Total farms	2809025	200907
Olive production farms	1194536	79061
(%)	**42.5**	**39.4**

% of agricultural farms for olives production
ISTAT, 5° censimento dell'agricoltura italiana

The high number of olive tree cultivation farms is justified since the farms percentage with SAU<1 is the most diffused.

	%
Italy	49.7
Tuscany	43

% olive production farms (SAU<1)

Moreover it's evident the economic weakness of these farms even if it's possibile to point out that most of these have various cultivations.
The employed number in oil olive mill is hardly determinable because farms are very small (SAU<1). Frequently the farm management is familiar with seasonal labour and often not regularizated. Besides the presence of many olive growers member of cooperative societies for oil olive mill management produces the development of cooperation and collaboration within farmers.

An other characteristic of the italian olive oil mills with respect to the whole agricultural sector is the production to the base cost. In the agricultural calculations productions are valuated at base price without tax and with pubblic contribution. (L'agricoltura italiana conta).
The olive cultivation weighs upon the total (44.464 milion €) about for the 5% (2.130 milion €)

1.3 Olive oils description and definition

Annex I to the Regulation N. 136/66/EEC of the Council of 22 September 1966 on the establishment of a common organisation of the market in oils and fats, as modified by Council Regulation (EC) No 1513/2001, contanines names and definitions of oliv oil and olive residues oil as established in the art.35.
In the Regulation n. 2568/91/EEC there is a more specified description concerning both oils characteristics and chemical analysis.

Regulation No 136/66/EEC of the Council of 22 September 1966 on the establishment of a common organisation of the market in oils and fats

ANNEX Descriptions and definitions referred to in Article 35
1. Virgin olive oil (the expression "pure virgin olive oil" may also be used): olive oil produced by mechanical processes and free from any admixtures of other types of oil or of olive oil extracted in a different manner.
Virgin olive oil is classified as follows:
(a) **Extra**: olive oil of absolutely perfect flavour, with a free fatty acid content expressed as oleic acid of not more than 1 g per 100 g;
(b) **Fine**: olive oil with the same characteristics as "Extra" but with a free fatty acid content expressed as oleic acid of not more than 1 75 g per 100 g;
(c) **Ordinary** (the expression "semi-fine" may also be used): olive oil of good flavour with a free fatty acid content expressed as oleic acid of not more than 3 73 g per 100 g;
(d) **Lampante** (lamp-oil): off-flavour olive oil or olive oil with a free fatty acid content expressed as oleic acid of more than 3 73 g per 100 g.

2. Refined olive oil (the expression "pure refined olive oil" may also be used): olive oil obtained by refining virgin olive oil.

3. Pure olive oil: oil consisting of a blend of virgin olive oil and refined olive oil.

4. Olive-residue oil: (as modified by Council Regulation (EC) No 1513/2001) Oil obtained from olive pomace by treatment with solvents or by physical means or oil corresponding to lampante olive oil, except for certain specified characteristics, excluding oil obtained by means of re-esterification and mixtures with other types of oils, and the other characteristics of which comply with those laid down for this category.

5. Refined olive-residue oil: oil obtained by refining the oil specified in 4, intended for human consumption.

6. Refined olive-residue oil and olive oil: oil consisting of a blend of refined olive-residue oil and virgin olive oil.

7. Olive-residue oil for technical use: any oil extracted from the products falling within heading No ex 23.04 listed in Article 1 (2) (e) other than those specified in 1 to 6.

1.4 Oil produced quantity

Number of operative olive oil mill in Italy and in Tuscany is decreased from 2000 to 2004 of 10%.

	2000	*2001*	*2002*	*2003*	**2004**
Tuscany	425	411	400	396	382
Italy	6.140	5.744	5.737	5.763	5.695

Operative oil mill in Italy and Tuscany; 2000 - 2004
AgeControl, Agea, 2004

Nevertheless olives processed in the last years not are highly decreased. This event shows that a oil mill reorganization is carriyng out with an increase of big oil mills.

Year	**Processed olives** *t*10³*	**Olive oil** *t*10³*	**Olive oil yeald** *t/t*100*
2000	3674.2	711.1	19.4
2001	2744.9	507.1	18.5
2002	3302.3	639.4	19.4
2003	3174.0	574.9	18.1
2004	3484.0	630.3	18.1
Mean	*3275.9*	*612.6*	18.7

Olive oil produced in Italy; 2000 - 2004
AgeControl , ISTAT, "Rapporto 2003/2004", Allegato1

Year	**Processed olives** *t*10³*	**Olive oil** *t*10³*	**Olive oil yeald** *t/t*100*
2000	115.6	15.8	14.8
2001	117.2	16.2	14.8
2002	154.9	21.9	15.2
2003	75.9	11.0	16.5
2004	213.2	27.6	13.8
Mean	*135.3*	*18.5*	*15.0*

Olive oil produced in Tuscany; 2000 - 2004
Regione Toscana

Knowing the olive tree number existing in Italy and in Tuscany and on average the oil produced for year it's possibile to estimate the mean oil production for tree on the regional territory.

Italy	4.1
Tuscany	1.4

Olive oil produced by tree (kg)

1.5 Oil consumption data

Olive oil worldwide consumption in the years 1999-2003 has been about 730.000 tons.

	1999/2000	2000/2001	2001/2002	2002/2003	Unità di misura
Italy	714	729	735	740	$t*10^3$
World	2422	2566	2549	2606	$t*10^3$

Oil consumption in Italy and in the world
U.Na.Pr.Ol. COI, 2003

The price changes according to oil kind as showed in the next table.

	(€/kg)
Extra vergine olive oil	4.21
Vergine olive oil	4.09
Lamp - oil (olive)	3.5
Refined olive oil	4.37
Refined olive-residue oil	2.45

Oil Prices
ISMEA

Oil produced not is enough to cover internal consumptions because part of the oil national production is addressed to the export. Almost the totality of the olives crusched in Italy come from national production; olives importation from others countries represents a non relevant part and regards essentially the ended product.

2004 (January - December)	Import		Export		Balance	
	$t*10^3$	10^3 €	$t*10^3$	10^3 €	$t*10^3$	10^3 €
Olive oil (total)	**583**	**1334368**	**344**	**1014171**	**-239**	**-320197**
Olive oil	560	1311915	309	961313	-251	-350602
Vergine olive oil	393	944155	194	655080	-199	-289075
Vergine lamp-oil (olive), Ac.>3	110	241772	12	22541	-98	-219231
Refined olive oil, acid. no>0	57	125988	103	283691	46	157703
Refined olive-residue oil (total)	23	22453	35	52858	12	30405
Not treated olive-residue oil	15	12809	2	1389	-13	-11420
Refined olive – residue oil	8	9645	33	51469	25	41824

Import and export; 2004
ISMEA, ISTAT

1.6 Costs in the olive oil mill management

Even if it’s hardly to find some average data that represent italian olive grove, it’s neverthless possible to supply some indications on production costs.
It’s necessary to point out, concerning all following calculations, that:

- the costs are referred to a 1 hectare surface;
- the typical olive grove examined is full productive (between 20 and 30 years) in a level or not much sloped ground, with 277 trees/ha and plant breeding in polyfonic vase;
- the average production for tree is 18 kg with a mean extraction yield of 16 %. The olives production is 49,86 quintals and the olive oli production is 797,76 kg;
- the labour costs are about 8,8 €/h includine contributes and other expenses to be charged to the employer account;
- maintenance, assurance and amortization costs haven’t been considered.

1. *Pruning*
- *Manual (one-year):*
There are many kinds of pruning that are more or less expensive and invasive for the culture:
Considering about 20 minutes as average time for tree a worker can prune no more of 24 tree in a day. The working hours necessary are 11,5; so the cost for year is 812,53 €.

- *Manual (two-year):*
In this case every year the pruning of half tree is carried out: 138.5 tree/year. The average time for tree is about the same because the cutting are made with chain saws. Valuating about 30 minutes for tree (16 tree for day) the working days are 8,6 for year. The cost is 609,40 €/year.

-Annual pruning with pneumatic or electric equipping made by a pruners team
A pruners team (4 persons) with suitable equipping to operate from ground can prune about 200 trees/day. The average pay for a pruner is in this case about 15 €. For the reference hectare (277 trees) will be necessary 11,08 hours that are the equivalent of 664.80 € for year.

-Two -annual pruning with pneumatic or electric equipping made by a pruners team
In this case every year the pruning of half trees is carried out: 138.5 tree/year. A pruners team (4 persons) with suitable equipping to operate from ground can prune about 120 trees/day. The average pay for a pruner is in this case about 15 €. For every year will be necessary 9,2 hours that are the equivalent of 664.80 € for year.

2. Picking

Picking can be carrie dout by hand or with equipment.

- *Stripping off by hand*

A worker can pick on average 1 quintal of olives in 8 hours. With 4 persons the daily productivity is 4 quintals; so 12,5 days will be necessary to pick the whole production (49,86 quntals). The cost is 3.510,14 €.

- *Stripping off with pneumatic or electric equipment*

The productivity of this kind of equipment is about 80 kg/h. A team of 4 persons (2 persons with equipment and 2 persons assigned to spreading and picking lengths of material could pick 12,8 quintals of olives for day (4 days could be necesary for the whole reference hectare). The cost is 1.096,92 €. The equipment cost (excluded tractor) is 2.500 € . Considering 208.33 €/y as amortization in 12 years and 25 € as assurance and maintanance costs, 233.33 €/y are necessary to have the suitable equipment. Adding cost of fuel and lubriicant consumption (5 /day, 20€ for 4 days) the total cost is 1.410,25 €/year.

-*Picking with shaking machines and nets*

This solution can't be proposed for a surface so small because the price of chiese machines is about 35.000€. The rent price inclusive of the driver is about 50€/h. Considering a work team of 4 persons (with driver) and producing on average about 250 kg/h, 2,49 working days will be necessary for the whole production picking. The total cost is 1.523,72 €/year.

3.Other costs

- Cultivation or grass cutting up (4 for year): the cost inclusive of labour is 350€.
- Manuring: the cost inclusive of labour for spreading is 200€.
- Protection plants: the cost for 4 treatments are about 150 €.
- Overheads: the cost is 100 €.
- Amortization of olive grove: in 37 years with 5% interest rate the cost is 300 €.
- Pressing: in soma areas (Calabria and Puglia) of the italian territory this cost is smaller of 10€ for olives quintal but in other areas (Tuscany) it can be also 17 €/quintal. Considering an average cost of 13 €/quintal the total cost for this phase is 648,18 €.

4. *Production contributes*

In this item the public contributes (national, regional or by EC) are aggregated. These contributes are calculated with respect to the oil quantity produced (93 €/quintal). The extimated incomes are 741,92 €/ha.

It's possibile on the basis of the collected data to indicate the more onerous and favourable solution for the producer.

Maximum production cost

- With manual one –year pruning and handly stripping off: the total cost is 6.070,86 €,
- Contribute for production: 741,92 €

Oil cost: 6,68 €/kg

Minimum production cost

- With two-year pruning with pneumatic or electric equipment carried out by a work team, the total cost is 3.712,43 €;
- Contribute for production: 741,92 €

Oil cost: 3,72 €/kg.

The management cost of an olive oil mill can be summarized in the next table.

PRUNING	€/ha (annual costs)
Manual (one-year)	812.53
Manual (two-year)	609.4
Mechanized (one-year)	664.8
Mechanized (two-year)	554
mean	***660.18***
PICKING	
Manual (one-year)	3510.14
Mechanized	1410.25
Mechanized with net	1523.72
mean	***2148.03***
OTHER COSTS	
Land cultivation	350
Dressing	200
Plant protection products	150
Overheads	100
Amortization olive grove (30 years)	300
Pressing	648.18
total	***1748.18***
TOTAL COSTs	**4556.4**

Average costs (€/ha for year)

Concerning OMW disposal costs that are into account to olive oil mills for a three phases and traditional plant no treated olive husks are collected without costs. Otherwise collection cost in other cases is about 15- 24 €/mc. So the incidence of the disposal expense for the oil mill is about the 15 %.

1.7 Wastes production assessment

1.7.1 Branches

The branches removed by a fully-grown tree in full production is about between 7 and a 5 kg for tree.
At the present branches are disposed with open air combustion. This solution involves neverthless a relevant burden of work and consequently big costs. There is the possibility to obtain, trough the use of special machineries already present for the arboriculture, vegetal fuel for thermal machines alimentation.
Considering a quantity of 11 kg of branches removed for tree as an average value the flux produced in one year is:

- in Tuscany 143.000 tons;
- in Italy 1,65 milion of tons.

1.7.2 Husks and oil mill wastewater

Data actually present (ISTAT, ARSIA, ISMEA, Unaprol, CNO..) supply active oil mills number and olives quantities totally processed. Only in some cases the olives quantity for oil mill and husk produced are individuated
Neverthless in the last years almost all productive oil mills (except for those that are very small) have changed their processes in three phases systems with water saving.
The advantages of this solution are:

- Greater efficiency and milling capacity with respet to the traditional system;
- Smaller quantity of water used during the process with respect to the traditional three phases system and so a smaller quantity of wastewater produced;
- Smaller humidity for husks resulting from the process with respect to the two phase system (50% against about 60% and more).

Wastes produced can be assessed on the basis of the processed olives quantity (weight) considering a typical three phases plant with water saving:

- Husks (humidity 48-50%): 50%;
- OMW:45%.

Therefore the mean wastes volume produced for year is:

- In Tuscany: 61.000 tons of OMW and 68.000 tons of not treated husks;
- In italy about 1,5 milion of OMW tons and 1,6 milion of husks.

These wastes fluxes are showed in the next table.

Branches $t*10^3$	Olive Wastewater Mill $t*10^3$	Olive husks $t*10^3$
143	61	68

Assesed wastes for year, Tuscany

Branches $t*10^6$	Olive Wastewater Mill $t*10^3$	Olive husks $t*10^3$
1.65	1.474	1.638

Assesed wastes for year, Italy

OMW and humid husks are disposed with spreading on lands. This solution, even if it's allowed by law, it's the cause of many doubts with regard to its environmental sostenibility. OMW have an organic load of 20 g/l; they are characterized by an acid pH (about 5) and include a relevant quantity of poliphenolic compounds (3 g/l) that inhibit the soil biomass.
Besides this solution can produce a run-off effect due to the soil proofing.

2. Legislation

2.1 OMW disposal legislation

Law n. 319/1976

- Assimilation with other wastewaters;
- No spreading on arable lands;
- Purification or landfill disposal obligation.

Interdepartmental committee for waters pollution protection deliberation - 8 may 1980

- Assimilation with non industrial wastewaters;
- Competences assigned to the Regions.

Law n. 574/1996

- spreading on land
  - max 50 m3/Ha – OMW coming from oil mill with traditional production cycle; 80 m3/Ha – OMW coming from continuous production cycle;
  - no spreading:
    - lands with distance < 300 m from protected areas - picking up water for human consumption (D.Lgs. 31/2001);
    - lands with distance < 200 m from urban areas;
    - cultivated lands;
    - lands with ground water level < 10 m from zero level;
    - covered by snow, saturated or flooded lands;
  - OMW storage in the oil mill less than 30 days (limit protracted to 3 months - D.Lgs 22/1997).

- Announcement to the mayor at least 30 days before spreading on cultivated lands
  - technical report drawn up by qualified professional (agronomist, land surveyor, geologist): description and assessment of land geomorphology, hydrology and environmental general characteristics, related cartography and timetable of spreading activities

- Competent authority will be able to ask for other verifications
  - the mayor can reduce OMW quantities to spread or he can stop spreading
  - regions and provincial administrations can drawn up a spreading programme for the provincial area

- administrative sanctions.

D.Lgs.258/2000 (integration of D.Lgs.152/99

- Regions regulate OMW agronomic use fixing timetable, announcement conditions, control procedure and sanctions

6 July 2005 Decree

- it sets conditions (attachment 1) of preventive announcement that have to be regulated by Regions (D. lgs 152/99);

- kind of lands that have to be excluded (OMW spreading):
  - distance < 10 m by river bank;
  - distance < 10 m by sandy shore or lake water;
  - lands with slope >15 % and lacking of hydraulic and agricultural setting;
  - woods
  - gardens and public areas;
  - quarry.

- Storage and transport
  - no mixing OMW with other wastewater (zootechnic, agroindustrial, etc.) or wastes
    - regions have to individualize technical and management solutions to limit odour emissions and aerosols production;
    - checks: Regions fix minimum number that have to be executed by competent authority;
    - checks are preventive and subsequent.

D.M. 05/02/1998 and D.Lgs n. 22/97: they allow to put on the market by-products coming by olive pressing

- wastes recovery: Artt. 32 e 33 of D.Lgs 22/1997 and D.M. 05/02/1998;

- recycling for materials recovery. OMW can be used for:
  - natural pigments recovery through ultra-filtration to separate elements (fodders), natural colorants and antioxidants;
  - substratum for biomass growth;
  - biodegradable polymers productions;
  - antimicrobic elements extraction;
  - antioxidants elements extraction for medicines production;
  - poliphenolic elements extraction interesting for health research;
  - elements used as repellent of some cultures pathology.

2.2 Olive husks legislation

Legislation on olive husks management distinguishes between:

1. no treated olive husk coming from two phases centrifugal plants with humidity about 65-70%;
2. treated olive husk that is produced in traditional extraction plants and in three phases systems or in olive oil mill from non treated husks.

NO TREATED HUSKS

Law n. 574/1996

- ❑ No treatment before spreading since OMW can be used as fertilizing (making an exception to the regulations law 19 October 1984, n. 748, and subsequent modifications)

- ■ Alternative: registration in no dangerous wastes category – simplified procedures for recovery (artt. 31, 33 D. Lgs. n. 22/1997)
  - ❑ Simplified procedures could involve concerning the treatment phase:
    - ■ Biogas production trough anaerobic digestion
    - ■ Composting trough aerobic biological treatment

TREATED HUSHKS

D.M. 05/02/1998: no dangerous waste category – semplified procedures for recovery (artt. 31, 33 D. Lgs. n. 22/1997)

- ❑ OH can be straight disposed as wastes or subjected to recovery activity (production and recycling of plastic materials charged with wood dust).

DPCM 08/10/2004: can be used as fuel

- ❑ Inside to the production plant and outside (in this last case the product have to respect other requirement: identification system with plant production name and localization, production year and certification of required characteristics fixed by law)

Ashes	≤ 4%
Humidity	≤ 15%
n-Hexane	≤ 30mg/kg
Organic solvents	absent
Chlorinated	absent
PCI	≥ 4000 Kcal/kg

Values that have to be respected to use treated husk as fuel

3. Oil-mill sub-products disposal technologies

The elevated number of small sized oil mills, their dislocation on the land, the seasonality of the product and the conviction that spreading, which is allowed by the current legislation, would be totally innocuous for the environment, made difficult to find alternative solutions for the disposal of oil mill wastewaters and humid husks, especially from a economic sustainability point of view. Thus, before of assessing the different disposal technologies found in literature, an analysis of the impact of the spreading technique of oil mill waste on the land is needed.

3.1 Evaluation of the effects of spreading on the land for fertirrigation

Up to date the question whether the spreading technique is damaging or not for the environmental equilibrium is not clear: research has been undergone for four decades, but the problem is still very complex and no unambiguous results have been reached. Below an analysis of the positive and negative effects of the spreading technique is reported.
The environmental impact assessment regards, in this case:

- the duration of the effects;
- the incidence on the crops;
- the incidence on vegetation;
- soil anoxia and run-off;
- groundwater and surface water contamination;
- interference with urban settings.

The supporters of spreading aim at enriching soil with organic and mineral substances, while obtaining an inexpensive way for waste-water disposal. According to several studies, oil mill wastewaters contain nutritive elements (potassium, and, in minor amount, nitrogen, phosphorus and magnesium). According to this thesis, thus, the oil mill, wastewters are a way of improving the soil physical and chemical properties.

On the other side, some authors observe that the high value of natural organic compounds, measured through the BOD_5 and COD, is one of the disadvantage of the spreading technique: good quality waste-waters should have a BOD_5 in the range 10—20 mg/l and a COD in the range 30—60 mg/l, while waste-waters deriving from olive processing plants have COD on the order of hundreds of g/l.
Two characteristics which make some researchers dubious about the spreading technique are: the high value of polyphenols and the pH. Polyphenols contained in oil processing wastes are hardly degradable. Furthermore they have an anti-microbial action, sensibly disturbing the oil mill wastewaters biodegradation.
Given the high levels of polyphenols in oil mill wastewaters and their low biodegradability, high concentrations of these compounds have been found in soil where spreading was applied. However, these increases are usually

temporary and, even in case of huge contamination, rarely persist for more than three months.
Several authors report that phenols are retained by colloidal soil particles and/or biodegraded by agricultural soils, but phenols were detected in wells (even deep wells) near small and medium sized oil mills, where spreading is a common technique. This phenomenon is believed to be related to stratigraphic discontinuities, wrong wells construction, not adequate spreading and rains.
Other studies claim that the toxicity of the phenolic fraction is related to its capability of attacking biologic membranes. This toxicity is highly dependent by the compounds hydrophobicity and affects the soil microbiologic characterisation.
As far as soil pH variations are concerned, literature results agree on the fact that this parameter is hardly influenced by the application of the spreading technique if wastewaters fulfil legislative requests. A soil pH decrease was observed only in case of very high doses.

In order to test the effects of spreading on soil, and then on vegetation germination, several experiments have been carried out.
Many authors observed an increase on the production rate for selected crops. Literature analysis allows to conclude that oil mills wastewaters, if adequately spreaded more than 25-30 days before seeding, have a beneficial effects on the crops, and, however do not impact negatively.
Other authors, considering the potential polluting load, advise against the agronomic use of oil mills wastewaters: high mineral salt concentrations, low pH and the presence of phytotoxic agents can provoke damages to the cultivations. Generally a remarkable inhibiting effect on germination can be found in spread cultivations. The phytotoxic effect is particularly evident in herbaceous cultivations, potatoes and weeds, and generally it disappears after three months. However this effect can be detected only for doses exceeding law limits.
Some experimental results are remarkable: no particular contraindications exist for oil mills wastewaters spreading on olive groves at rest. A neutral pH was detected in spread soils, while non-spread soils have pH equal to 5. Nitrogen levels were higher than in non-spread soils, increasing the carbon/nitrogen ratio, which is an index of the organic substances humification process.

The analysis and quantification of soil physical modifications induced by spreading regards many factor, first of all the soil properties, but also climatic conditions and chemical composition of the spread liquid, with particular attention to organic substance quality, decomposition velocity and spreading technique.

Porosity is the main indicator of the soil structural qualities, thus its characterisation is fundamental for assessing spreading impact on soils.

Available information highlights that oil mills wastewaters spreading affects soil porosity: it seems to decrease in the first weeks, then it remarkably increases after about 1 months. This effect regards in particular pores in the range 0.5 – 50 μm, which constitute the water reserve for plants and microorganisms.
Macroporosity usually increases following spreading treatments, and this increase depends on soil type and water volume, and is generally proportional to the spread wastewater quantity. At very high doses, beyond 200 m^3/ha, soil structural damages can be observed, especially in clayey soils, with a remarkable porosity decrease. Water retention, strongly influenced by porosity, increases as well. This is due, beside the porosity increase, to a direct effect of the wastewater organic fraction and the decomposition products, which have an high adsorption capacity.
Another decisive factor is the time of the year. Spring treatments give the best results, because the optimal humidity and temperature conditions promote the soil biologic activity. This can be a problem because pressing is made in January, and thus wastewaters must be stored.
Although these parameters indicate a water infiltration improvement in the soil after the treatment, it should be noted that, in the first period, there is a waterproofness given by fat particles adsorbed at soil surface. This action decreases with time as the fat substances degrade. Excessive doses can increase this waterproofness and provoke a further decrease of infiltration.
The liquid volume must be adequately calculated also for soil characterised by high water conductibility (> 150 mm/h), because high percolation levels can lead part of the wastewaters organic fraction in the groundwaters.

In conclusion, it can be stated that the spreading technique, if practised accounting for each relevant variable, can have beneficial effects for soils; it is not realistic, however, to think that every precaution followed during experimental campaigns can actually be taken in routine treatments.
The law in this field poses limits in order to practise this technique without environmental risks, but it should be highlighted the difficulty of applying law prescription in many real situations, especially for the fact that huge quantities of liquid must be disposed in very short time, often in not favourable seasons. An *in-situ* control of disposal operations is very difficult, if not impossible. A confirmation can be found in the fact that high waste quantities are illegally disposed to date.

3.2 Disposal technologies

Depuration processes applied to oil mills wastewaters till now experimented are the same used for industrial wastewaters (chemical-organic pollution with high concentration).
Technologies proposed and experimentated are biological, thermal or chemical-phisics processes that essentially reduce volume and/or pollution to minimize the environemntal deterioration risk.
Among the main solution there are:

- chemical-phisics treatments;
- treatments with advanced ossidation,
- treatments with mwmbranes;
- thermal treatments;
- biological degradation (composting, anaerobic and/or aerobic digestion);
- biological degradation with use of specialized biomass;
- recovery treatments of sub products (thermal treatments, distillation, reverse osmosis);
- combined treatments.

These technologies have reached different develop levels from experimentation to the industrial scale. Nevertheless any of these processes is at the present better than others at market level.
Apart from the chosen process the OMW disposal plant localization near every single oil mill it's a solution that it can't be proposed (high investiments, management problems, etc.). Then it's necessary to make use of cooperative disposal plants that are adeguately disposed in the territory and with specific solutions for the wastewaters volumes storage.
In this study, after a small description of the main treatment processes, the analysis will be focus on two techonologies: the aerobic degradaton with specialized biomass and the combustion.

3.2.1 Chemical-physics treatments

These kinds of treatments are essentially at different steps processes including homogenization, precipitation and/or sedimentation of hanghing solids trough the reagents use.
Many thickeners have been experimented and have been combined to determine the most active: lime, bentonite, ferric chloride (Sarika et al., 2004; Aktas et al., 2001).
The treatment with thickeners:

- it needs high consumption of neutralization and coagulation reagents that produce relevant quantities of sludges to dispose;
- it produce an effluent that have to be subject to other processes.

Anaerobic treatment have fine results.

The process total cost is linked to the reagents used in the sludges treatment cost.

3.2.2 Advanced oxidation processes

The main technologies of these processes are:

- ozonization;
- oxidation trough ultraviolet radiation;
- oxidastion trough Fenton reagent;
- electrochemical oxidation.

These processes produce the polluttants mineralization with CO2, water and salts production and they turn some bio-refractory compounds in biodegradable intermediate of reaction(Boni et al 2005).
In the last years reserch concerning the advanced ossidation processes on OMW application has supplied these results:

- ozone (Benitez et al., 1999) has produced the 22% of COD abatment and has fully removed olyphenols;
- electrolytic processes (Giannes et al., 2003; Israilides et al., 1997) have reached abatment efficiency of the 93% for COD and 99% for poliphenols concentration with fully removal of solis compuounds;
- the Fenton process (Gernijak at al., 2003; Rivas et al., 2001) the COD reamval has been of 74% and the polyphenols removal has been of 87%.

These results are linked to the maximum yield of the process. The main prolem is the implementation cost (Mantzavinos et al., 2004).
Other authors Benitez et al., 1997) have focussed the studies on combined process with anaeriobic traetment showing fine results.

3.2.3 Processes with membranes

Membrane is a phisical thin barrier that allow to the susbstances to pass trough it or to be retained. The separation kind is determined by the memebrane charachteristcics. Generally these processes are classified on the basis of the substances retained dimension as following:

- Microfiltration (it retains bacteria);
- Ultrafiltration (it retains proteins and hanghing solids);
- Nnofiltration (it retains sugars);
- Revers osmosis (it retains salts).

Before this process it's necessary to subject wastewaters to a pretratment to remove big hanghing solids.
The application of these methods to the OMW treatments, due to the high pollution concentration sand to the kind of polluttants, can't be considered as a resolutive treatment but as lightening process or as final treatment (TDC OLIVE, 2004).
The main problems applying these methods to the OMW treatment are:

- Not relevant efficency (30-60%),

- High costs for reagents and membranes washing (more times for day);
- High cost for memnbranes that have to be replaced frequently;
- High energetic consumption.
- The problems that are resulted by the application of this technologies for the OMW depuration are common. (Arinelli, 2001).

3.2.4 Thermal processes

Thermal processe can be separated in two typolgies:

- destructive;
- not destructive.

The first one destroys the organic substances of OMW solving any disposal problem even if with high costs. The second one are evaporation processes that are well-know in chemical industry and in the desalination of seawater.

3.2.4.1 Wast-to-energy

This solution includes the organic compounds of OMW destruction at high temperatute with oxygen presence and the full evaporation of the OMW water.
This process is suitable for husks and OMW solid fraction treatment becasuse these parts have an high concentration of organic substances. Moreover when wastewaters pollution is highest this method is the most favourable with respect to the mechanical - biological process.
The main problems of this solution are:

- high humidity of wastewaters;
- used ful quantity;
- ashes and emissions production.

(Mininni et al, 1998; Amirante et al. 1982)

3.2.4.2 Distillation/Evaporation

The evaporation reduces wasteaters volumes and collects not volatile substances. Sometimes this tretament can be carried out at low pressure or in vacuum conditions. Distillation processes, that involve before sugars and alchols fermentation and chemical correction of pH, separate teh OMW in two parts: condensed vapour and muddy residue that has the same characteristics of a chemical sludge: it's a special waste that necessary it have to be subjected to an other treatment.
In the condensed redisue the COD value is again high (about 15000÷25000 ppm.)
Therefore the main problems for this solution are:

- high energetic cost for plant running;
- difficulty to sipose the produced;
- other treatments for effluent (TDC OLIVE, 2004).

3.2.5 Biological processes

Biological processes are the first methods used to dispose oil mill wastewaters. Moreover these processes are cheaper than chemical, phisical or thermal treatments both from an energetic and managing point of view. Finally the small quantity of sludges produced during the process, due to the small quantity of chemical product used, are easily to dispose.
These methods are efficient in spite of the seasonal production of wastewater because the abatment rate of biomass that produces methane is enough small and the reactors can be easily reactivated also after many months of inactivity (Mantzavinos et al., 2004).
Nevertheless biological process of OMW have many problems for the high concentration of pollution (both organic load and small biodegradability). So these processes can't be used directly for OMW treatment but OMW have to be diluted (70-100%) before. In the oxidation phase highet volumes are required and very relevant quantity of sludges, that have to be stabilized, are produced (Dionissios et al. 2004).

3.2.5.1 Composting

The necessity to supply to the users for OMW simple and reliable treatment systems has orientated the analysis to biological processes with aerobic stabilization typical of the composting (Ciancabilla et al., 2003).
This technic is used mainly for husks because the composting is a process of solid substance transformation. For the application to the OMW it's necessry to supply a organic support, with high absorbent power; OMW will be spread on the top of this support that it's composed by wood or in alternative the composting is used on mixt husk- OMW.
The main problem of this olution is an unpleasant smell emissions. It's possible to remedy this problem applying bio-filters that retain gas coming from to the decomposed material. The filter aplication neverthless causes a process costs increase. Compost has an economic value and it can be used with different aims:

- to improve the soil and to promote the biological bacterial activity for contamined soil remediation;
- to control the vegetal and aniaml parasitics;
- to fertilize cultures;
- to limit erosin and to preserve the landscpe;
- to reafforest and to reclaim humid lans;
- to revive the habitat.

A disavantage of this method there is the production of percolating fluxes that have to be treated (TDC OLIVE, 2004).

3.2.5.2 Anaerobic treatment

The anaerobic process is particularly interesting for wastewaters with high biodegradable concentrations because it has a small energetic consumption and it supplies, with the generated biogas, the energy production. Neverthless concerning OMW it's not possible to apply this process to the wastewaters without some preliminar treatment because the presence of some coumpounds, as potassium and polyphenols, inibhits the anaerobic biomass. Therefore it's necessary to dilute OMW with water (ratio from 1 to 10) or to subjet the wastewaters with preliminar chemical, biological or with specialized biomass processes.
For the diluited OMW treatment different anaerobic processes with favourable results have been used: anaerobic contact, the UASB (Upflow Anaerobic Sludge Blanket) and anaerobic filters. The main difference of these treatments is how the biomass is retained in the reactor: the processs with contact uses hanghing biomass; the UASB uses the anerobic biomass capacity to make sludge bows, otherwise anaerobic filters use biomass adherent to fix supports.
Generally the process in bioreactors with hanghing biomass don't allow to obtain in terms of COD depuration (Fiestas et al., 1984) excellent results because high mechanical agitation aids bacteria that produce acids with respct to those that produce methane. Greater reasults there are in UASB where the agitation velocity is reduced to aid the sedimentation. Anaerobic filters with adherent biomass moreover, due to the relevant concentrations of biomass that can obtain, allow to limit wastewaters toxicity and to reduce time for the start with respect to the UASB reactors (Hamdi e Garcia, 1991); this process is the most suitable for the OMW treatment.
Particulary efficient concerning the OMW treatment is the succession of anaerobic and aerobic processes with specilized biomass. These microorganisms have showed great abatment capacity of organic load but also in combined processes the substances (polyphenols) that inhibit the anaerobic biomass (Borja et al., 1995).

3.2.5.3 Aerobic treatment

The application of aerobic processes with typical biomass used in urban wastewaters depuration to the OMW treatment has showed a small abatment capacity. Moreover this technology can be used only if:

- the BOD_5 concentration is reduced to values smaller than 3000 mg/l;
- the OMW composition is changed with nutrients addition to reach the BOD_5, N e P ratio to the optimun value of 100:5:1 (1.8 kg N and 0.22 kg P for processed olives tons)

The process realization involves urban and oil mill wastewater mixtures treatment to obtain both a pollution load reduction and nutrients concentration improvement.
These processes are often used because of there is an inhibition action produced by polyphenolic aromatic compounds present in the wastewaters

concerning the biological degradation. Another problem is the production of great quantities of sludge. Therefore this process is used only as final process following other treatments that can reduce polyphenolic quantities.

4. Biological treatment with specialized biomass

In the last years some systems with specilized biomass in the polyphenolic compounds degradation have been studied at experimental level. Obtained results are encouraging because the COD and polyphenolic abatment values are more than 70%.
In the following part the results of a study carried out with this technique are summarized. The aim of the study was to asses in a preliminary way the possibility to implement a complete process for the OMW disposal.
The first phase of the study has been involved to select and to increase growth of aerobic biomass able to use as substratum poliphenols of OMW. The objective of this phase is to obtain fango attivo easily consistent with OMW because this characterstic is essential in traetment plant for small and seasonal capacity.
Subsequentely the COD and poliphenols abatment capacity has been assessed in a pilot plant working in fed-batch modality. At the same time the calorific value of the dewatered franction of OMW has been assesed. This is is for its characteristics similar to the OH. This analysis have been developed to know disposal possibility of the OMW dewatered fraction by combustion.
OMW has been subjected, as pretreatment, to a mechanical centrifuge to separate dewatered phase by liquid phase. After 2 hours settling (liquid phase) has been obtained:

- a oily franction that has been used to valuate its calorific value;
- a watery fraction that has benn used to develop aerobic depuration processes.

Wastewater	Volum (ml)	Weight (kg)	% (volum)	% (weight)
No treated	1600	1.52	100	100
Dewatered	876	0.8	54.75	52.63
Surnatant oil with solids	100	0.09	6.25	5.93
Water	624	0.63	39	41.44

Obtained fractions after pretreatment

The biomass growth has been monitored through COD, poliphenols and oxigen consumption measures and through microscope observations.
When growth is finished the pilot plant has been conduced in fed-batch modality: after the schievement of bacterial respiration next to endogenous conditions, the volume has been subjected to a sedimentation phase to separate depurated water by biomass. After this phase the supernatant has been drawn and the same volume but centrifugated has been introduced

<u>Pretreatment</u>
After treatment with centrifugal the SST abatment has been about 98%.

	Not treated OMW	OMW treated with centrifugal
pH	4.4 ÷ 4.8	4.6 ÷ 5.12
COD [mg/l]	262750 ÷ 301600	48850 ÷ 72720
Total polyphenols [g/l]	9.6 ÷ 10.6	2.36 ÷ 2.93
TSS [g/l]	113.5 ÷ 128.4	2.19 ÷ 3.02
VSS [%]	91.63 ÷ 94.5	94.5÷ 95.6

Comparison betwen no treated wastewater and fraction with water after centrifugal phase

Caloric value assessment

The dewatered fraction of OMW has been subjected to an other phase with centrifugal machine to optimize the mechanical dewatering. The result obtained has been assesed with a weight and volum balance with respect to the OMW sample not treated.

	Process start	End process	Dewatered (%)
Weight (kg)	1.52	0.64	42.1
Volum (ml)	1600	714	44.6

Results after centrigal phase of solid fraction

The humidity calculated with essiccation in a 105°C stove has been about 73% that is similar to the humidity of other similar sludges that can be easily transport with a shovel (75-80%).

TSS%	26.6
Humidity %	73.4

Total Solid Substances and humidity in solid fraction

Results of test in a specific equipment (bomba calorimetrica) show a calori value of 30.997 kJ/kg that is higher than the caloric value obtained for RDF (20.000 kJ/kg).

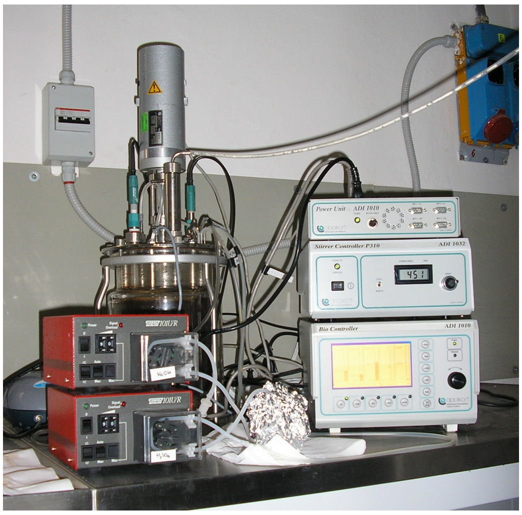
P.C.S. (kJ/kg)	%Humidity	%Hydrogen	Humidity (kJ/kg)	Water from Hydrogen (kJ/kgST)	P.C.I. (kJ/kg)	P.C.I.non treated (kJ/kgTQ)
30997	73.4	6	1835	359	28803	7662

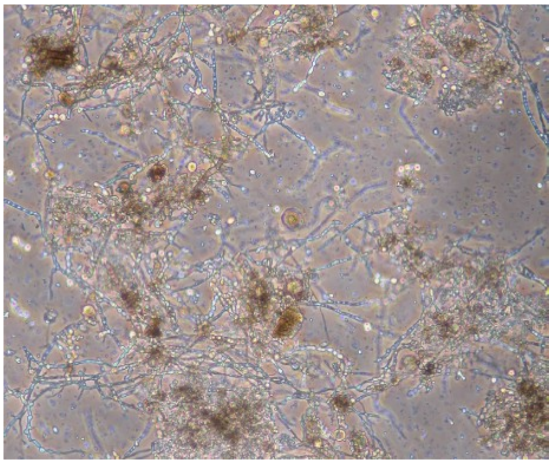
Results

The main problem is the high humidity of the dewatered fraction obtained with centrifugal machine by the OMW.

<u>Aerobic process with specialized biomass</u>

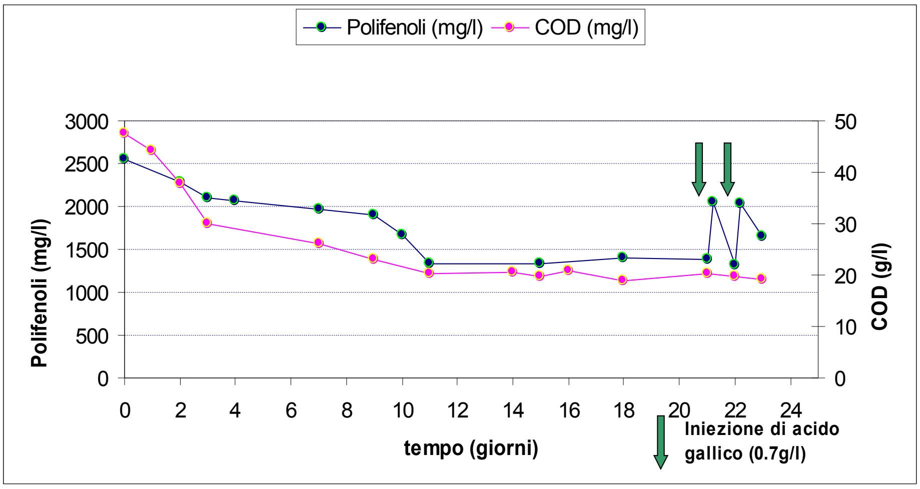
The pilot plant has been conduced in fed-batch modality and after 30 days biomass growth and COD and total polyphenols reduction (rispectively 58% and 48%) have been observed.





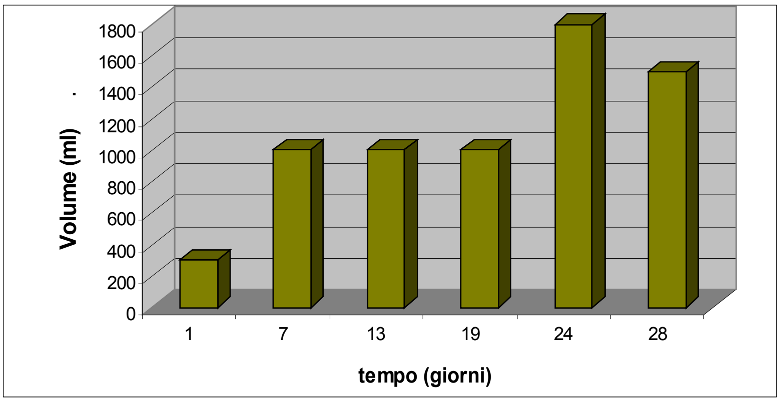
Reactor used for specialized biomass growth and biomass microscope

Tests with injection of phenolic elements (gallic acid, p-cumarico e vanillico, phenols) have proved the biomass capcity to completely degrade these elements.



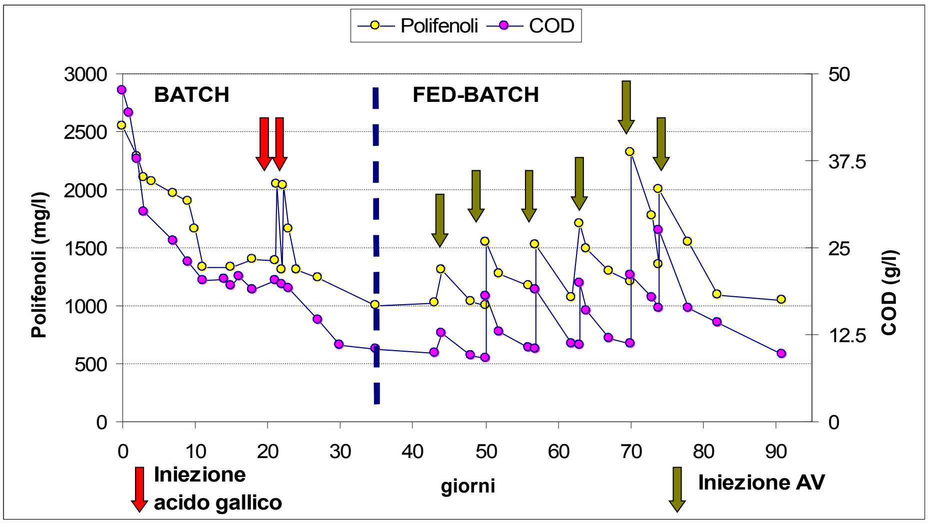
COD and total polyphenols concentration during the biomass selection

Volumes and time used in the phase of fed-batch modality are showed in the following graph.



Worked volumes during the fed-batch phase

The abatment results obtained with the proposed process are of 80% with regard COD and 90% for total polyphenols.



COD and total polyphenols during the whole experimentation

The proposed treatment process through biomass has supplied good results that are summarized in the next table.

	No treated phase	Effluent (Day 27°)	Removal (%)	Effluent (day 90°)	Removal (%)
COD (mg/l)	47600	20200	58	11246	80
Polyphenols (mg/l)	2550	1135	48	255	90

Removal valles obatined during batch and fed-batch phase

This study, as others in this field, suggests the possibility to realize a biological treatment for OMW with specialized biomass but at the present ths technology not has been applied at real scale in industrial plant so it's not possible to assess its effective competiveness.

5. Assessment of alternative scenarios for wastes of oil production disposal in Tuscany

In the industrial process for olive oil production high quntities of wastes, subproducts and watewater are produced. Wastes disposal involve high economical cost and considerable environmental pollution.
Different kinds of wastes characteristic of the olive oil production are produced in following phases.
The OMW and humid husks disposal is carried out mainly with spreading on lands. Even if this solution is allowed by law there are some dubts concening its environmental sustenibility.
Branches (vegetal residues) are produced in the pruning phase. At the present the more diffused solution for branches disposal is the open air combustion. But this solution involves high risk for fire propagation in non cultivated areas and can produce by enviromental point of view relevant pollution due to the uncontrolled combustion conditions.
Therefore, for all waste fluxes produced some alternative solutions for disposal in tuscany have been hypotized with respect in particular to the energetic recovery as described in the next table.

Branches	Open air combustion and waste to energy plant combustioon comparison
OMW	Drying of humid fraction and waste to energy of the dried fraction
	Anaerobic disgestion and use for energetic recovery of produced biogas

Disposal scenarios

Concerning branches two disposal solutions have been compared: open air combustion and in a waste to energy plant combustion. In this case we have prepared both a balance of the energetic potentiality linked to the wastes utilization and an environmental comparison of the produced emissions in the examined scenarios.
For treated husks and OMW the disposal soltuions studied (husks waste to energy and OMW driyng/anaerobic digestion) are quite different from actual disposal. Moreover the solution considered in this study concerns energy recovery whereas spreading on lands can be considered a substance recovery solution. Therefore comparison of these solutions is hardly due to the hierarchy extabilished by italian law.
For these fractions, since the environmental comparison not has been carried out, a energetic balance has been prepared.
For OMW two alternative hypothesis have been considered:

- drying of water content and waste-to-energy of the dried fraction;
- anaerobic digestion of the whole flow with energetic recovery from produced biogas.

In the following table the energetic contribute assessment of olive oil production wastes are summarized. These flows show an high energetic content that not adeguately are used in the actual management.

	t/y	Caloric value (MJ/kg)	MJ/y available
Branches	143.000	18,9	5,95E+08
HO	32.661	14,65	4,79E+08
OMW	61.000	14,65 (*)	1,01E+08 (*)

Residuals produced - Tuscany – and energy value available assessement

(*) Dewatered fraction

Concerning the OMW the available energetic value is referred to the dewatered content (about 13,6%). In the next table the electric energy that is possible to produce by these scraps in conventional plants with steam cycle is showed.

	MW	**MWh/year**
EE (branches)	2,20E+01	1,65E+05
EE (HO)	3,90E+00	2,92E+04
EE prodotta (OMW) (*)	8,21E-01	6,16E+03
Total	**2,67E+01**	**2,01E+05**

Electrical Energy that can be produced by olive oil mill in Tuscany

(*) water content about 86,4%

Energy content of branches and OH can be directly utilized. On the contrary for OMW it's necessary a drying process. This process require considerable energy consumption (1,58E+08 MJ/y) that is greater than energy that can be produced by dewatered fraction. So this choice can't be considered opportune.
Moreover the OMW quantities produced are considerable since the transport phase to treatment plants could be very onerous. Therefore this treatment has been excluded.
Therefore a similar balance has been verified for OMW anaerobic digestion in a specific plant and for energy use of biogas produced in this phase.
With this process up to 95% of OMW solid and dissolved components have removed and turned in biogas through a specific anaerobic phase at 36°C. Effluent is subject also to an another treatment (aerobic phase or membrane filtration). Water purifying can be used in industrial processes or to irrigate agricultural lands.
Biogas production in this process is extimates about 40 mc/mc OMW and related electrical energy production is 210 kWh/mc OMW.
In the next table is showed enerrgetic contribute concerning the OMW anaerobic digestion phase produced in Tuscany for year.

OMW [t]	61.000
Water content [t] (*)	52.704
biogas production[mc/a]	2,32E+06
Electrical energy production[MJ/a]	**4,38E+07**
Energy produced [MW/a]	1,62E+00
Energy produced [MWh/a]	1,22E+04

Energy content that can be produced by OMW anaerobic digestion

(*) water content about 86,4%

For a complete analysis concerning the solution sostenibility the fuel consumption has been considered for OMW transport to an hypotetical digestion plant (baricentric location with respect to the capital of the provence where olive oil production is highest - Grosseto, Firenze, Arezzo, Pisa - production > 2.000 t/y) to determine the distance over than this solution isn't favourable for energy recovery.
Consumption for departure (fill load) and back (no load) has been extimated in 349,9 g/km of diesel.
Trasport is important because of typical productive structure of this industrial sector that is characterized by the presence of farms on all regional territory.
Means of transport considered for simulation model are "Heavy Duty Vehicles" (HDV): diesel fuel, load > 16 t, mean velocity 40 km/h, extraurban way [CORINAIR].
On this basis the energetic content that is necessary to move the whole OMW quantity produced in Tuscany to the considered plant has been assessed.

diesel [g/km] departure and back	349,9
Energy required [MJ/km]	14,94
distance plant [km]	500
OMW density [kg/mc]	0,0011
Mean transport load [mc]	20
OMW [mc]	57974,4
Loads number	2,90E+03
Energy required [MJ/a]	**4,33E+07**

Energy content necessary for OMW transport assessement

As it's possible to observe in the previuous table this solution not is favourable for the energy recovery over 500 km. If the distance is smaller of 500 km this solution could be favourable but could be valuated in economic way.

Finally, concerning branches, emissions produced in an open air combustion process (actual scenario) and in a WTE plant have been assessed.
In the following environmental balances the values of CORINAIR have been used for the emission factors characterization of combustion processes in an open air scenario.
Concerning emissions characterization coming by WTE plant a specific model of simulation prepared by Dipartimento di Energetica "Sergio Stecco" has been used. This model is able to represent the thermodynamic equilibrium for a combustion with excess of air, controlled combustion temperature and energy recovery in boiler trough Hirn cycle.

In the following table the characteristics of the thermal treatment kiln that has been used in the WTE simultioon model are showed.

T= 950 °C	
Boiler economizer temperature	200°C
Steam temperature	400 °C
Steam SH nominal pressure	40 bar
Steam condenser nominal pressure	0.2 bar

WTE plant characteristics

In the following table the branches mean chemical composition that has been used in the WTE simulation model is showed.

Caloric value	16.800
Inerts [%]	4,5
C [%]	34,7
H [%]	6,2
O [%]	13,5
N [%]	0,8
S [%]	0,10
Cl [%]	0,2
Humidity [%]	40

Branches chemical-physic characteristcics

In the following tables the emission factors (CORINAIR) for open air combustion of agricultural residues are showed.

PCDD	10	microg I-TEQ/t
PAHs	100	g/t
VOCs	2	kg/t
NH3	1,9	kg/t
NH4	0,5	kg/t

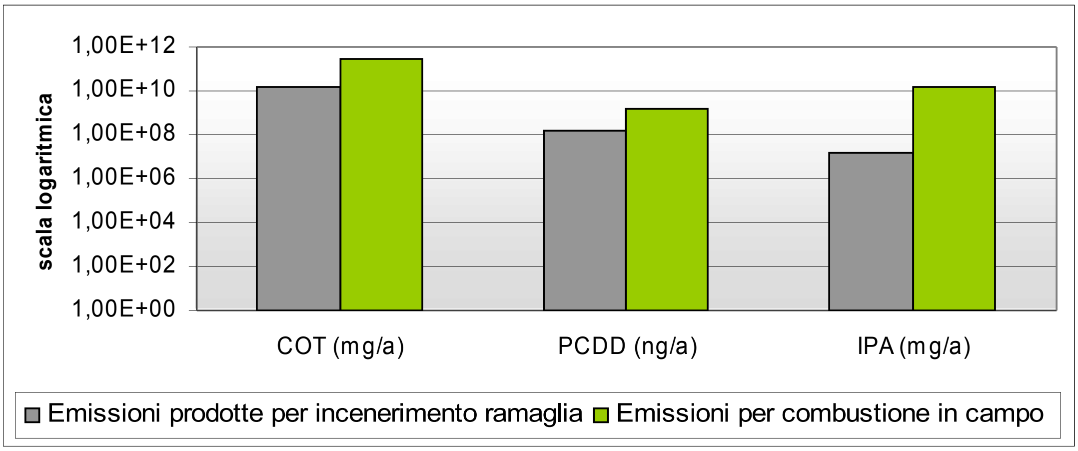
Open air combustion emissions factors of agricultural residues

To compare open air burning of branches with its combustion in a WTE plant PCDD, IPA and COV are analysed as reference polluttants.
In the next table emissiond produced in the different scenarios are showed considering emissions production of 11.310 Nm3/ton and considering emissions limits of Directive 2000/76/CE.

	WTE branches emissions	**Open air burning brunches**
COT (mg/a)	1,62E+10	2,86E+11
PCDD (ng/a)	1,62E+08	1,43E+09
IPA (mg/a)	1,62E+07	1,43E+10

Produced emissons of two scenarios

In the next figure emissions concerning the two disposal tipology considered are showed.



Emissions of two considered scenarios

As it's possible to observe in the previous figure the emissions produced in an incontrolled open air combustion are greatest for all polluttants considered. So by the environemntal point of view the WTE solution are certenly favourable.

To conclude i'ts possibile to assert that:

- wastes produced in oilve oil mill have a considerable caloric value that at this time in part i'ts not adeguately utilized and in part it's lost with an ironmental impact greater with respect to an controlled process;
- disposal of OH and branches in WTE plants is favourable both in the energetic way and in the environmental one. The environmental advantage that coming by the WTE in comparison with open air burning of branches is particularly considerable;
- concerning OMW the drying and WTE of dewatered fraction for energy recovery isn't sustainable whereas sustenibility of the second hypothesis (anaerobic digestion) have to be verify in economic way.