State Of The Art Of Anaerobic Digestion In Italy

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For Italy, in 2002, EurObserv'ER estimates a biogas production of 155 ktoe (about 1.8 millions of MWh). More than 1/3 of this biogas production comes from landfills of MSW.

To encourage biogas recovery systems, in 1992 the Italian Government outlined a provision (CIP n. 6/1992) offering incentives for self-production of electric energy from biomass, paying 0.135-0.15 €/kWh against an average cost of 0.08-0.09 €/kWh. However, this rule is stopped from July 1996 and today is under revision. Italian Programme for Renewable Energy from Biomass is part of the Italian politics for reduction of greenhouse gases emissions, according to Kyoto Protocol. Now the value of Electric Energy from biogas (green certificate) is 0.12-0.13 €/kWh.

In Italy, at the end of 1999, 72 biogas plants are operating on animal slurry; five of these are centralised plants and 67 are farm plants. In Italy at the end of the eighties, a new generation of biogas systems for animal (mainly pig) slurry were developed which are extremely simplified and low-cost, involving the use of plastic cover over a slurry storage tank. These systems have been developed not only for the purpose of energy recovery but also for controlling odours and stabilizing the wastes. Though no official census has been made after 1999, information gathered from the firms that produce this type of system indicates that approximately 70 of these plants have been installed in Italy up to now. The systems operate at low temperature or at a controlled temperature.

CRPA had monitored some of these biogas plants, in particular a plant installed in a large pig farm located in the province of Parma. The biogas is used for a co-generator that can supply about 50 kW of electric power and 120 kW of thermal power. The productive parameters, energetic balance and economical analysis of the biogas plant are presented in the paper: the biogas production is about 141,000 m^3/year, about 429 m^3/t lw year; the production of electric energy is about 203,000 kWh/year.

In the last two years, in Italy too, the interest in the codigestion of animal slurry, energy crops and organic waste is increasing and now, winter 2003, some codigestion plants are building and/or designing.

In the paper we also present the situation in Italy of anaerobic treatment of sewage sludge, of agro-industrial waste, of organic fraction of MSW and of landfill gas utilization. We present the contribution of anaerobic digestion to reduction of methane emission from animal manure too.

Enhancement of the anaerobic digestion process of primary and secondary sludge by thermal and chemical pre-treatment

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Anaerobic digestion is a technique for activated sludge stabilisation which is applied worldwide. The anaerobic digestion process follows four major steps: hydrolysis, acidogenesis, acetogenesis and methanogenesis with hydrolysis as the rate-limiting step of the overall process during activated sludge digestion. Different pre-treatment processes have been investigated to accelerate sludge hydrolysis including thermal, mechanic and chemical treatment as the most applied techniques.

In the present work, chemical treatment using NaOH has been applied to primary and secondary sludge from a municipal waste water treatment plant in order to improve the anaerobic digestion process by reducing the mean hydraulic retention time and increasing methane production. Thermal treatment has also been studied applied to secondary sludge.

Contact time (ranging from 30 to 480 minutes) and NaOH concentration (0.05-0.3 mol/l) were the factors considered during the study of chemical treatment. Thermal treatment was applied to secondary sludge at different temperatures (110-134ºC) and times (20-90 min) in an autoclave. The effectiveness of the two processes was evaluated by means of three parameters: the degree of disintegration using the chemical oxygen demand (% DD_{COD}), the increment in soluble protein concentration (SPC, in percentage respect to the concentration in the original sludge) and the increment of the relationship between filterable volatile solids and the total volatile solids (FVS/TVS, in percentage).

Highest NaOH concentration (0.3 mol/l) and temperature (134ºC) tested were found as the best conditions respectively for chemical and thermal treatment in the range of values studied. The time during which the treatment is applied also influences the process but in a less extend. Table 1 summarises the values obtained for the parameters used to determine the effectiveness of the process under the best operation conditions found for each treatment.

Table 1. Effectiveness of chemical (NaOH) and thermal pre-treatments of primary and secondary sludge under the best conditions found for each of them

Pre-treatment	Type of sludge	Time (min)	Na(OH) conc (mol/l)	Temperature (ºC)	FVS/TVS % incr.	SPC % incr.	DD_{COD} %
Chemical	Primary	255	0.3	-	509	3365	52
Chemical	Secondary	255	0.3	-	686	3437	84
Thermal	Secondary	55	-	134	1104	2978	50

In conclusion, solubilization of organic matter from activated sludge can be achieved by both thermal and chemical treatment. This fact is expected to accelerate the hydrolytic step of activated sludge anaerobic digestion. Temperature and NaOH concentration are the factors that influence the effectiveness of the each treatment in most extend.

Anaerobic Co-digestion of Organic Fraction of Municipal Solid Wastes and Industrial Greases

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The potential of mesophilic anaerobic digestion for the treatment of residual grease through co-digestion with the organic fraction of municipal solid wastes (OFMSW) has been evaluated. Co-digestion process was conducted in a metacrylate pilot plant (14 litres of effective volume) working in semi-continuous regime ('wet' process) in the mesophilic range (37 ºC). The hydraulic retention time was 18 days.

Reactor performance was routinely monitored by measuring pH, organic load, TS (Total Solids), TVS (Total Volatile Solids), VFA (Volatile Fatty Acids), LCFA (Long Chain Fatty Acids), alkalinity and biogas production and composition. Grease content was measured using the Soxhlet method.

During the start-up the reactor was fed with simulated OFMSW (diluted dry pet food). It was inoculated with sludge from an industrial-scale anaerobic digestion plant treating mixed MSW. After reaching the designed organic load, the co-digestion process was initiated. The grease used consisted of a waste from the food processing industry, which composition was very similar to that of dry pet food, especially in the LCFA profile.

The TVS content in organic load was gradually increased with TVS coming from residual grease by a percentage of 7 % each residence time. Normal operation of the pilot plant was observed for grease content up to 28 % in the organic load. No accumulation of LCFA or VFA was detected. The removal of total grease was about 90 % throughout the experiment.

The most important results of the co-digestion process are resumed in table 1.

Table 1. Operation conditions during the co-digestion of OFMSW and residual grease.

Grease in influent (%)	Theoretical organic load (kg TVS/m^3·day)	Biogas composition (CH_4 %)	Biogas production (m^3 CH_4/kg TVS removed)	Grease removal (%)
0	0.97	58.3	0.44	-
4	1.01	58.3	0.35	-
7	1.04	55.9	0.32	87.9
14	1.11	57.2	0.42	90.0
21	1.17	59	0.32	95.1
28	1.24	61.9	0.39	91.2

In conclusion, anaerobic co-digestion of OFMSW and fat wastes appears to be a suitable technology to treat this wastes recovering energy in form of biogas.

Study of biochemical and microbiological parameters during composting of pine and eucalyptus bark

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One of the possible uses of residues from the pulp and paper processing industry is the formulation of substrates to produce plants in containers as an alternative to peat, which is a very expensive and finite resource. However, these residues should be composted in order to obtain high quality substrates. This study aims to follow several biochemical and microbiological parameters to understand changes during the aerobic biodegradation process.

Three composting experiments were carried out using: pine bark, eucalyptus bark and a mixture (50:50, v:v) of pine bark + eucalyptus bark. Sampling was performed at the beginning of the process (T1), at thermophilic phase (T2), at mesophilic phase (T3), at curing phase (T4) and at the ending of the composting process (T5). During the composting process the following biochemical parameters were measured: acid and alkaline phosphatases, lipase (C10), protease, urease, β-glucosidase and total cellulases. The microbiological populations of total aerobic bacteria, total fungi, actinomycetes, nitrifying bacteria, cellulolitic bacteria and fungi were also evaluated at the same stages. At the end of the process the composts obtained were characterised through the following physical-chemical parameters: moisture, pH, organic matter, Kjeldahl nitrogen, mineral nitrogen (ammonium and nitrate) and electrical conductivity.

Results showed that in general the highest microbiological populations occurred during the thermophilic phase (>40 ºC) of composting process. Regarding the enzymatic activities (Table 1) results showed that the maximum values were also observed during the thermophilic phase as well as during the mesophilic phase (<40 ºC). Referring the different types of materials used for the composting trials, in general, higher enzymatic activities were found for the eucalyptus bark. The assessment of compost quality showed that composts obtained can be used successfully in the formulation of substrates to produce plants in containers, namely for the compost obtained from eucalyptus bark.

Development of Environmentally Superior Technology to Replace Swine Lagoons in the USA.

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Systems of treatment technologies are needed that capture nutrients, reduce emissions of ammonia and nuisance odors, and kill harmful pathogens. A treatment system for liquid swine manure was developed to accomplish many of these tasks. The system was evaluated at full-scale during 2003 as part of the Smithfield Foods-Premium Standard Farms/North Carolina Attorney General agreement to replace current lagoons with Environmentally Superior Technology. The full-scale demonstration facility was installed in Goshen Ridge, a 4,400-head finishing farm in Duplin County, NC. The system greatly increases the efficiency of liquid-solid separation by injection of polymer to increase solids flocculation. Nitrogen management to reduce ammonia emissions is accomplished by passing the liquid through a module where immobilized bacteria transform nitrogen. Subsequent alkaline treatment of the wastewater in a phosphorus module precipitates recoverable phosphorus and kills pathogens. Treated wastewater can be recycled to clean hog houses or for crop irrigation. The system was successfully brought to steady-state operation with treatment performance that exceeded design expectations; it separated 97% of suspended solids, 99.9% of BOD, 98.9% of TKN and 94.8% of total P. Odorous compounds in the waste were reduced > 99% by treatment. In less than one year, the anaerobic lagoon that was replaced with the treatment system was converted into an aerobic pond with ammonia concentration lower than 15 ppm. The system has the potential for major positive impact as a functional advance in the treatment of animal waste. Beneficiaries of this work are pork producers, industrialists, entrepreneurs, policy makers, environmental and health regulators, Natural Resource Conservation Service, and the general public.

Table 1: Reduction of suspended solids, COD, BOD, and nutrient concentration by full-scale treatment system developed to replace swine lagoons in North Carolina.*

Water Quality Parameter	Raw Flushed Manure (mg/L)	After Solids Separation Treatment (mg/L)	After Biological N Treatment (mg/L)	After Phosphorus Treatment (mg/L)	Total System Efficiency (%)
TSS	10,441	679	129	268	97.4
BOD_5	6,425	3,305	16	7	99.9
TKN	1,975	1,241	32	24	98.8
NH_4-N	1,242	1,166	9	1	99.9
TP	596	192	149	31	94.8

* http://www.cals.ncsu.edu/waste_mgt/3-year%20Smithfield%20Report/pi%20report%20pdfs/super%20soil%20original.pdf

Full-scale combination of anaerobic digestion and concentration by evaporation at Garrigues County (Spain): evaluation of 2 years on operation

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Evaporation process is a reliable strategy to manage pig slurry (PS), removing water and recovering nutrients by concentration. The described centralised treatment plant is located at Garrigues County (Spain), able to treat *110.000 Mg/year* of PS, and it serves 90 farmers. The technology applied is VALPUREN^{TM} process, based on the combination of anaerobic digestion (AD) and evaporation. The benefits of this process combination have been previously reported at laboratory scale. In the present paper it is studied the influence of AD over the general process, after two years of full-scale operation.

The biogas yield (m^3 biogas/kg volatile solids added) is highly correlated with the organic content of PS and with the COD/VS ratio, that is a function of PS age and of management practices at farm level. Organic loading variation along time, due to these factors, could provide a not stable anaerobic digestion process with accumulation of volatile fatty acids (VFA). The key of evaporation process is to obtain a high-quality condensate that could be reused. It has been studied the influence of VFA content at the effluent of AD and COD of condensates (Figure 1) and also the influence of pH acidification prior to evaporation on ammonia content of condensate (Figure 2). The pH decrease in acidification process (previous to evaporation) can ensure a low free ammonia concentration (Figure 2), but it increases the un-ionised VFA fraction and the COD of condensates. AD ensures the decrease of total VFA concentration and other volatile organic compounds, and therefore it decreases the pollution of condensed water.

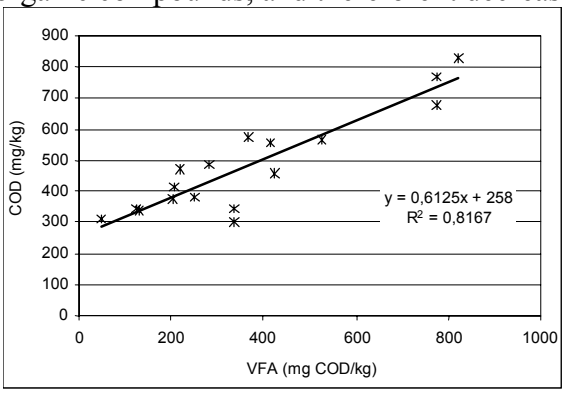

Figure 1. Correlation between organic matter in evaporation condensates and VFA content in anaerobic reactors

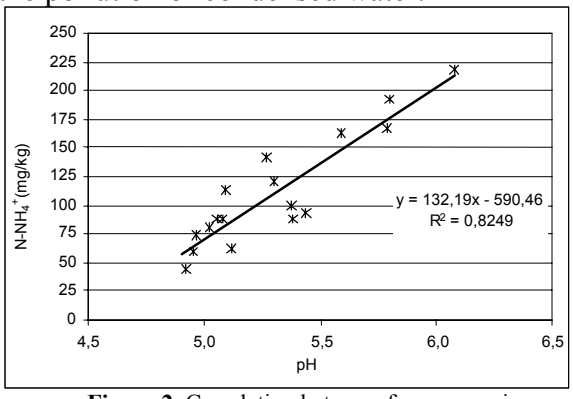

Figure 2. Correlation between free ammonia concentration as function of pH at acidification step

It is concluded that a stabilized AD improves biogas production and evaporation process. Management method at farm level is an issue of concern for a successful performance of a centralized treatment as this kind.

Investigations into the N-dynamics during composting under special consideration of denitrification

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Nitrogen (N) plays an important role during composting. On the one hand compost N may be a valuable plant nutrient; on the other N emissions during composting and compost application may have harmful effects on the environment (e.g. uncontrolled mineralization of organic compost N; NO_x-, N_2O-, NH_3-emissions). The N-dynamics was studied in app. 40 composting experiments using a laboratory composting unit with 100 L bioreactors. The kind of substrates (e.g. different real and model waste, variation of kind and content of ingredients) and composting parameters (e.g. temperature, aeration, moisture, pH, structural material) were varied. Besides the general parameters determining the course of composting (e.g. temperature, moisture, pH, CO_2 production) parameters which affects the N-management (total N, NH_3-, NO_3-, NO_2-N in substrate and leachate; NH_3-, N_2O-, NO_x-N in exhaust gas) were measured and N-balances generated. In the N-balances mostly a N-lack did appear with an maximum of almost 30 % in one case. It did increase most significantly during the cooling period in a lot of experiments. It can be assumed that the lack resulted from N_2-generation by denitrification. Partly this could be approved by N_2-measurements in the exhaust air. However, that measurements were not specific enough to allow quantification due to the very high N_2 content in the natural air. Following groups regarding the N-lack could be postulated: I) no lack, in 20 % of the experiments; II) lack starts during 1st week, 37 %; III) lack start after 1st week, 43%. The properties of the starting substrate had an impact. The substrates from all experiments with an early lack (group II) were distinguished by the others (e.g. impacts of type and content of structural material; particle size, moisture content or pH). Furthermore it was assumed, that the history of the substrate (age, storage) was from influence. The experiments without lack (group I) were distinguished from the others mainly by process regulation, whereas kind of aeration, temperature and turning regime had an impact.

N_2 can be generated as a product from biological denitrification. NO_3^- will be used as a substrate, which can be produced from NH_4^+ by nitrification. Nitrification and denitrification are generally considered to be relevant for mesophilic conditions, but also thermophilic processes are known. Furthermore, a chemical denitrification may occur as well, which shall be more relevant for higher temperatures. The experiments showed, that also thermophilic denitrification can be important in a lot of cases, since in all experiments from group II, the N-lack did start during thermophilic phase. The process of biological denitrification is probably more important than the chemical one due to the impact of waste history which propably significantly influences the microbial population. The knowledge about denitrification processes helps to produce composts tailor-made for certain applications and to reduces unwanted N-losses and –emissions.

Agricultural reuse of olive mill effluents after energy recovery

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Treatment and disposal of residues from olive-oil processing represents the main problem of the industry involved in the extraction of the olive oil due to the high volume annually produced.

Recently, the introduction of the "two phases" method of olive-oil extraction has drastically reduced the amount of processing water produced and the olive mill pulp is the only waste generated. The olive pulp produced contains high amount of carbohydrates and thus it could be an ideal substrate for the production of energy: ethanol, hydrogen and biogas (methane).

Aim of this research, within the BIOTROLL[1] project started at the beginning of the 2003, was: 1) the physical and chemical characterization of the olive pulp arising from the biological treatment for the production of i) ethanol and ii) hydrogen, and iii) the subsequent anaerobic treatment of the effluent with production of methane, and 2) the agricultural reuse of the final effluents as fertilizer.

Preliminary results showed that the first three effluents analyzed (olive pulp - OP, effluent from hydrogen - EH_2, and from methane - ECH_4) contain i) 28.4 (OP), 9.8 (EH_2) and 4.6 (ECH_4) of dry matter; ii) around 60% (dry weight) of organic carbon; iii) an appreciable quantity of macro (especially organic N, K_2O) and micronutrients and iv) a negligible amount of heavy metals. pH and electrical conductivity (EC) are in a normal range.

The addition of OP, EH_2, and ECH_4 to a Typic Ustipsamment soil (equal to 60, 120, 180 kg N ha^{-1}) has shown that i) different intensity of mineralization processes occur; ii) any phytotoxicity phenomenon and iii) a significant bio-stimulant effect on wheat seed germination (*Triticum durum*) was observed.

These results confirm that the quality of the effluents after the biological treatments are compatible with their agriculture reuse, especially in Mediterranean areas.

[1] Research supported with funds provided by EU, Fifth Framework Program, Life Quality, Project n. QLK5-CT-2002-02344 – BIOTROLL (Integrated Biological Treatment and Agricultural Reuse of Olive Mill Effluents with the Concurrent Recovery of Energy Sources).

Pretreatment of manure by separation as a method to improve gasproduction and economical performance of biogasplants

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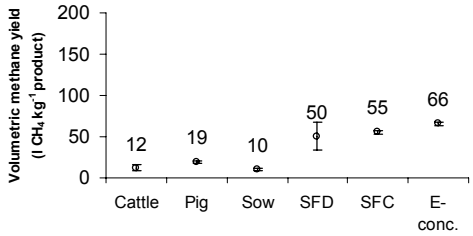
The gasproduction from liquid manure in terms of volume is low and often organic waste products has to be added to improve the economic performance of biogasplants designed for manure.

Pre-treatment of manure by separation is a way to make fractions of the manure with higher gas potential in terms of volume. Different solid-liquid separation technologies like centrifugation, chemical precipitation and "in stable" separation of feces/urine make production of solid manure fractions possible containing between 50-95% of the volatile solids in in 10-25% of the total volume of manure. Theoretical methane potential and biodegradability of three types of fractions deriving from manure separation were tested. The economical and synergetic effects for biogasplants and farmers by integrating solid-liquid separation at farms connected to a co-digestion plant were analyzed for different scenarios.

The ultimate methane yield (B_o) was determined in a batch experiment. The experiments were performed in 1100 ml infusion bottles. The bottles were closed with butyl rubber stoppers, sealed with aluminium crimps and incubated at 35 ± 0.5°C, after flushing with N_2. The test medium was feces taken directly after excretion from the pigs and solid fractions of manure produced by centrifugation or by chemical precipitation.Figure. The ultimate methane yield in terms of volume from cattle, pig manure, physical fractions of manure and straw. SFD (solid fraction from decanting centrifuge. SFC (solid fraction from chemical precipitation), E-conc (condensate after evaporation of water from liquid fraction after a decanting centrifuge)

Pre-treatment of manure by separation is a way to make fractions of the manure with

higher gas potential in terms of volume since the water can be drained from the solids making fractions with a higher VS concentration, hence the volumetric methane



productivity is higher in the physical fractions of manure compared to undiluted manure.

Evolution of chemical and physicochemical properties of MSW compost during three long-term maturing treatments

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Whereas the changes of analytical properties of municipal wastes during their composting are well-known, those occurring during the maturing stages have not been extensively studied. In a middle-scale (300 kg) experiment, we have measured the evolution of different chemical and physicochemical properties of MSW compost (pH, electrical conductivity, total, water-soluble, humified and humic carbon, E_4/E_6 ratio of humic acids, and organic nitrogen) during one year of three different treatments: maturing (product kept at optimal moisture and aireation levels), stocking (product compressed and uncontrolled, simulating the usual handling at composting plants) and vermistabilizing (compost digested by *Eisenia foetida*). The results show a larger degradation of organic matter during maturing and vermistabilization, increasing density and nutrient concentration of the compost, together with stabilization of pH and salinity levels. Small differences were found as for humic substances concentration and E_4/E_6 ratio.

Methane production from maize, grassland and animal manures through anaerobic digestion

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Biogas production from energy crops is a very promising option to generate renewable energy. Biogas plants require a targeted nutrient supply to make optimum use of energy crops. Currently, specific parameters on the anaerobic digestibility of energy crops are unavailable which restricts the exploitation of the promising potentials. The research project aimed at finding basic principles and data on the metabolic and energetic turnover during anaerobic digestion of animal manures, grassland and several maize varieties in agricultural biogas plants. The methane energy value system (MEVS) was developed. It estimates methane production from the nutrient composition of the digested substrates. The methane yield per hectare of energy crops can be estimated as well. Optimum varieties and harvesting times can be suggested. Methane production was investigated by incubation of the organic substrates in lab scale batch digesters.

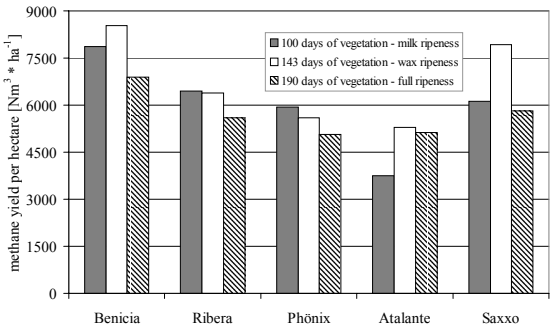

Figure 1. Methane yield per hectare from anaerobic digestion of maize varieties in dependency on the harvesting time

The new methane energy value system (MEVS) enables the calculation of the specific methane yield depending on the nutrient composition of maize, clover grass silages and animal manures. It helps to optimise biogas production by the following capabilities: estimation of the methane production of organic substrates from their nutrient composition; estimation of the nutrient requirement of micro-organisms that are responsible for anaerobic digestion; estimation of the power of agricultural biogas plants in dependency of amount and composition of organic substrates that are digested; recommendations on varieties and optimum harvesting time of energy crops; estimation of methane yield per hectare of energy crops, varieties and crop rotations.

Phytotoxicity decrease of water-soluble substances from olive mill dry residue by hydrolytic enzymes produced by saprobe fungi

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The dry mill oil residue constitutes an environmental problem due to its polluting capacity. This residue might be used as fertilizer due to their high organic content but it is necessary to eliminate its phytotoxicity using biological methods such as bioremediation with saprobe fungi. The aim of this work was to study the influence of saprobe fungi on the effect that has the water-soluble substances (ADOR) of residues from olive in the growth of the plants.

The aqueous extract of olive mill dry residue was incubated with *Penicillium chrysogenum*, *Fusarium lateritum* and *F. oxysporum* at 25 ºC during 15 days. The culture liquid was separated from the mycelium by centrifugation and the supernatant was used to analyze the effect of the ADOR in the growth of tomato plants. The aqueous extract of olive mill dry residue extracted, after the incubation with the saprobe fungi, was assayed to determine total phenolic contents and endoglucanase, endopolymethylgalacturonase and endoxyloglucanase activities.

All the saprobe fungi were able to decrease the phytotoxicity of ADOR, however the toxicity of this residue did not decrease in the same way. *P. chrysogenum* was capable to reduce the toxicity of ADOR when this residue was applied at the highest dose of 15%, *F. lateritum* was able to reduce the toxicity of ADOR when this residue was applied at the intermediate doses of 10 and 5% and *F. oxysporum* decrease the phytotoxicity of ADOR only when the residue was applied at the lowest dose of 2.5%. All saprobe fungi tested produced endoglucanase, endopolymetylgalacturonase and endoxiloglucanase enzymes when were grown in presence of ADOR. A close relationship between the decrease of phytotoxicity of ADOR and the amount of hydrolytic enzymes by saprobe fungi was found.

These results shows that hydrolytic enzymes can be important in the process of degradation of phytotoxic substances present in the dry mill oil residues.

Decrease of tomato toxicity caused by olive mill dry residues using arbuscular and saprobe fungi

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The two-stage centrifugation process to extract olive oil produces an olive mill dry residue (DOR). Addition of DOR to soil might result in increased plant growth because of their nutrient content; however, these residues contain phenolics compounds that may have negative effect on plant growth. The aim of this work is study the influence of arbuscular and saprobe fungi on the effect that has the dry residues from olive in the growth of the plants.

Olive mill dry residue was inoculated with *Coriolopsis rigida*, the static incubation was performed at 28ºC during 2, 10 and 20 weeks. After the incubation with the saprobe fungus, the DOR was sterilized and added to soil pots at concentrations of 0 and 60 gKg^{-1} soil. The arbuscular mycorrhizal fungus used was *G. mosseae*. Five grams of inoculum with spores, mycelium and infected root was added to each pot. Tomato plants were grown in a greenhouse under controlated conditions.

Shoot dry weight of tomato was decreased by the application of DOR to soil. The inoculation of *C. rigida* decrease the phytotoxic effect of DOR, however it is necessary 10 weeks of incubation of *C. rigida* to observe increase in the shoot dry weight of tomato to which this transformed DOR was applied compared with the plants of tomato to which apply not incubated DOR. The application of DOR incubated during 20 weeks with *C. rigida* to plant colonized with *G. mosseae,* increased the shoot dry weight of tomato compared with plants grown in the absence of DOR.

C. rigida was capable to eliminate the toxicity of DOR. The arbuscular mycorrhizal fungus *G. mosseae* was resistant to the actions of DOR and improve plant growth in presence of the DOR transformed by *C. rigida*. These results open the possibility of the use of DOR as organic fertilizer.

Selection of procymidone degrading microorganisms from composting of plant wastes

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The economical relevance of intensive agriculture in the South-East of Spain has been increased since greenhouse technology was established. Nevertheless, some negative aspects derived from this activity, as waste generation, may produce important adverse effects, mainly on environment. Among chemical contaminants, pesticides show a high potential risk. However, at the moment, an intensive agriculture lacking pesticides is inconceivable. Thus, possible solutions to solve this problem must be approached in a different way.

Bioremediation, the use of living organisms to minimize the environmental incidence caused by the accumulation of xenobiotics and other toxic substances, has been proposed as an interesting alternative to more traditional physical or chemical treatments. Specifically, the removal or reduction of this kind of molecules by microbial action shows many possibilities, as a consequence of natural or genetically acquired capabilities of microorganisms. On the basis of this microbial application, screening for microorganisms suitable for pesticide bioremediation, may be of interest as a first step in the biological treatment of these recalcitrant compounds. Thus, the aim of this work was the isolation of microbial strains that could be used as inoculants in composting processes, favouring the retirement of this kind of pesticide residues.

Samples obtained from composting heaps at different stages were screened for the presence of microorganisms able to degrade procymidone, a carboximide effective against fungi, used for horticultural protection. An enrichment selection process in media supplemented with the pesticide as sole carbon source led to the isolation of 65 microbial strains. The in-depth study of these microorganisms allowed a second selection of three bacteria, which showed a 35% reduction in procymidone concentration in just one day.

On the basis of these preliminary results, the selected microorganisms showed an important potential to be applied in composting, decreasing the concentration of procymidone.

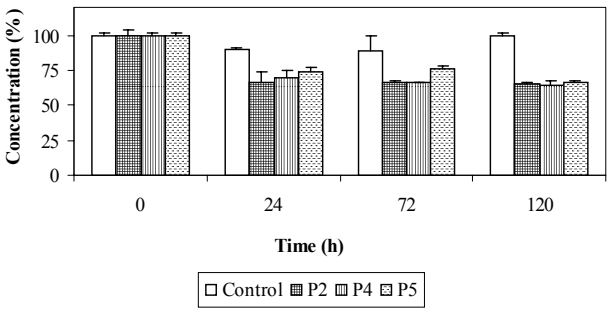

Figure 1. Procymidone degradation by isolated microorganisms.

Effect of the raw material and bacterial inoculation on humic and lignocellulosic fractions during composting of horticultural wastes

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The intensive agriculture practiced during the last 30 years at the Southeast of Spain has favoured the economic apogee of this zone. This practice involves negative aspects too, such as the production of enormous amounts of horticultural wastes, which are mainly composed of lignocellulosic material. Though several solutions have been proposed, composting of horticultural wastes seems to be one of the most interesting alternatives. This organic waste biotransformation allows the elimination of potentially dangerous contaminants and leeds to the obtention of mature compost, which is used as organic amendment. The aim of this work was to study the effect of inoculation and raw material composition on composting. In relation to this, evolution of humic and lignocellulosic fractions during the process were analysed.

Pepper plant wastes were arranged in 1,5 m^3 piles and mixed with other raw materials (Table 1). Windrows were initially inoculated with lignocellulolytic microorganisms from our own strain collection (Table 1). Lignocellulosic fractions evaluated were neutral detergent fibre (NDF) and acid detergent fibre (ADF). On the other hand, humic fractions analysed were total humic extracts (THE), humic (HA) and fulvic (FA) acids, and several humification indexes.

Results showed the influence of microbial inoculation on NDF and ADF values, while raw material only exerted some influence on NDF. In both cases, lower fibre account was achieved at the end of the process. On the other hand, microbial inoculation did not influence the different humic fractions while the type of raw material was found as a factor that significantly influenced the amount and proportion of humic compounds. Higher humification degrees were observed at the end of composting, although highest humic acid values were earlier accounted. From these observations it can be concluded that both inoculation and composition of raw material contributed to the final product characteristics and quality.

Table 1. Raw materials and inoculanting microorganisms used in the composting process

Raw material		Inoculant Microorganism	
Mixture	Proportion	Code	Class
P: O: A	3:1.6:1.4	162	Thermophile Bacterium
P: Pr: A	3:1:1.5	671	Thermophile Bacterium
P: R: A	3:1:1.5	252	Thermophile Actinomycete
P: A	3: 1		

P: pepper plant. O: olive-oil mill waste. Pr: pruning waste. R: rice straw. A: almond shell

Modelling of biological processes during aerobic treatment of pig slurry aiming at process optimisation

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Due to nitrate pollution of water resources, treatment process for animal manure were developed in order to reduce the quantity of organic nitrogen spread on soils in intensive production zones. For the treatment of pig slurry, the optimisation of the biological treatment using intermittent aeration require (i) a better knowledge of the composition and variations of the raw slurry entering the treatment unit and (ii) a better characterisation of the biological processes involved in the biological reactor.

Within this framework, characterization of the biodegradability of raw slurry using ultimate BOD and respirometry, and modelling of the characteristics of the slurry were carried out during this study. According to the results obtained, between 30 and 60% of the organic matter of pig slurry, expressed as COD, is biodegradable during aerobic treatment.

Then, biological processes were investigated using laboratory pilot reactor previously developed. Denitrification kinetics observed during these experiment were directly related to the biodegradability previously determined. Concerning nitrification, oxydation of ammonium to nitrite was less influenced by oxygen concentration than oxydation of nitrite to nitrate, leading to nitrite accumulation at low level of oxygen.

Finally, all results allowed the development of a mathematical model allowing to estimate the characteristics of the treated slurry depending on the characteristics of the breeding and the treatment unit. The results highlight different strategies of dimensioning and management according to characteristics of the raw slurry. The developed model will be used to define regulation options necessary for the optimisation.

Evaluating Two Secondary Treatment Alternatives For Sanitising Faecal Matter

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The second most nutrient-containing fraction from households, faecal matter, is highly likely to contain pathogens and thus requires some form of sanitising treatment. Two alternatives for this treatment, thermal composting and chemical treatment with ammonia, were evaluated in the present study and compared to treatment by simple storage for 50 days. The aim of the study was to find an environmentally friendly sanitation method for faecal matter.

Thermal composting of faeces together with food waste (35% dry matter content) resulted in a treatment temperature of over 65°C for 3 consecutive days. However, not all the material maintained this high temperature as the system tested was simple and the incoming air was not preheated. If the treatment is performed correctly it is possible to produce sanitised faecal matter, although there is always a risk for regrowth of pathogenic bacteria.

In the chemical treatment tested, an addition of 3%N-NH_3 increased the pH in the faecal material (10% DM) from 8 to 9.2 within one hour of application and resulted in a good reduction in the indicator organisms for bacteria (Salmonella and E-coli Dr < 0.7 days, Enterococci Dr <3 days) , viruses (Dr <7.5 days) and parasites (no viable organisms after 50 days). However, spore-forming bacteria remained unaffected. Chemical treatment requires a closed container for the process and a high water content of the faecal matter. The chemical ammonia (added as urea) does not become further degraded during the treatment, which results in no risk for regrowth and also an improvement in the fertiliser value of the treated matter as its nitrogen content is increased.

Storage of faecal matter (10% DM) only reduced the presence of faecal coliforms while the enterococci and the viruses were not reduced and viable salmonella and *Ascaris suum* were found throughout the 50 days of storage.

Key words: Chemical disinfection, Composting, Ecological Sanitation, Faeces, Sanitation

Municipal Waste Compost´s phytotoxicity on barley's germination and biomass

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Municipal Waste Compost (MWC) can produce phytotoxicity on plants and our goal will be to describe in which way or ways this phytotoxicity, at different MWC concentrations, is being affected in barley's germination and final biomass.

The experiment was carried out in spring, inside a greenhouse based on standard ISO 11.269-2 and using a clay soil as the matrix for Compost. The culture chosen was *Hordeum Vulgare* (barley) because this culture is also taking place in a wider study that is trying to figure out MWC long term effects on the agrosystem. The dose of Compost used were of 0 (control), 20, 150, 300, 450, 600, 750 y 900 The essay lasted 28 days during which the number of seeds germinated (G) was measured. After this period, the aerial(B_{pl}), root(B_r) and total (B_t) biomass of the plant was measured as well as the soil's electrical conductivity (EC) and soil's pH.

MWC´s phytotoxic effects on G can be observed in doses up from 750 $m^3 \cdot Ha^{-1}$. B_t has a quite similar behavior, B_r seems to be more affected with concentrations of just 20 $m^3 \cdot ha^{-1}$. B_r, unlike B_{pl} , shows a rise of up to 300 m^3 when compared with the control. The increase of EC is significantly correlated with the decrease of B_t. The pH is higher in the samples than the control but it becomes stabilized at a neutral but this doesn´t seem to be a differentiator factor of B or G.

As a result, MWC shows phytotoxicity on the barley plant with concentrations quite superior to the ones used in field. It can also be said that EC is one of the factors of this phytotoxicity. Finally, the plant's aerial biomass (B_{pl}) increases at medium concentrations of 300 $m^3 \cdot ha^{-1}$ being more phytotoxic on the root.

Heat inactivation of Porcine circovirus 2

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European regulation (EC 1774/2002) states that Category 3 animal by-products from healthy animals approved for human consumption requires pasteurization at 70°C for 60 minutes before biogas digestion, to produce a hygienically acceptable product. Porcine parvovirus (PPV), one of the most stable viruses known, have in studies with spiked substrate shown $\log_{10}$ reduction results of 1.4 – 3.2 after this treatment. However, a reduction of 4 or 5 $\log_{10}$ is recommended.

Porcine circovirus 2 (PCV2) have during the recent years been found in Europe as well as worldwide. This virus, in contrast to Porcine circovirus 1 (PCV1) is a definite pathogen, which is associated with PMWS (postweaning multisystemic wasting syndrome), as well as other disease syndromes in the pig. In Sweden, where PMWS has recently been diagnosed, PCV2 was earlier shown by retrospective serology to be very common without clinical symptoms. Concerning pure virus, no inactivation was seen for PCV1 and PPV after 15 minutes at 70°C. Therefore it would be of interest to compare the heat stabilites of PCV2 and PPV at higher temperatures. The experiments were carried out using a heated shaking water bath at 80°C and 90°C for 15 minutes. Duplicate experiments at 95°C for 5 seconds was performed, as this high temperature is of interest for manufacturers of gelatine from porcine raw material, for subsequent human consumption. PCV2 "1010-Stoon" and PPV 893/76 was titrated to an end-point using PK-15 A cells and immunoperoxidase detection.

Table 1

	Infectivity titre[a]							
	80°C		90°C		95°C		95°C	
Virus					Experiment 1		Experiment 2	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
PCV2	5.8	1.3	5.6	0.9	6.4	0.8	6.4	≤0.8[b]
PPV	8.3	1.8	7.7	≤0.8[b]	n.d. [a]		n.d.	

[a]Titres in $\log_{10}$ tissue culture infectious dose (TCID) $_{50}$ per ml calculated according to Kärber
[b]= no virus detected
[a] = not done

Highest reduction factors calculated were ≥7.2 $\log_{10}$ after 15 minutes at 90°C and ≥6.0 $\log_{10}$ after 5 seconds at 95 °C, for PPV and PCV2, respectively. As the results indicates that PCV2 is even more heat stable than PPV it should be taken into account as a plausible contaminant of substrate for biogas production. If the digested residue is used as fertilizer, this can be a health risk for animals and later on for humans.

A new structured mathematical model of the composting process

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The objectives of modelling are the development of mathematical tools to allow the integration of the knowledge on the considered phenomena, to orientate experimental design, to evaluate experimental results, to test hypothesis, to reveal relations among variables, to predict the evolution of a system and, definitively, to design optimised process and management strategies.

Models for composting process present a higher complexity than those for aerobic and anaerobic wastewater treatment, because of the solid medium heterogeneity. Models described in the literature are focused on the biological or physical aspects of composting. A new approach, considering the integration of biological and physical phenomena is the objective of the present work.

The present model considers a three-phase system, with mass and heat transfer, and biological processes including hidrolysis, growth, lysis and decomposition of microorganisms. The system is described with 31 state variables and 53 processes, following 31 ordinary non-linear differential equations, with proper initial and boundary conditions.

The considered volume is occupied by a solid-liquid phase and a gaseous phase. In the solid-liquid phase the organic matter is decomposed by microorganisms, with a release of of gases and heat, and an uptake of oxygen. Between liquid and gas phases, mass transfer of gases and water, through evaporation or condensation, is considered.

Hydrolysis term is used in this model for the transformation of a particulate substrate into its soluble monomers. A succession of different microorganism populations is described, with different capability of each group of microorganisms to degrade different substrates. Growth limitation by lack of substrate, water, oxygen and ammonia is considered and maximum growth rate dependence of temperature is also modelled.

For the preliminary test of the model, a set of parameters was defined estimated from different values obtained from the literature. A 4-5 Runge-Kutta-Fehlberg method was used for approaching the solution of the set of differential equations.

The simulation results were compared with experimental values described in the literature, obtaining a good qualitative approximation. Good approach was obtained for gaseous emissions, substrate degradation and temperature evolution. The sensitivity analysis performed orientates the experiments for further calibration, focussing on parameters and state variables requiring special attention.

Time Course Evolution of the Physico-Chemical Characteristics of a Mixture Containing Wood Ash, Sewage Sludge and Meat Flour

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A mixture containing 12% sludge, 80% ash and 8% meat flour, is incubated for several periods of time in order to determine its time course evolution. In such way we have attempted to simulate what's going on with the mixtures, the time before its spreading over the land.

We have used PET' containers of 500 cm^3 with 60 g of mixture, at room temperature. We have incubated replicated samples for two, four and six weeks, and then they are analysed for physico-chemical parameters.

Electrical conductivity, TKN and pH levels decrease as a function of the incubation time, as well as Na, Al and heavy metals available levels. However, the available levels of P, Ca, Mg, K, S and Fe increased with time. The spreading of the mixture on acid soils could be attractive, due to its nutrient content and low heavy metals levels.

Evaluation of a mixture of wood ash, sewage sludge and meat flour

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Important amounts of several wastes such as sewage sludge, wood ash (a by-product of timber industries) and meat flour from non ruminants animals (waste that has lost its traditional market) are generated currently. In this work we study mixtures composed of these wastes, proposed in order to promote its valorisation and agronomic recycling.

After previous studies, we concluded that the 12% sludge, 80% ash and 8% meat flour relationship was the most appropriate. This mixture shows clear advantages with regard to the individual wastes that contains. The mixture has less odour problems and also better stability as an aggregated solid. On the other hand the resultant product has attractive features fertilizer and soil conditioner.

Co-composting sewage sludge and fats. Optimal ratios and process evolution

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At present, composting is used in the treatment of a wide number of organic wastes, such as organic fraction of municipal wastes, municipal sewage sludge, other biosolids, etc. Other organic wastes of industrial origin can be also composted successfully. Among them, fat from food processing industry or slaughterhouses comprises a waste considered as difficult to be composted. The main problems associated with fat composting are: low water content and solubility, lack of porosity and a relatively low biodegradability of certain fats. Co-composting of this residue is the alternative proposed in the present work.

Laboratory experiments with increasing amounts of a typical fat waste and using sewage sludge as basic substrate for composting are presented. Values of routine parameters for composting process, fat content and lipolytic activity were monitored in aerated static lab-scale composters.

Table 1. Main results obtained in the co-composting experiments.

Sample	Maximum Temperature (ºC)	Thermophilic period (days)	Lipolytic activity (U/g)	Total fat removal (%)
Control	49	2	1.02	14.8
Fat 20 %	60	13	1.29	49.3
Fat 40 %	60	14	1.58	40.7
Fat 60 %	61	>18	-	24.2
Fat 80 %	48	8	-	3.1

In general, fat content could be increased up to 40%, showing positive effects on the composting of sewage sludge. Thermophilic period was maintained for longer times, which contributed to achieve a complete sanitation of the material. For higher amounts of fat content, however, oxygen diffusion was severely hampered. Therefore, a fat content of 40% could be considered as maximum in the co-composting process. On the other hand, high lipolytic activities were an evidence of the production of specific enzymes to degrade this fat-enriched material. Nevertheless, it must be pointed that a fraction of fat is not degraded within the composting time tested (21 days). In conclusion, co-composting with sewage sludge or other organic substrates can be considered as a viable alternative to treat fat wastes in high proportions (40%).

The efficiency of commercial additives for the composting process optimisation

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The efficiency of five commercial additives aimed to optimise the composting process and to reduce odour emissions, was tested on a mixture of sorted organic fraction from Municipal Solid Wastes with wooden residues. The measurements were made in an experimental pilot plant with 6 aerated static reactors (volume = 1 m^3 each). The reactors are equipped with a ventilation control device having either automatic regulation (by means of a temperature sensor placed inside the mass) or manual regulation (with the possibility to set times of pause and work as well as ventilation intensity). All the operating parameters were recorded continuously on a dedicated PC.

The efficiency was assessed by the mass balance, the static respiration index and the odour measurements by dynamic olfactometry (EN 13725/03).

No significant differences were measured on the process yield and on the static respiration index (SRI) between the additive treated and the untreated mixtures. At the end of the composting process the dry matter yield was between 78% and 90%, while the organic matter yield was between 64% and 80%. The SRI, on the whole, gradually decreases with the process. The starting values of the fresh mixtures, at the loading of the reactors, are in the range 1600-2250 mg O_2 kg SV^{-1} h^{-1}, very similar between treated and untreated, confirming a good mixture homogeneity. At the end of the composting process the SRI values are in the range 410-987 mg O_2 kg SV^{-1} h^{-1}.

Two out of five additives reduced odour emission at the first sampling occasion, that is at the starting of the composting process (few days after loading, when temperatures reached 45-50°C). Anyway, even if the average values are clearly different, no significant statistical difference (t-test $\leq$ 0.05) was revealed. On the whole, in all the trials, a relevant reduction of odour level was observed between the first sampling occasion and the following ones; at the 3rd sampling, after 3-4 weeks from the starting of the process, the odour concentration is close to 300 ou_E/m^3.

A contribution to the study of co-composting poultry and forest wastes

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In the Portuguese region of Viseu, the poultry breeding activity is very important. However, its wastes can contaminate soil and water. An important forest area also characterizes such region. The accumulation of settled forest waste increases the risk of forest fires, which originate, every year, serious damages with dramatic environmental consequences.

It is important to implement treatment systems for both of these types of solid organic wastes. Composting has the advantage of being a biological treatment system able to stabilise organic wastes that can be further used as fertilisers.

The present work intends to contribute to such a strategy by evaluating the possibility of co-composting poultry manure with vegetable residues.

The mechanisms associated with the bio-oxidation of the poultry manure alone or mixed with either straw or pine sawdust, were studied at a pilot-scale. The composting material(s) was structured with wood chips, in conic piles. Turning cycles were performed in order to control the main operational variables (aeration, temperature and moisture). The process monitorization involved the evaluation, through time, of several physical, chemical and microbiological conventional parameters. To evaluate the maturity/stability of the compost, the humic/fulvic acids ratio**,** the self-heating test and the germination index were used.

The evolution of the monitorized parameters correlated well with aeration and moisture control procedures, as well as with the characteristics of the composting wastes, namely the carbon/nitrogen ratio. In fact, the obtained results showed that the composting of the poultry manure, rich in nitrogen containing compounds, becomes more effective when it is mixed with other materials that serve as carbon source.

The co-composting procedure seems to be a good alternative to the valorisation of the studied types of waste, thus contributing to the resolution of some of the major environmental problems they can cause.

Aeration effect on nitrogenous emissions during the composting of turkey or cattle manure

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In the last years, there is increasing interest in controlling the pollutant emissions of farm techniques. Composting belongs to the recycling techniques for agricultural wastes. Aeration is one of the most important factors because composting is basically an aerobic transformation of organic matter. The aim of this study was to determine the effect of aeration on nitrogenous emissions during the composting of turkey and cattle manure as generated by farm-scale management practices: moisture increase, compaction and turning.

Around one ton of cattle manure and three tons of turkey manure were composted in six cells for 46 days. The manure was either moistened, compacted or turned. Temperature, mass, moisture, carbon and nitrogen content, porosity, bulk density, volume and emission of ammonia and nitrous oxide were monitored.

The results show that for similar manure the aeration increase induced higher ammonia and nitrous oxide emissions. In the case of cattle manure, the overall nitrogenous emissions were lower than that of turkey manure despite the turning. It was due to the higher carbon availability and the lower nitrogen availability reflected by the higher C:N ratio.

Therefore, the management of aeration should take into account the carbon availability in order to control the nitrogenous emissions when composting organic materials with high nitrogen availability.

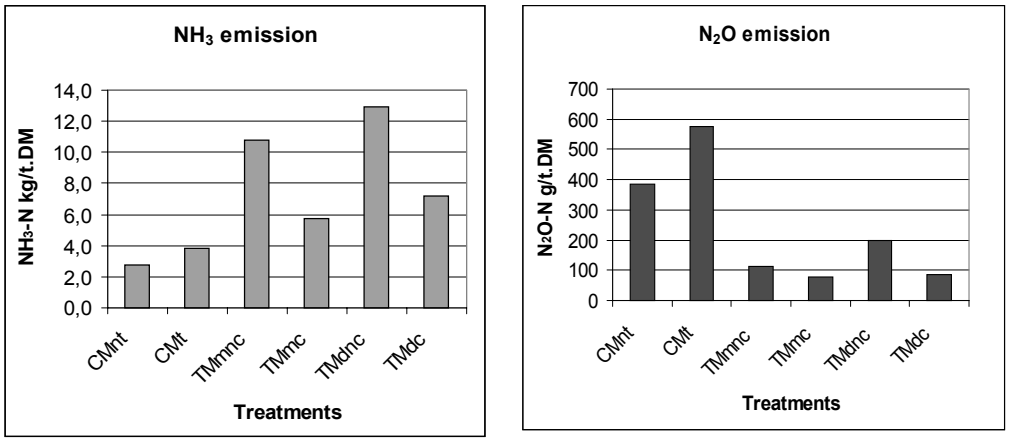

Figure 1 : Ammonia and nirous oxide emissions (g nitrogen per ton dry matter; CMnt: cattle manure not turned - CMt: cattle manure turned -TMmnc: turkey manure moist and not compacted – TMmc: turkey manure moist and compacted – TMdc: turkey manure dry and compacted – TMdnc: turkey manure dry and not compacted).

Improving composting treatment through modelling: Conception of an in-vessel composting model

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Composting processes are an interesting way to treat organic wastes and produce quality products that may be used as soil conditioners or organic fertilizers. Through two major phases inducing firstly biodegradable organic matter consumption and then humic substances synthesis, composting leads to obtain stabilized, dryer, sanitized and more homogeneous materials, ready to return to the soil. Nevertheless, composting end product's quality largely depends on the way to formulate the initial mixing and manage reactions occurring during the treatment. As composting is based on numerous interdependent biological, physical, chemical and thermal phenomena, this treatment is quite difficult to understand on the sole experimental way. Then, the aim of this study was to produce a mathematical composting model, which could be used as a predictive tool to understand composting phenomena and optimise the treatment.

An in-vessel 300-litre pilot composting treatment was studied. Three steps were considered to set up the composting model. Firstly, biological reactions were studied thanks to a respirometric method. A biological model, based on a Monod type kinetics was validated, and kinetic parameters were estimated. Secondly, the gas hydrodynamics was studied in the composting pilot. By using a gas tracing method, gas retention time distribution was measured and the gas flow pattern was modelled. Gas flow model was then used to propose heat and mass transfers models within the composting pilot. Thirdly, biological and transfers models were compiled in a one dimension composting model. This latter was programmed and solved with a Scilab software. The composting model enables to predict biodegradable organic matter fractions content, temperature, oxygen content and compost water content through the composting mass all along the treatment. First results were obtained with initial experimental data and non-calibrated parameters. Figure 1 shows results for temperature modelling. The model has now to be well calibrated and further validated on complementary experiments. Yet, it may already be considered as a very interesting tool to understand parameters influence on composting treatment result.

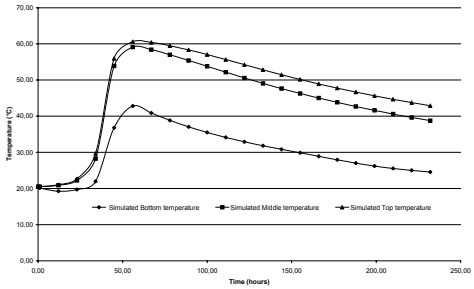

Figure 1. Temperature simulation within the composting pilot

Dry thermophilic anaerobic digestion of organic fraction of the municipal solid waste: focusing on the inoculum sources

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Anaerobic digestion is an attractive treatment strategy for organic fraction of municipal solid waste (OFMSW) and it is of great interest from an environmental point of view. The growth of full-scale applications and the low cost is due to the high energy recovery linked to the process in Europe. The dry thermophilic anaerobic digestion showed promising results in laboratory scale studies. The objective of this work was to evaluate the performance of six lab-scale reactors during start-up and steady-state phases using different inoculum sources. The organic fraction from the campus restaurant (University of Cádiz) was selected, dried, and homogenized to obtain a representative sample of sorted source of organic fraction of municipal solid waste (SS-OFMSW). The initial SS-OFMSW (78,6% ST) was adjusted to 35% total solid (TS) with water. In this experiment, the six different organic solids (Corn silage, rice hulls (RH) mixed with OFMSW, swine digest waste (SDW), sludge digest (SD), manure waste, SDW mixed with SD) were added (25% of inoculum) to digesters with SS-OFMSW. The operational parameters evaluated were pH, alkalinity, ammonia nitrogen (AN), solids, and biogas production and composition. The thermophilic temperature was controlled and monitored at 55ºC. The initial characteristics of SS-OFMSW and the SS-OFMSW mixed with inoculum sources are presented in table 1. The six sources of inoculum were found to be significantly different from each other regarding the analytical response parameters studied. Studies conducted at laboratory-scale shows that dry thermophilic anaerobic digestion in agitated reactors is suitable for degradation of SS-OFMSW. The best inoculum sources were RH mixed with OFMSW, SDW, sludge, manure waste, SDW with SD, being an attractive treatment strategy. The worst inoculum source was of the corn silage. Authors acknowledge Spanish MCyT Project N.PPQ2001-4032 and Brazil CAPES scholarship[1] for its support.

Table 1 – Initial characteristics of SS-OFMSW and SS-OFMSW diluted pre-digestion sources inoculum.

Parameter	*SS-OFMSW*	*SS-OFMSW + CORN SILAGE*	*SS-OFMSW + OFMSW7RH*	*SS-OFMSW + SDW*	*SS-OFMSW + SLUDGE*	*SS-OFMSW + MANURE*	*SS-OFMSW + SDW/ SLUDGE*
TS (g/kg)	786,8	318,2	330,43	321,74	285,71	367,7	315,79
VS (g/kg)	684,2	272,73	282,61	265,22	257,14	280,0	247,37
TSS (g/L)	15,1	3,0	3,5	2,0	3,5	5,0	6,0
Alkalinity (mg $CaCO_3$/mL)	4,6	208,0	82,5	101,5	82,25	93,0	81,75
Density (kg/m^3)	490	1010	1020	1010	1005	1100	1010
AN (mg NH_3-N/L)	112,0	0	1120,0	1120,.0	280,0	280,0	1120,0
COD (mg O_2/L)	19304,7	9494,93	17568,15	11678,25	6285,95	22341,0	6981,59

Composting potential of different inoculum sources on SEBAC system in treatment of municipal solid waste

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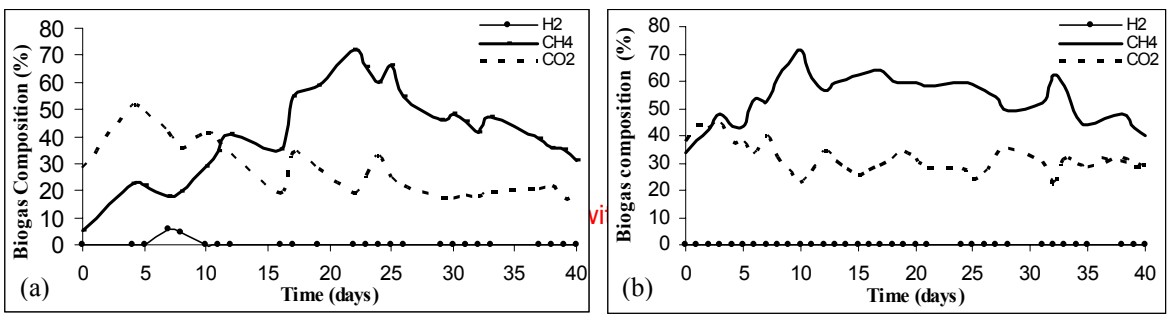
Anaerobic biological treatment of municipal solid waste (OFMSW) in thermophilic conditions has received increased attention due the possibility of producing gas from wastes. Among in the processes developed for accelerate anaerobic digestion is the SEBAC process. This technology consists of two reactors connected, one containing unsorted organic fraction solid waste and another with stabilized organic waste (inoculum source). The main objective is study the performance of start up phase in SEBAC reactors with two different inoculum sources from OFMSW treatment. The organic waste from the campus restaurant was dried and homogenized to obtain a representative sample the source sorted organic fraction of municipal solid waste (SS-OFMSW) at 35% total solid. The inoculum sources were: mesophilic digested sludge (MDS) supplied by the Guadalete Wastewater Treatment Plant, (Cadiz, Spain), and a mixture of SS-OFMSW and swine digested waste (SDW), obtained from previous experiment. The reactors were kept inside a special room from thermophilic temperature control at 55ºC, and daily the leachate recirculated was analyzed (pH, alkalinity, ammonia nitrogen, chemical demand carbon, solids, solids suspension, and composition and production biogas). In the start up phase of anaerobic degradation alls reactors (SS-OFMSW, SS-OFMSW/SDW and MDS) showed satisfactory performance in analytical parameters, adequate to maintain an optimal biological activity. The reactor SS-OFMSW/SDW presented a biodegradability of 35,3% and the reactor MDS of 30,6%, calculated from COD values. The inoculums SS-OFMSW/SDW and MDS showed in the stable phase a gas production of 7,5 *L/day* and 16,1 *L/day*, respectively. The mean methane production of 7,6 $CH_4L/gVSS$ for SS-OFMSW reactor and 6,5 $CH_4L/gVSS$ for MDS or proximally of 43,0%CH_4 and 59%CH_4, respectively (Figure 1). The MDS is a good stabilized organic waste (inoculum) for dry thermophilic anaerobic digestion from OFMSW treatment regarding the SEBAC reactors.

Authors acknowledge Spanish MCyT Project N.PPQ2001-4032 and Brazil CAPES scholarship[1] for its support.



The influence of C/N ratio, moisture and pH on the aerobic microbial activity of rice straw and sewage sludge blends

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The amount of sludge generated from water sewage treatment plants in Valencia Community is 59,500 dry tons per year and this quantity is expected to increase as a result of the new wastewater treatment plants required under the EU Wastewater Directive (91/271/EEC). On top of that, The Albufera Natural Park in Valencia yields 100 million Kg per year of rice residue, which when burned has the effect of provoking various respiratory diseases. Composting is one alternative for recycling agricultural residues and sewage sludge, and the end product can be used as fertilizer for land application. In order to study the composting process with these raw materials, environmental factors should be controlled. The aim of our study is to investigate the optimum C/N ratio, moisture and pH to maximize microbial activity.

The incubation of sewage sludge and rice straw mixtures were conducted using an experiment design with three different C/N ratios (17, 24 and 41), moistures (40, 60 and 70%) and pH (5.65, 6.65 and 8.75). The microbial activity was measured as manometric measurement of oxygen consumption (OxiTop Control).

The effect of different C/N ratio, moistures and pH on O_2 uptake by microorganims are shown in Table 1. The enhancement of microbial activity is induced by moisture content and pH increase, and by C/N ratio decrease. Our results suggest that the initial blend with these raw materials should be about 60-70% moisture content, while C/N ratio should be between 17-20 and the pH basic in the composting process.

Table 1. Respiration values of compost mixture at different initial: C/N ratios, moisture and pH.

Parameter		mg O_2 g^{-1} d. w. h^{-1}
C/N	17	1.08 (0.01)
	24	0.66 (0.02)
	41	0.39 (0.02)
Moisture (%)	40	0.21 (0.06)
	60	0.50 (0.08)
	70	0.67 (0.01)
pH	5.65	0.22 (0.08)
	6.65	0.60 (0.00)
	8.75	0.75 (0.02)

Double settling efficiency of slaughterhouse wastewater

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Our previous research show that a simple settling of slaughterhouse wastewaters is insufficiently, because many parameters grow out of maximal limits even for the wastewaters evacuated in the sewage system of localities (Borda et al. 2002, 2003).

In this study we tested the efficiency of wastewater double settling in a slaughterhouse in Baia-Mare (NV Romania). The abattoir slaughters a mean monthly number of 50 cattle and 90 swine. The amount of the final meat products resulted is about 60 tones every month. For the cleaning of the wastewater, this slaughterhouse has two settling tanks. After the secondary settling, the water is evacuated in the sewage system of the town.

The samples were collected from four points: at the entrance and emergence of the primary and of the secondary settling tanks. The results of the wastewater analyses are represented in table 1.

Table 1. The physical, chemical and bacteriological parameters of wastewater from the studied slaughterhouse.

Parameter	Raw wastewater	After double settling	D%
sediment (mL/L)	12	0.2	-98.33
total suspensions (mg/L)	742	161.10	-78.28
conductivity (μS/cm)	455	456.66	+0.36
pH	6.87	6.95	+1.16
fix residue (mg/L)	296.50	142.99	-51.77
ammonium (mg/L)	55.69	13.95	-74.95
COD-Mn (mg/L)	153.6	43.73	-71.52
BOD_5 (mg/L)	121.4	35.20	-71.00
TNG (CFU/mL)	172,802.7	5766	-96.66
total coliforms (nr./L)	2,283,333.33	341,266.7	-85.05
feces coliforms (nr./L)	2,283,333.33	147,964.04	-93.51

Note: The results represent the average of the 3 determinations for each parameter.
D%= percentage differences between raw wastewater and treated wastewater

By comparing the parameters obtained after double settling with the national standards for wastewater resulted that all parameters are set into the maximal limits established for the wastewater evacuated in the sewage system.

Co-composting process of sewage sludge and different proportions of OFMSW

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The main porpoise of this report is the study of the evolution of the co-composting process of sewage sludge with OFMSW in different proportions. Some of the physical-chemical parameters analysed were: temperature, pH, degree of humidity, organic matter, TOC, nutrients, etc.

Four composting tests have been developed (strings of triangular section) containing 16 tons of waste each, with a 10 % in weight of pruning waste: *Pile 1*, organic fraction of municipal solid waste (OFMSW); *Pile 2*, relationship in weight OFMSW/sewage sludge (2:1); *Pile 3*, relationship weight OFMSW/ sewage sludge (1:2); *Pile 4*, sewage sludge. Piles were aerated by mechanical turning (windrow composting system).

The main results obtained from the comparative analyses showed that the evolution of temperature, pH, organic material and relationship C/N is similar in each pile. Nevertheless both the period of fermentation process and the final value of pH increase as the proportion of OFMSW in the piles.

The conjunction of daily turns, high temperatures and alkaline pH produces an important loss of nitrogen (in ammonia cal form) in the first two weeks of fermentation to be subsequently maintained in practically constant values, except for pile 1 whose initial values of nitrogen were lower than other piles.

The main conclusions of the study are the following:

1. The process of composting, through over turned, OFMSW, sewage sludge and its mixture in proportions 2:1 and 1:2 after more than 8 months, has provided a compost with visibly positive properties for agricultural use.
2. The addition of sewage sludge provides stabilized and innocuous compost in a shorter period of time, with a higher proportion of organic matter and nutrients besides.
3. Physical and Chemical parameters analysed are subject to a high degree of variability and do not take into account biological activity that takes place in the material that is being composted. Therefore, complementary methods have to be employed, especially respirometric which help determine stability and maturity in the final product.

Study of the co-composting process of municipal solid waste and sewage sludge: stability and maturity

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The knowledge of stability and maturity degree of compost is of great importance for compost producers and its consumers. The compost stability is associated with the microbial activity, while its maturity is related to the absence of phytotoxic substances for the growth of plants. As a means of evaluating the stability degree of compost, many methods have been proposed, both chemical (pH, relation C/N, etc) and physical (temperature, moisture, etc). However, enzymatic and respiration tests appear to be the most appropriate. Maturity is determined basically by biotests with plants (phytotoxicity tests), in which the germinating power of seeds in a water extract of compost is determined.

Four composting tests have been developed (strings of triangular section) containing 16 tons of waste each, with a 10 % in weight of pruning waste: *Pile 1*, organic fraction of municipal solid waste (OFMSW); *Pile 2*, relationship in weight OFMSW/sewage sludge (2:1); *Pile 3*, relationship weight OFMSW/ sewage sludge (1:2); *Pile 4*, sewage sludge. Piles were aerated by mechanical turning (windrow composting system).

This report tries to develop methods to determine the degree of stability and maturity of compost (Table 1). The maturity was evaluated by using germination bioexperiments.

Table1 Main results of stability compost evaluation

Parameter	Pile 1	Pile 2	Pile 3	Pile 4
Basal Respiration ($mgCO_2/gDW/d$)	0.56	0.47	0.54	0.58
Dehydrogenase activity (mg INTF/gDW)	0.070	0.059	0.057	0.056
Protease activity ($mgNH_3/gDW$)	n.d.	n.d.	n.d.	n.d.
Phosphatase activity (MPNP/g DW) $*10^{-5}$	1.4	1.3	1.6	1.8
Urease activity ($mgNH_3/gDW$)	n.d.	n.d.	n.d.	n.d.

n.d.: non detected.

Calculation of different parameters related which the compost activity of compost can be used for the determination of an objective level of stability.

Ecotoxicological and biogermination test shows no inhibiting or toxical effect on the growing of shoots in the first stages of growing in all tests.

Enhancement of the Hydrolysis stage in Dry Anaerobic Digestion of OFMSW at thermophilic conditions by means of Thermo-Chemical Alkaline pre-treatment

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Nowadays, the Anaerobic Digestion (AD) is been studied widely how treatment of the organic fraction of municipal solid waste (OFMSW). This process has many advantages such as a low generation of sludge, a reduced energy consumption and a high methane production. The main disadvantage of AD is its slowness *(Moorhead, K. K., 1.993)*. Also anaerobic process operating under thermophilic (55 º C) conditions have gained much attention in recent years due to their apparent advantages, such high pathogen destruction, enhanced hydrolysis of complex organic/biological materials, and reduction in foaming *(Shihwu Sung, 2.003).* For these reasons we are studying the effect of the FORSU pre-treatment in the first stage of the process (*rate limiting step)*: the hydrolysis of proteins, carbohydrate and fats by Acidogenic microorganisms. The main objective is to increase the solubilization of organic matter, quantified as soluble COD, improving the biodegradability of substrate by the microbial population and, therefore, increasing the process rate. So far we are working with three types of pre-treatments: Thermal, Chemical and Thermo-Chemical. The last one has been tested sequentially and simultaneously.

Table 1. *Operational conditions and COD_S increments obtained with different pre-treatments.*

Assays	Pretreatment	T ª (º C)	Pressure (MPa)	Time (h)	Dose NaOH (g/L)	ΔCOD_S (%)
Battery 1	Thermal	121	2	1	0	4,23
(Thermo-chemical	Thermo-Chemical	121	2	1	24	47,35
sequential in	Thermo-Chemical	121	2	1	72	28,18
autoclave)	Chemical	ambient	1	*	24	9,60
Battery 2	Thermal	140	1	0,5	0	56,33
(Thermo-chemical	Thermo-Chemical	140	1	0,5	2,5	76,75
sequential in heater	Thermo-Chemical	140	1	0,5	4,5	62,68
stove)	Chemical	ambient	1	*	4.5	52,11

The results show that it was possible to increase soluble COD by Thermo-chemical pre-treatment. The best results were obtained with heater stove pre-treatment at moderate temperatures (140ºC during 30 minutes) and low doses of NaOH (2,5 g/L). For NaOH concentrations above of 5 g/L, the Anaerobic Digestion could be inhibited by excess of OH^- anions in the medium (pH increases until 13), prohibitive for the Methanogenic micro-organisms. The authors wish to thank to the MCyT, project PPQ2001-4032, for providing financial support for the realization of this work.

Thermophilic Anaerobic Degradation of Oily Watery Waste in Continuous-Flow Fluidized Bed Bioreactor

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The proper characteristics of watery oily waste, derived from industrial process, can provoke serious problems in the sewage sludge treatment plant. This type of waste have been considered like *danger waste* by the legislation in force (Law 10/1998, of 21 of april). The objective of the current work has been to study the applicability of the thermophilic anaerobic fluidized bed technology to reduce the contaminant matter of the oily effluents until the adequate level to their discharge to the urban collectors or any other final channels.

The waste coming from the factory of Delphi Automotive Systems S.A., located at Puerto Real (Cádiz). The unit used consists of a laboratory plant of fluidized bed integrating a bioreactor of 0.85 litres volume capacity, pH and temperature regulation and control systems. The start up of the fluidized bed bioreactor was carried out using as inouculum an open-pore sintered-glass material (SIRAN™) previously colonized.

After the start up of the unit, the process evolution modifying the hydraulic retention time (HRT) in the system and the organic loading rate (OLR) supply in the treatment of the oily wastewater was studied.

Experimentally, it was confirmed that AFB systems can achieve >70% chemical oxygen demand (COD) reduction at a COD loading of 50 gCOD/L·d and HRT of 1 hour. The greatest efficiency of substrate removal was 95% for an organic loading rate of 13 gCOD/L·d and HRT of 5 hours. These results let us to conclude the technical viability of the thermophilic anaerobic fluidized bed technology for the treatment of the oily watery waste.

Optimization of cellulase and hemicellulase production by microorganisms isolated from plant wastes composting piles

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Lignocellulolytic microorganisms produce cellulases, hemicellulases, pectinases and/or ligninases able to hydrolyze plant cellular walls. These microorganisms and their enzymes are being used for valorisation of plant residues together with many other industrial and environmental applications. Plant residues are very abundant in the south-east of Spain (Almeria), as a consequence of greenhouse intensive horticulture. More than 1 million tons plant wastes are generated every year. They are low-cost substrates that, on the other hand, need to be treated.

This research group isolated more than 75 bacteria and fungi with cellulolytic and hemicellulolytic activity from horticultural plant wastes composting piles after enrichment on cellulose and xylan, respectively. A group of 15 fungi were selected because of their ability to hydrolyze these polymers actively in agar plate assays. These microorganisms also showed high enzymatic activity and demonstrated a great potential for enzyme production. The aim of this work was to optimize cellulase and hemicellulase simultaneous production from low cost substrates such as plant residues.

These studies led to the design of a biphasic culture media for enzyme production composed by pepper plant residues as the sole carbon source amended with a mineral solution and yeast malt. Other culture conditions including shaking speed (150 rpm), pH of 5 and temperature incubation were also standardised. Optimal conditions allowed for the simultaneous production of high rates of carboxymethylcellulase and xylanase. Two strains were specially selected because of their high yields in enzyme production.

According to findings of this research horticultural plant residues may serve as a low cost substrate for cellulase and hemicellulase production by microorganisms originally isolated from composting piles. The potential applications of these enzymes embrace different areas including composting itself.

Bioreactor Co-composting of Sewage Sludges and Municipal Solid Waste

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Composting is an environmental-friendly method to tackle the disposal problem of sewage sludges and municipal solid waste. With appropriate nutrients, porosity, temperature and moisture content during composting, the pathogens will be destroyed and the organic matter will be stabilized producing a compost product that can contribute directly to soil fertility and conditioning. Composting process system has been modernized from the heap or windrow system to the reactor system which is a comparatively fast process. A 200 liters rotating drum composter was designed, fabricated and used in this co-composting study. This composter was designed in Universiti Putra Malaysia and was fabricated by Amsea Environment Sdn. Bhd. Three different types of dewatered sewage sludges i.e. septic tank, oxidation pond and activated sewage sludge were successfully co-composted with municipal solid waste in a two-stage process. For the bioreactor composting, the waste mixture was fermented for 7 days inside the bioreactor followed by curing in a windrow pile until fully matured. A 2:1 (w/w) ratio of municipal solid waste and sewage sludge was found to give the best initial C/N ratio for the composting process. The breakdown of organic materials inside the composter did not lead to an increasing the temperature to the thermophilic range. Heated air was supplied to the composter to increase the temperature of the composting process. Shredded garden waste was added as bulking agent. Bioreactor co-composting took around 40-45 days to produce matured compost. The characteristics of the sewage sludge compost products were almost similar compared to commercially available compost. The planting out performance of the compost product with spinach showed satisfactory result.

Natural zeolites – Remedy for Concentrated Animal Feeding Operations and sustainable agriculture

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The disposal and use of animal manures are major concerns of Concentrated Animal Feeding Operations (CAFO) worldwide. Concerns are both environmental and economic. Environmental, because noxious odors from ammonia volatilization, leaching of nitrates into ground and surface waters, and excessive amount of heavy metals in the manure. Economic, because costs of disposal, compliance to environmental regulations, and loss of valuable nutrients from the farming. Livestock manure is often spread on cultivated fields. But the manure's depletion (often over 50%) of nitrogen through ammonia volatilization and nitrate leaching, lowers the nitrogen : phosphorus (N:P) ratio required for an appropriate fertilization.

Both, empirical evidence and chemical composition of natural zeolites support their mixture with animal manures as an environmentally friendly approach and solves the problems. They eliminate noxious odors, nitrate leaching and adsorb heavy metals associated with manure disposal and its beneficial use.

Natural zeolites are aluminosilicate minerals, which occur in many countries. Clinoptilolite, one of over 40 minerals of natural zeolite group, is uniquely characterized by capabilities of absorption, adsorption, and cation exchange. Clinoptilolite has a rigid network structure that permits adsorption of ammonia. Pore openings within the clinoptilolite network structure are too small for nitrifying bacteria to enter and utilize the sequestered ammonia. Therefore, this ammonia is safe from either volatilization or bacterial conversion to nitrate.

Agricultural crops can use nitrogen sequestered in and on demand desorbed from the clinoptilolite. For that reason, in many countries natural zeolites are already being beneficially applied for soil amendments. Zeolites, pre-loaded with nitrogen, are very effective slow-release fertilizers. Zeolites, contrary to bentonite and other clay minerals, absorb and release moisture without any expansion of their volume. This property makes natural zeolites exceptionally valuable for agricultural soils, particularly in the regions where water conservation and its efficient use are important.

Thus, the clinoptilolite-rich zeolites, beside their various applications, are the best remedy for CAFO. Particularly in the context of CAFOs' required any pollution zero discharge, the agriculture faces the challenge; in order to be sustainable it has to be integrated; manure disposal instead to be burden with environmental liability, by value-added product should result in production of valuable natural fertilizer.

Effect of a sulphuric acid - ferric sulphate mix addition on the composting of domestic sewage sludge and olive mill solid wastes

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Composting is one of the several biowaste management options that allows an important waste volume reduction and also produces a valuable product such as agriculture fertilizer. The aim of this work is to study the effect of a chemical reagent ("Oligosoil") addition on the co-composting of two kinds of biowaste: domestic sewage sludge and olive mill solid wastes. *Oligosoil* is an industrial by-product of Tioxide-Europe S.A., and is mainly composed of ferric sulphate with a low amount of sulphuric acid. Batch pilot scale composting experiments were done using eventually turned static piles (3 m^3 each) in the Castilla La Mancha University experimental farm. Each pile was composed by a mixing of the above related two wastes, using an initial ratio C/N=24 and a certain amount of *Oligosoil*. Periodically turnings were applied and some factors as humidity (around 52%), excess oxygen level and temperature were controlled. Soil pollution was avoided by using non-permeable plastic material at the bottom of the piles in order to recover leachate. Waste characterization was made during the process measuring C, N and P, content and several metals according to Spanish compost regulations.

Two variables were studied: the amount of *Oligosoil* added (0, 10 and 20% in the total pile volume), and the time of addition (at the beginning of the process, at the maximum temperature moment, and at the decreasing temperature period). The main results were:

- *Oligosoil* addition inhibited the biological process. The pH dropped to 2 causing death of microbiological population but also sterilization. So, the C degradation process changed from biological to chemical oxidation.
- Since the acid reagent was added, aeration, and thus turning, was not nedded.
- The typical composting temperature profile was not observed when *Oligosoil* was used. Temperature did not overcome 35ºC.
- The C mineralization rate increased when higher amounts of *Oligosoil* were added. A single mathematical model was used to calculate a kinetic constant and evaluate this effect. Addition of *Oligosoil* at the maximum temperature point increased also the C mineralization rates.
- *Oligosoil* addition caused that the final compost contained higher amounts of Fe, valuable nutrient for olive agriculture. The heavy metals levels were maintained under the maximum concentrations indicated by Spanish regulations.

Zeolite as feed additive to reduce manure mineral content

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Farm operation intensification brings challenges in managing manures for the environmental protection of natural resources. Often, transport distances and crop land availability impose serious constraints on the disposal of livestock manures enriched in nutrients from improving diet quality, since most livestock can digest only 30% of feed minerals as opposed to 70% of hydrocarbons. Among the 45 types of zeolites which are clay like minerals mined from sedimentary deposits, clinoptilolite is known for its specific adsorption of ammonium and for its capability in improving feed protein digestion.

A feed test was conducted to establish the adjustments in feed protein and energy levels to maximize the effects of clinoptilolite in improving digestion and thus reducing manure mineral content. The test had 8 treatments: 4 clinoptilolite levels (0, 2, 4 and 6%), 2 feed quality (standard energy and protein versus 90% standard energy and protein) and 2 sex (male and female). The trial used 192 hogs split into 4 groups of 6 (3 females and 3 males) and grown from 23 to 105kg.

The experimental zeolite (90%+ clinoptilolite) was subjected to laboratory simulated digestive tract conditions which demonstrated that clinoptilolite is stable even at a pH of 1.5 and that it releases less than 10% of its already low heavy metal content. Furthermore, clinoptilolite only losses 15% of its ammonium adsorption capacity at a pH of 1.5 (120 cmol $^{(+)}$ /kg) compared to 7.0 (140 cmol $^{(+)}$ /kg).

The results indicated a 5 and 3% improvement in energy and protein digestibility using 4% clinoptilolite. Some advantage may be gained by using 2% clinoptilolite up to 40Kg and 6% after 80kg, but for the farm operator, 4% is easier to manage while providing insignificant reductions in performance. A proper feed energy to protein ratio with 4% zeolite inclusion can produce leaner carcasses.

The Feasibility of Olive Husk Co-Composting with Cotton Waste

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Olive husks (OH), obtained from the olive oil two-phase system extraction, pose important problems for composting due to the high concentration of lignocellulosic substances, and above all to the high fat content, which make difficult the mixture preparation and the development of the initial phase of composting process.

A composting pile was prepared by mixing OH with cotton waste (CW) as a good bulking agent (67% OH + 33% CW, dry weight), in a static pile system with forced ventilation. The evolution of ventilation demand showed an initial delay in raising the maximum microbial activity, due to the sticky texture resulting from the high fat concentration in OH, which may imply low porosity. High fat concentration caused problems associated with compaction and oxygen entry in the composting mass. After this first phase, the evolution of the composting process was satisfactory. The thermophilic phase lasted 49 days whilst the active phase lasted 91 days. The mixture was then allowed to mature over a period of two months (maturation phase).

During the active phase a high degradation of fat was observed (84%). However, the degradation of lignocellulosic compounds from olive stones was low. The evolution of the humification and maturity parameters TOC/TN, PHA, HAC/FAC, CEC/TOC showed an increase in the humification degree during the active phase. These parameters, together with the basal respiration and FDA hydrolytic activity, indicated that, at the end of the active phase, the material was mature and biologically stabilised to a sufficient degree for agricultural purposes. After the maturation phase a compost with a high nutritional value and stabilised OM was obtained. In conclusion, HO can be co-composted with CW as bulking agent, which improves the texture of the initial mixture, minimizing the negative effect of fat from OH.

Utilization Of Sorbents In The Treatment Of Pig Excreta

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However, incorrect manipulation with this substrate presents a risk to the environment resulting from the microbiological and chemical properties and emissions released by this substrate during decomposition.

The solid fraction of pig slurry is populated with many microorganisms and may also contain agents of diseases transmissible to man. For this reason they should be treated before used in agriculture. Our investigations dealt with the influence of the addition of 1% and 2% zeolite upon the solid fraction of pig slurry stored outside in a shelter-protected experimental dung-hill.

Zeolites are natural sorption materials that, due to their unique properties, can affect the viability of microorganisms and appear prospective in the treatment of pig excreta. The addition of zeolite in two concentrations (1% and 2%) used in our experiments resulted in a decrease in the number of microorganisms (total bacterial counts, psychrophilic, coliform and fecal coliform bacteria) in the solid fraction of pig slurry throughout the observation period. The samples for microbiological examination were taken after 1, 2, 5, 7, 12, 21, 28 and 40 days of storage.

Despite high environmental temperatures total plate counts ranged from $6.0x10^6$ to $3.1x10^9$. After 5 days of storage 1% and 2% addition of zeolite particularly affected the numbers of coliforms and fecal coliforms. After 7 days maximum decrease in the counts of mesophilic $3.9x10^5$ and psychrophilic microorganisms $4.8x10^5$ was observed in the substrate containing 1% zeolite while in the substrates containing 1% and 2% of zeolite coliform and fecal coliform counts were decrease.The substrates with 2% zeolite showed to $3.0x10^5$ in total bacterial counts and to $4.0x10^5$ in the counts of psychrophilic bacteria. In the subsequent samplings up to the end of the experiment the effect of zeolite gradually decreased.

The presented results point at the real possibilities of the use of zeolites in the treatment of pig excreta aimed at decreasing the counts of patahogenic microorganisms.

Key words: zeolite (clinoptilolite), solid fraction, pig slurry, microorganisms

Composting “alperujo”, the main by-product of the Spanish olive oil industry

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The massive establishment of the two-phase continuous centrifugation system for the industrial olive oil extraction in Spain has led to the yearly production of about four million tons of an acidic and very humid solid material called “alperujo” (AL), mainly rich in organic matter, also containing potassium, nitrogen, fats and water soluble carbohydrates and phenols. Its composting was performed in order to obtain a final valuable product that could be used as soil organic fertiliser and avoid the problems associated with its disposal. Grape stalk (GS) was added to AL as bulking agent to increase its deficient porosity, as also urea to decrease its high C/N ratio. The pile was managed during 34 weeks with forced aeration (Rutgers strategy) complemented with three turnings (4^{th}, 10^{th} and 21^{st} weeks) for improving the substrate homogeneity and the oxygen supply, then allowed to mature during 4 months.

The temperature remained below 25 ^{o}C until the 1^{st} turning was performed, then increased to the thermophilic range (55ºC). Changes were less apparent after the 2^{nd} and 3^{rd} turnings. The GS added to AL was not effective in absorbing its excess water, which probably reduced the free air pores and, thus, the aeration conditions before the 1^{st} turning. At this stage, the acidic pH scarcely increased but rapidly raised up to 7.3 after the 1^{st} turning and progressively reached end-values somewhat higher than 8.0. The total loss of organic matter (OM) accounted for approximately 50% of the initial content and the total nitrogen content increased, thus the C/N ratio declined from 37 to 21 along the experiment. Also, the initial production of ammonium nitrogen increased from values near 200 mg kg^{-1} to 600 mg kg^{-1} at the thermopilic phase, later diminished with no noticeable parallel increase in nitric nitrogen. The water-soluble carbon greatly decreased until the 10^{th} week and the water-soluble carbohydrates until the 4^{th} week, revealing their great availability for microbial metabolism even coinciding with the starting low temperature. Later, their decline continued more gradually until the end of the process.

The total fat content evolved from 8% to about 1% along the experiment, the slowest degradation coincided with the initial delayed pH evolution and only started clearly to decline after the 1^{st} turning. Also, the water-soluble phenols decreased during the active phase of composting. Coinciding with these declines, the high initial phytotoxicity rapidly decreased. The non-phytotoxic mature compost obtained was very rich in OM and contained substantial amounts of potassium and also of nitrogen, mainly organic and slowly available for plant nutrition, whereas the content of the remainder macro and micronutrients was rather low.

Effectiveness and environmental impact of swine manure composting

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In the frame of CNR-MIUR National Program on "Recycling of agricutural-industrial wastes", three prototypes of turning machine were realized. The first and the second operated on the solid fraction of cattle, rabbit and poultry manure. The third prototype was further improved and operated on the solid fraction obtained from swine manure after liquid/solid separation.

Objectives of the trials of swine solid manure composting were to test the effectiveness of such a new prototype of turning machine, to make a qualitative evaluation of the process and of the tinal product by monitoring different parameters and to study the environmental impacts on air during the process. To accomplish these objectives, the monitored parameters were: process temperature, oxygen concentration into the biomass, emission of noxious gases (CH_4, CO_2, NH_3, N_2O), respiration index, humification index, total and volatile solids, carbon and nitrogen, pH and microbial load.

The turning machine has proved to be effective from technical point of view: the aeration level deriving from the turning of the biomass showed to be very good. The excessive moisture of the starting material not interfered with the correct evolution of the process and the final compost had good qualitative characteristics (fig. 1). Gas emissions from compost windrow had a decreasing trend from thermophilic to curing phase (fig. 2).

In conclusion, this method of managing manure could represent an interesting opportunity for swine farms, however potential impacts on air have to be considered.

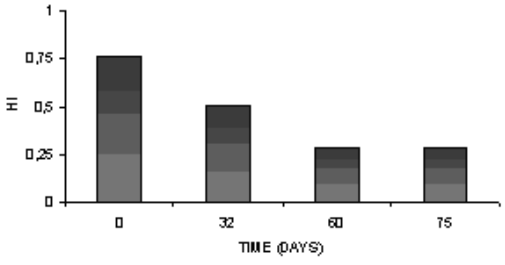

Figure 1. Humification index HI during composting process.

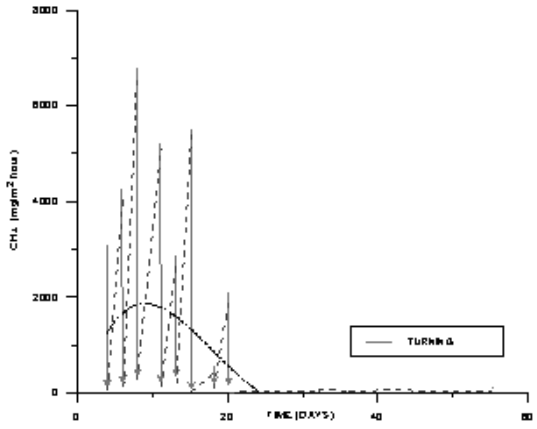

Figure 2. Gas emissions from windrow during composting process.