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Summary

SESSION I

The role of Biodegradable Waste Management in the fight against Desertification and Greenhouse effect

(Rosanna Laraia, ANPA)

Waste generation is becoming a very important problem due to the improvement of the economic conditions, the rapid growing of industry and the growth of population and urban areas.
Differentiation of productive processes has caused diversification of waste typologies with great environmental consequences.
The growing amount of waste is the cause of reduction of resources, and its quality, in terms of hazardous content, the cause of environmental problems during management phase.

More attention should be paid to waste prevention and minimisation practises accordingly to Community Waste Strategy, which sets out a hierarchy of actions giving preference to waste-management options of minimisation, then reuse, material recycling and energy recovery and last safe disposal.
The challenge of decreasing waste quantities cannot be solved only by means of efficient waste management and recycling. There is an urgent need for a sustainable waste management where waste prevention, reduction of resources depletion, energy consumption and minimisation of emissions at the source should be given high priority. Waste must be handled as a part of the total material flow.
Integrated waste management strategy should be based on the principles that preventive actions should be taken:
- reduction of production and use of hazardous substance
- recovery, re-use and recycling must be preferred to energy recovery also by improving waste collection and source separation
- landfilling should be allowed only for non-recyclable treated materials

Various health and environmental problems linked to the current management of waste could be reduced by diverting waste away from landfills and incinerators thus preventing and minimising the environmental impacts of waste treatment and disposal.

Composting in integrated waste management

Composting of separately collected biodegradable waste seems to be advantageous in countries where soils have become very poor in organic matter.
Recycling biodegradable waste is a priority set out by Italian law 22/97 in terms of separate collection targets: 15% in weight of total municipal waste in 1999, 25% in 2001 and 35% in 2003.
Although source separation of organic waste is not compulsory, it is necessary in order to reach the medium-term recycling targets of 35%.
Separation at source is becoming the important part of waste management system, yielding high recycling rates on the account of the high - quality separately collected fractions. Composting of biodegradable waste with a low content of impurities is more likely to meet compost standards according to Italian law 748/84 on fertilisers and be suitable for sale and use with environmental benefits.

Today agriculture is oriented to high quality compost deriving from separately collected biodegradable waste while there is no interest in agriculture for compost from mixed solid waste.
Compost derived from mixed municipal waste has to be land applied keeping a control on soil

quality before and after use. This kind of compost could be used in land reclamation projects. Legislation can play an important role to emphasise the recovery of organic fraction of municipal waste. Existing legislation on quality compost should be integrated with rules on low quality compost that guarantee both real new markets for this kind of material and high level protection for the environment.

It has been estimated by ANPA that the amount of compost deriving from the maximum collection rate of biowaste (about 100 kg per capita, equal to 2,4 million tons of compost) would fulfil only 1.2% of the needs for organic matter in national agriculture.

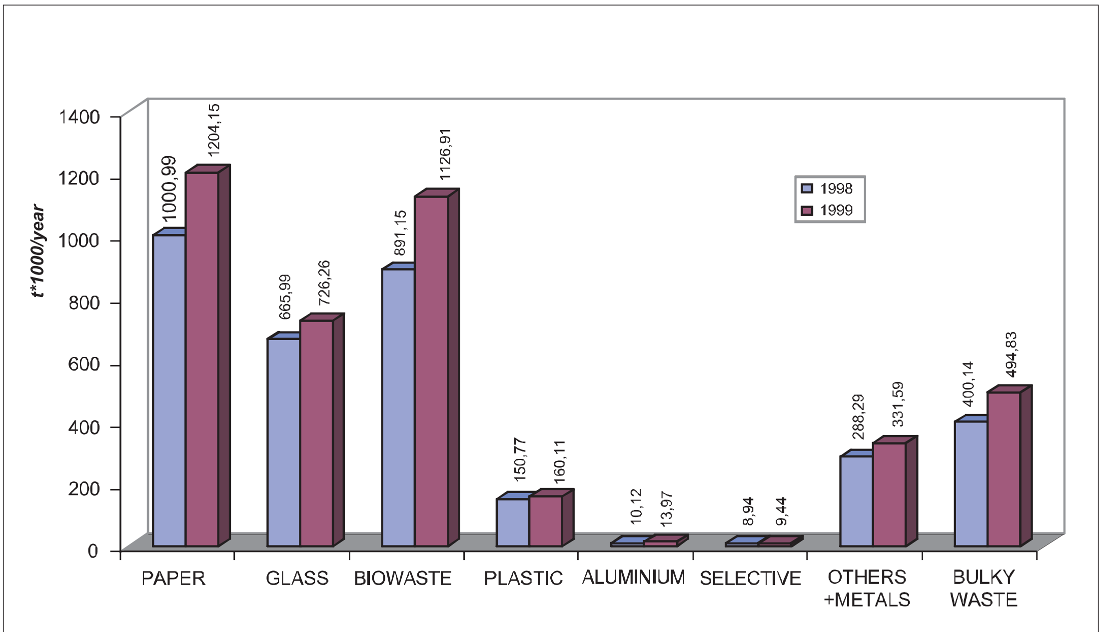

Fig. 1: Selected municipal waste (variation 1998/1999)

A study by Veneto Region, published in 1997, evaluate Italian needs of compost at 15 million tons/year.

Separate collection of biodegradable waste in Italy

In Italy municipal waste generation amounted to 28.36 million tons in 1999 corresponding to a per capita generation of 491.75 kilos. The 13,08% of total waste generated, about 3,7 million tons (+1.9% with respect to 1998), have been separately collected (Rapporto Rifiuti 2001 - ANPA-ONR).
Northern Italy's results show more efficiency in separate collection practices in comparison to Central and Southern regions: Lombardia, with 33,3% separate collection, has exceeded the 2001 target fixed by Law 22/97 (25%) and is near to the 2003 target (35%), Veneto with 23,9% has exceeded the 1999 target (15%) and is very near to the 2001 target (25%), Trentino-Alto Adige with 19,12% Emilia Romagna with 19,1%, Toscana with 16,8% Friuli Venezia Giulia with 16,1%, and Piemonte with 14,96 have fulfilled the 1999 target (15%). The separate collection in Southern regions, with the exception of Basilicata (2,25%) Puglia (3,7%) and Abruzzo (4,31%), is lower than 2%.
In order to reach the high collection target, source separation of biodegradable waste is needed; with respect to 1997, in 1999 separately collected biodegradable waste increased

by 52%.
This trend is confirmed for 2000.

State of art of composting in Italy

In Italy, the number of composting facilities for mixed waste increased from 30 in 1997 to 41 in 1999 while treated waste quantities increased from 1,6 million tons to 2,2 million tons (+34,5%) (Rapporto Rifiuti 2001 - ANPA-ONR).
As regards selected biodegradable waste, treated quantities rose from 900.000 tons in 1997

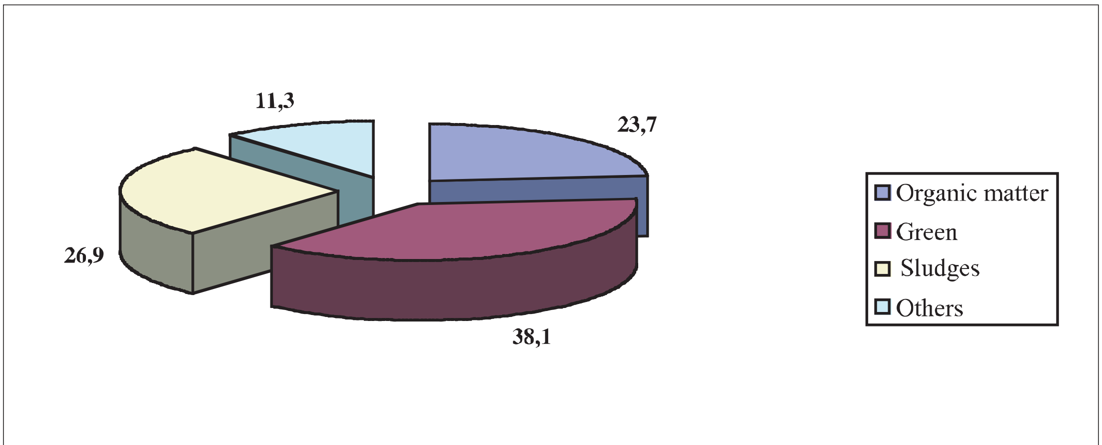

Fig. 2: Composting of selected biodegradable waste - 1999

to 1.36 million tons in 1999. The numbers of facilities was 137 in 1999 against 85 in 1997. The total composting capacity in 1999 amounted to 2.175.155 tons.

Desertification and reduction of greenhouse emission: the role of compost

The role of composting in the integrated waste management is to reduce the amount of municipal waste requiring disposal (by almost one fourth) and to provide a nutrient-rich soil amendment. Indeed the use of compost on land improves soil structure, texture, aeration, and water retention and contributes to erosion control, soil fertility, proper pH balance, and healthy root development in plants.
Desertification is a real problem due to climate changes, human pressure, physical, chemical and biological degradation affecting the soils.
Intensive humus-consuming crops, use of mineral fertiliser rich in phosphorous, nitrogen and potassium make soils hungry for organic matter and create a favourable situation to facilitate the erosion process.
Desertification could be caused by deforestation and by salinisation linked to incorrect irrigation in dry regions.
The Rio Conference believed desertification to be one of the priority problems. In 1994 in Paris the United Nations adopted a Convention to fight desertification (INCD).
In recent years Italy, according to such a Convention, issued specific guidelines to solve this problem.
In Italy there are a lot of areas that have been deforested (Sicilia, Sardegna, Calabria, Basilicata) and other that have adopted intensive crops (Pianura Padana), thus resulting in a high desertification rate.
It is estimated that 27% of the Italian territory is vulnerable to desertification and 69% is estimated to have moderate risk.

The degradation of soils is due to the loss of organic matter. Organic matter means fertility, permeability and stable structure of soil.
In order to counteract the depletion of organic matter in the soil, the use of compost to restore fertility and improve the growth of crops should be promoted by means of financial and economic tools.
The Kyoto Protocol, adopted by many countries meeting in Japan in 1997, aimed at significantly reducing greenhouse gas emissions. If ratified by enough countries, the treaty would commit the developed countries, including the United States, to reduce their emissions of six greenhouse gases on average of five percent below 1990 levels during a five-year period beginning in 2008.
The main agents of global warming, making a distinction between a natural and an anthropogenic greenhouse effect, are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and halogenated chlorofluorocarbons (CFCs), SF_6, hydrofluorocarbons (HCF).
Landfilling organic waste produces methane. Indeed landfilled materials degrade very slowly due to the lack of oxygen. As it decomposes, it produces methane gas and acid leachate, which are both environmental problems. In 1997, in Italy 44% of methane emissions derived from waste treatment and disposal (mainly due to landfill and sludge treatment); in 1990, in the EU, waste disposal is responsible for 32% methane global emissions. On this account, landfill directive 99/31/EC establishes that waste has to be properly treated prior to landfill.
The Protocol of Kyoto adopted measures for CO_2 reduction in agriculture.
Climate conditions combined with incorrect agricultural practices deplete organic matter and accelerate mineralisation of soils.
In this sense, the use of compost on soil could compensate for the loss of organic matter resulting from mineralisation.
Compost is an organic matter with a slow release of carbon; it has been estimated that increasing organic carbon by 0.15% in Italian soils would be equivalent to fixing a CO_2 quantity equal to the total national emissions due to fossil fuel combustion over one year.[1]
Compost is an efficient tool to reduce CO_2 emissions and to fix carbon in the soil in the form of humic substances, thus restoring fertility and allowing the assimilation of CO_2 through the increasing of green or vegetable production.

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The role of biodegradable waste management for improving soil quality in the Community

(Luca Marmo, Sustainable Resources Unit, DG Environment, European Commission*)

Introduction

It is interesting to note that the issues of soil and soil protection, although are present in many pieces of Community legislation, are very seldom focused upon and dealt with in their own right. If we take for example the Fifth Environmental Action Programme (1993 – 2000), we will not find a specific chapter on soil. Of course, many of the targets of the programme have a bearing on soil and soil eco-systems one way or the other. However, they do so in an indirect manner. This is partly due to the fact that Article 175 of the EC Treaty requires unanimity for "measures concerning town and country planning" as well as for "land use", which in practice has meant that soil-related issues have been regarded as a local matter in the context of subsidiarity. In part it is also due to the fact that soil is a much more difficult medium than air or water to characterise, and soil distress takes a long time to show its negative effects.
The situation is beginning to change with the Sixth Environmental Action Programme[2] which dedicates an entire section to the issue of soil protection and proposes the elaboration of a thematic strategy on soil protection for the Community.

The impact of human activities on soil

Unlike air, water, and biota, which are mobile systems, soil is site-specific, although more stable than the other three systems, it shows great geographical and temporal variability. Soil has at list six main functions relevant to human life[3]:

- The production of biomass by agriculture and forestry;
- Filtering, buffering and transformation activity, between the atmosphere, ground water, and the plant cover, protecting the environment (and especially humans) through the protection of the food chain and drinking water reserves;
- Soils are biological habitats and gene reserves, much larger in quantity and in quality than all the mass above ground;
- Soils serve as a spatial base for technical, industrial and socio-economic structures and their development, e.g. for the construction of industrial premises, houses, transport systems, sport and recreation areas, dumping of refuse, amongst other uses;
- Soils are used as a source of raw materials, e.g. clay, sand and gravel for construction, and also as a reserve of water and energy;
- Finally, soils are a geogenic and cultural heritage, forming an essential part of the landscape in which we live and containing palaeontological and archaeological treasures of high value for the understanding of the history of earth and mankind.

The problems of soil degradation and destruction are caused by the competition between these different forms of land use. Therefore, new perceptions and concepts for sustainable land use should be developed, which are in conformity with the constraints of nature. In this context, sustainable land use and protection of soil can be defined as the spatial (local or regional) and temporal harmonisation of all main uses of soil and land, so as to minimise irreversible effects. This is a political rather than a scientific issue.
Soil is affected by physical, chemical and biological degradation caused by human activities

(*) The opinions expressed in this paper are of the author and do not represent in any way European Commission

[2] European Commission, *Communication from the Commission on the sixth environment action programme of the European Community "Environment 2010: Our future, Our choice"*, COM(2001) 31 final of 24.1.2001.

[3] L Montanarella, *Soil at the interface between agriculture and environment*, in "Agriculture, environment, rural development – Facts and figures – A challenge for agriculture", DG AGRI/ ENV/ Eurostat, European Commission, 1999.

such as agriculture, urban development, industrial production, road construction, and, more generally, demographic pressure and climate change.

Waste and soil – why are they linked?

Waste when it is not recycled represents an enormous loss of resources both in the form of material and energy. Waste generation is increasing in the EU and amounted to about 3.5 tonnes of solid waste per person in 1995 (excluding agricultural waste), mainly from manufacturing, construction & demolition and mining, for a total of 1.3 billion tonnes.

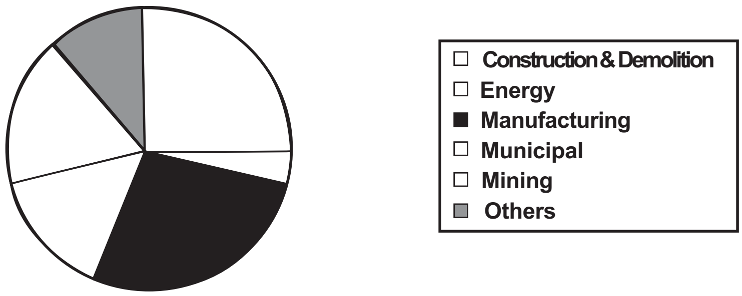


Figure 1: Waste generation in the EU15+3 in 1995 by sector[4]

An increased awareness of the drawbacks on the environment of waste mismanagement led the Community to adopt a Waste Management Strategy in 1989[5]. The strategy set out four strategic guidelines listed in order of priority (the so-called waste hierarchy): prevention, re-use and recycling, optimisation of disposal as well as regulation of transport of waste. The main strategic guidelines were maintained in the 1996 review of the Community Strategy[6], adding that preference should in general be given to the recovery of material over energy recovery. Three pieces of legislation constitute the backbone of the Community waste management policy: the Waste Framework Directive 75/442/EEC[7], the Hazardous Waste Directive 91/689/EEC[8] and the Waste Shipment Regulation (ECC) 259/93[9].
Article 4 of the Waste Framework Directive states that waste is to be recovered or disposed of without endangering human health and without using processes or methods, which could harm the environment; in particular, without risk of harm to water, air, soil, plants and animals and without adversely affecting the countryside or places of special interest. Specific pieces of legislation take care of the particular aspects of given waste management sectors such as the use

[4] European Environment Agency, *Environment in the European Union at the turn of the century,* Environmental assessment report No. 2, 1999.
[5] European Commission, *Communication from the Commission to the Council and to the European Parliament on a Community strategy for waste management,* SEC(89) 934 final of 18.09.89.
[6] European Commission, Communication from the *Commission on the review of the Community Strategy for Waste Management,* COM(96) 399 final of 30.7.1996.
[7] Council Directive 75/442/EEC of 15 July 1975 on waste (OJ L 194, 25.7.1975, p. 39) as amended by Council Directive 91/156/EEC of 18 March 1991 (OJ L 78, 26.3.1991, p. 32) and Commission Decision 96/350/EC of 24 May 1996 adapting Annexes IIA and IIB to Council Directive 75/442/EEC on waste (OJ L 135, 6.6.1996, p. 32).
[8] Council Directive 91/689/EEC of 12 December 1991 on hazardous waste (OJ L 377, 31.12.1991, p. 20).
[9] Council Regulation (EEC) No 259/93 of 1 February 1993 on the supervision and control of shipments of waste within, into and out of the European Community (OJ L 30, 6.2.1993, p. 1).

of sewage sludge in agriculture and landfill of municipal waste. This legislation lays down specific measures for the protection of soil when waste is spread onto or dumped on land.
It is clear that the vast majority of waste ends up, one way or the other, on the soil either directly (through spreading of sewage sludge or animal manure, or landfilling) or indirectly (as in the case of incineration where the pollutants emitted during the combustion process are subsequently deposited on the soil or the bottom ash is used in road construction). It is therefore of the utmost importance that waste legislation takes complete care of the aspects pertaining to soil protection when setting down rules for the management of waste.

Landfill of waste

Although the Community Strategy for Waste Management 1996 calls for waste avoidance and its diminution at source, the quantity of waste produced per capita in the Community is increasing. On average, 65% of municipal waste is still landfilled, despite this option having the lowest ranking in the waste hierarchy. In several Member States this percentage exceeds 80%. Of the approximately 190 million tonnes of municipal waste generated in the EU in 1995 (i.e. 400 kg per capita), around 30% is composed of biodegradable and highly putrescible wastes such as food scraps, cuttings from parks and green waste from gardens.
A landfill presents many environmental problems. The most important include emissions of hazardous substances to soil and ground water, emissions of methane into the atmosphere (impact on climate change), dust, noise, explosion risks as well as deterioration of land use and quality (including loss of natural areas).
These dangers, amongst other factors, are the drive behind the recently adopted Landfill Directive 1999/31/EC which aims at ensuring that landfills are properly managed during their active lifetime and properly monitored when they are filled up.
The provisions contained in the Directive are based on the principle of classification of landfills according to the types of waste - hazardous, non-hazardous and inert waste - accepted by them. This classification is coupled with procedures for issuing waste acceptance permits, for control and monitoring in the operational phase and for landfill closure; these procedures are also the subject of provisions to be implemented by the competent national authorities.
One of the main innovations of the Directive refers to the introduction of a quantified reduction strategy for the landfilling of biodegradable municipal waste. The volume of this type of waste accepted for landfill must be reduced to 65%, 50% and 35% of the tonnage produced in 1995 by 2005, 2009 and 2016 respectively. This rate of reduction should encourage the development of new methods of eliminating waste – such as composting, production of biogas etc.

Sewage sludge

Soil protection is the main goal of the Sewage Sludge Directive 86/278/EEC[10] on the protection of the environment, and in particular the soil, when sewage sludge is used in agriculture. Sewage sludge is a by-product of the cleaning process of waste waters. It can be contaminated by heavy metals whose build-up in soil can damage soil functions, in particular the micro-organisms that live in the soil. Some 6.5 million tonnes of sludge (dry matter) are produced every year in the Community. It is estimated that by 2005 there will be a 40% increase in the total quantity due to the progressive implementation of Directive 91/271/EEC concerning urban waste water.
Topsoil is of crucial importance for the well being of soil micro-organisms, plants and animals.

[10] Council Directive 86/278/EEC of 12 June 1986 on the protection of the environment, and in particular the soil, when sewage sludge is used in agriculture (OJ L 181, 4.7.1986, p. 6).

Some heavy metals may have the effect of impairing the natural mechanisms through which soil microbes reproduce and therefore depleting the bio-potential of the soil eco-system. Moreover, if the concentration is high enough, heavy metals can overcome the natural cell barrier in plant roots and end up in the edible part of vegetables. Some heavy metals (notably cadmium) would then accumulate in organs of animals and man and cause poisoning effects.
The Sewage Sludge Directive establishes the principle that as a rule sewage sludge ought to be treated before its use. Treated sludge is defined as sludge which has undergone biological, chemical or heat treatment, long-term storage or any other appropriate process so as to significantly reduce its fermentability and the health hazards resulting from its use. An exception to this general rule may be allowed by Member States on condition that the untreated raw sludge is injected or worked into the soil.

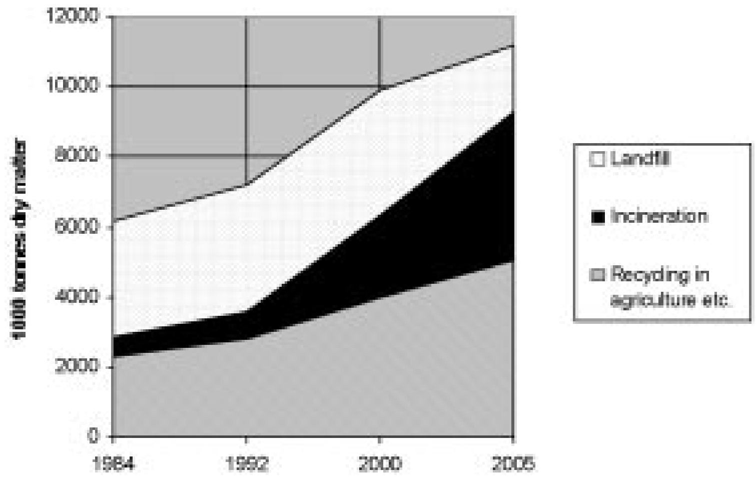


Figure 2: Sludge projections in the EU (1984-2005)[11]

The Directive provides for maximum heavy metal concentrations in sewage sludge for re-use in agriculture as well as for maximum heavy metals concentrations in soil. The aim is to avoid the possibility of spreading of sludge on the same agricultural plot increasing heavy metal concentrations to such a level that could potentially cause adverse effects on the soil eco-system. However, it should be noted that with present loading limits it could be foreseen that maximum concentrations would be easily reached within a few decades. If we want to keep open the possibility of re-using sewage sludge on agricultural soil, it seems vitally important that we reduce the overall pollution caused by heavy metals – and organic compounds – in waste water. This means that products and materials of everyday use along with industrial processes need to be progressively upgraded in order to reduce their load in polluting substances.

The Commission has in its work programme the revision of Directive 86/278/EEC in order to bring it up to date with technological progress and scientific knowledge. Some of the areas that could possibly be tackled are the definition of "treated sludge", the threshold limits for heavy metals – the vast majority of Member States have transposed the Directive into national legis-

[11] European Commission, *Implementation of Council Directive 91/271/EEC of 21 May 1991 concerning urban waste water treatment, as amended by Commission Directive 98/15/EC of 27 February 1998 – Summary of the measures implemented by the Member States and assessment of the information received pursuant to Articles 17 and 13 of the directive,* COM (1998) 775 final of 15.1.1999.

lation with more stringent limits – the monitoring of organic compounds of anthropogenic origin, the long-term protection of soils from the slow build-up of heavy metals.

Mining activities

Minerals are extracted from heaps of ore by pouring chemical or biological reagents over them. In the case of chemical leaching an acid or cyanide solution is commonly used (especially on ores containing gold or copper). In the case of microbial leaching bacteria (or algae) are used to extract minerals such as uranium, molybdenum, radium, selenium or lead from ore heaps or mine waters.

Tailings (or tails), the solid material left over from the ore milling process, may be stored or disposed of in a variety of ways: dumped at the mine/mill site or in specially constructed tailing ponds. The water and tailing waste from the mining and milling operations are discharged into settlement and treatment lagoons, termed "tailing ponds". Here, the fine particles can settle and organic reagents from the milling process can biologically decompose.

Mining activities have a wide range of environmental impacts at every stage of their operations. Management of tailings is one of the most significant environmental aspects of mining operations. Failure to achieve suitable tailing containment can have serious adverse effects on soil due to the contamination from treatment residues and the chemicals used in the extraction process. They can be a source of both acute pollution, realising large, often concentrated amounts in a short time (due to accidents) as well as diffuse pollution, a rather constant emission of relatively low concentrations during a long time.

As an example of what can happen to a tailing pond, the so-called Doñana accident[12] is a sober lesson. The accident happened on 25 April 1998 at the lead-zinc mine of Los Frailes at Aznalcóllar near Seville (Spain). A tailings dam failure released 4-5 million cubic metres of toxic tailing slurries and liquid into nearby Río Agrio, a tributary to Río Guadiamar. The slurry wave covered several thousand hectares of farmland, and it continues to threaten the Doñana National Park, a UN World Heritage Area. Since 1999 the Environmental Ministry of Andalusia has knowledge of new high acidity and metal concentrations in the water of the Guadiamar river near the Los Frailes mine. The subsoil of the dam is contaminated as a result of the dam failure, and the contaminated seepage flows into the channel of the Guadiamar at the rate of 86,400 litres of acidic water per day.

At present, a statistical overview of all mining activities at European level does not exist. Some data are available from Eurostat, according to which some 18%, i.e. 300 million tonnes, of the total 1.3 billion tonnes of solid waste (agricultural waste excluded) generated in the EU15+3 in 1995 were mining waste. A study is currently being carried out on behalf of the Commission's services in order to find out to what extent it is common practice to use tailing ponds to dispose of the mining waste. Another important issue is the number of disused tailing ponds as a result of decommissioning of the mine. In a certain number of Member States this number could be rather large and cause serious problems on the environment due to lack of monitoring and care.

Waste used for construction purposes

Waste used for construction purposes can be a threat to the quality of soil. An example could be the use of incineration slag as a road material. Based on available information the total amount of slag is estimated to be between 6 and 9 million tonnes per year in EEA countries. In a number of countries the slag is recycled and used for road construction, embankments and

[12] A very good description of what happened and an update on the situation can be found in the following web site: http://antenna.apc.org/~wise/uranium/mdaflf.html.

noise barriers as well as for concrete production. When analysing the chemical composition of incinerator slag a major concern is the heavy metals content which is in many cases considerably higher than the concentrations occurring naturally in soil. This means that in many cases the use of slag for construction purposes may in the long term lead to contamination of surrounding areas with dust containing heavy metals if the surface is not sealed.

The relationship between biodegradable waste and soil

In 1998 something like 200 million tonnes of municipal solid waste (MSW) were produced in the Community[13]. Roughly speaking more than half of it was biodegradable waste. Because of its huge volume and the negative effects it causes when landfilled, biodegradable waste has been given special attention in the Landfill Directive 1999/31/EC. However, if properly managed this waste stream may contribute towards the reduction of methane emissions and provide a step forward in terms of effective resource management.
In particular:

- biological treatment contributes towards the fight against the greenhouse effect because it diverts biodegradable waste from landfilling and incineration where it produces methane, a powerful greenhouse gas, and carbon dioxide;
- the use of compost in agriculture is a way of maintaining or restoring the quality of our soils because of the unique properties of the humified organic matter contained in the compost itself. It has a special relevance in the southern regions of Europe where it is a valuable instrument for the fight against organic matter depletion, desertification and soil erosion erosion but also in areas continuously used in arable production where organic matter levels are decreasing. Preliminary estimates[14] indicate that 74% of the land in Southern Europe is covered by soils containing less that 2% organic carbon (less than 3.4% organic matter) in the topsoil (0-30cm). In these conditions agronomists define a soil as in a pre-desertification stage;
- the use of compost in horticulture and in home gardening is a valid and valuable substitute for peat[15] thus reducing the rate of exploitation of wet lands, which typically contain sensitive and rare ecosystems.

Depending on local conditions, food and drink habits, climate and degree of industrialisation, between 30 and 50% of MSW consists of biodegradable waste. In the context of MSW, biodegradable waste is composed of food and food residues from households and public buildings – such as schools, offices, restaurants, canteens etc –, green waste from gardens and parks – such as hedge trimmings, grass cuttings, tree branches etc –, residues from fruit and vegetable markets, and the like. Although biodegradable, paper waste is not included in the above mentioned figures because it is felt that paper recycling is a better option than composting. Recycling maintains the physical structure of paper fibres, thus recycled paper needs less energy and raw materials to be produced.
Incineration and landfilling are the two most common management practices for dealing with MSW in the whole of the Community. For instance, around 65% of MSW is still landfilled, although in some Member States (such as Greece, Ireland, Portugal and the United Kingdom) this percentage exceeds 80%.

[13] Eurostat, *Environment statistics: pocketbook 2000,* Luxembourg, OPOCE, 2000.
[14] P Zdruli, R Jones, L Montanarella, *Organic Matter in the Soils in Southern Europe,* Expert Report prepared for DG XI.E.3 by the European Soil Bureau (JRC – Ispra), 29 April 1999.
[15] E Maltby, C P Immirzi, D P McLaren, *Do Not Disturb! Peatbogs and the Greenhouse Effect,* Friends of the Earth, 1992.

Management options for biodegradable waste

Landfill

Biodegradable waste decomposes in landfills following a long ecological cycle of tens and often hundreds of years. The decomposition produces landfill gas and highly polluting leachate. However, the major share of the waste remains in the landfill and the nutrients are not available for plant growth. When less organic matter is landfilled, less landfill gas is produced. Landfill gas, if not captured, contributes considerably to the greenhouse effect. In fact landfill gas is mainly composed of methane, which is twenty times more powerful than carbon dioxide in terms of climate change effects. It has been calculated[16] that the methane emissions from landfills account for 30% of the global anthropogenic emissions of methane to the atmosphere.

By keeping the organic matter away from landfills the available landfill capacity can be used over a longer period of time. This capacity can be used for materials for which treatment or reuse is not possible. Furthermore, less space is lost for other purposes, such as infrastructural works – this may especially be of importance in densely populated areas.

These motivations, among others, have guided the recently adopted Landfill Directive 1999/31/EC. Article 5 of the Directive introduces targets for the reduction of biodegradable municipal waste to landfill. The dates for reduction of biodegradable waste to landfill are as follow:

- reduction to 75% (by weight) of total biodegradable municipal waste produced in 1995 by 2006;
- reduction to 50% by 2009;
- reduction to 35% by 2016.

Incineration

Incineration of MSW leaves about 30% of the initial waste mass to be dealt with as ash and flue gas cleaning residues which are often hazardous a cause of the contamination by heavy metals and in most cases are anyway landfilled.

When the biodegradable fraction of MSW is incinerated the organic matter is decomposed into carbon dioxide[17]. It is often said that biodegradable waste, or indeed waste in general, is a renewable source of energy and a valid substitute for fossil fuels in order to meet the targets for carbon dioxide reduction as agreed in Kyoto. This is just part of the picture.

In fact, the energy recovered from the incineration of waste comes from those highly calorific fractions – such as plastics, tyres and synthetic textiles – that are produced from crude oil. Thus, their incineration cannot be regarded as CO_2-neutral. As for the biodegradable fraction, it is mainly constituted of food scraps that is a wet waste which diminishes the overall efficiency of the incineration process. This means that the combustion of the highly calorific waste fractions is in fact 'helping' the combustion of biodegradable waste. More energy would be recovered if biodegradable waste were not to be incinerated along with other wastes.

Biological treatments

In nature living organisms which have reached the end of their life-cycle decompose and give back to the environment the organic matter of which they are constituted. There are two different ways in which this can happen – in the presence of oxygen (aerobic process) and without oxygen (anaer-

[16] European Commission, *Strategy Paper for Reducing Methane Emissions*, COM(96) 557 final of 15.11.96.

[17] In fact, it could be more fairly stated that the aim of an incinerator is the production of carbon dioxide. The organic matter present in the biodegradable fraction of MSW is composed by carbon. The incineration process, by definition, aims at the destruction of its feed material through oxidation. Oxidation means that carbon and oxygen are locked together with the release of a certain quantity of energy in the form of heat. The combination of carbon and oxygen produces carbon dioxide.

obic process). These two processes involve different microorganisms – such as bacteria, fungi, earthworms etc – whose reproduction under controlled conditions needs to be carefully planned.
Composting
Under controlled conditions composting mimics conditions and speeds up what happens every day in the natural environment when living organisms and plants die. The microorganisms that start and finish the process off are called mesophiles. These grow when the compost is cool. However, microbiological activity generates heat and when the temperature rises in the heap beyond a certain point, mesophiles can no longer keep growing. At this stage organisms called thermophiles take over and the temperature rises even more. Once the foods are digested, the temperature of the heap gradually falls and the mesophiles take over once more. At the end of the process, the material in a composting heap become so degraded that any further change is extremely slow. The compost is than said to be mature and is now a rich earthly material that has a vast range of uses.
Because the composting process is hot – it may reach temperatures of up to 70°C or more – the heat helps to disinfect the waste of harmful microorganisms and also kills off unwanted weed seeds and roots.
The process through which compost is produced is straightforward and in principle does not need any kind of machinery to be performed. A simple heap in a garden is sufficient for starting the process off and if the heap is turned regularly – in order to let moisture and air in – in six months or less, depending on the weather, biodegradable waste is transformed into compost.

Anaerobic digestion
The anaerobic process involves methanogenic bacteria and has gaseous emissions constituted by methane, carbon dioxide and water. The residue is called 'digestate' and can be further separated into fibre and liquor. The fibre is bulky and contains a low level of plant nutrients. After a further period of maturation under aerobic conditions, the digestate becomes compost that can be used in agriculture. The liquor is the liquid residue of the anaerobic digestion process. Anaerobic digestion is rather sensitive to environmental conditions and is difficult to be artificially reproduced because it involves different methanogenic bacteria which work under different conditions (e.g. different temperatures and pH). If compared with composting plants, anaerobic digestion plants can be more capital intensive, although they have the advantage of producing biogas that can be used for the production of energy. Biogas is a mixture of different gaseous compounds, mainly methane (50-80%), carbon dioxide (15-45%) and water vapour (5%). Because of the presence of sulphur in the organic matter, the gas has to be purified from hydrogen sulphide, which is highly toxic and corrosive. What is left can than be upgraded, if necessary, to natural gas standards and used as a source of energy for the production of heat and electricity.
The choice between composting and anaerobic digestion for a specific situation depends on local requirements concerning, for example, odour emissions, capacity and energy production and other local aspects such as the waste characteristics and composition. In areas with limited natural energy resources or high costs for energy production, the energy that can be obtained through the combustion of biogas can be very useful. In these areas anaerobic digestion might be the best option. If energy is not an important issue or distribution and use of the energy produced by anaerobic digestion might be a problem, composting systems could be preferred.

Environmental advantages of using compost
Compost is an earthly rich and humus-like material that smells like freshly turned forest soil. It can be used as soil improver, soil conditioner, organic fertiliser, mulch, soil substitute, as part of top dressing, potting or seed compost, as a part of growing medium in grow bags etc. However, the suitable final destination depends on many factors, including degree of maturity, feed-

stock material, and whether the compost is sieved. Each of the possible uses of compost presents some environmental advantages when compared with the available products competing to service the market.
There are a number of applications for which compost can be used which fall into two main categories: namely growing media and soil improvers. Growing media are rooting substrates other than soil in situ, in which plants are grown. Soil improvers are materials of any origin that can be added to the soil to improve its physical condition without harmful effect. Within this category there are three sub-divisions:

- soil conditioners which are incorporated into the soil to stabilise structure, improve water retention or soil workability;
- mulches which are laid onto topsoil in order to reduce moisture loss, control weed growth, improve visual appearance, improve bearing strength or minimise erosion;
- planting material to improve the physical condition within the planting pit for trees and shrubs.

Organic matter recycling & soil depletion

In order to underpin the sustainable development of society, as much as possible of our resources have to be recycled, and recycled responsibly. The agricultural sector needs a secure, long term supply of nutrients and organic matter (humus) to compensate for losses through harvest, grazing and leakage into surface water, groundwater and the atmosphere. The trend towards continuous cropping reinforces the need of nutrient recycling. Compost serves both purposes, primarily as a supplier of micronutrients and humic substances – such as humic and fulvic acids – but also, to a lesser extent, as a supplier of nutrients such as nitrogen, potassium and phosphorus.
Composting of biodegradable waste and use of the resulting compost on arable land provides one of the keys to solving to the progressive impoverishment of agricultural soils. It has not only the advantage of replenishing organic matter levels but it also locks organic carbon into the soil that otherwise would disperse into the atmosphere.
The over exploitation of agricultural soils in the Community is of great concern both to agronomists and soil experts. Intensive arable agriculture relies on a continuous rotation of different types of crops on the same plot, the only component systematically restored being mineral fertilisers. Whilst mineral fertilisers ensure that nitrogen, phosphorus, potassium and other essential nutrients are given back to the soil, they cannot provide another vital ingredient to healthy soils, namely organic matter. Organic matter is a complex mix of proteins, humic and fulvic acids and other components essential to the well being of soil, crops and soil biomass. It is produced by plants through the photosynthesis process and the slow action of microorganisms – bacteria, fungi, earthworms etc – during the course of hundreds of years. Only naturally induced biological processes based on the photosynthesis of carbon are able to produce organic matter.
Many soils in the Community, especially those in southern regions, badly need additional organic matter. A level of between 2.5 and 3% of organic matter in soil is considered the bare minimum for the long term use of agricultural soils[18], however soils with less than 1% organic matter are not uncommon in the EU. Preliminary estimates[19] indicate that 74% of the land in Southern Europe is covered by soils containing less that 2% organic carbon (less than 3.4% organic matter) in the topsoil (0-30cm). In these conditions agronomists define a soil as in a pre-desertification stage. There are figures from the UK which show that the percentage of soils with less than 3.6% organic matter rose from about 35% to about 42% in the fifteen years to 1995.

[18] However, it should be pointed out that organic matter and soil type are related. A soil needs the correct content of organic matter in order to be productive, not absolutely a high content in all cases.
[19] See reference to footnote 14.

In order to decrease the rate of soil depletion it appears from the available data extremely urgent to restore organic matter levels into agricultural soils. This can be done readily through the production of compost out of biodegradable waste[20]. The composting process mimics what happens to decaying organic matter in nature and ensures that the organic matter needed by soils is not fully destroyed, but significantly transformed into a slowly-decaying storage of carbon. Indeed, biodegradable waste is transformed into a humus-like product that is extremely valuable as a soil improver.

Carbon sink & the greenhouse effect

Organic matter is principally composed, by definition, of carbon. When it is incinerated or combusted the carbon in the organic matter combines with the oxygen in the atmosphere and realeses carbon dioxide. Carbon dioxide, along with other gases, is widely held to be responsible as one of the main causes of the greenhouse effect, a principal driver of global climate change. The incineration of organic matter as biodegradable waste contributes towards the emissions of CO_2 into the atmosphere and does not lead to any saving in overall CO_2 emissions.
However, the picture is radically different when biodegradable waste is composted. Although there are carbon dioxide emissions into the atmosphere due to the partial decomposition processes that take place within the composting heap, the resulting compost 'locks' a significant part of the initial organic carbon in the form of humified and slow-release organic matter, i. E. not in the form of gaseous emission. The use in agriculture or any other use in soil of compost contributes on the one hand to the fight against soil depletion, and on the other to build-up of organic carbon content in soils.
It has been calculated[21] that an increase of 0.15% of organic carbon, i.e. 0.26% organic matter, in Italian arable soils would lock in soil and soil biomass the same amount of carbon that is currently released into the atmosphere in one year in Italy by the use of fossil fuels. It can be assumed that similar proportions are valid for the whole of the Community, at least at similar conditions of anthropic density per unit arable land area. From this it follows that composting of biodegradable waste is an effective and environmentally conscious means of diverting carbon dioxide from the atmosphere and converting it into organic carbon in soils and therefore a valid tool to fight against the greenhouse effect.
Like humus in soil, the decomposition rate of organic matter into compost is approximately 1 to 2% per year, which corresponds to a half-life of 35 to 70 years. In other words, by subjecting biodegradable waste to composting and thus converting it into stable humus one can build a significant sink of organic carbon in the biosphere, releasing CO_2 over a long period of time[22].
A recent report[23] has evaluated the compost potential for carbon sequestration to 30 kg CO_2-equivalent per tonne of waste.

Compost vs. mineral fertilisers

Although composted material would not be classified as a fertiliser strictu sensu, the use of compost for agricultural purposes may be of some help in diminishing the quantities of mineral fer-

[20] Without forgetting that the most effective way for maintaining a good content of organic matter is through appropriate agricultural practices such as correct crop rotation, mulching, intercrops, specific root crops etc. There is plenty of possibilities which are, unfortunately, not always used.
[21] Speech given by Professor Paolo Sequi at the *Compost Symposium,* Vienna, 29-30 October 1998 (unpublished).
[22] M Vande Woestyne, V Gellens, I Anasi, W Verstraete, *Anaerobic digestion and inter-regional recycling of organic soil supplements* in Biogas Technology as an Environmental Solution to Pollution, Fourth FAO/SREN Workshop, FAO, 1994.
[23] A Smith *et al., Waste management options and climate change,* final report to the European Commission by AEA Technology, 2001.

tilisers needed to be employed for restoring nutrient levels into the soil. The growing of vegetable crops requires a constant supply of nutrients. Nitrogen, phosphorus and potassium have to be constantly supplied to the plants in order to maintain a steady crop production.
Mineral fertilisers are produced from a variety of sources. However they generally need energy to be produced, sometimes by way of extraction of raw materials. For instance, the production of a phosphorus-based fertiliser requires shipment of phosphate rocks and an appropriate treatment with sulphuric acid in order to make the phosphorus readily available for plant growth (treatment transforms tri-calcic P – that is not available to roots – into bi-calcic and mono-calcic P, much more available). The process needs energy to be performed; moreover, it is common knowledge that phosphate rocks are usually contaminated by cadmium.
Compost derives from the transformation process of biological materials which all contains nitrogen, phosphorus and potassium to a certain extent. Due to the composting process, these biodegradable wastes are converted into a humus-rich material where the nutrients are in a form available to plants, albeit slowly. The use of compost therefore contributes towards the diminution of the employment of mineral fertilisers, with all the added advantages this potentially entails from a public health and environmental perspective.
It should be pointed out that the concentration of nutrients in the compost is rather low. Thus, it is not actually possible to envisage a total substitution of mineral fertilisers by compost. However, an increase of organic matter content in the soil strongly increases the efficiency of chemical fertilisation and plant nutrition itself, as:

- organic nitrogen is much more slowly released, thus meeting “natural” uptake speed (N stemming from chemical fertilisers is often lost to some extent into groundwater, as it gets massively released all at once, and into the air as NH_3 – especially from urea – particularly during hot weather when applied to “bare” ground);
- potassium is protected by the organic matter from absorption at the surface and inside clayey particles;
- phosphorus is protected from co-precipitation with calcium.

Fundamentally though the best feature of compost (together with manure, straw etc) as compared to mineral fertilisers is that the latter cannot supply any organic matter at all. Moreover, since compost is basically derived from food waste, it is the logical recycling system for nutrients and thus contributing to N P K supply and replenishment.

Alternative to peat

Peat is a limited resource with a very long production time. In fact, peat bogs are important refuges for rare and unique species. Peat has a fundamental ecological role in water regulation. Peat bogs play an important role in storing carbon that is released as carbon dioxide when a peat bog is damaged. Although peatlands cover around half the surface area covered by tropical rainforests, they contain over three to three and a half times more carbon[24]. Yet these bogs are being destroyed all over the world for conversion to agricultural land, afforestation, and commercial extraction of peat for fuel and horticulture.
Peat dominates the horticultural market because it is a well-established, effective and relatively cheap product, requiring no processing. The price of peat is low because the environmental costs associated with its extraction and use are not reflected in its price.
The use of non-peat materials should be encouraged wherever possible. Compost is an excellent alternative to peat for many uses and would help reduce the amount of peat that is extracted every year.

[24] See reference in footnote 15.

Market potential for compost

Once suitable biodegradable waste is collected and composted, one may wonder whether the resultant compost will find a market or a beneficial outlet, and thus generate income. Sometimes worries are expressed about the capacity of the market to absorb the present compost production, let alone an increased amount of compost. These worries can be easily put aside when one considers a number of factors.

The total arable land available for agricultural purposes in the Community amounts to some 88 million hectares (excluding permanent grassland, forests and wooded areas). The total potential production of compost, if all the potentially compostable fraction of municipal waste were to be treated in this way, is some 20 million tonnes. A typical agronomic use of compost on arable land would employ some 10 tonnes of dry matter per hectare, i.e. 20 tonnes of compost per hectare. This means that 1 million hectares of arable land, i.e. only 1.1% of the total, would absorb the entire compost production of the Community.

Of course, this only gives a rough idea of the market potential for compost insofar it does not take account of local variations due, for example, to the distance between the location of the compost production site and farmland, to the amount of animal manure locally produced, to the need for organic matter addition to the soil which will be higher in the south of Europe because of climate conditions etc.

However, use of compost in open fields is just one of the possible market outlets. Other markets are use in horticulture (open air or greenhouse cultivation of vegetables, in particular mushrooms), floriculture, home gardening, landscaping activities (parks, land restoration, golf courses) and so on. Just to give an example[25], Italy imports every year some 400,000 tonnes of peat-based materials for horticulture, floriculture and home gardening purposes. Some 30 to 40% of these materials could be substituted by compost – and indeed they are in those regions where compost is actually produced. These market outlets are more profitable for the compost producers because peat-based materials have a rather high price. Typical prices for compost sold in bulk to farmers in Italy are 2.5-7.5 €/t whereas one tonne of compost sold for home gardening can fetch up to 30€.

The potential market for compost constituted by the landscaping sector managed by municipalities such as for public parks and gardens should not be neglected. Municipalities could use the compost produced out of the treatment of their own green waste in order to avoid to buy soil improvers and growing media on the market[26].

Conclusion

The adoption of the Landfill Directive will bring about a great deal of changes because of the obligation for reducing the amount of biodegradable waste going to a landfill. There is though the very real danger that incineration capacity could rise in certain regions, not only significantly but especially in southern regions, in order to meet the target requirements of the Directive[27].

At the same time many areas in Europe have a serious shortage of organic matter levels in soil and could use soil improvers to help restore this fundamental component to levels suitable to cope with the demands of modern agricultural practices and to combat the process leading to soil degradation and desertification. On top of that, the continuous increase of carbon dioxide

[25] M Centemero, R Ragazzi, E Favoino, *Label policies, marketing strategies and technical development of compost market in the European Countries, Proceedings* ORBIT99, part II, pp. 355-362, Weimar, September 1999.

[26] It should be added that governments at national and supranational level have the possibility to employ eco-taxation in order to reflect environmental costs in prices.

[27] For example, in the UK the *Waste Strategy 2000* for England and Wales foresees to build up to 165 new incinerators for meeting the targets of the Directive.

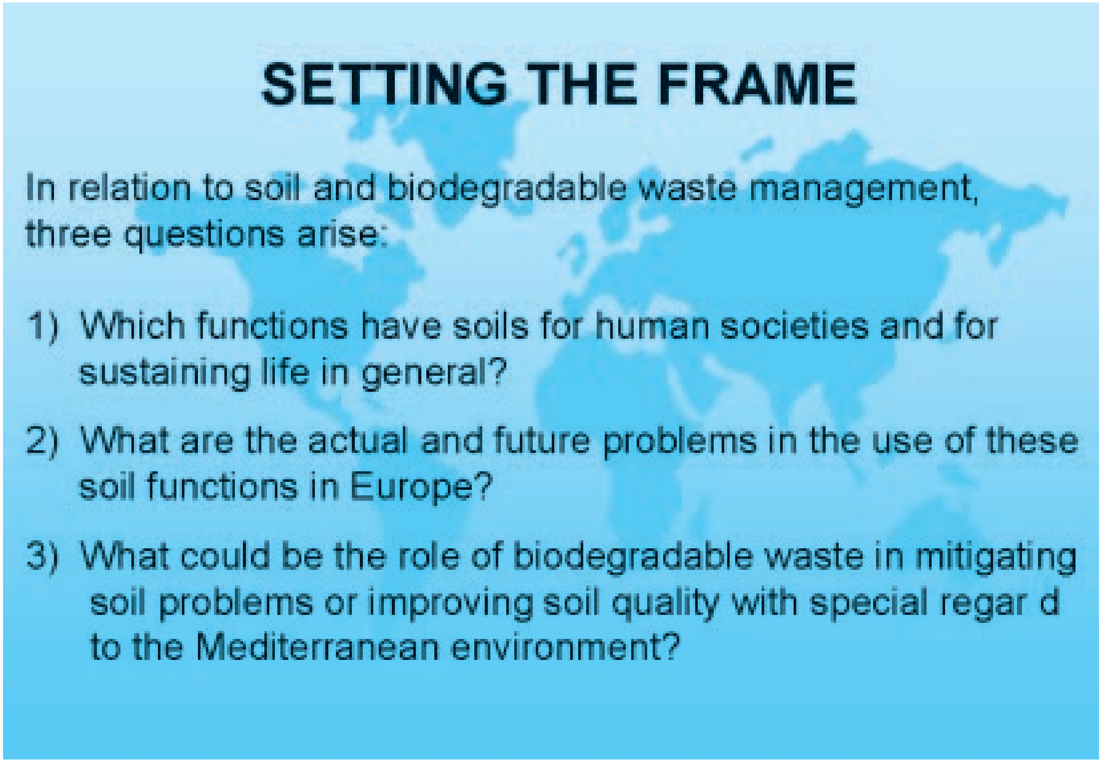
concentration in the atmosphere requires the adoption of waste management techniques that do not worsen the greenhouse effect.
Biological treatment of biodegradable waste such as composting and anaerobic digestion can contribute to solving the above mentioned concerns and to closing the circle of beneficial nutrient return to its soil based origin. Composting and anaerobic digestion do not destroy the organic matter contained in biodegradable waste, produce a final material – compost – suitable for use in agriculture and contribute towards the diminution of carbon dioxide in the atmosphere. In the case of anaerobic digestion there is also the advantage of producing biogas that can be used to generate heat and electricity.
In order to achieve these objectives, two key-issues would have to be addressed:

- how to provide large quantities of suitable biodegradable waste for biological treatment;
- how to promote the use of the resulting compost on soils.

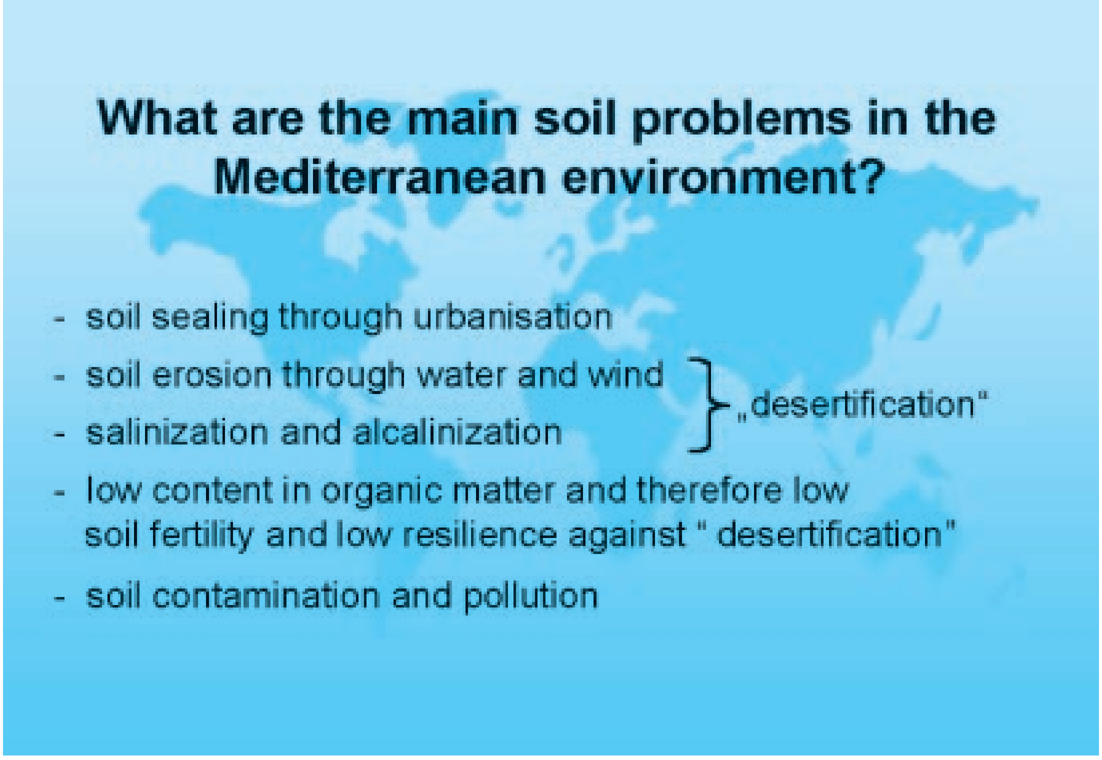
Those Member States that are more advanced in the field of biological treatment for biodegradable waste have set up separate collection schemes so that biodegradable waste is not contaminated by pollutants and it is already possible to produce a high quality compost. Along with this, they have regulated compost standards either passing legislation or stimulating the producers to develop widely recognised and guaranteed marks. In fact, separate collection and adequate standards seem to be two important factors in determining quality of compost, availability of outlets and the acceptability of the product.

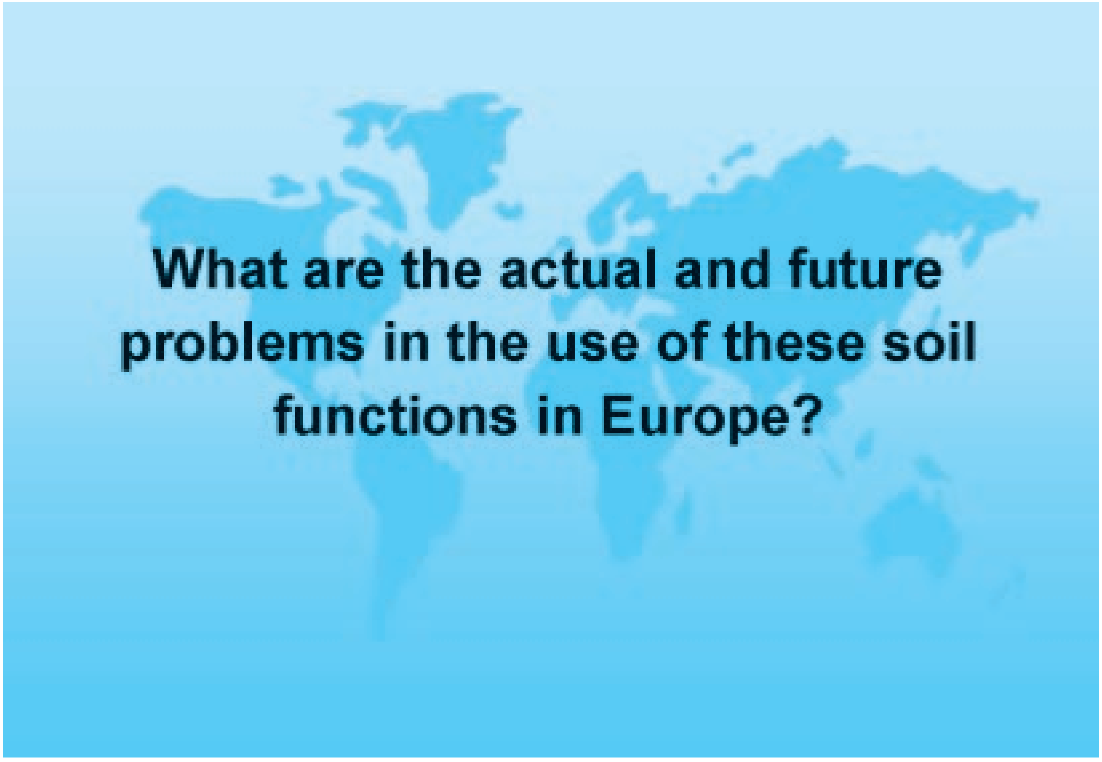
Soil and Terrestral Envirnment

(Winfried E.H. Blum, University of Agricultural Science, Vienna)




What are the actual and future problems in the use of these soil functions in Europe?


What are the main soil problems in the Mediterranean environment?
- soil sealing through urbanisation
- soil erosion through water and wind
- salinization and alcalinization
„desertification"
- low content in organic matter and therefore low soil fertility and low resilience against " desertification"
- soil contamination and pollution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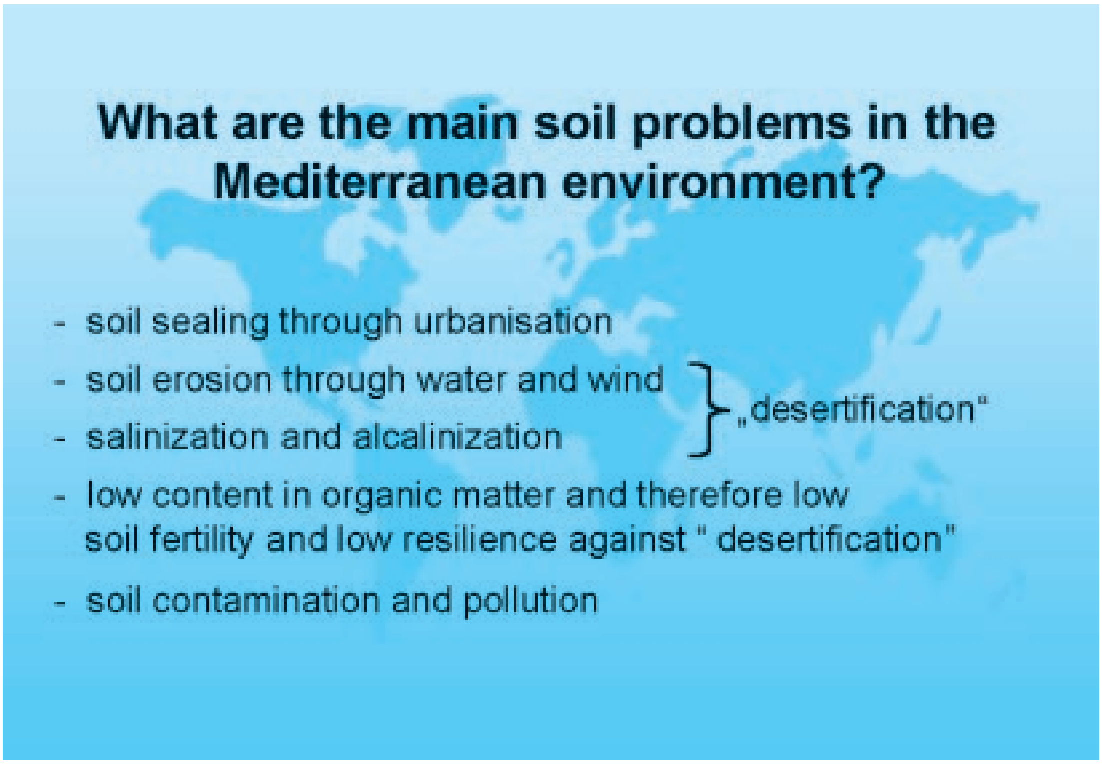
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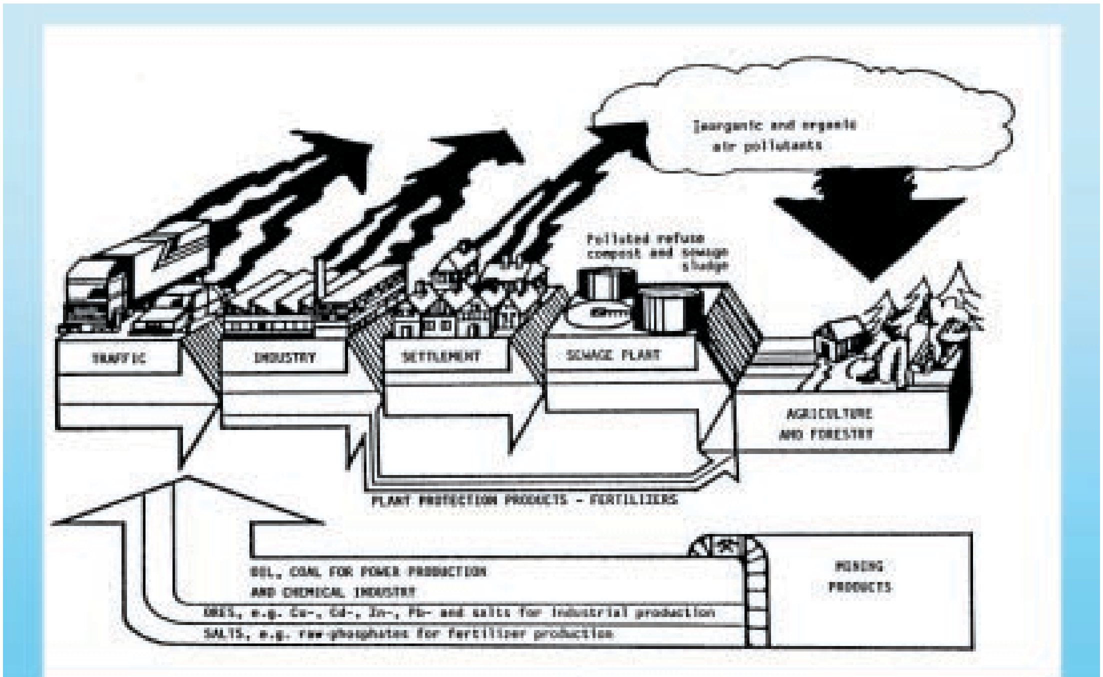

SOIL POLLUTION BY HEAVY METALS THROUGH EXCESSIVE USE OF FOSSIL ENERGY AND RAW MATERIALS (BLUM 1988)

The status of the Mediterranean soils

(Jean-Paul Legros, INRA-ENSA Science du sol and Giannantonio Petruzzelli, Istituto per la Chimica del Terreno, Area di Ricerca CNR)

Introduction

A very useful synthesis was made on the soil quality in France [BORNAND et LEHMAN, 1997] even if it is not specially focused on the Mediterranean regions. To evaluate the status of the Mediterranean soils it is useful to consider the external factors that influence the preservation or the degradation of the soils (causes of vulnerability), to consider also the physical, chemical and biological degradations that affect the soils (impacts), and to review the indicators of soil quality that allow us to make an accurate diagnostic for a given soil.

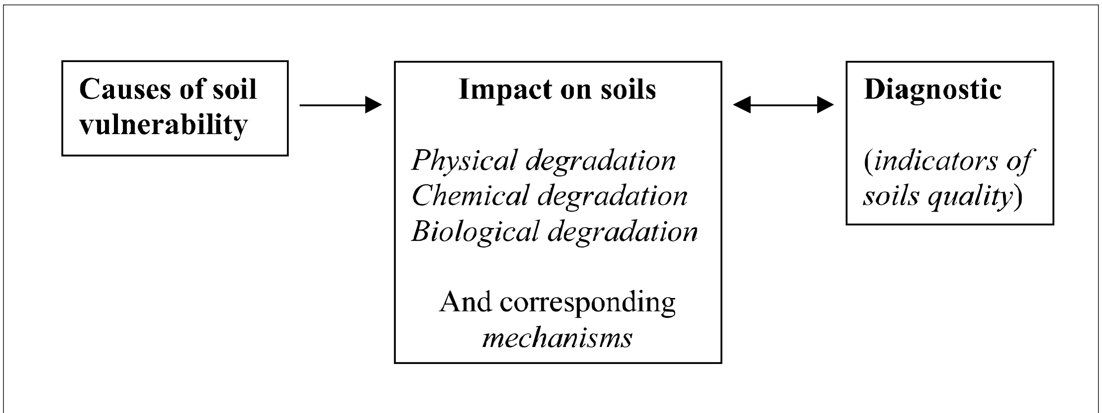

Figure 1: Approach of the soil quality.

Causes of vulnerability

The soil of the Mediterranean regions are developed in very sensible environments. The main causes of vulnerability are listed in table 1.

Table 1: Main causes of Mediterranean soil vulnerability

Climate Erosivity	Climate droughts
Soil Erodibility	Urbanisation and infrastructures
Relief	Mechanical agriculture
Forest fires	

Climate erosivity. In the Mediterranean regions, the rainfall is distributed through the year in an irregular manner. Some months are dry and other very humid with a very high rainfall intensity. This situation leads to erosion as indicated by the Universal Soil Loss Equation (USLE).

Soil erodibility. As the climate is dry during summer, the competition is high for water. That is the reason why farmers growth crops that do not cover the surface very well, for example olive tree orchards in which the trees are in a small quantity and under which the soils are bare (then the Potential EvapoTranspiration is reduced and some fruits can be harvested). This is naturally a favourable situation to facilitate the erosion process taking into account the fact that the soil organic matter content is reduced in parallel.
Relief. The Mediterranean region are more or less mountainous and this is also a factor increasing the sensibility of the landscape to water runoff.

Climate droughts. The climate is irregular. In the south part of the Maghreb, some years are dry without any rainfall. In the worse cases, the vegetation disappears and the organic matter too. The remaining soil water is very low, in equilibrium with the air humidity. As the water is the best efficient link between the soil particles, these particles are separated. The wind is able to transport away the smallest. The desertification is starting. The mechanism is not really reversible even if rainy events come back because the ability of the soil to stock water is not recovered.

Urbanisation and infrastructures. The Mediterranean region is the most popular tourist region of the World [UNEP-EEA, 2000]. So an important part of the arable soils are progressively sealed by urbanisation and transport infrastructures. Most of the towns are very old and were positioned in the best arable plains in old times during which agriculture was the mean to get food and survive. Then the town development eats the best soil resources.

Mechanical agriculture. For 20 years some new difficulties appears concerning the cultivation in the Mediterranean regions [LEGROS et al, 1998].
The first point is the disappearing of draught animals that implies the reduction of the organic matter returns.
The second point is the structure degradation and the strong soil compaction. Several reasons explain the recent and serious soil compaction of the Mediterranean soils :
1) decrease of organic mater as indicated above,
2) use of heavy machines,
3) method of zero tillage. This method has some advantages. To pass a plough in a vineyard is long and difficult. It can be made only by specialists to avoid the destruction of the vine plants. On the contrary, the spreading of herbicides to destroy the seeds is made quickly and easily by everyone. The cost is lowered. Unfortunately, the consequences are the destruction of the earth worms and of the weeds roots. In other words, the organisms that build all the small pipes conducting the water in soils of low permeability are removed. The results are both compaction, runoff and hydromorphy if the climate is sufficiently humid.

Impacts on soils

The table 2 present the main physical, chemical and biological degradation affecting the sols in the Mediterranean countries [from BARBERIS et al, 2000, modified]. But, as it will be seen immediately, most of these phenomena are linked.
Several types of degradation conduct to the soil destruction. Examples: sealing, suppression of wetlands, strong salinisation. Some phenomena will be described below with their mechanisms.

Table 2: Main phenomena linked with soil degradation

Physical degradation	Chemical degradation	Biological degradations
Compaction, crusting	Chemical impoverishment	Biodiversity reduction
Organic matter reduction	N accumulation	Soil respiration reduction
Soil porosity reduction		
	P accumulation	Enzymatic activity modifcation
Structure degradation	Carbonatation	
Hydraulic conductivity reduction	Salinization, alcalinisation	
Water retention capacity reduction	Acidification	
Water erosion, Wind erosion	Pesticides accumulation	
Soil depth reduction	Metal accumulation	

Physical degradation

When the soil compaction begins it is commonly accepted as a good thing by the farmers because the trafficability is ameliorated. Unfortunately, the compaction continues to increase slowly, up to a limit above which the yields are reduced. When bare, the soils are exposed to the rain and a soil crust is formed after rainy events if the texture is fine. This crust is porous but the pores are not connected [USON and POCH, 2000]. Then the quantity of soil material removed by lateral flow during the future rainy events will be greatly increased.
In the Mediterranean regions the men occupied their unstable physical environment for a very long time. If we refer to pedological studies we can see that the rate of soil formation is very low. For example, since the end of the last glacial period some soils made from an easy weathered marl reach hardly 2 metres depth under forest. This value represents 0.2 mm of soil formation each year. With a bulk density of 1.3 this is also 2.6 tonnes added to the base of the soils each year. Under forest, the erosion is absent and the soil becomes thicker. But, if it is cultivated, even if the methods of plough are conservative, the erosion will past above this limit of 2.6 tonnes/year. Several specialists think that the threshold, in average, is not 2.6 tonnes but 1.0 tonne. Unfortunately, in Andalucia for example [de la ROSA et al, 1999], an erosion risk under 5 tonnes/ha/an corresponds to the best situation and is seen only in 14% of the 237 fields studied ! In the same study, roughly half of the fields sample correspond to a soil erosion rate reaching or going beyond 10 tonnes/year/ha. In these conditions, most of the soils become thinner, year after years. Five thousands years after the beginning of cultivation, they are near to be entirely removed ! By contrast, in Atlantic or Continental regions, most of the soils and fields are eroded under this limit of 2.6 tonnes/ha/year and are not threatened of full disappearing.
When the soils become superficial and stony, it is very difficult to cultivate them. So, they are used for grazing (sheep, goats) and often overgrazing. At this stage of the degradation process the most simplest method to clean the landscape and to avoid the apparition of trees and shrubs is to set fire each five or ten years. After the fire, the soils are bare and exposed to rain drops. Moreover, it was recently demonstrated [CERDÀ, 1998] that soil under grass or shrubs have aggregates no so resistant that soils under forest (organic matter impoverishment, thermal and hydric shocks). Then erosion continues, reinforced.
In these conditions it was written [de la ROSA et al, 1999]: "With the present rate of erosion, considerable areas in these countries (Mediterranean) may reach a state of ultimate physical degradation, beyond a point of no return within 50-75 years".
One can separate the case of hard and of soft rocks. On hard rock (limestone, granite…), the hurt is done. In Mediterranean region the speed of weathering is not sufficient and the soils have disappeared in many regions. Only traces of soils subsist between the rocks cracks and between boulders. It is the case on the calcareous plateaux and on the igneous mountains. On the contrary, on soft rocks, like marl or clay, deep soils remains often, in Tuscany for example.

Chemical degradation

Chemical impoverishment
An other point concerning cultivation is often omitted. Since the beginning of agriculture, 5000 years ago [YAALON, 1997], the soils were used without any mineral fertilisation. So centuries after centuries, the soils became poorer and poorer in phosphor and potassium [BOULAINE et LEGROS, 1998]. For this reason, the agricultural yields, in the beginning of the 19th century were not more important concerning wheat than the yields during the Roman period in spite of some trials of massive organic matter inputs. In 1840, Liebig, in Germany, explained the principles of the mineral fertilisation but he was understood and followed only after 1870.

Today the chemical status of the soil is not improved everywhere. Under forests, under natural meadows and in some vineyards and orchards the level of fertility remains very low in many Mediterranean Countries! The fertiliser deficit is increased by the modern agriculture (deep and frequent ploughing, dry farming, irrigation,) that exploits better the soil but often without sufficient mineral and organic returns [MHIRI et BOUSNINA, 1997]. The same authors mention a "mining agriculture" (no returns).

Nitrogen accumulation

On the contrary, modern agriculture is based on mineral fertilisation and it could happen that the supply of fertilisers far exceeds plant requirements. Nitrogen can be considered as an example. Nitrogen leaching is essentially due to incomplete element utilisation and uptake by plants, the nitrate form is scarcely retained by soil surfaces and its downward movement is not hindered. Nitrogen leaching is of particular concern in arable land because mineralisation proceeds after harvest i.e. without vegetation. The consequence is groundwater contamination in the long term.
Nitrate loading to ground water is considered a problem in Mediterranean country. It is linked to nitrogen application rate, but also to soil type, irrigation practices and land use. Leaching in sandy soils is greatest than in clay soils, also as the result of lower denitrification.

P accumulation

Phosphate has a very different behaviour in the soil system, also this element is not completely utilised in the root zone, due to its unavailability derived from strong bonding on soil constituents. This property prevents P leaching, but induces a requirement of a relative overdose of P. Soil parameters affecting phosphate bonding are organic matter, clay minerals, calcium carbonate, oxides and hydroxides of Fe and Al. The transport of solid particles in runoff water lead to accumulation of P in river and lakes with a bloom of algae.
Average data of P fertilisers consumption in Mediterranean agriculture are not easy to evaluate since often farmers utilise quantities greater than the official recommended.

Carbonatation and salinisation
Without irrigation, if the winter are sufficiently humid, the salt are naturally removed from the soil profiles. This is the case for the very soluble salts as ClNa but this concerns also some less soluble products as SO_4Ca and CO_3Ca. From a chemical point of view, CO_3Ca is a salt. From an agronomic view, it is not a salt because its solubility in water is relatively low. So the plants are not very affected using the water of a calcareous soil… if we neglect some problem of chlorosis. The "normal soil" in the humid Mediterranean region on calcareous stones is not calcareous and not saline. It is neutral (eutric) and can be found under some very old forests. But, in the common situations, as the soil is truncated by erosion and mixed with stones by the plough, it is maintained in a calcareous status.
By contrast, in the dry Mediterranean regions, the CO_3Ca is not removed because the humid period inside the year is small. The carbonates, if washed, do not move toward the bottom of the soil and come back to the upper horizons transported by water that rises up by capillarity. The natural limit (under forest) between non calcareous and calcareous soils in Mediterranean regions is some where in the north of Algeria [DJILI, 2000].
If we continue toward the south even the soluble salts are not removed outside of the profiles. There is not a well defined latitudinal limit because rare and strong rainy events (each decade for example) wash soils that were considered before as definitely lost [MHIRI et BOUSNINA, 1997]!

With irrigation, in the dry regions the salinisation risk is high and very difficult to avoid. Suppose (theoretical assumption !) that we irrigate with a pure mineral water as Perrier. The quantity of salt in a litre is 35,4 mg of NaCl that represent 283 kg added each year for one ha if we use a water quantity of 80 cm that is a common rate. On the ground the salts would accumulate because there is no leaching by water. Some centuries after, with our pure mineral water, we would get a saline soil ! Unfortunately, the waters used for irrigation in the dry countries are concentrated by evaporation and far from pure mineral water. So, the salinisation is often rapid. Everywhere, the soil cultivation increases the water demand (crop transpiration). Then the upward movement of the water increases too with a risk of salinisation more important. One says that some Mediterranean civilisations disappeared in relation with progressive salinisation of there countries.

Several reasons explains a recent increase of salinity [HERRERO and SNYDER, 1997].
1) The salinisation process is mainly the salt concentration linked with the transpiration of water by crops. So salinity increases if the agricultural productivity is ameliorated without conservative measures against salt.
2) When the cultivation is developed in a region without a general system of water supply and drainage, the chloride content of the drainage waters and of the rivers is increased.
3) The practice of intensive land levelling to permit flood irrigation exhumes often soil materials that are rich in salts and that were never washed before by the rains.
4) In the non irrigated lands, drought is perceived as the major problem but, when irrigation starts, the salt problem appears.

Pesticides accumulation

The use of chemicals in Agriculture leads to water pollution. The most important characteristic to consider is the persistency of the molecules, which is determined by the degradability, but also solubility and volatility in the soil environment. Leaching of pesticides and similar compounds can depend on degradability and possibility of strong bonding with organic matter and clay particles.
To estimate the pollution several watersheds are studied in Europe including the Roujan watershed in the Montpellier's region. There, it was demonstrated that only small quantities of simazine and diuron are transported outside of the watershed (1 or 2% of the sprayed quantities). These losses are linked with the first strong rainy events after spraying even if they appear 100 days later or more. During the transport, the instantaneous concentrations of chemical in the surface waters can be high and dangerous [LENNARTZ et al, 1997]. If one compares the lost of herbicide in lateral flow at the scale of the field and at the scale of the watershed it appears that a major part of the product disappears before to leave the watershed. In other words, the herbicide reinfiltrates to the groundwater by seepage through ditches [LOUCHARD et al, 2000]. After what happens is no clear. The chemical are split in more or less known molecules that remain in the soil and water at low concentration for an unknown time. One says that the vine is not contaminated because the fermentation during the grape transformation destroys the organic chemicals.
Nevertheless repeated application of organic chemicals to soil are of increasing concern in Mediterranean agriculture and severe regulations strictly control the use and the introduction of new compounds.

Metal pollution

Characterisation of the degree of pollution of soil by heavy metals is one of the main problem in soil chemistry. Many heavy metals are also essential micro-elements since they are indis-

pensable in biological processes (e.g. Cu, Zn, Ni). However, account must be taken of the fact that this characteristic is maintained only up to a certain level beyond which these elements become toxic. With respect to the non-essential metals, living organisms show a certain tolerance up to a threshold after which they show symptoms of toxicity.
The definition of the background level of heavy metals in soil is important to evaluate if any increase produced by agricultural practice, atmospheric deposition etc. has occurred. In the definition of background values it is necessary to consider that heavy metals are naturally present in soils and that there is an enormous variability of concentrations found in natural soils. Based on analyses of numerous Italian soils it has been possible to define a range of concentrations, found in different types of soils, which do not present negative effects as regards soil fertility, crop productivity, water quality or the environment in general. These values are shown in Table 3.

For France, all the references are available in two large synthesis [BAIZE, 1997 – BOURRELIER et BERTHELIN, 1998].
In the table 3, the value of 120 for copper can be found in many soils cultivated with vines. Since the apparition of mildiew (Plasmopara viticola) and until few decades, grape growers use Cu (Bordeaux mixture) to protect the vineyards. So the level of Cu contamination is high in many soils of the Mediterranean region, sometimes up to 250 mg/kg [BRUN, 1998]. Cu remains strongly fixed on organic matter and on clay inside the first horizon of the soils.

Table 3: Concentration intervals of heavy metals found in agricultural Italian soils. The data are expressed in mg/Kg.

Metal	"normal" concentrations
Zinc	10 – 150
Copper	10 - 120
Lead	5 - 120
Cadmium	0.1 - 5
Nickel	5 - 120
Chromium	10 - 150
Mercury	0.01 - 1
Arsenic	2.5 - 15
Molybdenum	0.1 - 5
Cobalt	1 - 20

The value of 120 for lead is common in soils near major roads. Also the high values of nickel and Chromium is a specific feature of Mediterranean regions whose soils greatly differ from those of northern Europe, due to the different parent material and climate effects.
The wide intervals in the table reflect the notable differences between the soils in the various Italian regions. Given the heterogeneity of the soil, together with possible analytical and/or sampling uncertainties, heavy metal values slightly greater (10 – 30 %) than those shown can generally still be considered as natural values.

Total heavy metal content in agricultural soils represents only the initial point for knowledge of the degree of pollution and it is often of little importance in evaluating plant uptake and the potential transfer to the food chain. Knowledge of the environmental mobility of the different chemical species of heavy metals is essential to understand the risks deriving from pollution for man and the environment. It is therefore fundamental to quantify those metal fractions which can become part of the liquid phase of the soil. This phase represents both the resource from which plants and other organisms take water and inorganic and organic nutrition, and is also the means of diffusion of these elements.
In schematic terms the heavy metals in the soil can be considered to be present in various chemical forms:
1) Soluble in water:
  a) as free cations,

b) as complexes with organic and inorganic bonds.
2) On the exchange sites of clay minerals in an "exchangeable"form.
3) Adsorbed specifically, on clay surfaces or on ferrous and manganese oxides; adsorbed and/or complexed by the organic matter.
4) Occluded or coprecipitated with carbonate phosphate oxides or other secondary minerals,
5) As cations in the primary minerals following isomorphic substitutions of Fe and Al.

The retaining or releasing reactions of heavy metals include the processes of precipitation and dissolution, ionic exchange, adsorption and desorption, partition of the elements in the different chemical pools. These processes are firstly dependent on pH and are essentially associated with clay content and organic matter, and with ferrous oxides and hydroxides.
Information concerning soil contamination is still patchy, and generally not easily available among Mediterranean countries. This reflects the diverse interest that countries have for their own particular soil problems. Moreover information concerning soil are held by different organisation and authorities, so that collection and evaluation of data are very difficult.

For heavy metals, the main sources of contamination are :
Use of mineral fertilisers (N, P, K) with heavy metals content. A typical example is given by the presence of Cadmium in phosphate fertilisers, which therefore contribute to total soil Cadmium burden. The Cadmium content, depends on the origin of the raw phosphate used in the productive process. There are considerable differences from 5 mg/Kg Cd to as high as 300 mg/Kg. Phosphate from Marocco and Tunisia have a mean concentration around 15-30 mg/Kg.
Use of manures and sewages with Heavy metals content [LEGROS et al, 2001] (case of Cu and Zn in swine slurries).
Roads (Pb in benzine),
Atmosphere (pollution transported by air),
Opencast minig; the pollution is often well delimited and high (hot spots). The contamination of the surrounding landscapes is related with erosion of spoil banks [PORTA et al, 1989].
All the kinds of degradation reviewed are cumulative. So the lost of arable lands is important in the Mediterranean region. For example, this represents about 37.000 ha definitively lost for Tunisia each year [MIHRI, 1999]. Much more information on soil degradation is available in two interesting synthetic books [ROBERT, 1996 – STENGEL et GELIN, 1998].

Soil quality indicators

Recently the Italian National Agency for the protection of the Environment ANPA has created the National thematic center on soil and contaminated sites (CTN SSC) with the aim, among the others, to choice useful indices and indicators to describe Italian soil quality. In table 4 are reported the selected indices according to the DPSIR system [BARBERIS et al, 2000].

Table 4: Soil quality indicators [BARBERIS et al, 2000].

pH	Total heavy metals	Pesticide in groundwater
CEC	Heavy metal availability	Surface water total P
Texture	Pesticide use	N and P contribution to rivers and seas
Organic matter	Nutrient-balance of the soil (nutrient input/output)	Protected areas
Available P and K	Nitrate in groundwater	Electric conductivity-EC

Conclusion: Towards a better future?

To reduce the man pressure on soils
Probably, the situation of the soils will ameliorate naturally in the next future on the north limit of the Mediterranean sea in relation with the diminution of the man pressure on land. As a great part of the population moves towards the towns, most of the lands cultivated on strong slopes return back to natural and protective vegetation [UBALDE et al, 1999]. Moreover, the use of bush (garrigue, maquis) as firewood is no longer profitable and the forest is not over-exploited now. But the risk of fire remains high and often increases.
On the south shore of the Mediterranean sea, the density of the population is high and the forest is deeply exploited. The erosion rates is high. A part of the soils continues to disappear definitely.

To return back to classical methods of cultivation
In the region of Montpellier, in the laboratory of one of the authors, it was demonstrated that the quantity of soil material removed by erosion is in strong relation with the lateral water flows during the rainy events of highest intensity. So the zero tillage, with the use of chemical, that makes the soils bare and smooth is worse concerning erosion risk than traditional cultivation with a plough that makes an irregular soil surface [COULOMA, 1998]. On traditionally ploughed parcels the erosion is 4 tonnes/years. On the parcels with zero tillage the erosion is the double or more. For the same reason, the annual herbicide loads in surface waters on cultivated vineyards soils are reduced 3 to 15 times if one compares with those of the parcels with zero tillage [LOUCHARD, 1999].

To cover the soils with grass
One solution to avoid erosion and to maintain a good trafficability in vineyards and orchards is to growth grass between the plants ranks. In theory, this method, widely used in the north vineyards (Burgondy, Alsace, …) is not perfectly convenient for the Mediterranean region, in rainfed vineyards, in relation with the competition for water between the grass and the crop. But, this common idea needs to be evaluated for two reasons:
1) The roots of the vine plants and the roots of the grass do not extract water in the same soil horizons. So the competition is not as evident as predicted, in Spain for example [USON et al, 1998].
2) It was demonstrated that, with a grass cover, the infiltration of water is much better than with a bare soil [LEONARD et ANDRIEUX, 1998]. So with grass the winter rains are better stored in the soils and can be used in the dry period.
For these reasons experiments are needed to see the true consequences of introducing grass in orchards and vineyards. These trials must be pursued several years because remains the hypothesis of a water deficit covered, for example, at 80% by the annual rain and at 20% by the soils reserves stored when begins the experiment. When this is true, the lack of water may appear only the second of the third year of experiment as seen by USON et al above. In Languedoc such experiments are planed by INRA and the Hérault Agricultural Chamber. Naturally, it is always possible to cut the grass in the dry period of the year, to destroy it or to use grass varieties that do not survive in summer.

To use the organic wastes
One other way to ameliorate the situation is naturally to use the organic waste provided by crop industries and by the development of towns. This seems to be advantageous in countries in which organic matter is often lacking. But several specific difficulties must be solved:
- These is a rapid oxygen consumption if organic matter is added in great quantity. This is accompanied by the strong collapse of the redox potential. If the products added undertakes

fermentation, organic acids are produced and the pH diminishes often strongly [COCKBORNE et al, 1999]. This is favourable to the dissolution of toxic ions: Fe++ and Mn++. In other words, the quantities of waste must be limited and spread in the dry season if the winters are humid.
- Some of these organic products are rich in salts. So one must control their salinity and the evolution of the soil salinity specially in the dry regions, where the salinisation risk is high.
- As seen above, some Mediterranean soils are rich in metal. So the metal content of waste must be measured.

To develop the countries and their financial power
The soil saline reclamation method is perfectly known. One needs only:
- pure irrigation water in sufficient quantity not only to satisfy the plant requirements but also to wash outside of the soil the salts that are there,
- a lot of money to construct the pipelines to carry on the incoming pure water and to eliminate the saline water extracted by drainage,
- a computer technology of high level to manage, for a whole region, the circulation, the use and the elimination of two water systems with thousands of users.

The method works perfectly in California [LEGROS, 1996]. But, in most part of the Mediterranean region, the wanted technology is not available...

To use law, promote education and set up programs
The main point is probably the necessity for everybody to understand that soil is not a renewable resource. It this is achieved, it becomes possible to organise conservation programs, to inject money in the soil management and to use laws as an additional tool to progress toward a better soil use and protection.

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Industrial Contaminated Sites-Propectives in Southern Europe

(Simonetta Tunesi)

First Italian decree on site clean-up 1989:

- derelict sites; industrial waste dumping
- regional inventories of potentially contaminated sites
- regional priorities
- national and regional funds

Several Regions have begun remediation activities and regional laws have been approved

Regional approaches for selecting polluted sites were based on threshold values

As a result of the 1989 decree:

Region	Sites potentially contaminated	Short term	Long term
Emilia-Romagna	3182	66	91
Lombardia	2120	25	70
Piemonte	116	55	-
Sicilia	110	4	9
Toscana	309	73	166
Liguria	13	-	-
National *94-99 data	8792	705	1122

As a consequence of those first investigations, in 1998 with a National law, 14 sites were declared

National Interest Sites

and 300 million Euro were allocated for remediation (up to 50% total cost)

Activities begun in 1999 with working groups formed by national, regional and local personnel assessing remedial projects submitted by site owners

The most recent Italian national legislation was issued on December 1999:

- **sites of every dimension and type**
- **even operating sites**
- **regional inventories of contaminated sites**
- **maximum acceptable concentration values**
- **values set for two categories of use:**
  - green areas / residential
  - service / industrial

The remedial interventions have to address:

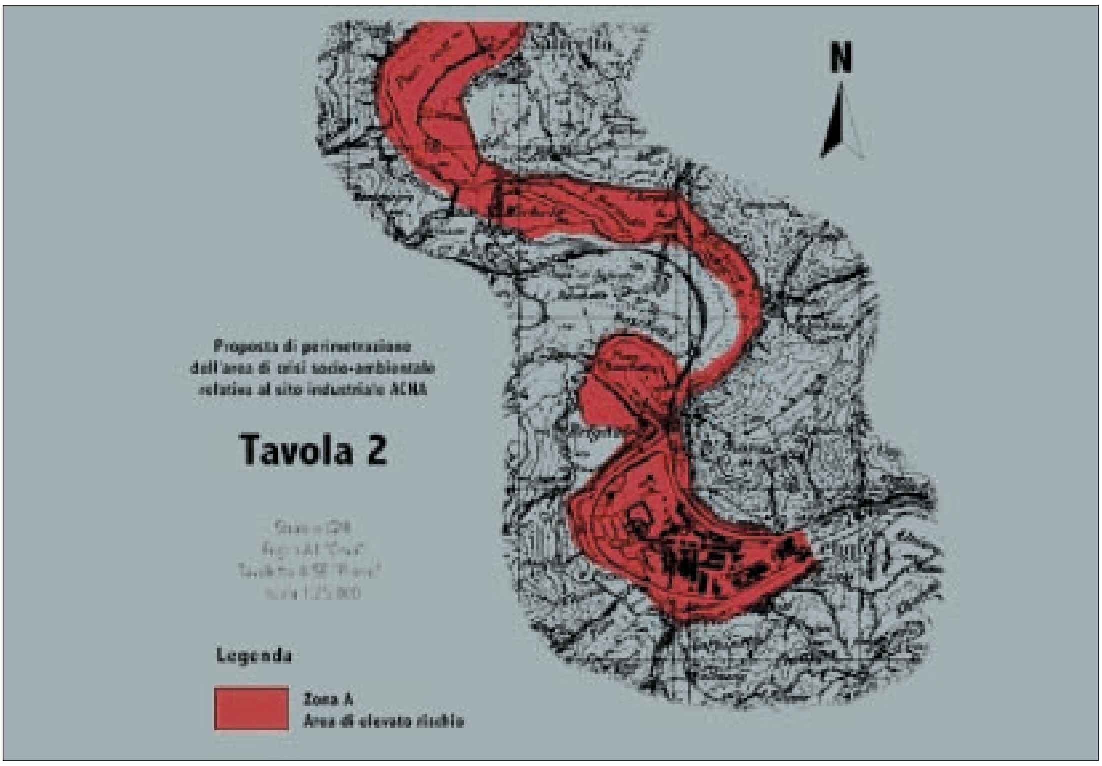
- **the location of the sites**
- **the whole area that could have been impacted by the site**

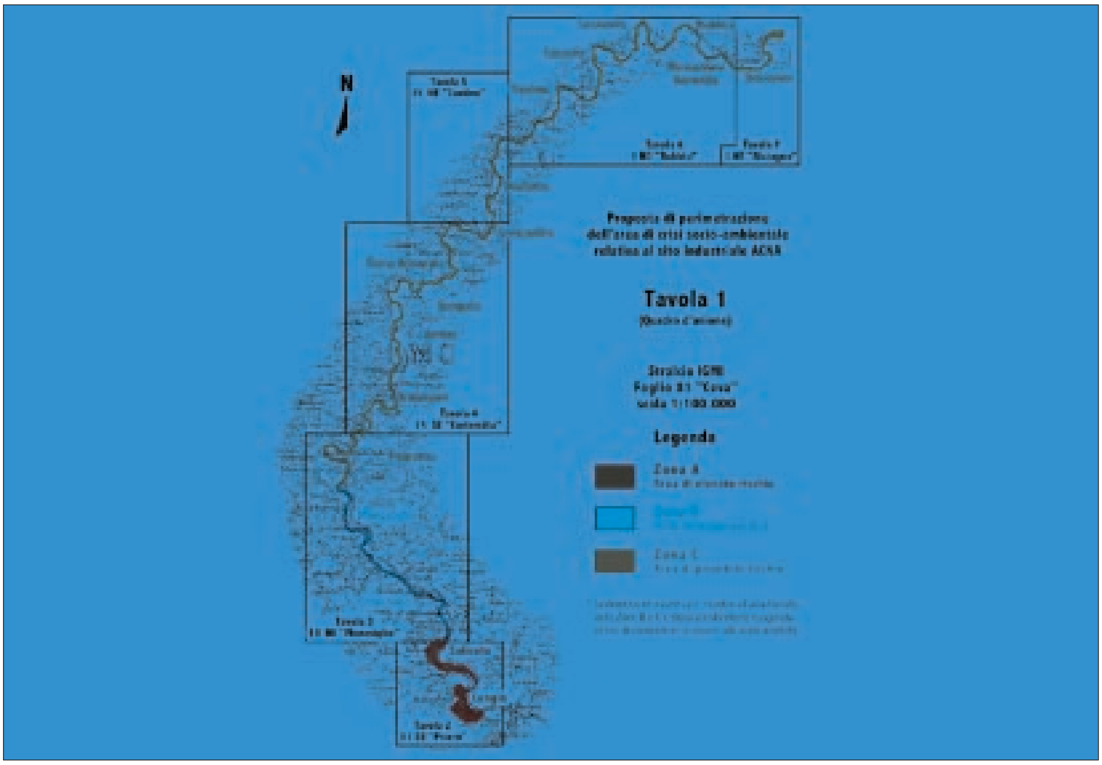
At present public authorities are conducting the investigations for the characterisation of external areas

Case study: the characterisation of the external area for the ACNA site has been implemented on the basis of a Conceptual Model of the river environment

Environmental media investigated:

- groundwater
- surface water
- river sediments
- river soil
- river biomonitoring





Soil and subsoil Maximum Acceptable Concentrations

Metals mg kg^{1} as d.m.	green/residential	service/industrial
Antimony	10	30
Arsenic	20	50
Cadmium	2	15
Cobalt	20	250
Cromium tot	150	800
Cromium VI	2	15
Mercury	1	5
Nichel	120	500
Lead	100	1000
Copper	120	600
Selenium	3	15
Tin	1	350
Vanadium	90	250
Zinc	150	1500

Groundwater Maximum Acceptable Concentrations

	$\mu g\ L^{-1}$
Cromium tot	50
Cromium (VI)	5
Iron	200
Mercury	1
Nichel	20
Lead	10
Chrysene	5
Dibenzo (a, h) anthracene	0.01
Indeno (1,2,3 - c, d) pyrene	0.1
Chloromethane	1.5
Trichloromethane	0.15
Vinyl chloride	0.5
1,2-Dichloroethane	3

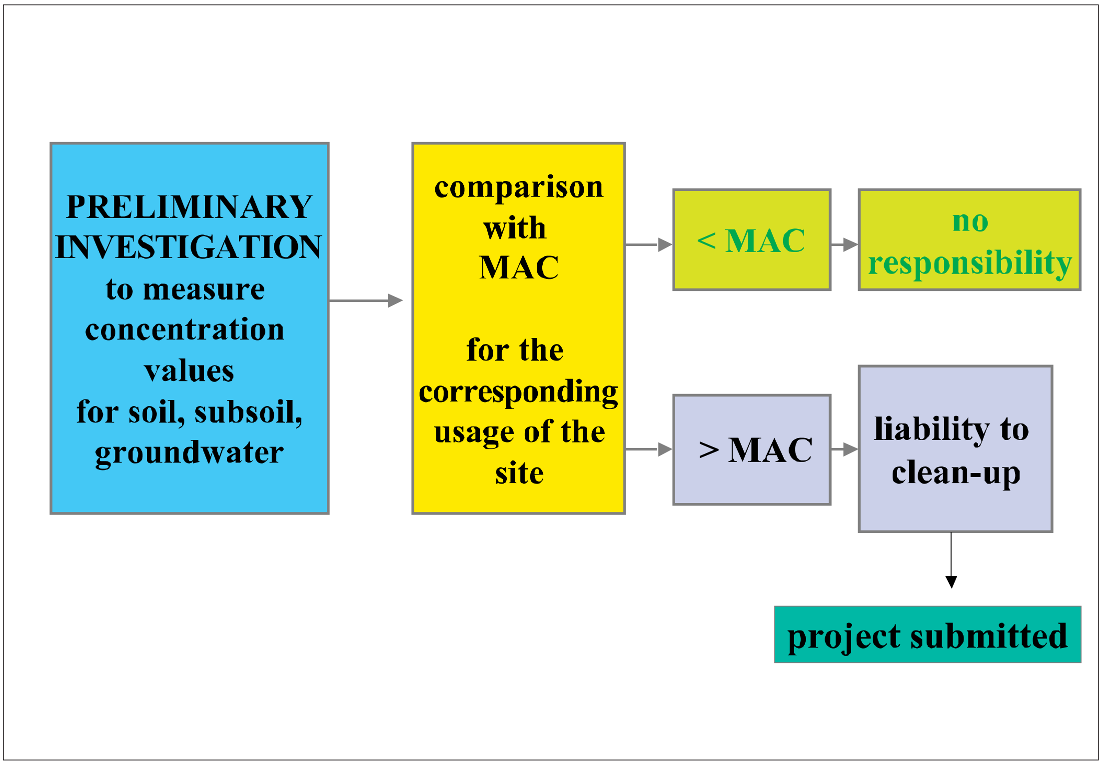
Setting of threshold values

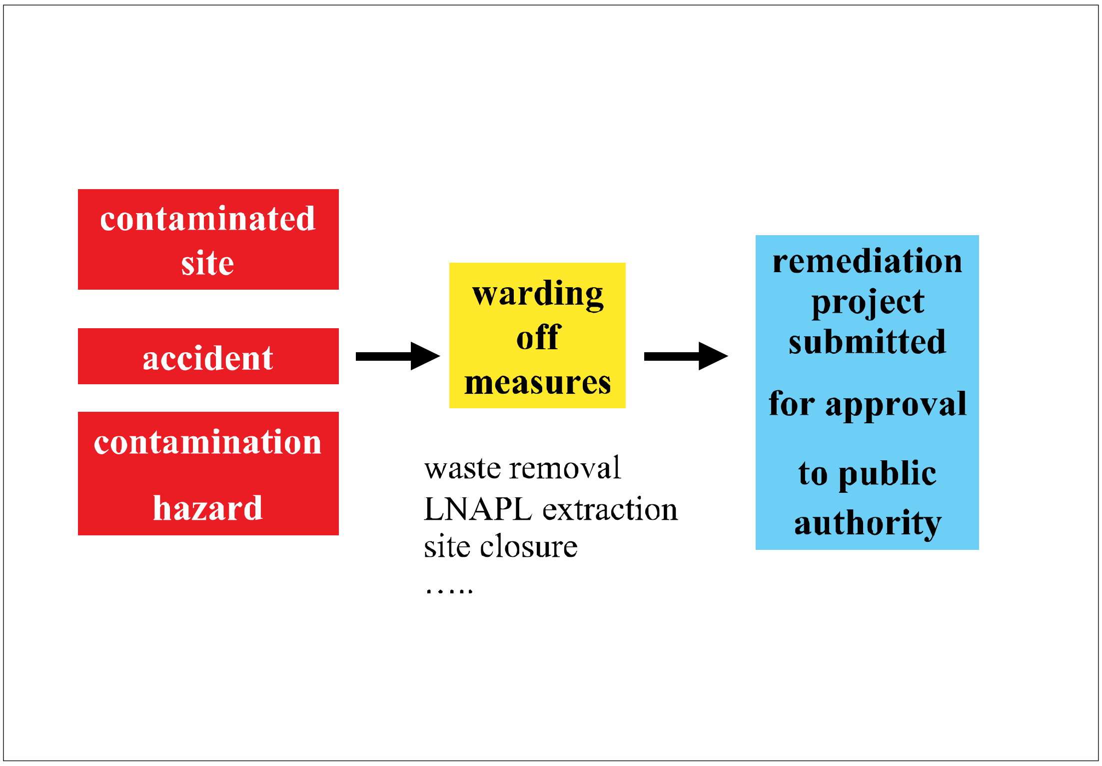
PROs

- the selection criterion does not rely on the expertise of the technical personnel of local administrations
- no private/public disputes over the label "polluted sites"

CONs

- even sites with low level of pollution might be included in the remedial procedure
- the responsible party has to prove that the risk posed by those sites can be managed


PRELIMINARY INVESTIGATION to measure concentration values for soil, subsoil, groundwater
comparison with MAC
for the corresponding usage of the site
< MAC
no responsibility
> MAC
liability to clean-up
project submitted


contaminated site
accident
contamination hazard
warding off measures
waste removal
LNAPL extraction
site closure
…..
remediation project submitted
for approval
to public authority

The Remediation project
is made by three documents

1. CHARACTERISATION PLAN

↓

execution of investigation activities

↓

2. PRELIMINARY PROJECT PLAN

↓

3. DEFINITIVE PROJECT PLAN

the Italian regulation defines in detail the contents and the requirements of the different projects documents

by the same technical approach

the liable party elaborates remedial strategies

the public authority assesses the quality of project design

1. CHARACTERISATION PLAN

- collection and organisation of existing data
- description of site and of the environment that could have been impacted
- preliminary Conceptual Model
- design of the initial investigation plan

EXECUTION OF THE INVESTIGATION PLAN

- collection of environmental media samples
- sample formation
- sample preservation, transportation,

Control of activities and laboratory analysis (10%) by public authorities

2. PRELIMINARY PROJECT PLAN

- **analysis of pollution levels:** hot spots, contaminants, statistical treatments of data,..
- **evaluation of the technologies suitable for the specific case**
- **selection of the remedial scheme on the basis of effectiveness of best available technologies**

REMEDIAL SCHEMES

MAC can be reached

Remediation with safety measures:

residual concentrations > MAC will be left in environmental media

isolation of primary source of contamination - wastes

2. PRELIMINARY PROJECT PLAN

- site specific risk analysis
- comparison of remedial scenarios
- description of the selected scenario
- evaluation of the need to split remedial operation by areas

Criteria for technology selection

- reduce concentration in environmental media to MAC
- clean-up without soil removal: in-situ and on-site techniques
- if MAC cannot be achieved even by the application of BAT, residual concentration > MAC can be allowed

Criteria for technology selection

- **the residual concentration that can be achieved by the efficient application of technologies are to be evaluated by risk analysis methods**

- **remediation that allows residual concentrations has to be coupled with safety measures (**such as hydraulic barriers**) or usage limitations**

- **reduce the period of controls after intervention**

3. DEFINITIVE PROJECT PLAN

- **Timing**
- **costs**
- **detail of remedial works and operations**

The remedial scenario is made by the combination of:

1. characterisation of environmental media in the site and the surrounding area; impact assessment
2. selection of technologies for the reduction of contaminants concentration in environmental media
3. safety measures that intercept the migration of residual contamination and usage restrictions
4. risk management at the end of remedial activities

ANPA activities:

- data-base on remedial technologies
- technologies application case-studies
- guidelines for project design
- structure of national inventory

Open problems

- sampling strategies for national sites
- capability of storing and processing national data
- assessing different sampling approaches
- estimate and liability for environmental damage
- national priorities

Open problems

- permanent safety measures of vast areas (time bombs)
- by mean of risk analysis, application of technologies that justify residual concentrations
- lack of personnel for control of operation in site
- control of environmental quality after completion of remediation

Compost biotechnology in an integrated management of degradable organic waste and in the reclamation of disturbed soils

(Giovanni Vallini, University of Verona - Department of Science and Technology, Laboratories of Microbial Biotechnology an Environmental Microbiology)

Introduction

Composting is by definition the solid-phase biological decomposition of organic residues that occurs in aerobic conditions by exploiting the substrate self-heating as a consequence of the microbial oxidative reactions. This process leads to the production of compost, a humus-like, dark, crumbly material that can be used as fertiliser to reintegrate organic matter in agricultural soils. Therefore composting has been considered for a long time a proper way to treat and recycle organic wastes such as crop residues, live-stock manure, biodegradable fractions from municipal solid waste (MSW), sewage sludge, fish waste, pulp and paper and sawmill wastes as well as by-products from a variety of food-processing industries (Vallini et al., 1984a; Vallini et al., 1984b). The use of composting to stabilise putrescible wastes and to transform them into a valuable resource knows today an expanding trend in many countries, as landfill sites become scarce and expensive, and as people are more aware of the impacts that land disposal or mass burning of unsorted wastes have on the environment. In many industrialised countries, governments have already stated, or are going to define, goals or legislative mandates to drastically reduce the volume of organic wastes being sent to landfills or incinerators.
Nevertheless, it is worth pointing out that, even lacking programmes of separate collection that allow the management of clean organic residues for high-quality compost production (product-oriented perspective), composting might be usefully applied for the stabilisation of unsorted MSW or whatever rotting organic matrix to be then landfilled (treatment-oriented perspective). The reduction in volume and the loss of putrescibility gained with a preliminary composting step make these wastes more suitable for landfill disposal since space is saved, leachate production and biogas release minimised, and odour emission prevented.
Still in the same perspective of treatment-oriented processes, composting is nowadays more and more considered an important tool for the conversion of a number of chemical wastes (e.g. oil refinery sludge) into innocuous, stabilised end-products or the detoxification of soils contaminated with noxious organic pollutants (e.g. polycyclic aromatic hydrocarbons and explosives) (Vallini, 1997).
This lecture will deal with the examination of advanced technological options for the control of the composting microbial ecosystem intended for either the treatment of putrescible organic matrices for compost production or the degradation of polluting chemicals in both industrial wastes and soils.

Composting of organic wastes in a product-oriented perspective

Basic knowledge for process control - Although composting is often referred to sophisticated associations of machinery that determine as many plant configurations capable of transforming organic matrices into a stabilised end-product, people should consider it primarily as a biological process (Finstein and Morris, 1975; de Bertoldi et al., 1983). This means that, if composting has to be a success, proper process design and management must be based on the fulfilment of requirements of a variety of microorganisms which represent the active agents of the stabilisation reactions. Thus, optimisation of composting at a biotechnological scale (i.e. improvement of decomposition rate, pathogen abatement, and odour management) requires the knowledge of the key factors that affect such a peculiar microbial ecosystem.

The main physical and chemical parameters which control the activity of microorganisms during composting are:
a) temperature that must be considered under all aspects of external conditions, heat production within the matrix as a consequence of biological activity, heat transfer, and heat management;
b) moisture
c) oxygen supply
d) pH
e) carbon to nitrogen (C:N) ratio

and

f) physico-mechanical characteristics of the material being composted

If the prominent goal of composting is the production of a soil organic amendant which should meet qualitative standards in order to result acceptable for agricultural uses, the

g) composition of the starting substrate biomass

must be taken also in great account.

Temperature is probably the most important factor affecting the metabolism of the microbes during composting. It is either a consequence and a determinant of the microbial activity. In general, composting is characterised by a step of temperature rising, possibly to the thermophilic range (T > 50°C). Composting of putrescible organic wastes is typically a thermophilic process in which the most favourable range of temperatures for microbial decomposition should be maintained between 55 and 60°C, and should not exceed 65°C in any case. Temperatures in excess of 55°C for several days (at least three) are usually instrumental in inactivation of pathogenic organisms, especially when septic materials such as sewage sludge are processed. Above 60°C the metabolic activity of microorganisms begins to decline. To maintain temperature within the optimal range during the thermophilic phase, substrate biomass aeration should be provided. Moving air through the matrix has the potential to dissipate heat excess. Heat removal occurs primarily via sensitive heating of aeration air, while evaporation can also remove heat because of the high heat required for water vaporisation.
Moisture is of crucial importance in maintaining microbial activity within a composting matrix. Optimum metabolic rates can be achieved by reaching the maximum water content that still does not restrict O_2 transfer and utilisation. In fact, excessive wet composting masses become anaerobic with consequent generation of unpleasant and pervasive odours. On the other hand, decomposition slows dramatically in mixtures under 40% moisture. Water content of the substrates should be 55-65% at the start of the process, with the higher values recommended for composting with turning or whatever movement of the substrate biomass. If the aerobic biotransformation of initial organic waste is correctly managed, moisture progressively decreases as composting proceeds towards complete biomass stabilisation.
Oxygen supply allows oxidative reactions to predominate in composting matrices. Inadequate O_2 levels lead to the establishment of an anaerobic microflora which can produce odorous compounds and phytotoxic metabolites. Substrate density and ready availability determine high O_2 utilisation rates in putrescible wastes. Diffusion rates greatly depend on the matrix physical characteristics such as porosity, particle size, and moisture content. To maintain microbial metabolism predominantly aerobic, interstitial O_2 concentrations near 10% should be guaranteed.

Microbes driving compost stabilisation operate best in the range of pHs between 6.5 and 8.0. Nevertheless, the natural self correcting or buffering capacity of the process makes it possible to proceed over the much wider range of 5.5 to 9.0. Although adjustment of pH in the starting biomass is rarely required, this factor should be conditioned in matrices with high nitrogen contents. Actually, pHs higher than 8.5, joined to temperatures in the thermophilic range, favour ammonification that may contribute to the unpleasant odorous emissions from composting matrices.
Of many elements required for microbial growth, carbon (C) and nitrogen (N) of a given matrix represent the most selective nutrients which affect substrate decomposition throughout composting. Nevertheless, these two elements have to be not only simply available, but necessarily in a balanced ratio. Generally, a C/N ratio of 25:1 to 30:1 is considered ideal for faster compost stabilisation. At lower ratios, nitrogen will be supplied in excess and will be lost as ammonia, causing undesirable odours. If the carbon of a specific compostable material (e.g. lignin rich residues) is scarcely available (i.e. resistant to biological degradation), a higher C/N ratio in the initial substrate biomass can still be acceptable. However, matrices with C/N ratios higher than 40:1 decompose at relatively slow rates, so longer composting times are needed.
Physical characteristics of an organic matrix being composted exert a conspicuous influence on the course of the stabilisation process. As the microbial reactions must occur in aerobic conditions, substrate biomass should always maintain adequate porosity in order to favour the movement of air and hence sufficient oxygen supply within the interstitial atmosphere. Porosity is a function of either structure (mechanical strength to collapsing) and size of the matrix particles. Thus, preliminary size reduction of compostable materials should be a good compromise between the goal of increasing the surface area-to-volume ratio of the particles, that enhances microbial decomposition rates, and the need of preventing matrix compaction due to the excessive shredding of the initial substrate. Organic wastes which are poorly structured and too wet (e.g. food residues, manure, sewage sludge) require to be mixed with proper bulking agents (e.g. wood chips, wood shavings, coarse sawdust) in order to improve porosity and mitigate moisture content.
Finally, it must be emphasised that composting should be restricted to clean organic residues, if the treatment of putrescible wastes is finalised to the production of humidified fertilisers. Composition and characteristics of the starting matrix will greatly condition the quality of finished compost. Actually, the presence of non-degradable materials and possibly toxic contaminants in waste streams sent to a composting facility may be often irreparably prejudicial for the marketability of the end product. For instance, mechanically sorted organic fraction of MSW is still too contaminated with plastics, glass, other inerts, and chemical pollutants (e.g. heavy metals and household hazardous wastes), so it can not lead to the production of an acceptable compost, although the stabilisation process is correctly carried out. Therefore, it appears evident that production of usable compost from MSW or other composite wastes can be solely attained through activation of programmes for the collection of source-separated organic fractions.

Process control by different composting strategies for the stabilisation of energy-dense and *easily degradable organic wastes* - Exploitation of composting as an environmental biotechnology for the management of organic wastes only relies on those systems which lead to a satisfactory control of the process, that means high decomposition rates within relatively short stabilisation times. All these systems have been developed with the attempt to ensure the basic requirements of adequate oxygen supply and temperature control in the narrow range of 55 to 65°C. In this context, composting technologies available today can be assigned to two main categories (de Bertoldi et al., 1985; Rynk, 1992), depending on the arrangement of the substrate biomass during stabilisation: 1) open systems, in which matrices being composted, although treated within a building, are not retained in any kind of container, and 2) in-vessel systems, in which organic waste to be stabilised is confined in true bioreactors. Open systems

include windrow composting and aerated static pile composting, while in-vessel systems refer to composting performed in vertical reactors (e.g. silos), horizontal reactors (e.g. rotating drums), and aerated dynamic trenches, also known as agitated beds. The type of the system to be possibly adopted in a given circumstance depends on the land area available, the characteristics and the amount of waste being treated, and the estimated time required for the stabilisation of the initial material. Although they are generally recognised as expensive technologies, in-vessel systems however are often considered more reliable for greater process control than open systems. As it will be shown later, this is not completely true.
Windrow composting consists in the formation of the substrate biomass in narrow elongated piles which are periodically turned. Depending on the organic waste characteristics and the turning equipment available (e.g. bucket loader, elevating-face conveyor, straddling windrow turner), windrow cross-section can vary from 1.5 to 3.0 meters in height and from 3.0 to 6.0 meters in width, with the lower values recommended for dense materials like sewage sludge mixtures. Turning frequency is chiefly determined by windrow dimensions, matrix porosity, and moisture content. Windrows must be arranged on an impermeable concrete surface in order to avoid leachate dispersion into the ground and to improve equipment handling in rainy weather. Advantages of this composting system are the possibility to manage large volumes of waste, a good stabilisation of the end-product, and relatively low capital investment. Disadvantages are great land requirement, high labour costs, odour release with the turning operations, and possible failure of adequate pathogen inactivation.
Aerated static pile composting occurs in stacks shaped like windrows which are not however mechanically turned until the matrix stabilisation has been reached. The lack of periodical mixing limits the application of this composting method to materials that can maintain a stable structure throughout the process. To improve porosity, appropriate cellulosic bulking agents such as wood chips are usually incorporated in the initial mixtures. Process control is normally performed through deliberate air delivery into the matrix by means of perforated pipes placed in a layer of coarse material at the base of the piles, or embedded into the composting concrete pad underneath metal grilles. The pipes are connected to blowers which operate by timer-schedule to ensure either vacuum-induced aeration (Beltsville strategy) (Epstein et al., 1976; Willson et al., 1980) or forced-pressure ventilation. This latter is often managed via feedback control of the temperature which governs blower actuation "by demand" during the thermophilic phase (Rutgers strategy) (Finstein et al., 1980; Finstein et al., 1983). Static piles should not exceed 2.5 meters in height in order to allow homogeneous diffusion of the air through the matrix. Furthermore, it may be necessary to cover the piles with a 10cm layer of mature compost, triturated straw, or whatever bulking agent available. This layer protects the composting matrix from drying, insulates it from the ambient temperature so determining pathogen destruction even in the outer portions of the pile, discourages flies and other insects, and acts as a sort of filter for ammonia and odours released from the pile. Of the different aerated static pile systems, only the Rutgers strategy seems to allow an optimal control of the process and, consequently, a slight reduction of the stabilisation times. This means less land requirement than in windrow composting. In general, aerated static pile systems ensure a high degree of pathogen destruction and a good odour control.
Vertical and horizontal reactors specifically refer to completely closed containers in which the substrate biomass is normally retained for a few days or weeks (usually two) until only partial stabilisation is reached. Closed reactors are intended to let the initial substrates overcome the early stages of composting when odour release and process control are most critical. Once out of the reactor, the composting matrix is then formed in windrows or piles to get complete maturation. These systems are usually associated with high capital and maintenance costs. Even the control of the process may result in difficulties sometimes when heterogeneous materials such as the organic fraction of MSW are fed into the closed reactors.

In silos substrate biomass is loaded daily at the top of the reactor while an identical volume of partially-stabilised material is removed from the bottom. Aeration is typically provided by forced-pressure ventilation, with the airflow opposite to the substrate biomass flow. Nevertheless, because of the height of these reactors (usually 4.0 meters), air distribution often is not homogeneous and, therefore, neither temperature nor oxygen can be maintained at optimal levels throughout the matrix profile. As with static pile composting, a stable porous structure of the substrate biomass is required in vertical reactors that normally lack internal mixing. In a few plant configurations, a second aerated silo may be considered in which the partially-stabilised matrix is definitively cured.
Rotating drums are large cylindrical reactors mounted horizontally on sets of geminate bearings that give the cylinders a slow rotating motion by engaging special crown wheels. Rotation causes continuous mixing of the substrate biomass fed at the loading end of the reactor, and allows the mixture to move through the cylinder towards the discharge end. Aeration is provided by introducing air from the discharge end. So, the air moves in the opposite direction as the substrate biomass and diffuses into the organic matrix as it tumbles. Typical dimensions of rotating drums are 3.0 meters in diameter by 35 meters in length, with a daily capacity of approximately 50 metric tons and a retention time of three days. It is evident that such a short residence time can allow only the beginning of microbial substrate decomposition which must be then accomplished through a second stage of stabilisation, usually in windrows or aerated static piles. Therefore, rotating drums seem to function better as size reduction and homogenising technology than as true bioreactors. Furthermore, the difficulty to maintain aerobic conditions in the cylinders may result in a slight ammonia volatilisation. Also substrate hygienisation, emphasised as an important effect of rotating drums, might eventually prove itself to be a drawback if the risk of pathogen re-contamination is considered. In fact, the organic matrix coming from the discharge end of the reactor is almost pasteurised and, hence, even scarcely colonised by useful microbes. Thus, once re-arranged in windrows, it could be invaded again by harmful microorganisms which should not face any competition.
Today, the most promising technology among in-vessel composting systems is represented by the so-called aerated dynamic trenches (agitated beds). They combine movement of the substrate biomass during composting with controlled aeration. These reactors typically consist in long, rectangular, above-ground trenches with lateral walls and open ends. The material being composted is fed at the loading end of the bed. Turning is usually effected by an overhead bridge crane running on rails along the top of the trench walls. This machine is fitted with a cylindrical cutter the same width as the trench. The position of the cutter can be regulated in height although, when operating, it is set to scrape the substrate biomass up from the bottom of the trench. This material then passes onto an inclined elevating conveyor which discharges it once more in the trench, behind the bridge crane as this latter moves forward on the rails. Each passage of the crane moves the organic matrix towards the discharge end of the reactor. Turning is important to break up clumps of particles, maintain porosity, and even aerate the mass. Nevertheless, oxygen supply for microbial reactions and heat dissipation are mostly guaranteed by blowing air in the composting matrix through a set of pipes recessed in the floor, along the trench, and covered with grilles and/or gravel. Moreover, since the substrate biomass shows a gradient of stabilisation moving from the front end to the discharge end of the reactor, the trench is often sectioned into different aeration zones along its length. Each zone is served by a blower, individually governed through feedback control of the temperature or by timer-schedule. So appropriate amounts of air can be delivered to the composting matrix, according to the different stages of the process. Residence times of five to six weeks have been proven to cause complete stabilisation of different mixtures of organic waste (Vallini et al., 1990). Aerated dynamic trenches have also shown to perform efficient control of odorous emissions and pathogen destruction.

Composting application in a treatment-oriented perspective

Composting potential for the decomposition of hazardous materials - The effectiveness of composting as a means of detoxification of industrial waste has been reported for different kind of matrices such as tannery sludge (Vallini et al., 1989), spent mycelia from antibiotic production, pesticide laden wastewaters (Kuo and Regan, 1992), petroleum extraction and heavy oil refinery sludges (Findlay et al., 1991; Baheri et al., 1996) as well as coal tar (Taddeo et al., 1989). Increasingly stringent environmental regulations have made traditional disposal methods such as landfilling no longer acceptable for this waste. In particular, as far as oil refinery sludges are concerned, even incineration and pyrolysis often result as prohibitively expensive.
Hazardous wastes are usually mixed with lignocellulosic bulking agents before being processed. The role of bulking materials is either to absorb liquids or to dilute concentrated, dense, toxic matrices. In both cases a suitable physical environment for microbial activity is created. Moreover, solid-phase substrates, with a large surface area are receptive to hydrophobic as well as hydrophilic compounds. Mixtures can be then placed in aerated static piles, formed in windrows, or fed to reactor vessels. If wooden co-substrates are used, addition of nutrients such as nitrogen and phosphorus (P) may be required. On the other hand, no nutrient supply is necessary with rich bulking materials like spent mushroom substrate (SMS) which has been utilised as both an absorption matrix and a source of active microorganisms to degrade pesticide residuals (e.g. carbamate insecticides such as carbaryl, carbofuran, and aldicarb) (Regan, 1994). Typical composting temperatures are in the range of thermophily (> 55°C).
Windrows or piles should always be underlain by a hard surface, and arrangements should be made for collecting and disposing of runoff and leachate from the materials. The possible release of toxic volatile organic compounds (VOCs) during the treatment should be even considered, especially if turned windrow composting is adopted. Thus, confinement of the mixtures being composted should be ensured in closed buildings or shelters which can allow vapour removal by suction. Enclosure is particularly mandatory when aromatic compounds are involved. Emissions are then treated in special scrubbers or biofilters.

Composting as an ex situ soil bioremediation technology - In the last decade, composting has been evaluated as an ex situ, solid phase biological technology to degrade organic compounds in contaminated soils and sediments. This treatment has given very good results with hazardous chemicals such as either aliphatic or polynuclear aromatic hydrocarbons (PAHs), volatile solvents, as well as explosives.
Excavated polluted matrices are mixed with different kinds of bulking agents and organic amendments, and placed in closed, temporary structures such as plastic tunnels, prepared on lined pads. An obvious reason for the enclosure of soil mixtures during the treatment is to prevent harmful gaseous emissions into the atmosphere and to control leachate release. Addition of organic substrates serves both to enhance porosity of the soil mixtures and to supply nutrients (C, N, P, and possibly microelements) for a variety of microorganisms, which can degrade the hazardous pollutants under co-metabolic conditions. Proper amendment selection is also needed to promote thermophilic microbial activity in the soil mixtures. In fact, high temperature is the most relevant feature of the composting environment, and the elevated temperatures reached during the thermophilic phase can increase the enzyme kinetics involved in biodegradation reactions. Furthermore, at composting temperatures in the range of thermophily, both solubility and mass transfer rates of the polluting compounds usually increase, thereby making them more available to the microbial metabolism. Nevertheless, evidence exists that above 60° C the number of different microbial species in the composting matrices is drastically reduced (Finstein et al., 1986). This means that mesophilic composting, in which

the temperature ceiling of 37° C is established, usually presents a much richer community of microorganisms. Thus, the possible degradation of a wider number of organic pollutants should be taken into account when composting is carried out in the mesophilic range. Anyway, even during thermophilic composting, the dynamics of physico-chemical conditions within the composting mass determines the exposure of the polluting compounds to a variety of microorganisms. After the treatment, cleaned soils are moved again to pristine locations.
Two basic composting systems have been so far implemented for bioremediation of contaminated soil: turned windrows and aerated static piles, also known as biopiles. Nevertheless windrow composting is nowadays considered to be the most cost-effective biotreatment alternative to the incineration.
Aerated static pile composting has been shown to be successful in the abatement of aliphatic hydrocarbons in mixtures of polluted soil, sheep manure and wood chips in the ratio of 1:1:1 (Kamnikar, 1992). The process duration was estimated in eleven weeks.
Soil composting in the presence of wood preservatives, including pentachlorophenol (PCP) and creosote, has been carried out at the University of Helsinki. Passively aerated windrows were adopted for processing soil mixed with 35% of softwood bark and 3% of vegetable ash (Valo and Salkinoja-Salonen, 1986). The concentrations of chlorophenols were reduced from 212 mg kg^{-1} to 30 mg kg^{-1} within four summer months. These levels were further reduced to only 15 mg kg^{-1} after an additional year of composting. The temperatures of the processed matrix fluctuated in the range of mesophily (5-32° C).
Application of composting to the treatment of soils contaminated with PAHs has been widely described (Crawford et al., 1993). Both biopiles and windrows have been used. For instance, aerated static piles have been recently arranged at the Dubose Oil Product Co. Superfund site in Cantonment, Florida (EPA, 1995). Composting was used in this site to treat soil contaminated with a variety of PAHs such as acenaphthylene, acenaphthene, anthracene, benzo(a)anthracene, benzo(b,k)fluoranthenes, benzo(a)pyrene, benzo(g)perylene, chrysene, dibenzo(a,h)anthracenes, fluorene, fluoranthene, indeno(1,2,3) pyrene, naphthalene, phenanthrene, pyrene, and 2-methylnaphthalene. PCP and VOCs, including benzene, xylene, trichloroethylene (TCE), and 1,2-dichloroethylene (DCE), were also present. The composting system used at Dubose consisted of soil piles arranged for forced aeration, in which native microbial population was improved through bioaugmentation with an inoculum prepared in a special tank by seeding a nutrient solution with soil aliquots. A modular pre-engineered building with reinforced PVC fabric was installed for the soil confinement. A leachate collection system was also operating. Off-gases collected by the aeration equipment were treated using granular activated carbon adsorbers prior to the discharge to atmosphere. Soil clean-up goals established for Dubose site were met. For total PAHs, before-treatment concentrations ranged from 50.8 to 576.2 mg kg^{-1}, while after-treatment concentrations ranged from 3.3 to 49.9 mg kg^{-1} (average: 19 mg kg^{-1}). For PCP, before-treatment concentrations ranged from 7.67 to 160 mg kg^{-1}, while after-treatment concentrations ranged from 16.5 to 36.3 mg kg^{-1}. The primary removal mechanism identified for PAHs in this application was biodegradation; however, volatilisation was identified as the main mechanism for removal of VOCs.
Finally, composting has been also proven to success in bioremediation of soils and sediments contaminated with organo-nitro explosives and propellants. At the Umatilla U.S. Army Depot Activity site in Hermiston, Oregon (Weston, 1993), soil contaminated from the discharge of explosives' wastewater into unlined lagoons from 1950 to 1965, was treated in both aerated static pile and turned windrow configurations. Contaminants were represented mainly by 2,4,6-trinitrotoluene (TNT), hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), and octahydro-1,3,5,7-tetranitro-1,3,5,7-tetraazocine (HMX). After excavation, the soil was screened to remove large rocks and debris. It was then transported to a composting pad with temporary structure to provide containment. Sawdust, alfalfa, manure, and other agricultural wastes

were used as amendments. The composting process occurred in the temperature range of 15 to 60° C. With the windrow method, turning was 3 to 7 times per week. In static piles, aeration blowers were set to cool the composting matrix whenever 60° C had been exceeded. After forty days of treatment, composting reduced initial average contaminants as follows: TNT from 1,574 mg kg^{-1} to 4 mg kg^{-1} (aerated static piles and turned windrows); RDX from 944 mg kg-1 to 7 mg kg^{-1} (static piles) and 2 mg kg^{-1} (windrows); HMX from 159 mg kg^{-1} to 47 mg kg^{-1} (static piles) and 5 mg kg^{-1} (windrows). Therefore windrow composting showed the potential to be the most effective method.
Another study performed at the U.S. Naval Submarine Base site in Bangor, Washington, confirms the process performances with the abatement of TNT from 822 mg kg^{-1} to 8 mg kg^{-1} after 60 days of composting in windrows (Craig, 1994).

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The Role of Anaerobic Digestion for the Production of Energy and soil Improvers

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Introduction

When speaking about anaerobic digestion in this Conference it must be remembered that two other international symposia on the specific topic of anaerobic digestion of solid waste as a way for the management of biodegradable wastes with a view to the environment and to energy recovery have previously been organised. These were held in 1992 in Venice and in 1999 in Barcelona.

I was honoured to participate in the scientific committee at both of these symposia and in writing the symposium final remarks (Cecchi et al.,1992; Verstraete et al., 1999) It seems logical to remember the opinions given by these two pools of world experts following the analysis of the best scientific and R&D news that was presented by various authors during the two events.

In 1992, the first ISAD-SW took place in Venice (Cecchi et al., 1992) and during that event, the following statements were justified:

- AD of solid waste is a developed technology;
- with this technology, the OFMSW can be converted to compost of excellent quality at costs not higher than conventional composting and with considerably higher speed and less net odours;
- the thermophilic range of temperature (55°C) is to be preferred since it appears more profitable;
- the idea that the thermophilic process is difficult to manage was proven incorrect;
- a trend towards the separate collection of wet easily biodegradable organic fractions of MSW was underlined and, as consequence, the feasibility of AD in contrast with direct application of composting;
- not all the organic wastes can be anaerobically digested and, in some cases, composting seems more suitable (i.e. for lignin containing wastes; for pre- and polishing treatments);
- two phase AD emerges as an applicable approach to be studied;
- the concept of co-digestion of different substrates is also notable;
- more attention should be paid to AD applications;
- AD qualifies as a most valuable environmental biotechnology;
- AD is perfectly compatible with other solid and liquid wastes treatment processes.

After the second ISAD-SW held in Barcelona these conclusions have been taken into consideration both at research and application level. However, two results do not appear to be in accord with the previous ISAD-SW'92 results:

- the use of mesophilic or thermophilic range of temperature (several Authors report a quite similar yields using both these conditions);
- the level of ammonia toxicity for the process (it has been demonstrated that up to 12.000 mg/l of NH_4-N can be maintained with a stable process).

Of the other results presented in Barcelona to define the future work in this topic, the most important were:

- the importance of the pre-treatments on the yields improvements and reactor stability;
- the environmental concerns about CO_2 emissions in a global balance involving the use of the AD process in waste management.
- the integration of this unique unit process in overall sustainable waste treatment.

Anaerobic digestion, when considered in the context of Life Cycle Analysis (LCA) offers a number of interesting features:

- the recovery of energy (100-150 m^3_{biogas}/$ton_{bio\text{-}wastes}$) is an important factor, particularly in third world countries;
- aerobic treatment of solids is inevitably giving rise to extensive emission of undesired volatiles such as ketones, aldehydes, ammonia and even methane (several kg per ton waste treated). In anaerobic treatment, all gases are contained and via the use of the biogas burned to produce energy;
- one aspect that particularly deserves to be further explored is the capacity of anaerobic digestion to decompose chlorinated organics and thus achieve a putative decontamination of organochlorines. Indeed, the problems concerning the fate of micro-pollutants (nonylphenol, heavy metals, PCBs, dioxins) and the overall end-product quality have become a major factor for all types of wastes treatments and anaerobic digestion offers specific potentials in this respect.

In the future, the following aspects hereby appear of crucial importance:

- increased/optimised source separation;
- development of more reliable cycles (for instance within a single community or producer-consumer configuration) to increase responsibility and confidence. It was emphasised that improved communication between various waste management people and users of compost is essential to guarantee the future of organic matter recycling.

Moreover, there is a need for an extra societal impetus in order to make anaerobic digestion of solid wastes a mainstream technology. As schematised in Figure 1, it could be integrated optimally in a sustainable treatment scheme providing both technological diversity and flexibility and it can generate optimal eco-efficiency.

Indeed, since the Kyoto agreements of 1998, the industrialised world is obliged to explore possibilities to reduce CO_2 emissions by at least 5%. It can be agreed that:

- anaerobic digestion allows the recovery of the rapidly biodegradable biomass present in the wastes in the form of biogas;
- the digested residue can be considered as a quite stable organic matter which upon proper storage conditions (e.g. water logged or acidic soils) will have a very slow turnover of several decades at least;
- proper technology and land planning can upgrade the end product of the biowaste digestion to a form of sequestered carbon. It is conceivable that in this way the natural imbalance in CO_2 can be adjusted by re-storing or creating organic rich soils, peat bogs and moors.

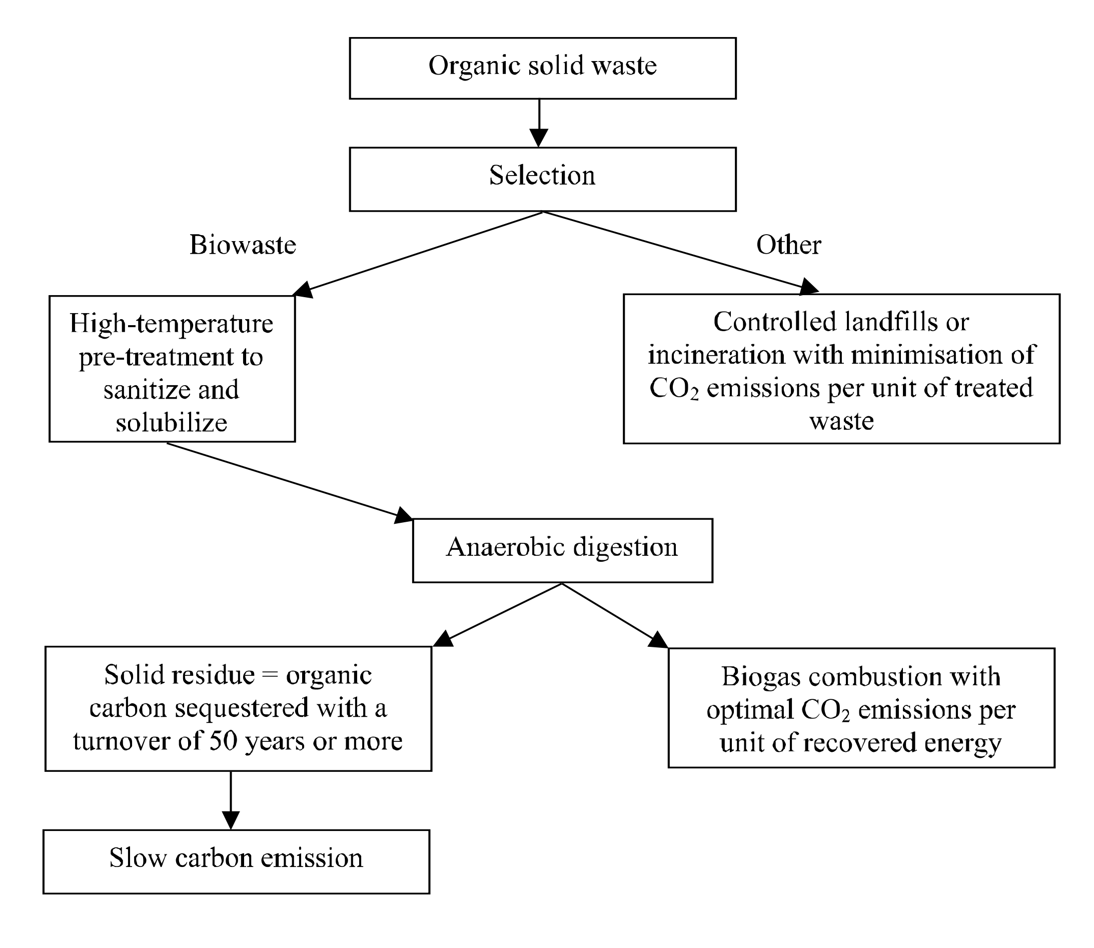

Figure 1: Possible role for OFMSW anaerobic digestion in the potential greenhouse effect

Accordingly, this presentation will focus on:

- the application of the AD process during the last ten years (data provided by De Baere (1999) in the Symposium of Barcelona);
- the two generally accepted process schemes for the industrial application of aerobic or anaerobic solid waste treatments and the related role in soil quality improvement and energy recovery;
- an environmental comparison between the two processes, taking into account the papers presented by Hans Kubler and Michael Rumphorst (1999) and by Edelmann (1999) in Barcelona;

State of the art of full scale anaerobic digestion plants in the last ten years

The data reported here are some of the most significant figures detailed by De Baere during the Barcelona ISAD-SW Symposium.
The study presented was limited to plants in operation or under construction treating at least 10% organic solid waste from market waste or municipal solid waste in the last ten years 53 plants across Europe, were analyzed according to the following parameters:

Evolution of capacity (Fig.2)

Capacity evolution rate was of around 30 Ktons per year during the period between '90 to '95, while the rate of increase averaged 150 Ktons per year for the period '96 to 2000. An increase of 200 Ktons per year is expected in 2001. The number of plants for those same periods rose from 2.4 to 7.2 plants per year The average capacity, initially at 24,420 tons per year gradually decreased until 1998, then increased towards averages of 50,000s ton per year due to plans for large grey or mixed waste digestion projects.

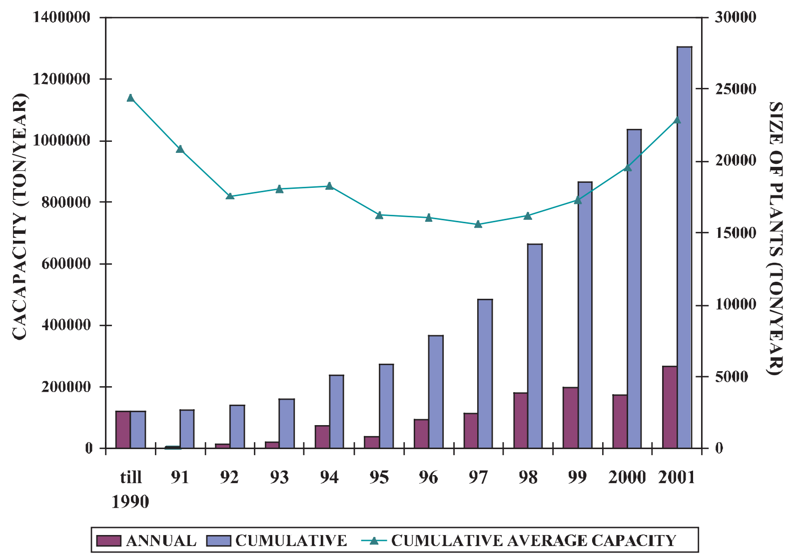

Figure 2: Installed capacity and size of plants.

Mesophilic versus thermophilic operation (Figs.3-4)

Plants were initially operated only at the mesophilic range of temperature (see Fig.3).

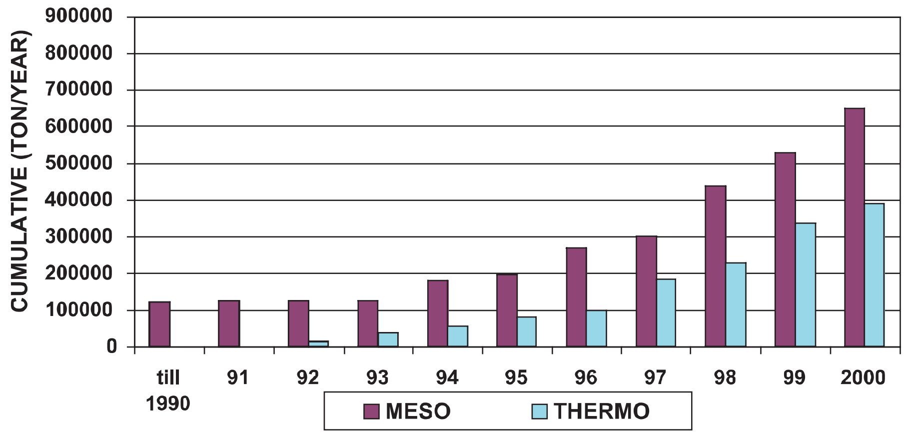

Figure 3: Mesophilic versus thermophilic: cumulative capacity

The first thermophilic plants came on line in 1992 and 1993. The capacity of mesophilic operation increased by 350,000 tons between '94 and '99, while thermophilic capacity increased by 280,000 tons. I.e. there were respective increases per year of 70,000 tons and 56,000 tons. Thermophilic operation was developed later but has now been established as a reliable and accepted mode of fermentation. More mesophilic plants were added in some years while more thermophilic capacity was constructed in others (see Fig.4). No clear trend can be observed.

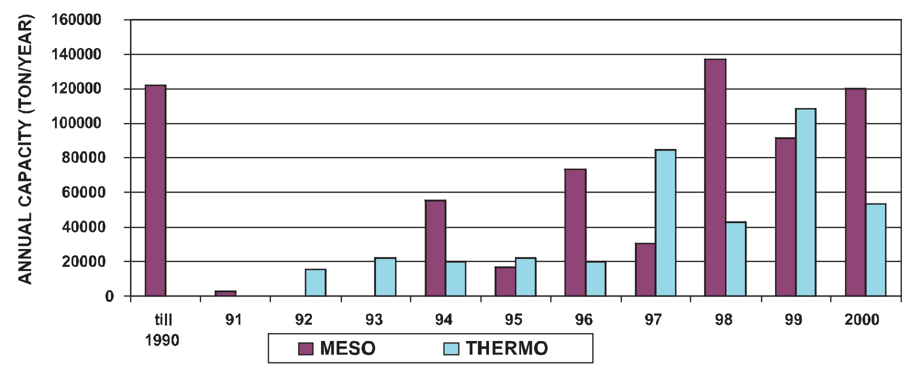

Figure 4: Mesophilic versus thermophilic: annual capacity.

Wet versus dry fermentation (Fig.5)

Between 1990 and 1993, more wet plants were constructed; afterwards, dry digestion prevailed (more than 15%TS). No clear technology trend is observed at the moment.

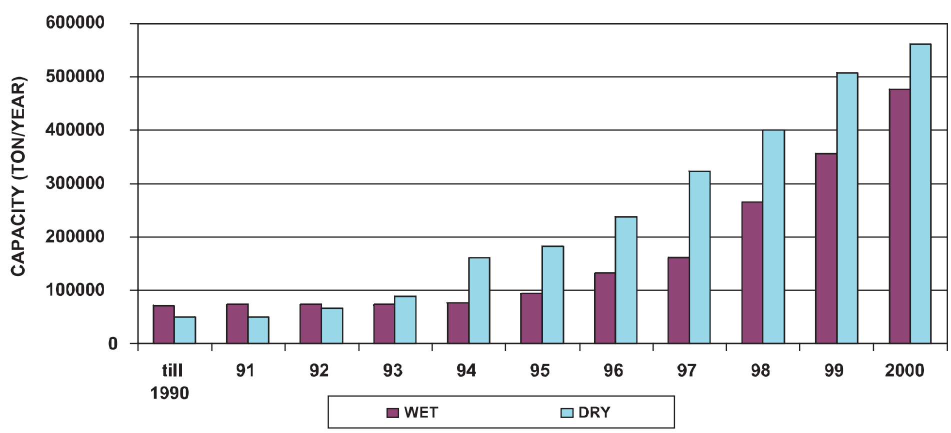

Figure 5: Wet versus dry.

Two-phase versus one-phase digestion (Fig. 6)

Research has been carried out regarding two-phase and one-phase digestion. In practice two-phase digestion has not been able to substantiate its claimed advantages. Only 10.6% of the available capacity is provided by two-phase digestion systems.

Figure 6: One phase versus two phase.

Co-digestion (Fig. 7)

Co-digestion is not used as much as was expected. It is quite common that an organic solid co-substrate is added to manure digesters in small amounts but only in exceptional cases is solid waste from households or market waste added. This is probably due to specific handling and pre-treatment requirements, such as the removal of inerts or size reduction.

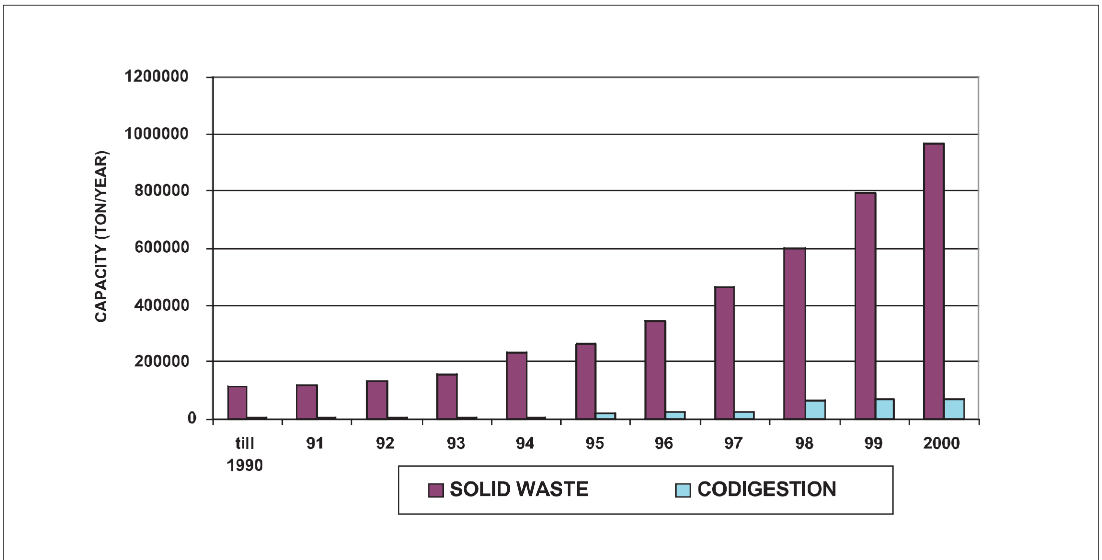

Figure 7: Co-digestion versus solid waste digestion.

Mixed waste versus biowaste (Fig. 8)

The introduction of source separated collection caused a boom in the construction of composting plants for biowaste. Digestion of mixed household waste remained stable while it is expected that treatment of separately collected biowaste will increase.

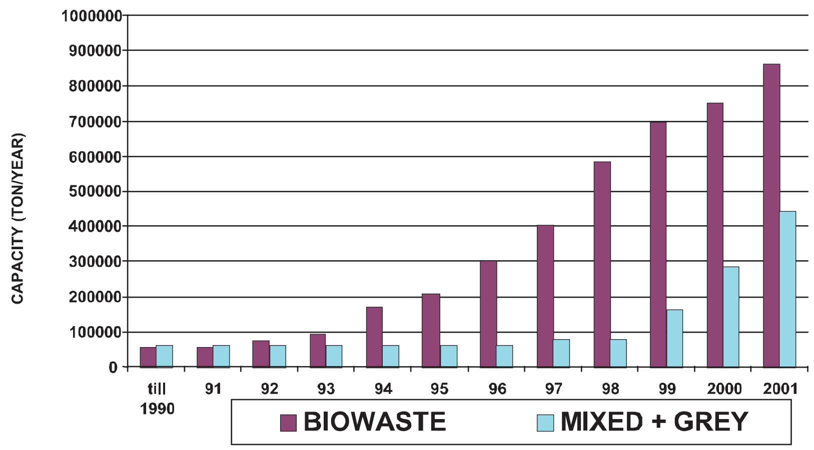

Figure 8: Mixed versus biowaste.

Anaerobic versus aerobic (Fig. 9; Tab. 1)

Composting capacity increased by about 7.5 millions tons whereas anaerobic digestion capacity increased by about 0.44 millions tons. That is only 6% of the total capacity increase (see Fig. 9).

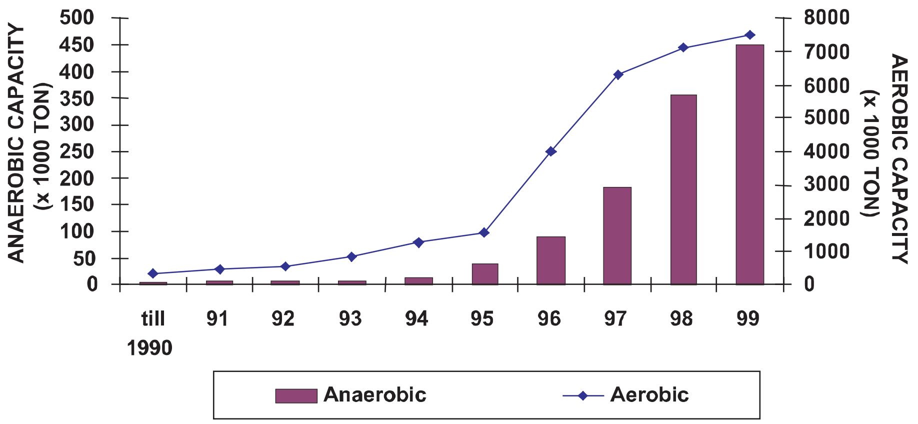

Figure 9: Development of aerobic and anaerobic composting capacity in Germany.

This was probably due to the following considerations:

- anaerobic digestion was not considered as a fully proven technology until around 1995
- the anaerobic technology was more expensive;
- municipalities opted for less risk and less investment.

Anaerobic capacity currently represents:

- less than 5% of the total composting capacity in Europe.

However, in some countries the market share has reached more than 10% (see Tab. 1):

- The Netherlands: 11.9%
- Belgium: 15.6%
- Switzerland: 26.6%

Table 1: Capacity in some European countries

Country	Capacity (ton/y)	Composting capacity
Germany	449605	6 %
Belgium	67000	15.6 %
The Netherlands	197000	11.9 %
Switzerland	78500	26.6 %

Scheme of anaerobic and aerobic industrial plants and their role in soil quality and energy recovery

The evaluation of these two options shouldn't be confined to the stages in the biological process biological, the overall quality of the final product should be taken into account, as well as its interactions with the environment and the attempt for quality enhancement. While there is a need to evaluate some stages, others are well understood such as pre-treatments, compost production and gaseous and liquid wastes conditioning. Furthermore the quality of produced compost, waste gases and wastewaters must be compared for the two options.

According to the mean actual composition of the source separated organic fraction of municipal solid waste and to a literature review, Genon (1999) has drawn the mass balance for the aerobic and anaerobic processes (see Figs 10 and 11). The most important data of the two processes are summarised in Tab 2.

Table 2: Main characteristics of anaerobic and aerobic processes

	Anaerobic process	Aerobic process
Biogas production, m^3/t^*	100 ÷ 200	–
Residual solids TS basis, %	50 ÷ 60	50
Compost production, kg/t*	200 ÷ 300	300 ÷ 400
Energy production, kWh/t*	100 ÷ 250	-70 ÷ -90
Wastewater, m^3/t^*	1 ÷ 0.2	-
Air for fermentation, m^3/t^*	–	3600 ÷ 10000
Air for stabilization, m^3/t^*	800 ÷ 1700**	800 ÷ 1700

The ranges depend on the OFMSW quality; (*): tons of inlet material; (**) has been considered the same figure for composting.

The excess water from the digestion process can be purified with mechanical-biological treatments including nitrification and denitrification to limit the impact of digestion wastewater into the values typical for composting.
In the field of profitable cultivations, substrates blended with anaerobic compost (after aerobic post-composting) show results comparable to typical compost-based substrates.
The contaminants present in the anaerobic compost are the same as in conventional composts.
To moderate odours and pathogens emissions, both processes are usually carried out in closed buildings and waste air is treated with biofilters.
Current knowledge indicates there are no specific differences when sanitary and toxicity aspects are considered; thus it is possible to perform a first ecological evaluation of carbon dioxide emissions.

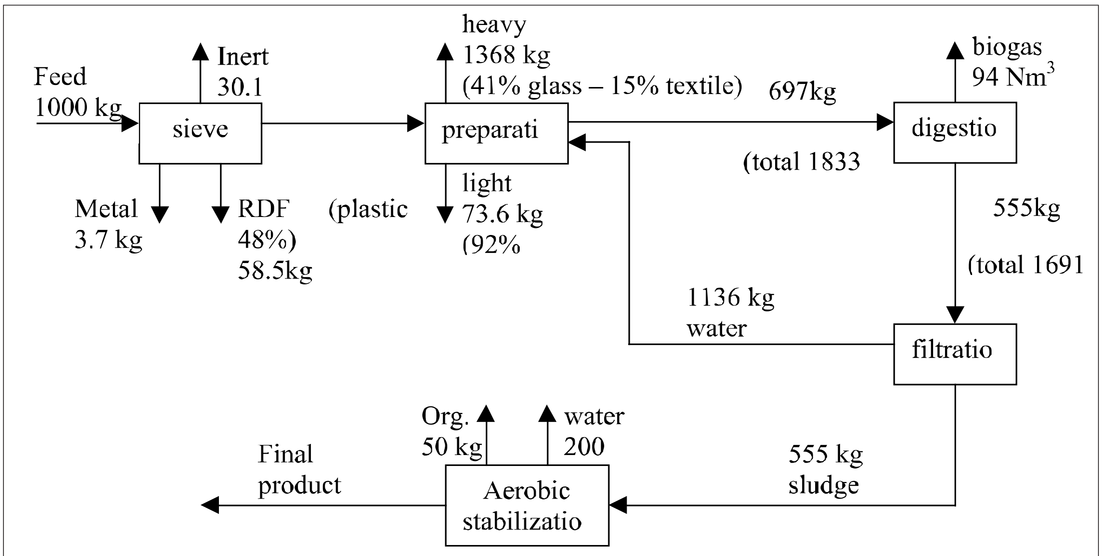

Figure 10: Anaerobic digestion scheme and mass balance

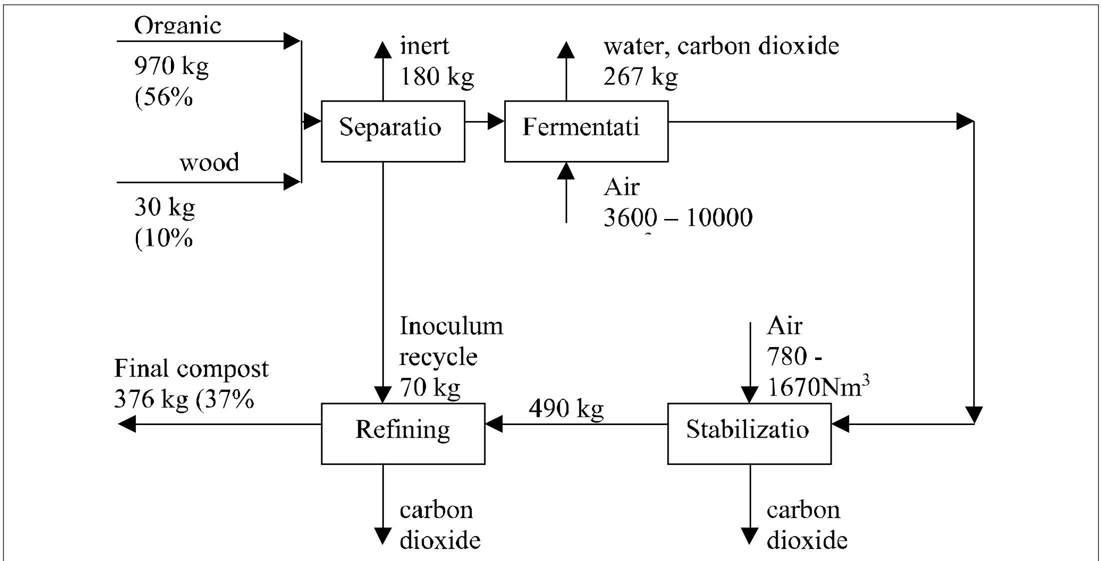

Figure 11: Aerobic composting scheme and mass balance

Evaluation of energetic and CO_2 balance for aerobic and anaerobic processes

This kind of evaluation was presented by Kübler and Rumphorst during the Barcelona Symposium using the process schemes shown in Fig.12 (the same schemes previously used for the mass balances) and considering, as a first approximation, energy production and CO_2 emission as the real elements for the final comparison.

Composting and combination approaches (Fig.12). The authors chose a plant capacity of 15,000 tonnes of the organic fraction of municipal solid waste (OFMSW) per year. In the case of composting the authors supposed that for compost maturation an intensive composting system would have been required after waste pre-treatment for contaminants removal. Further processing guarantees the quality of the mature compost. Waste air from the various stages of the process is purified and the condensate produced by intensive composting is discharged as excess water (Fig.12).

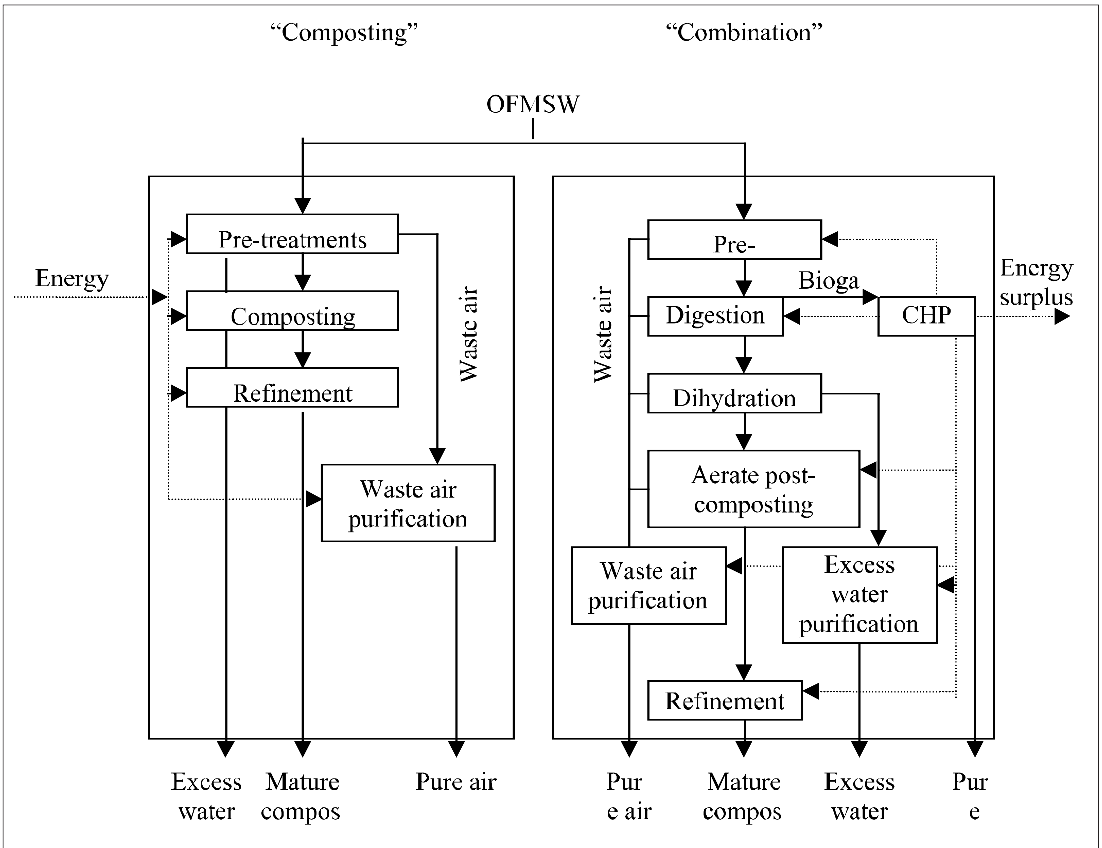

Figure 12: Flow chart and balance for the evaluated processes

In the combined process the digester residue is dried and fed to an aerated composter to produce mature compost. Further processing guarantees the quality of the mature compost. Excess water is purified and discharged. Waste air is also purified. Biogas is energetically used by a combined heat-power (CHP) generator. The process stages are supplied with electricity and heat and the surplus is used externally (Fig. 12).
In performing the CO_2 emissions balance a distinction must be set between the biological (aer-

obic/anaerobic) process emissions and the energy production. A further distinction must be made about electricity and heat. Table 3 summarises the base balances for energy and CO_2.

Table 3: Base balances for energy and CO_2

	Unit	Composting	Digestion
Waste input	Mg/y	15,000	15,000
Electricity specific requirements	kWh/Mg	50	100
Thermal energy specific requirements	kWh/Mg	0	100
Organic substrate degradation	%	60	Digestion: 55 Post-composting: 30
Specific biogas production	Nm3/Mg	-	115
Methane content in biogas	Vol.%	-	65
Carbon dioxide content in biogas	Vol.%	-	35
Biogas specific energy	kWh/Nm^3	-	6.46
CHP electricity yield	%	-	35
CHP heat yield	%	-	35
CO_2 specific emission per required external power	kg/kWh	-	0.61
CO_2 specific emission per required external heat	kg/kWh	-	0.34

CO_2 emissions with aerobic composting. Electricity requirements for a composting plant are nearly 50 kWh_{el}/Mg. This is usually obtained though the use of fossil fuels. With modern composting processes, heat management within the process is, as much as possible, optimised. Thus the authors assumed that any excess heat due the low temperature level doesn't allow any substitution of primary energy.

Total carbon dioxide emissions from a composting plant can be computed as follows: the sum of CO_2 load released by biodegradation of organic substances during composting and the CO_2 developed during electricity production. During composting 243 kg of CO_2 per Mg of OFMSW is produced. This value is calculated assuming that a ton of OFMSW contains almost 245 kg of dry organic matter, about 45% of which is carbon, of which 60% ends up being degraded and oxidised to CO_2. This means that the examined plant produces an annual emission of 3,639 Mg CO_2. Furthermore, there is carbon dioxide emission due to the power production. With a specific power requirement of 50 kWhel/Mg OFMSW, natural carbon dioxide emission due to biodegradation increases by 458 Mg CO_2 per year.

CO_2 emissions for the combined system. To study CO_2 emissions for a combined plant it is first necessary to examine the energy balance. With the combination of biological processes and extensive purification systems for excess water, a power requirement of 100 kWh_{el}/Mg OFMSW can be expected. The energy requirement for reactor heat loss and for the thermal treatment of the product will vary depending on the process management. Practical experience shows that a value of 100 kWhth/Mg OFMSW is usually not exceeded.

The results from a plant for OFMSW digestion show an annual average degradation of 55% of the organic matter. Methane content in biogas is influenced by the composition of the treated waste. It can roughly be assumed that, a mean composition of the biogas is 65 Vol.% CH_4 and 35 Vol.% CO_2. Thus wastes with 245 kg of dry organic matter/ton can lead to a biogas production of 115 Nm^3/Mg. 15,000 Mg of wastes therefore has a potential primary energy of 11.15 GWh.

Using biogas for energy production in a combined heat-power station (CHP) it is feasible to obtain 3,901 MWh/y of electricity and 6,130 MWh/y of heat. After subtracting the electricity and heat requirements for the combination plant, a surplus of 2,401 MWh/y of electricity and 4,630 MWh/y of heat remains which can be substituted for primary energy.

The authors found the following CO_2 emissions from biological treatment and from biogas energetic reuse:

- Post-composting produces nearly 36 $kgCO_2$/Mg OFMSW. 30% of the organic matter was assumed to be degraded in the post-composting step. Almost 45% is carbon emitted as carbon dioxide. On this basis an annual production of 819 Mg CO_2 was calculated.
- The biogas contains carbon dioxide. The specific load is 79 $kgCO_2$/Mg OFMSW, producing an annual emission of 1,186 Mg/year.
- During biogas burning methane is converted to carbon divide, thus the plant CO_2 emissions increase by nearly 2,202 Mg/year.

In the examined cases the substitution of the primary energy with the electricity surplus reduces the carbon dioxide emission by almost 1,465 Mg/y. If the excess heat could be used, for instance, in a surrounding industrial area, further energy would be substituted. On the basis of a specific emission for carbon dioxide of 0.336 kg/kWhth, total emissions can be further reduced by 1,556 Mg/y. Then, referring to a combined plant with anaerobic digestion and aerobic post-composting, the carbon dioxide emission is composed as follows: 2,000 $MgCO_2$/y directly from the biological treatment and 2,200 $MgCO_2$/y indirectly by the use of the developed biogas. In the total balance carbon dioxide emissions can be avoided if primary energy sources are substituted.

Comparison between the CO_2 balances. The energy balances are shown in Tab.4. Based on these data an emission of 4,097 $MgCO_2$/y was found by the authors for pure composting of 15,000 Mg OFMSW/y (Tab.5). The 13% of the total emissions are emissions caused by the use of external energy sources (e.g. fossil fuels) to help the degradation of 3,639 Mg/y of organic matter.

Table 4: Energy balance as kWh/y (Kübler, 1999)

	Composting	Digestion
Plant energy requirement	-750000	-1500000
Plant heat requirement	0	-1500000
CHP energy production	0	+3900829
CHP heat production	0	+6129874
Deficit (-)/surplus (+) of electricity	-750000	+2400829
Deficit (-)/surplus (+) of heat	0	+4629874

Table 5: CO_2 balance as $MgCO_2$/y (Kübler, 1999)

	Composting	Digestion
CO_2 emissions from composting areas	3639	819
CO_2 load in biogas		1186
CO_2 emissions from biological treatments	3639	2005
CO_2 emissions from biogas use		2202
CO_2 emissions from the use of external electrical sources	458	0
CO_2 emissions substituted by the electricity surplus	0	-1465
CO_2 emissions substituted by the heat surplus	0	-1556
Sum of CO_2 emissions		
Without heat reuse	4097	2473
With heat reuse	4097	1187

A further environmental balance has also been carried out by Edelmann (1999) by considering the ecobalances (expressed in Ecoindicator points) for a larger variety of technologies, namely:

- EC: fully Enclosed and automated Composting plant with waste air treatment in a biofilter;
- OC: Open Composting in boxes covered by a roof and in open windrows
- DP: fully enclosed thermophilic one step plug flow Digestion (horizontal Kompogas-digester) with aerobic Post-treatment in an enclosed building equipped with compost biofilters
- DE: combination of thermophilic Digestion combined with fully Enclosed, automated composting in boxes (BRV-technology), where 40% of the raw material was digested before the addition to the compost line. The air is cleaned by bio-washers.
- DO: combination of multiple stage, thermophilic batch Digestion (romOpur-technology) combined with Open windrow composting where 60% of the raw material was digested before the addition to the compost line
- IS: Incineration in a modern incineration plant including Scrubbing of the exhaust gas streams.

The author found that the biotechnological treatments for biogenic waste treatment are generally favourable to incineration. He also found that the pure composting technologies he analysed (EC: fully enclosed and automated composting plant with waste air treatment in a biofilter and OC: open composting in boxes covered by a roof and in pen windrows) appeared to be less ecological than digestion: the higher the percentage of digestion, the better the score.
When comparing the different technologies, energy plays a predominant role. Edelmann found that digestion plants are better from an ecological point of view because they do not need external fossil and electrical energy. If only one quarter of the biogenic waste is digested a plant can be self-sufficient in energy. The production of renewable energy has positive consequences on nearly all impact categories because of savings of or compensation for nuclear and fossil energy. This reduces the impacts of parameters such as radioactivity, dust, SO_2, CO, NO_x, greenhouse gases, ozone depletion, acidification or carcinogenic substances. Digestion plants could show even better ecobalances, if they were constructed near an industry which could use the waste heat of electricity production all year round. On the contrary it is nearly impossible to take advantage of waste heat while composting.

Conclusions

The statements made above, and reported by various authors lead, without any doubt, to:

- the confirmation that aerobic composting and anaerobic digestion are two valid biologically-based techniques that, if properly designed and inserted in their surrounding reality, can both give valuable results in terms of both ecological and economical aspects.
- the conclusion that the industrial application of these two technologies has led conclusively to positive results, this is particularly the case if the configuration is well-managed and applied to the proper substrates (which can vary, for instance, in requirements for the water content; i.e. drier substrates for composting and wetter substrates for digestion).
- the conclusion that the proper application of the different matrix leads to a various range of different applications which are equally distributed between the two kinds of technologies. On the contrary, in these last years, the use of anaerobic digestion applications seems to have been less significant than the use of composting technologies. This is incomprehensible since anaerobic digestion techniques have proven to offer substantial benefits, complementary to composting techniques.

According to these conclusions, it must be noted that:

- these technologies must be seen as real industrial applications and so due care should be taken in order to treat them like industrial plants;

the development of these techniques, and their wider use, should be desirable to society in general and in particular to political authorities involved in environmental management. This is because they positively fit the Life Cycle Assessment approach.

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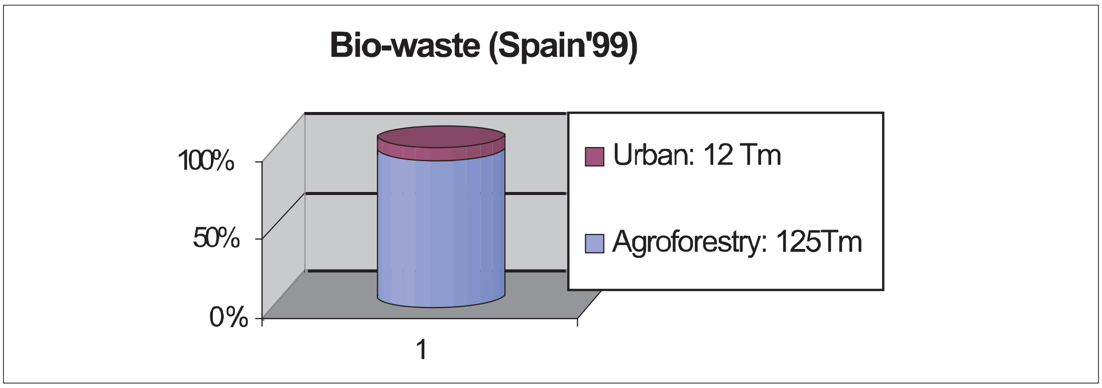
Compost – a burden on local authorities or an opportunity for sustainable agriculture?

(Julio Berbel Vecino, Universitad de Cordoba)

Biowaste (sludge, manure, etc.) is a waste rich in organic matter, once the potentially hazardous elements (metals, some organic compounds, pathogens) are prevented it becomes a valuable input to Mediterranean soils. The over exploitation and advance of desertification and loss of environmental quality due to poor soil conditions is a severe risk in many areas of the EU. Mineral fertilizers can restore nitrogen and phosphorous but are unable to supply organic matter which is essential to the adequate soil biomass environment. On the other hand stricter norms on sludge and biowaste from the EU Directives will imply a higher cost to city waste management, we will try to explain the impact of the new compost norms in cities.



Generation bio-waste 1996: (000 t/y)	
Sludge	
Spain	528
UE-15	6.500
Solid waste	
Spain	6.600
UE-15	60.000
Manure	
Spain	80.000
UE-15	1.020.000

There is a continuous increase in organic waste generation. In Spain sludge in 1998 was around 668 t, and is estimated by Ministry for 2006 in 1.300 t/y (150% increase above 96 data).

BiowasteUrban vs Rural

- **Urban: 12 Tm/y**
  - Organic waste
  - Yard 'green' waste
  - Sludge
- **Rural: 125 Tm/y**
  - Agricultural and livestock extensive
  - Intensive farming
  - Processing plants for food, fibres and forestry.

Balance between use of organic waste in agriculture implies a compromise of two criteria:
- pollution of soil and water
- avoid exhaustion of mineral resources (phosphate rock)

Additionally use of sludge and other organic waste on soil implies:
- landfilling waste diversion
- mineral nutrients savings
- fossil fuel saving and Kioto goals
- erosion control
- nature protection through reduced mineral fertilizer

Environmental instruments (gen)

- NORMATIVE: Stricter norms in (Hg, As, contain,ban on CFC, landfill norms, etc.
- ECOMOMICS: Market and prices, ECOTAX.
- SOCIAL: Education.
  - MAIN LOCAL INSTRUMENT ARE:
    - ECOTAX (LIMITED)
    - NORMATIVE (LIMITED)

OCDE (1997) favours an 'integrated' approach with the use of the three type of instruments:
- normative
- economical
- social

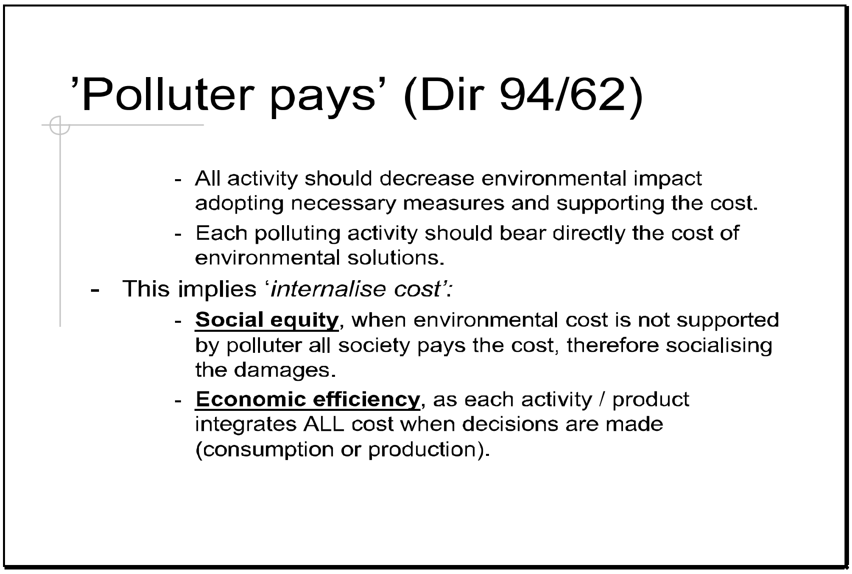
The advantage of economical against technical is that the first one poses a continuous incentive to improve performance meanwhile the technical norms once are achieved there is not incentive for further improvement.

Nevertheless for sludge, clear standards are needed in order to:
- risk avoidance
- nature protection
- and even market creation.

Economic instruments for environmental policy

- **Taxes,** compulsory payments to the State (or City) but not related to resource use. Payments are related to income rather than use.
- **Charges,** compulsory payments related *directly or indirectly* to the cost of cleaning the pollution or correct the impact.
  - Charges may be flat rate, or variable fee moving from old general tax to PAYT systems.

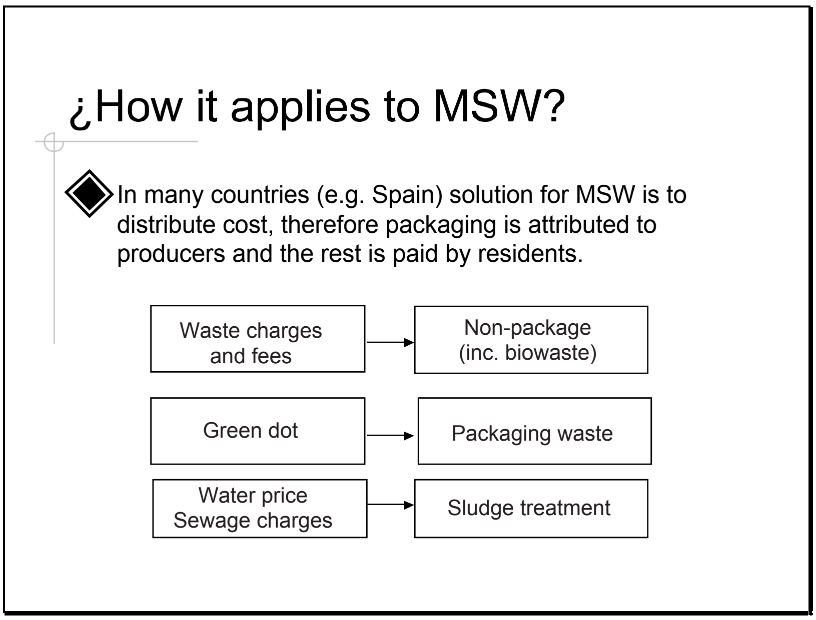
Cities may use some economic instruments for sludge management, specially minimisation and quality control.
Already water prices in most countries are set in order to pay the full cost of water supply and sewage treatment (including sludge disposal).
Water price can be called an 'ecotax' as the amount of pollution both in quantity and quality can be supported fully by polluter.
Nevertheless approach and solutions for sludge treatment should as much as possible 'cost effective' to avoid a burden on domestic user and companies.
OCDE (1999) Economic Instruments for Pollution Control and Natural Resources Management in OCDE Countries: a Survey. Working Paper ENVEPOC/GEEI (98) 35/REV1. http://www.oecd.org/env/docs/epocgeei9835.pdf



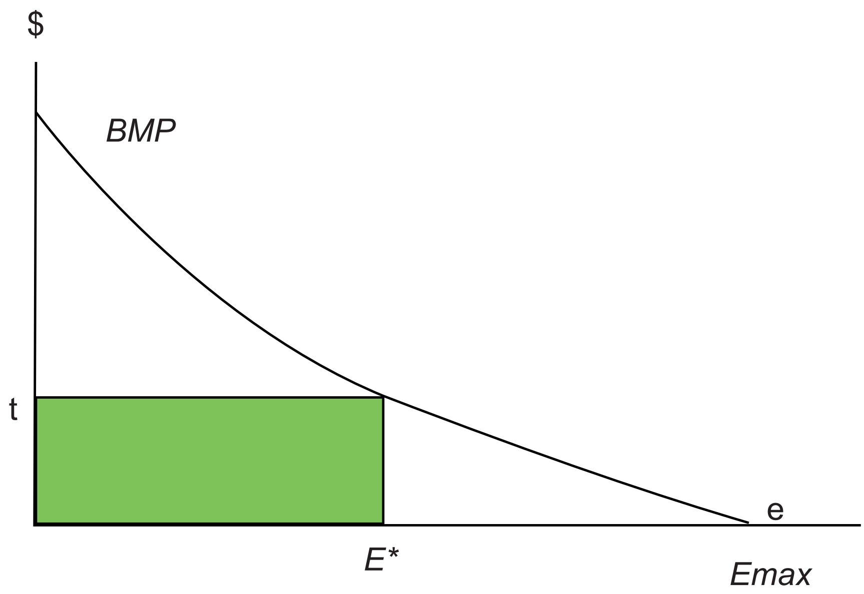
Additionally to the directive 94/62 we should consider also the Water Framework Directive (2000/EC) that in article 9 reads as follows.

<M.E. shall take into account of the principle of the recovery of the cost of services including environmental (…) in accordance with the polluter pays principle’.
(…) water pricing policies provide adequate incentives for users to use water resources efficiently …>

This implies that user of water should pay the cost of sludge disposal in any case.
Finally financial equilibrium of city budgets requires the translation of price increases to polluters.



Packaging Directive translation to National Laws implies that producers should pay the full cost of packaging waste management.
General MSW including biodegradable waste (25-50% of MSW) has different regulations in Europe, the most common one implies city authority for full cost recovery through charges and taxes.
UK local authorities are not allowed to fix taxes and other countries have an upper limit to taxes such that they should lesser or equal to cost.
Water and sewage treatment is allowed the full cost recovery to polluter in most of the EU countries.
The recent debate on WFD has highlighted this issue.
Nevertheless at the present level of cost of sludge management it is around 3% of total price of water and 12-15% over total cost sewage treatment.



Theoretically, as the polluter consumes water and produces sludge the amount produced is not the maximum when the polluter does not pays any externality, but as the normative imposes higher cost to the polluter to the level 't', the amount disposed is reduced. The shadowed area 't x Q' is the value of the environmental protection.
Part of the protection to the environment creates employment for the management of the waste. OCDE (1997). Environmental policies and employment.

Effects of TopfelOrdinance

Germany	1991	1995	1998
Pack-waste (Kg/per)	94,7	84,28	82,00
% decr.	--	-11,00%	-13,40%

The success of the packaging ordinance can be seen in:

- prevention at source
- recycling goals achieved

This may be used a model to avoid mistakes and adopt valuable experience.
http://www.gruener-punkt.de

Gains from recycling (COM (98) 463)

Material	Waste (Kg)	% Rec	Energy Savving	Jobs
Ferrus	70.000	43	60-70%	100.000
Non Fe	3.500	57	60-95%	80.000
Paper	30.000	46	--	60.000
Plastic	17.000	6	--	60.000
Textiles	4.200	20	--	20.000
Glass	7.400	50	20%	15.000

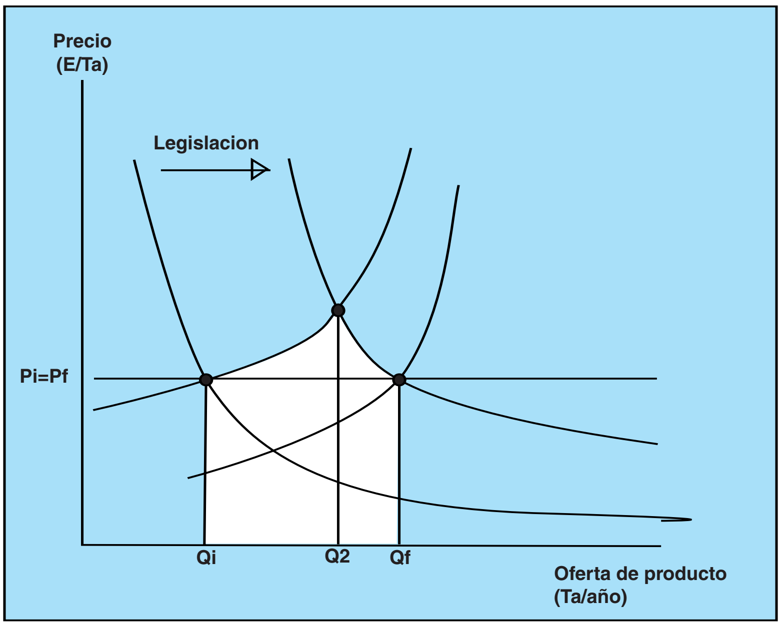
It is difficult to evaluate the employment created by stricter organic waste norms and by landfill directive application but it is obvious that more employment is need when organic waste needs to be treated against landfilling the waste.
Regarding organic waste, the Ordinance on Bio-Wastes came into force Oct 1st 1998, and has produced the following impact:

- separated collected biowaste from 1 million tons (1990) to 10. Million tons (2000)
- bio-composting plants from 130 (1990) to 500 (1997) and still growing
- According Bundesgütegemeinschaft Kompost 4.000 people are employed in the sector in Germany 2000.

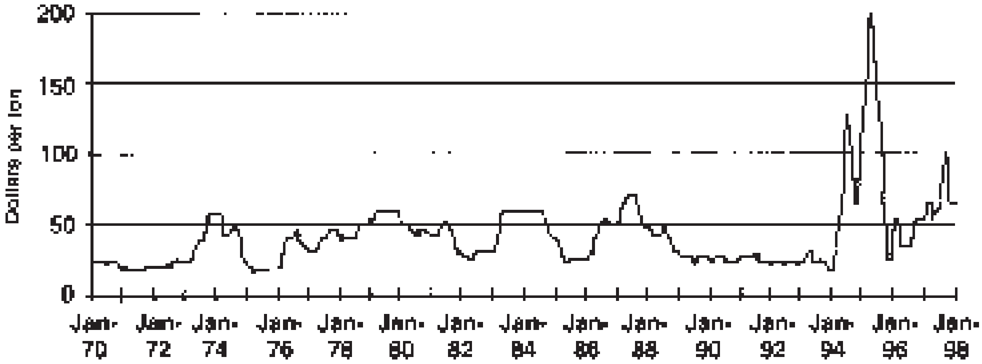
Consequences of packaging directive on Cities

- Increase cost both logistic and processing (+30% -50%)
- Reduce landfill
- Increase recycling
- Improve local sustainability
- Create local jobs.
- Global effects positive
- FINANCIALLY NEUTRAL BY LAW.

The selective collection and recycling subsidies that packaging directive induced has moved collection and treatment cost of waste globally an 30-50% increase.
This has saved landfill space (10-50% depending city).
Recycling rates increased in all materials, some of them reaching a technical maximum 90% glass in some countries.
The Delors Report on Employment in Europe points out recycling and environmental services as a source of jobs in Europe. From the economic point of view, we are paying in this generation the environmental degradation, and when the option selected is more labour intensive in comparison the environmental protection has a positive impact on employment. When the proximity principle is applied, the jobs are demanded locally. (COM 97/592)
But the law also entitles cities to recover all cost in waste management (with the UK exception).



The case of recycled paper minimum contain standard implies that demand curve moves rightward, i.e. There is a global increase in paper consumption. Obviously as supply is not prepared to satisfy this increased demand (from Q_i to Q_2). At the new higher price capacity of production grows to meet demand, the new dynamic equilibrium is at Qf with a higher consumption of recycled material.
Unfortunately the case of sludge is a different situation as demand is not increased by any normative because there are environmental and health risk that needs to be addressed.
Farmers and NGO have serious concerns about it.



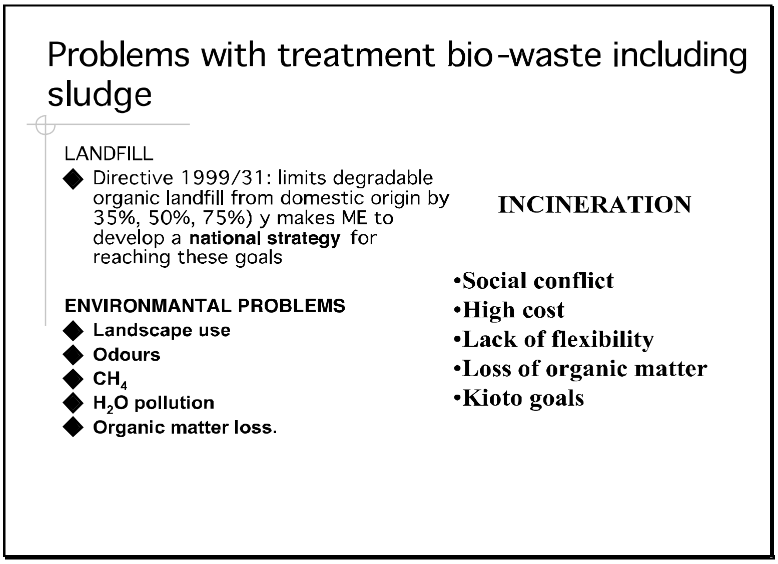
Surce: Miller Freeman

The figure shows the price of recycled paper during two decades, and we can see how it has a floor around 25 USD/ton and prices move in the range 25 to 60 USD during almost 15 years.
The increase in paper price is the introduction of a minimum contain recycled paper by Federal Law, price increases are explained by shortages in the supply that are solved at medium term.
Result is the creation a growth both in demand and supply of recycled paper.

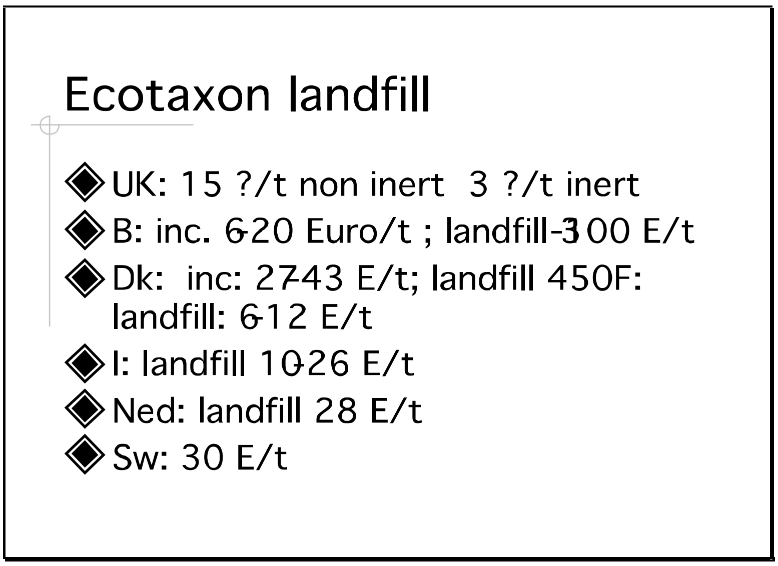
Landfill directive 99/31

- Increase safety norms
- Ban on organic waste >25% (2016)
- Increase management cost (x100%)
- Global effects positive
- (Again Cost-neutral for local governments).

In general landfill directives assume a high level of environmental protection. We can define it as a pure Normative instrument, but the real consequence is to be very selective in the treatment of the different type of landfilled materials.
Landfill directive by setting stricter limits on dumping waste has a economic consequence by increasing significantly the cost of landfill.
Obviously this increase of landfill cost has been softened by the support measures to prevention and recycling in the packaging industry, but we LACK of similar policy in the organic fraction of waste including sludge.



The most frequent options of sludge treatment are landfill and incineration, but the last one is expensive due to the high water contain in sludge.
Also we find social conflict with strong opposition to incineration in Mediterranean countries.
Incineration of sludge due to the low calorific value is not very positive in environmental balance.



Most countries have set a landfill tax that increases additionally the price of dumping waste, and this tax is selective on material that may be recycled. All Eu members (except Esp, Port, Gre, Lux) have already a tax on landfilling that increases the relative cost of dumping waste (http://www.clubresiduos.org/informcer.htm).

Consequences of Dir.99/31 (gen)

- Make recycling more attractive
- Increase cost of landfill
- Increase safety of landfill
- It is co-ordinatedwith packaging waste and biowastenorms.
- High level of environmental quality

Landfill directive is complementary to Packaging directive and probably in the future with compost and sludge directives.

By increasing the relative cost of a the of treatment (i.e. Landfill) the recycling option is more favoured. This has been accompanied in the packaging waste but need to be done in the bio-waste fraction.

Biowasterecycling and cities (I)

- We should learn from packaging
- Need of GLOBAL National plans
- Needs for market creation:
  - Standards
  - Demand shift: private and public
- Integrated approach (demand depends upon quality of sludge)

Following this line of reasoning, we should learn from packaging specially in the success in minimisation by prevention as a response to eco-tax (green dot charges). Therefore, the translation of the principle of PPP will be an incentive to minimisation.
Also as in the packaging industry global (national and European) consortiums should be build to co-ordinate efforts (such as the Ecoemballages, DDS systems, etc.).
The needs for recycling facilities creation through companies may be supported by these consortiums.
The recycling facilities for packaging (paper, glass, ferrous,..) should be built in the case of bio-waste by co-operation between users and suppliers, by setting voluntary agreements and standards.
Demand is quite different in the case of packaging and bio-waste, therefore Government involvement is required.

Biowasterecycling and cities (II)

- Financial: PAYT, 100% of cost
  - Most cities still run waste services with losses, (e.g. Wiencover only 94% cost)
- Technical:
  - R+D on methodologies for waste treatment
  - Objective 'risk assessment
- Economical: European integrated approach.

Most EU Member Estates give autonomy to cities to set taxes on waste collection and treatment with only the case of UK cities that are not allowed to set taxes. The legal framework varies but we may say that any norm should be financially neutral to cities.
Nevertheless cost efficiency should be a goal by itself avoiding to charge taxpayers with excessive economic pressure.
Research should be done to avoid unnecessary expensive treatments (e.g. Higienisation of sludge when destination is incineration).
Objective risk assessment, probably too much stress is put into heavy metals from sludge when no control is done in other sources (fertiliser, manure, atmospheric).
Also the European approach may apply the principle 'think global, act locally' and take into account the need for organic matter in the Mediterranean soils.

Cost effective approach

- Prevention by source control.
- Soil focused control: i.e. Sewage sludge, animal manures, compost and inorganic fertilized under common rules.
- Clear rules and stable framework for public operators about: standards, mechanism of control, legal responsibility.
- Enhance demand through collaboration with farming systems (subsidies, R+D, etc.).
- Sludge management in Spain is around 3% of full price of water or 12% of sewage cost.

Any legal and technical framework should be clear and stable to promote investment, both public and private.
A strong support of farming system research should be done and it is necessary to create wide consortiums for 'living soils'.

Conclusion

- Clear rules and definitions.
- Enhance demand of a product with agronomic value through:
  - technical control norms.
  - economic and market rules.
- Stable framework.
- Prevention at source.
- Integrated approach for all organic waste.

Most of the Southern Europe lack proper conditions of organic contain in soils, and soil loss and lack of fertility (with use of chemical fertilisers), therefore, organic resources contained by sludge and other organic waste should not go to landfills and future application of EU directives will not allow that occur.
Therefore a movement towards conversion of waste into resource should be done and all actors (cities, farmers, EU, member states, researchers) should co-operate to solve the technical and economical problems that will be obstacles to this conversion.

Composting and biological treatment in Southern European Countries: an overview

(Liliana Cortellini, Environmental expert and Enzo Favonio, Scuola Agraria del Parco di Monza Working Group on Composting)

Abstract

Recent policy developments have led to a fast growth for source separation of biowaste and composting in Italy and Catalunya. Programs in France are also underway, whilst Portugal and Greece are planning pilot projects in this field.

The purpose of this contribution is to describe latest and most significant developments in composting of selected organic waste materials in Southern European Countries; the effects played by recycling targets set out by latest laws and regulations on Integrated Management of MSW and the contribution of organic waste to those recycling targets gets examined.

The document provides some notes about:
- features and performances (quality, quantity) of source separation systems for food/green waste in Italy, Spain and France as compared to other EU Countries
- the dimension of the "composting system" as to number of plants and their treatment capacity and throughputs
- specific features of farming, and perspectives for use of compost in Mediterranean Countries
- effects of waste management policies and technical regulations on the development of biological treatment of Restwaste.

Introduction: The Potential Role Of Composting In Integrated Waste Management Strategies In Southern Europe

Biodegradable organic waste represents a significant fraction of waste. As far as MSW are concerned, on a European basis 32% (Barth, 2000) is fermentable waste (yard and food waste).

This percentage is generally higher in Southern European Countries: according to a recent study promoted by the Commission (ECOTEC, 2000), reported percentage of organic waste is 44,1% in Spain, 33,6% in Italy, 37% in Portugal, 47% in Greece; the only exception being France with 28,8% (ADEME, 2000).

It can thus be said that, out of a total MSW production in Europe at 200 million tonnes (DHV, 1997), 60,6 million tonnes are biodegradable organic waste (including food and yard waste); 54% of total organic waste (33 million tonnes) should be coming form Southern European Countries.

Other relevant biodegradable organic wastes are:
- sewage sludge, which production is expected to increase from 27, 6 million tonnes in 1992 (dry matter content standardised at 20%) to 41,67 million tonnes in 2005, as a simple consequence to the implementation of EU Directive 91/271 on Urban Wastewaters (Magoarou, 2000);
- waste from food processing facilities: 15 million tonnes.

According to these numbers, recycling of biodegradable organic waste (fermentable fraction of municipal solid waste, sludge, food processing waste etc.) is a priority in order to fulfil the goals of recycling and limitation of landfilling. It is also consistent with the provisions of the EC Directive 99/31 on landfilling, that as for a sharp reduction of organic waste o be landfilled.

Composting of source separated organic waste;

- plays an important role in an integrated waste management strategy which, according to the principles established by the EC and Member States, give priority to the prevention and recycling of materials over other options;
- it is a valuable tool in order to recycle the organic fraction of MSW;
- it significantly improves the agronomic quality and safety of sludge, and of other organic waste and animal slurries to be land applied;
- it is a valuable source of well stabilised, humified organic matter; this is relevant in particular in Southern European Countries in order to maintain soil fertility, which is threatened by the decreasing content of organic matter in the soil (lower than 2% in most Regions); it therefore represents an effective, relevant tool to fight desertification.

The Development Of Programs For Source Separation Of Household Organic Waste In Mediterranean Countries

We must above all underline the role that composting is gaining as a tool for integrated management of municipal waste; further to a growing number of provisions in national or local legislation, and to mandatory programs outlined at a national level or in single Regions, a growing number of districts in Southern Member States have lately adopted those strategies already well developed in Central and Northern Europe, aiming at source segregation of the organic fraction of municipal waste. During last years, the development has been particularly noticeable in Northern Italy and Catalunya.

In Italy for instance some 600 Municipalities had already been reported to run source separation programs for food waste early in 1999.

For the time being, the development of recycling programs mainly refers to Northern Italy, though many programs are starting in central and southern regions; among these, noteworthy is the situation in some districts in Abruzzo, where 2 municipalities were reported in 1999 at more than 50% recycling rate thanks to door-to-door schemes for sorting food waste.

Table 1 refers to the 1999 update; numbers are now likely to be at more than 1000 Municipalities across Italy (the overall number of Italian Municipalities being a bit more than 8000). During last spring and summer, many more towns – even among those with medium to high population – have started separation of food waste in Southern Italy: e.g. Matera (some 60.000 people) and Battipaglia (60.000). The

Table 1: Municipalities and inhabitants involved in source separation programs for food waste (update: Jan, 1999)

Region	Municipalities	Inhabitants
Abruzzo	11	76.511
Campania	8	93.865
Emilia-Romagna	36	218.682
Liguria	2	4.900
Lombardia	329	3.027.950
Marche	2	6.000
Piemonte	41	109.184
Toscana	12	113.724
Veneto	109	887.151
Trentino – Alto Adige	26	46.012
Total	576	4.583.979

most important fingerprint of such a development is represented by huge capital investments to buy tools for source separation (trolley bins, buckets, bags, lorries) and to build composting plants; for instance, in September 2000 the Special Governmental Task Force ("Commissariato") for Waste Management in Campania awarded a tender for some 15 new composting sites (averaging 5000 tonnes/year each) for source separated food and yard waste, to be spread over Campania.

In parallel to the development of source separation, the number of composting sites for source separated organic waste is steadily growing.

The main cause for such a growth in source separation of food and green waste has to be found in recent developments of environmental policy. Decree 22/97, the National Waste Management Law (Feb. 1997) sets a recycling goal at 35 % to be met within 2003. Source separation of the organic waste is not compulsory, and it is just depicted as a "priority". Still, food waste source separation is a need in order to reach the medium-term recycling targets of 35 %. In effect, intensive collection of dry recyclables (paper, glass, plastic, etc.) does not allow local authorities – in general – to meet such a goal (it has to be noted that home composting and demolition debris are not included into the total figure of recycling rate). Thus, most Regions and Provinces are including source separation of food waste in their Waste Management Plans.

Source separation of food waste has already allowed some Provinces, Milan Province included (some 190 Municipalities, > 3.500.000 inhabitants), to meet the 2003 recycling goal (35%), with many single Municipalities overcoming 60 %. 2 Provinces (Lecco and Bergamo) have already overcome 45% recycling rate on aggregate. The use of specific tools and systems for door-to-door source separation of food waste has proven to be effective with relevance to quantity and quality of food waste collected, and very cost-competitive.

The collection of yard waste is even more developed, above all in such regions as Lombardia, Veneto and Piemonte (some 4000 municipalities, 17.500.000 inhabitants) where it has been made compulsory since 1994. Many other Regions, above all in Northern Italy, such as Emilia Romagna and Tuscany also are recording a wide extension of programs to collect yard waste, even though they have no compulsory action in such respect.
The new legislation has enhanced the will of many Local Authorities to start and develop innovative waste management programs. Actually, even before the issuing of Decree 22/97, in some Municipalities and Provinces integrated programs to maximise recycling were run, especially due to local waste disposal crisis. The first Municipalities to run food waste separation started towards 1990 while first wide territorial programs were implemented in years 1994 and 1995 in Lombardia. After the Decree has been issued, many Authorities responsible for waste management planning have regarded recycling and composting as the main tool in Waste management.

Biological treatment on the whole is experiencing a fast and huge growth in Spain, as well.

If we consider schemes for source segregation, Catalunya is undoubtedly becoming the leading situation in Spain. Actually source segregation of "bassura orgánica" (organic waste) has been developed also in other areas, both rural and urban; among these latter, an outstanding scheme – if we refer to the population covered - has already long been run in Cordoba (some 300.000 inhabitants), with pretty good outcomes; what has to be positively enlightened is the detailed assessment of operational features, costs, outcomes of the Cordoba scheme led by the Public Cleansing Service itself, that witnesses a strong will to go further.

When we come to Catalunya (Girò, 2000), as per July 2000, 63 Municipalities were reported to source separate biowaste, for an overall population of some 430.000 inhabitants (see also table 2) the November update was yielding 72 Municipalities and 640.000 inhabitants; in the Barcelona Metropolitan Area itself, they were 21 out of 33, covering 150.000 inhabitants with a forecast development to 300.000 inhabitants within the end of year 2000. The Catalan development takes it steps from a Regional Law (Law 6/93) setting out compulsory programs for the source segregation of organic waste in all Municipalities with a population over 5000 inhabitants. This mandate affects 158 municipalities with a population of 5.3 million inhabitants, or nearly 90% of Catalunya's population. The remaining Municipalities, those with populations under 5,000 inhabitants, are not required to comply, although they may participate - and many are doing so - on a voluntary basis.

Though deadlines for the full development of programs set out back in 1993 had to be postponed, the strategy has steadily grown up and will continue to be fully developed. The Metropolitan Waste Management Plan sets a target for 350.000 tonnes biowaste (including big producers) to be source separated by year 2006 (that means covering all the population inside the Metropolitan Area).

Table 2: Source separation of biowaste in Catlunya: development of programs

	Compulsory Municipalities > 5000 inhabitants		Voluntary Municipalities < 5000 inhabitants		Total Municipalities	
	Municipalities	Inhabitants	Municipalities	Inhabitant	Municipalities	Inhabitants
Overall	158	5,304,724	786	785,316	944	6,090,040
Schemes until July 2000	49	393,000	14	40,000	63	433,000

Lately a similar regulatory approach has been adopted by the Spanish National Law on Waste Management 10/98 and by the PNRU (National Plan for the Management of Municipal Waste) 2.000-2006, which specifies that all municipalities with a population above 5.000 inhabitants (within 2.001) and those with a population above 1.000 inhabitants (within 2.006) have to run schemes for the source separation of municipal wastes. Though no further explanation is provided for what materials should be tackled by schemes to be included in "source separation", it seems generally agreed that – also under the spur of what's happening in Catalunya – the strategy will also cover source segregation of organic waste. For instance, it must be noted that a National Composting Programme has been defined accordingly. In this programme targets and deadlines for recycling of organic matter by means of composting, and anaerobic digestion, have been defined.

This led many Regions to include provisions for the development of programs for the source segregation of organic waste in their local plans. Let's quote:

- ☐ Comunitat Valenciana (Pla Integral de Residus de la Comunitat Valenciana)
- ☐ the Autonomous Waste Management Plan of the Autonomous Community of Madrid, with provisions for separate collection of biowaste to be established as a general rule in a second phase, as from 2003.
- ☐ Comunidad Autónoma de Aragón has included in its Plan de Ordenación de la

Gestión de Residuos Sólidos Urbanos the implementation of the separate collection of biowaste.

- Comunidad Autónoma de Castilla - La Mancha has also established in its Plan de Gestión de Residuos Urbanos de Castilla – La Mancha the implementation of the separate collection of biowaste.
- Comunitat Autònoma de les Illes Balears, by means the Pla Director Sectorial per a la Gestió dels Residus Urbans a Mallorca, and, in a near future, with the elaboration of the Pla Director Sectorial per a la Gestió dels Residus a les Illes Balears and the Law on Wastes for the Balearic Islands, has also fixed the implementation of separate collection of biowaste.

Though Portugal has taken its steps in the field of mixed waste composting, so far, some pilot schemes for source separation have already been planned. Within a few months source segregated organic waste should be collected at least at big producers in Lisboa.
Coming to France, by far most of its current composting capacity of source separated materials (some 800.000 tonnes) refers to yard waste.

Nonetheless, some 30 pilot programs for source segregation of biowaste (including food waste) through doorstep schemes have been started. A summary table follows (table 5), describing main features of the pilot schemes as described in national reports. At a glance, it seems that French schemes lean on Central European models; that means the collection in most situations of yard waste along with food waste in the same bin.

No reliable information has been made available, yet, to us on planned programs in the short term for the source segregation of biowaste in Greece. Though composting of source separated organic waste has been applied, in general it deals with sludge and agroindustrial by-products. Nonetheless, in past years a pilot scheme had been outlined in Crete island; furthermore, we lately recorded a growing interest by committed officers and technicians - e.g. towards the schemes run in other Countries, problems and tools for composting of food waste, etc. - that let us think of next positive developments in this field.

Table 3: French pilot schemes for source segregation of biowaste

District	Biodechets t/a	Covered population	Biodechets Kg/inhab year	% single family dwellings	-% of yard waste inside Biowaste	Type of tool	Notes
District des trois Frontieres	3.662	24.000	153	80	80	Trolley bins 120-240-340	
District des Sud Bassin	4.860	30.500	159	88	95	Trolley bins 140-260	
SITCOM Coté Sud des Landes		5.360		92		Trolley bins 240 + paper bags 15 l	
Communauté d'Agglomeration d'Agen		1.500		100		Trolley bins 240, a few 1 20-180	
SITCOM Nord-Allier	620	2.800	221	100	75	Trolley bins 120-240	
SIVOM du Pont Fort de Saint Lò	2.333	13.100	178	100	75	Trolley bins 120-240	
SITCOM de Buxy-Saint-Gengoux-le-National	369	2.720	136	97	65	Trolley bins 120-240	
Communauté Urbaine de Creusot Montceau	6.250	70.000	89	80	0	Plastic bags 20 l	food waste gets collected alone, with no yard waste in it
Communauté de Communes de la Region de Guegnon	710	9.897	72	85	98	Plastic bags 50 - 100 l	
SITCOM de la Region de Rambouillet	2.044	29.000	70	100	87	Double-compart trolley bins 180-260-340 l	
SAN de Cergy-Pontoise	2.241	25.800	87	100	90	Trolley bins 140 l, bags 80 l	
Ville de Beziers	200	3.000	67	100	75	Trolley bins 120-240	
SITCOM de l'Ouest Audois/SYDOM de l'Aude	74	2.681	28	100	10	Trolley bins 330-660 l, buckets with biodegradable bags	
SYNTOMA	152	2.380	64	100	20	Buckets 10 – 35 l	food waste gets collected alone, with no yard waste in it
SIVOM de Coursan Narbonne Rural	430	4.008	107	100		Containers 660 l, buckets 15 l	
Communauté de Communes du Bassin de Pompey	836	9.000	93	83	70	Trolley bins 120 l	
SISOV	154	1.118	138	95	70	Trolley bins 120-240	
SIVOM de Bapaume	5.003	23.667	211	100	70	Trolley bins 120 l	
SIRFAG SIRDCGUTOM	8.867	57.326	155	91	80	Trolley bins 120-240	
Lillé Metropole Commonauté Urbaine	21.852	233.629	94	100	85	Double-compart trolley bins 180-260 l	

continua

segue

District	Biodechets t/a	Covered population	Biodechets Kg/inhab year	% single family dwellings	-% of yard waste inside Biowaste	Type of tool	Notes
SIRTOM du Laonnois		3.830	0	72		Trolley bins 120-240	
Communauté de Communes de la Vallée de l'Oise	9	100	90	99	10	Bins 35 l	food waste gets collected alone, with no yard waste in it
Communauté de Communes de la Region de la Villedieu du Clain	600	13.000	46	100		Aerated trolley bins 120 l	
Communauté de Communes du Pays Santon	310	2.000	155	100		Trolley bins 120-240	
Ville de Niort	4.510	32.271	140	65	90	Trolley bins 120-240	
Communauté de Communes des Duyes et Bléone	8	270	30	100	5	Trolley bins 120 l	
Communauté de Communes du Canton de Clelles	260	1.460	178	100	35	Trolley bins 120-240	
TOTAL / AVERAGE	66.354	604.417	110				

The Contribution Of Different Waste Materials To Recycling And The Importance Of Sorting Food Waste

As source separation grows up, we get important suggestions about items on which efforts have to be concentrated in order to reach high recycling rates. (Consorzio Provinciale della Brianza Milanese, 1997; Legambiente, 1998; Provincia di Lecco, 1997; Provincia di Lodi, 1998; Provincia di Milano, 1998 a).

Traditionally, source separation systems were meant to be simply added to common MSW collection. Recycling paper, glass and plastics by means of road containers did not imply structural changes in the MSW collection. With such systems, separation rates range between 2 and 15%, depending above all on the frequency of distribution of road containers, with frequencies of less than 500 inhabitants/container - per each material - performing best. Table 4 reports on the maximum specific contributions of such systems for different waste materials.

Table 4: Maximum specific contribution of different materials (values in kg inh^{-1} y^{-1}); outcomes refer to situations with high frequency of distribution of containers (1 every 400-500 people)

Material	Specific contribution (kg inh^{-1} y^{-1})
Glass (mixed)	20-30
Paper	20-30
Plastic containers	4-5

More recently, integrated source separation systems have been introduced. "Integrated" source separation means that higher separation rates and above all the segregation of compostable fractions such as food waste, make it possible to change also the features of collection systems for Restwaste. In such respect, a central role is played by food waste source separation. In Italy the contribution of food waste alone – when led with "door-to-door" systems - accounts for some 60-90 kg inh^{-1}y^{-1} (Consorzio Brianza Milanese, 1998); these numbers have to be added to yard trimmings (generally run with specific collection systems, different from schemes for food waste) whose contribution ranges between 30 and 150 kg inh^{-1}y^{-1}, depending on urbanisation and diffusion of home composting. The overall contribution of compostable fractions therefore averages a 20-40% recycling rate.

Very often, where the source separation of food waste gets applied, it is accompanied by the introduction of door-to-door collection of paper. This allows separation of some 40-60 kg inh^{-1}y^{-1} waste paper (Legambiente, 1998), that means 2 to 3 times more than the specific contribution of collection through road containers. In general, we could say that door-to-door collection is a powerful way to reach high recycling rates; this applies above all to those materials whose contribution is relevant such as paper and food waste.

From a quantitative point of view, fermentable material (food waste) accounts for a major percentage of MSW; and this is particularly true in Southern Europe. In Northern Italy food waste percentage ranges between 27 and 40% out of total MSW; in Southern Regions they range between 35 and 50%, mainly due to lower presence of packaging in a poorer economy and the custom to have meals at home with a lower use of pre-cooked and/or frozen products (that produce less food waste). Many times in Mediterranean Countries food waste has been reported to overpass 50% out of total Municipal Solid Waste.

Table 5: Waste composition in Spain

Organic Matter	44,06 %
Paper and board	21,18 %
Plastics	10,59%
Glass	6,93%
Ferrous Metals	3,43%
Non-Ferrous Metals	0,68%
Wood	0,96 %
Textiles	4,81%
Others	7,36 %

As to Spain, as far as we know one of last official surveys (Medio Ambiente en España 1998, numbers referring to 1997) has reported an average composition of MSW (in weight) as expressed in table 5. Even at a first glance, the importance of food waste to meet high recycling targets gets confirmed.

From a quantitative point of view, fermentable material (food waste) accounts for a major percentage of MSW; and this is particularly true in Southern Europe. In Northern Italy percentages of food waste range between 25 and 40% out of total MSW; in Southern Regions they range between 35 and 50%, mainly due to lower presence of packaging in a poorer economy and the custom to have meals at home with a lower use of pre-cooked and/or frozen products (that produce less food waste).

From a qualitative point of view, the more fermentable material gets sorted and recycled, the less production of biogas and leachate is to be expected in landfilling and the better thermal valorisation of "restwaste" can be envisaged.

Main Performances Of Sorting Schemes For Food Waste

Performances of schemes may be judged under many standpoints. The quantity of collected compostable waste is important indeed, though its outcomes must be carefully dealt with; for instance, we should try to detect an overall growth in waste collection in parallel to the development of source separation programs, due to a high delivery of yard waste that previously was home-composted. We dwell upon this subject elsewhere in these Proceedings (Favoino, Girò, 2001).
As to quality (table 6), the material collected in doorstep programs shows on average a 97-98% purity, well beyond a suitable target that could be set at a 90-95% purity, depending on

the plant sorting equipment; it has to be noted that with a 97% purity and more it is possible to tip the material directly to the composting section, without any pre-sorting step.

Table 6: Source separated food waste purity in some Italian areas and municipalities (sources: Provincia di Milano, 1998; Favoino, 1999; Bigliardi, 1998)

Area/Municipality	Inhabitants	Purity (Compostable materials) % w/w
Milan Province		
(March '98):		
Albiate	4.713	98.8
Arese	19.230	98.1
Bellusco	5.971	98.4
Biassono	10.493	95.0
Brugherio	30.800	98.8
Buccinasco	23.890	96.5
Castano Primo	9.652	99.3
Cinisello Balsamo	75.650	98.2
Cologno Monzese	50.121	93.0
Desio	34.849	99.0
Melegnano	16.112	98.0
Monza	119.187	97.4
Novate Milanese	20.028	94.3
Paderno Dugnano	44.748	93.7
Rosate	4.332	97.4
Trezzo Sull'adda	11.177	98.1
Varedo	12.720	99.7
"Padova1" Basin (March '98) 26 Municipalities	203.429	98.7
Modena Province Nonantola (March '98) (April '98)	11.127 11.127	99.79 99.89

In Italy and Spain, in general, where door-to-door collection of food waste is on place, yard waste gets collected on a different, less intensive scheme; namely. through direct delivery by households at Civic Amenity Sites (also named as "Piattaforme Ecologiche" or "Ecocentri" in Italy, "Déchetteries" in France) or with a specific doorstep collection, but with a much lower frequency; this is meant to make deliveries a bit more difficult and thus have yard waste managed by households as a home-compostable material to the largest possible extent; this helps keeping low the overall MSW production figure.

One point is to be specifically stressed. We have to underline that the recycling of dry fractions and packaging materials (paper, glass, plastics, etc…) could lead – as an undesired side-effect – to the concentration of the fermentable material inside "restwaste", if food waste is not effectively separated. This is what actually occurs even in those Countries (Germany, Holland, Austria, etc.) where biowaste source separation has already gone a long way and plays a major role in the overall environmental strategy; that means, in those Countries separation of dry recyclables is more effective than that of food waste. For instance, in the Netherlands and Germany, the percentage of food waste inside "restwaste" is often reported to be at 40-50% (Wiemer, Kern, 1995; Baden Baden Amt für Umweltschutz, 1996). Effective schemes put in place in Italy, above all where a "door-to-door" is run, make the percentage of organic waste inside Restwaste to fall below 15%, thanks to some specific features of collection schemes that make people feel pretty comfortable with the delivery of food waste (e.g. high collection frequencies, use of watertight "Biobags", etc.). This in turn makes it possible to cut down collection frequencies for restwaste, that appears to be one of main tools to optimise the system and make it cost-competitive.

Thanks to the optimisation tools put in place by door-to-door schemes (lower frequencies of collection for restwaste, use of bulk lorries instead of compactors for the collection of food waste, as bulky yard waste is not allowed to be delivered along, etc.), the collection system has proven to be cost-competitive. Such features and performances of optimised collection schemes get more thoroughly described elsewhere in these Proceedings (Favoino, Girò 2001).

In general, it could be said that where optimised door-to-door collection systems are run, the overall waste collection costs (i.e. for food waste + restwaste + dry recyclables) may be similar or even lower than the previous costs of mixed MSW collection.

In a recent national survey, we recorded an average cost for mixed MSW collection of some 30-34 €/inh.year; overall costs for door-to-door systems sorting food waste were at some 25-30 €/inh.year (details are reported elsewhere in these Proceedings, Favoino, 2000). Single case-histories have confirmed positive trends on the way to an overall collection cost reduction following the implementation of door-to-door source separation (e.g. Cinisello, 75.000 inh., having cut the costs from 2,35 Million € down to 2,15 Million €). In the following scheme we summarise those tools that are making it possible for many Municipalities to cut down overall collection costs with door-to-door schemes.
Usually the same effects cannot be expected for those situations where food waste gets sorted through 'road containers'. In such situations, a much lower quantity of food waste gets separated – in general, by far less than 100 grams.inh^{-1}.day^{-1}, due to the less comfortable situations for households; this in turn doesn't allow a less frequent collection for restwaste and the collection of food waste is thus an "added cost" to previous costs of MSW collection; furthermore, road containers allow a high delivery of yard waste, and this asks for compacting vehicles (packer trucks) to be used. Such systems are nowadays used in such Regions as Emilia-Romagna and Tuscany; nevertheless, it often happens that Municipalities in those areas are turning to door-to-door systems.

Tool	Details	Applies where.....
Reduction of collection quency for "restwaste"	Effective systems to collect food waste – allowing people feel comfortable – yield more than 180-220 grams. inh^{-1}. day^{-1} and make its percentage in the "Restwaste" fall below 15-20 % and less.	…frequent collection rounds are freused (warmer climates, such as Mediterranean ones)
Use of bulk lorries instead of compactors	Bulk density of food waste on its own is much higher (6-.7 kg/dm3) than when biowaste is composed of both food and green waste	…collection of food waste is being managed in order to keep it separated from collection of green waste (low volume bins available)
Cutting washing rounds/costs	The use of "personal bins" and watertight devices enables households to take care of bins on their own	…a "door – to – door" program is suit able (private space available)

The Composting Capacity In Some Southern European Countries

Italy

Italy faced a significant development of source separated waste composting capacity in the last ten years, also as a consequence of the implementation of the new regulation on waste and the development of source collection.
According to the preliminary results of a survey from ANPA the number of plants increased from 10 in 1993 to 114 in 1999 (135 if we consider also sites with a capacity of less than 1000 tonnes per year); in the same time frame, the source separated waste treatment increased from 0,25 to 1,34 million tonnes (table 7).

**Table 7: Trend of the composting capacity for source separated organic waste in Italy
Source: ANPA**

Year	Number of composting plants	Treatment of source separated waste (1000* t/year)
1993	10	250
1994	26	450
1997	85	899
1999	137	1361

In 1999, 24% source separated waste treated in composting plant was food waste, 38% yard waste, 27% sludge, 11% other organic waste materials

44 additional plants were not in operation, or under construction or planned, with an overall capacity of 0,63 million tonnes/year, so that the overall treatment capacity is expected to increase shortly from 2,2 million tonnes in 1999 to 2,8 million tonnes.

The Italian "composting capacity", is mainly concentrated in Northern and Central regions; however, more recently, many efforts have been made, in Southern Regions, in order to cover the gap starting or increasing the composting capacity. This refers above all to Campania (already mentioned), and Puglia; in this latter Region for instance, recently a tender has been issued by the Governmental Task Force on Waste Management, aimed at building 8 large-sized new composting plants. In many cases, public initiatives have been backed up or even anticipated by private action, that finds a growing place for profitable operational conditions, as fees for landfilling are getting higher and higher.

As a consequence of the overall composting capacity, the production of high quality compost in Italy, in 1999, has been estimated at 600.000-650.000 tonnes.

Italy show also a relevant treatment capacity of unsorted MSW. "Composting" of mixed MSW or (more and more frequently) residual waste left over after source segregation of recyclables, is nowadays being referred to as "stabilisation" and is undergoing a strategical change of role. We'll go back to assessing this role and its aim of biological treatment of mixed MSW further on, at chapter 7. For the time being, we mention a survey carried out by ANPA in 1999 that has recorded 41 mixed MSW sorting and stabilisation plants, with a total capacity of 3,8 million tonnes of MSW, though their actual throughput has been 2,2 million tonnes.

Spain

The capacity of biological treatment is to date mostly covered by composting of unsorted waste (production of "grey compost"). Composting facilities in different Regions are listed in table 8.

The overall composting capacity is reported at some 3 million tonnes of waste, mostly covered by plants for unsorted waste.
Consistently to the development of source separate collection, Catalunya is the Region with the larger capacity of composting for source separated organic waste. Table 9 shows the present and expected short-term capacity in this Region.

A specific feature of the Spanish situation is that a large capacity for anaerobic digestion is being developed, as mechanisms for public funding of capital investments tend to make it cost-competitive. Just on the basis of projects already underway, the overall Spanish capacity for anaerobic digestion will be likely to be at some 2 million tonnes in the medium term; anyway, as most facilities are meant to treat mixed MSW, the actual capacity of digesters will cover only a minor flux (underflow materials stemming from primary screening), of total input waste being delivered at the plant. To date, 8 plants are being built.

Table 8: Composting plants in Spain (update: late 2000) (Source: Generalitat de Catalunya, Departament de Medi Ambient, Junta de Residus)

Region	Source separated waste			Mixed municipal waste			Total
	Operating	Under Construction or planned	Total	Operating Construction or planned	Under	Total	
Andalucia	2	0	2	8	1	8	10
Aragon	0	8	8	0	0	0	8
Asturias	0	0	0	0	0	0	0
Iles baleares	0	1	1	1	1	2	3
Islas canarias	0	3	3	2	0	2	5
Cantabria	0	0	0	0	0	0	0
Castilla-La Mancha	0	0	0	3	1	4	4
Castilla y Leon	0	0	0	2	2	4	4
Catalunya*	9	8	17	0	0	0	17
Comunitat Valenciana	0	10	10	8	3	11	21
Estremadura	0	0	0	0	2	2	2
Galicia	0	5	5	0	0	0	5
Madrid	1	0	1	2	2	4	5
Murcia	0	0	0	1	0	1	1
Navarra	1	1	2	0	0	0	2
Euskadi	1	0	1	0	0	0	1
La Rioja	0	0	0	0	0	0	0
Ceuta	0	0	0	0	0	0	0
Melilla	0	0	0	0	0	0	0
TOTAL Spain	11	39	50	26	12	38	88

Table 9: Present and short-term treatment capacity of composting plants for source separated organic waste in Catalunya (Spain).(Source: Generalitat de Catalunya, Departament de Medi Ambient, Junta de Residus)

	Operating	Under construction	Planned	Total
Composting plants	9	5	3	17
Treatment capacity (tonnes/year)	122.900	165.020	140.000	427.920

(update: late 2000)

France

In France one of last surveys (ADEME, 2000), reported that, in 1998, 7% of MSW were composted (1,9 million tonnes out of 26,5 million tonnes): 77 plant were treating mixed MSW.

Many facilities treating unsorted MSW are either being phased out, or converted into biological treatment of Restwaste prior to landfilling, or upgraded to composting of source separated biowaste.

With reference to yard waste, in 1998 800.000 tonnes had been composted in approximately 100 composting sites, most of them with low-tech features. Nonetheless, the development of source separation of biowaste (see also chapter 2) is of course affecting a parallel growth of facilities fitted with technologies for process management and for odour treatment.

Composting As A Tool To Recover Humified Organic Matter: Use And Market Of Compost In Mediterranean Agriculture

Here we would like to propose an assessment on the role of organic fertility in Mediterranean Countries, and on related marketing conditions, on the basis of some specific data stemming from the Italian situation.

Compost from source separated organic waste was for instance reported in Italy at some 0,6 million tonnes in 1999 The product is mostly sold to growing media producers, who mix it with other materials, bag and sell it. In such marketing conditions (Centemero, 1999), actual prices range between 7 and 12 Euro.mc-1 (product screened at 10-15 mm mesh size, sold in bulk at the plant).

Market conditions are favourable and provide a pretty sound confidence among the operators. It seldom happens that quality compost is given to users free of charge (e.g. in those situations where plant managers find the tipping fees already fully profitable or they just rely upon cost savings in comparison to landfilling or incineration); this happens, for instance, when a Public Company runs a plant and has not a good knowledge of marketing conditions, neither skills to develop marketing strategies. Most often, on the contrary, good marketing conditions are fully exploited, above all when operators have established an effective marketing network.

It is noteworthy that it has not been unusual, so far, to have also compost stemming from mixed MSW used and even marketed – above all in Southern, humus-consuming Regions; this holds true even though mixed MSW compost has to be land-applied only at a maximum loading rate and according to the principle of the so called 'controlled use', i.e. keeping a control on soil quality before and after its use. In recent times, however, the awareness that only quality composted products stemming from source segregated materials have to be addressed as useful tools to restore fertility is growing among farmers. Their Organisations are working with

Research Centres to promote pilot trials, show farmers the advantage of using compost, and tentatively find an agreement on prices and conditions.

In order to ensure visibility and better marketing conditions for good products, the Producers' Association (CIC, 'Consorzio Italiano Compostatori') is now about to promote the start-up of a Quality Assurance System mirroring what has already been long done in Central Europe (see, for instance, the "Bundesgütegemeinschaft Kompost" – Federal Association on the Quality of Compost, Germany, or VLACO, Belgium, or KGVÖ, Austria, etc.)

There is a great awareness, among composting plant managers and research centres, that in next future the use of compost in field crops has to be developed, beside that for potting mixes, in order to back up the growth of compost production, that is forecast to grow many more times as a mere consequence of provisions of Decree 22/97.

It has to be underlined that specific weather and cropping conditions determine – in general - a huge request for organic matter in Mediterranean agriculture. Warm and dry climates and the intensive, humus-consuming crops (e.g. horticulture, fruit culture) make soils hungry for organic matter; decades of chemical fertilisation as a complete substitute for organic fertilisation have worsened the overall situation. We record many soils, not only in Southern Regions, but even in Northern flatlands, below 1.5 % organic matter. Moreover, the recent Dakar Conference about desertification has shown that Italy - as many other Mediterranean Countries - is threatened by desertification.
Desertification affects Spain (mainly Southern and Eastern Regions), Portugal (above all Alentejo), Southern France, Greece and Italy (southern Regions and many Districts elsewhere): 27% of the territory is estimated to be vulnerable to desertification.

According to the Convention to fight desertification Italy issued the guidelines of the National Action Plan[28]. Among measures to reduce the impact of the different human activities, composting of source separated collection of MSW and of biodegradable waste from agricolture is listed.

This picture leads, on the whole, to a favourable situation to promote the use of composted materials. Many Farmers' Associations are now addressing compost as a suitable tool to restore fertility and allow the growth of those crops that best fit Mediterranean climate (e.g. horticulture, fruit-trees, etc.).

More and more often Local Institutions outline programs and funding to promote the use of compost to increase soil humus; most often, main provisions of such Programs are

- funding farmers with a certain sum per unit area where compost gets land applied
- the preference for composted products in Tenders for public green areas (gardens, parks)
- funding farmers to replace old machinery when the new equipment is mechanically suitable to spread compost as an organic fertiliser; this is showing to be a new challenge for the development of compost marketing conditions (Bisaglia, Centemero 1998).

Regione Emilia Romagna (in Northern Italy) for instance, established in the plan for the Rural Development 2000-2006 a subsidy of 150 to 180 Euro per hectar to farmers taking the commitment to improve soil fertility, including the use of compost from source separated biowaste,

[28] D.P.C.M 26 Sept 1999. *Linee guida del Piano di Azione nazionale per la lotta alla desertificazione* (Guidelines of the National Action Plan to fight desertification).

the incorporation of crop residues, minimum tillage and avoiding the application of not composted sewage sludge.

In the same Region a regional law) (Regional Law 7 April 2000, n.25) has already been issued that sets subsidies for farmers to fund:
- the purchase of soil improvers;
- the purchase of machinery suitable for spreading soil improvers and animal manure;
- sustainable soil tillage and soil management in order to maintain and improve the content of organic matter in the soil.

Supporting the strategy on the agronomic side has to be foreseen in next future as one of the key elements in a general strategy that targets full recovery of the role of organic matter in agriculture from waste materials. Specific needs in Mediterranean conditions provide a reasonable confidence to do it.

The Last Step: Biological Treatment Before Landfilling

Since a long time, studies on the environmental side-effects of landfilling have focused on the importance to cut to the maximum possible extent the fermentability of the waste to be disposed of. As fermentable waste undergoes anaerobic conditions, it produces biogas (including methane, with a most noxious greenhouse effect), increases the chemical "strength" of leachate, causes settlements in the shape of the landfill. All this means in turn a long-term threat to groundwater and air, or at least a hurdle towards site reclamation; in any case it is a bothering issue for land managers and the population dwelling around landfill sites. This is why also the EC Directive 99/31 (about Landfilling) above all asks for biodegradable organic matter to be sharply cut down before landfilling.

Two ways are available to cut fermentability down: the first is source separation of fermentable food waste; the second is any pre-treatment (biological or thermal treatment) meant to degrade fermentable volatile solids before "burying" the waste.

We've already mentioned that the recycling of dry fractions and packaging materials can determine – as an undesired side-effect – the concentration of the fermentable material inside "restwaste", if food stuff is not effectively recycled (see above what has been mentioned as the "concentration effect" inside restwaste, § 4). For instance, in the Netherlands and Germany, the percentage of food waste inside "restwaste" is often reported to be at 40-50% (Wiemer, Kern, 1995; Baden Baden Amt für Umweltschutz, 1996); even in those Italian experiences were the most effective collection of food waste is reported, still we record percentages ranging from 10 to 20 % food stuffs inside restwaste.

Therefore, generally speaking, source separation and pre-treatment have to be combined on the way towards a sustainable landfill management. How should pre-treatment be managed? Firstly, we have to focus on methods to measure the stability (that is, the loss of fermentability) of the waste to be landfilled. In order to have standardised measurements some methods have already been proposed and used in the past. We would thus hereafter outline some possible ways to measure fermentability, and their influence on the development of an integrated waste management system in Mediterranean Countries.

The first noteworthy attempt to regulate this issue has been made by Germany, that in TASi (Technische Anleitungen – Siedlungsabfall, Technical Guidelines on Household Waste) asked for a 5% Volatile Solids content for the waste to be landfilled. We have to be aware that this is equivalent to depict incineration as the only possible pretreatment. Is it a suitable approach?

Many studies have long been focusing on the substantial equivalence of biological pre-treatment – the so called "cold" pre-treatment – in order to cut fermentability down (Leikam, Stegmann, 1997). This refers both to the biogas-production attitude and to the chemical "strength" of the resulting leachate, provide the biological treatment is long enough – and properly managed - to allow an effective microbial activity (Table 10). This is why Germany is now meaning to allow all those treatments, inasmuch as they show to be equivalent ("gleichwertig") to the effects claimed by the TASi.

Table 10: Effects of biological pre-treatment (from: Leikam, Stegmann, 1997, modified)

Feature	Final outcome	% reduction (as compared to initial)
Respiration rate	5 mg O2/g d.m. (96 h)	90-95%
	about 150 mg O2/kg VS.h	
COD,	< 100 mg/l	about 90%
total N in leachate	< 200 mg/l	
Gas production attitude	20 l/kg d.m	90%
Volume	final density (compacted): 1.2-1.4 t/m^3 mass loss (due to mineralisation): 20-40%	up to 60%

Furthermore, if we enforced a test method – such as the content of Volatile Solids – whose limit values could be met only through incineration, we would experience a much less "flexible" system for Integrated Waste Management, especially where it is at starting point. Incinerators – above all with BAT and Energy Recovery – could be seen as a suitable option in the "waste management chain"; though, be their adoption obliged, we would loose a main road towards the growth of recycling. We know that incinerators have to work at a certain throughput. If built before full development of recycling, this would hinder, for sure, a further growth of source separation and material recycling above all where they are still low and are forecast to undergo still a long growth: namely, many Mediterranean Countries.

Moreover, a biological treatment plant is suitable for future evolutions to become a quality composting plant. This can be done even progressively – following the growth of source separation - provide the biological section is "modular" enough, in order to use different bays, or lanes, or containers, or areas for quality composting, respectively for biological treatment of restwaste.

Above all, biological treatment seems to be a much more suitable option in areas less populated, with lower MSW production, that would not meet the capacities needed for an effective incineration, or should face high transportation costs.
Lately some new methods have been proposed in order to better describe the positive effects of biological treatment before landfilling. In general, they enable to describe more sharply – as compared to VS content - the environmental attitude of waste to be landfilled.
In particular, most test methods are focusing on :

- the respiration rate (e.g. "Respirometric Index")
- the biogas production attitude (e.g. "Gär-test")
- the chemical strength of the leachate (e.g. COD, BOD/COD rate, etc.)

New draft regulations in Italy, substantially set a certain IR (respirometric index) and BVS content (biodegradable volatile solids) to be attained. To focus only on biodegradable volatile solids instead of total VS enables to avoid any interference on VS by undegradable or not easily degradable organic compounds (e.g. plastics, polyethylene, wood). Such an approach is much more reliable than VS measurement to have a "true" description of undesired side-effects related to landfilling.

Biological treatment of residual waste is therefore now being developed in Italy as Decree 22/97 asks for the waste to be pre-treated before being landfilled within July, 16st 2001.

Biological treatment for Restwaste is now targeted on different possible aims:
- stabilisation prior to landfilling
- increase of the calorific value of Restwaste before thermal valorisation, as in the Dry stabilate method much developed in Germany
- use of organic amendments ("Grey compost" or "Stabilised Organic Fraction", S.O.F.) for land reclamation. It has to be mentioned that the huge need of organic matter in Mediterranean weather and cropping conditions (see § 5), leads to the need of saving quality compost only for application in cropping and gardening.

Some Regions and Provinces have already issued guidelines and/or technical regulations to allow the use of MSW compost for land reclamation (Favoino, 1998); their principles have been taken over by a draft national regulation expected to be issued in next future. Such regulations rely upon the hypothesis of one-off applications ("una tantum", only once) with high loads in order to promote biological activities in surface soil layers on exploited mines, slopes to be consolidated, anti-noise barriers, etc. As for use constrictions, regulations address above all the need to check both:
- load of heavy metals and
- load of nitrogen

Conclusions

Recent developments in waste management show the evidence that many Regions in Southern Europe are moving fast towards those strategies already developed in Central Europe. Source separation and composting of food and yard waste, play a key role in that. In fact, they are envisaged as the only tool that enables Local Authorities to meet high recycling targets set out. Source separation programs already in place, most of which concentrated in Northern Italy and Catalunya have widely shown the possibility to apply effectively to the Mediterranean area as well as in Central Europe.

In general, operators and Local Authorities think that the legal framework will confirm in next future composting and biological treatment as a main tool in the Integrated Waste Management System. Provisions of national and local regulations, programs started to comply and technical regulations already issued or on draft constitute, on the whole, a powerful framework that can't be dismissed easily; that means that composting and biological treatment have gained a steady role in the Integrated Waste Management System also in Southern European Countries, in order to overcome the present situation, still largely based on landfilling of unsorted, untreated MSW. The recent Landfill Directive, and its provisions about the reduction of biowaste to be landfilled, has been envisaged as a further validation of the strategies to be developed.

Systems run for source separation of food waste have shown to be effective and can improve some performances as compared to previous systems run in Europe. To summarise, it has been shown that in doorstep programs:

- there is a much bigger diversion of food waste from MSW – namely where a door-to-door collection is adopted – as compared to Central Europe (this prevents the "concentration effect" that has led the percentage of food scraps above 40% in Central Europe)
- hence, we record a lower tendency of "residual waste" to be fermentable, to produce leachate and attract insects; this allows in turn a lower collection frequency for "restwaste"
- collection costs can be kept at a lower level by means of reducing collection frequency for restwaste and using bulk lorries instead of packer trucks for food waste, as its bulk density without yard waste gets much higher.

Specific features of agricultural and cropping conditions in Mediterranean Countries show the need for huge quantities of composted materials. Central Institutions mean to support the promotion of the recovery of organic waste; the risk of desertification provides further powerful meanings to do that.

As seen from Southern Countries, with huge needs of organic matter to restore fertility, a comprehensive strategy for composting should :
- acknowledge quality composted products stemming from source separated materials as fertilisers to be used according to normal agronomic practises
- allow the use of compost stemming form MSW (and most sludges, except the best ones, suitable for production of high-quality composted products) in land reclamation projects; consider that these projects ask for higher compost loads; allow those loads as in these projects compost is used not repeatedly ("one-off" applications) and sites are bound to be used only for landscaping and forestry (no food crops).

The EC Directive 99/31 on Landfilling, wants the restwaste to be treated prior to landfilling. Biological treatment is forecast to be an effective tool, and treatment sites are growing by number and overall capacity. In technical regulations related to landfilling, some Member States, including Italy, are choosing a flexible approach to pre-treatment endorsing biological treatment as a suitable way to deal with restwaste, beside thermal treatment. Treatment plants may have different goals:
- Pre-landfilling stabilisation
- Thermal valorisation ("dry stabilate" method)
- Use in land reclamation

Regulations to be issued should take into account that mixed MSW compost (also known as SOF, "Stabilised Organic Fraction") could find an appropriate utilisation in land reclamation. The use of SOF (in land reclamation) should back that of quality compost (in cropping, gardening and nursery) to meet the huge need for organic matter, that is a main feature of the Mediterranean agronomic conditions. We are well aware that:

- defining the use in land reclamation on a sound scientific basis and
- keeping separated roles and goals for quality composting and SOF production

will be some major challenges in next future.

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SESSION II

An assessment of effective, optimised schemes for source separation of organiaste in Mediterranean Districts

(Enzo Favonio Gruppo di Studio sul Compostaggio e la Gestione Integrata dei Rifiuti, Scuola Agraria del Parco di Monza and Francesc Giró i Fontanals, Generalitat de Catalunya, Junta de Residus)

Abstract

Recent legislation in some Mediterranean Countries and Districts has given a strong impulse to the renewal of waste management systems on the whole. The European Union's landfill directive provides a further incentive to divert biodegradable materials from the municipal solid waste. Backed by information stemming from a pretty important number of schemes currently on place above all in Italy, but also in Spain and France, this Document explores the issues involved in developing an effective and cost-competitive waste management system which incorporates separate collection of organic wastes by households. Details on tools to cut costs down are also shown. The outcomes of the survey and further evaluations hold valid also for other situations, and in particular for other Mediterranean Countries.

Source Separation Of Organic Waste In Mediterranean Countries: An Overlook

Source separation, and namely that of food waste, has recently undergone a huge growth in Mediterranean Countries, and above all in Italy and some Spanish districts.

In Italy, the main reason for that has been the issuing of the National Waste Management Law (Decree 22/97, also known as the "Ronchi Decree")
The decree clearly points out that:

- waste reduction and material recovery, re-use and recycling must be preferred to energy recovery and landfilling (which is seen as last resort)
- specific recycling targets (for each Province) are set at:
  - 15 per cent by March 1999
  - 25 per cent by March 2001
  - 35 per cent by March 2003
- landfilling is allowed only for non-recyclable or treated materials (since July 2001)
- waste collection must be organised according to efficiency, effectiveness and cost-optimisation

In order to achieve the recycling targets, source separation in Italy is now undergoing an impressive growth. Attention is focusing particularly on the predominant waste fractions (such as paper and compostable organic waste). Although source separation of organic waste (kitchen and garden waste) is not compulsory, it is becoming the real back-bone of the waste management system, yielding (particularly when operated with door-to-door systems, also worded as "doorstep" or "curbside" schemes) recycling rates as high as 20 – 40 per cent on its own. The overall recycling rate can thus reach as high as 50-60% in single Municipalities (up to 75-80% in tiny ones). Those Provinces where the system has already undergone a wide development, have already met on the whole recycling rates as high as 45% (table 1: the average in wide Districts is of course below top results in single Municipalities, as it takes into account those Municipalities where the system hasn't been implemented yet).

Table 1: Recycling rates in some Provinces in Northern Italy

PROVINCE	Recycling rate % out of total MSW
Bergamo	44,4
Cremona	35,1
Lecco	45,6
Lodi	34,0
Milano	37,6
Milano (without Milan town)	46,1

In general, the intensive collection of dry recyclables alone (paper, glass, metal and plastic) cannot allow municipalities to meet the 35 per cent recycling goal for 2003. Accordingly, most regions and provinces now plan to promote source separation of food and yard waste from households and big producers (restaurants, canteens, greengrocers, etc).

By January 1999, some 600 municipalities were already running separate collection schemes for food waste. The number is steadily growing and it is likely to have overcome 1000 Municipalities to date, including highly-urbanised areas (e.g. Turin town, with some 500.000 inhabitants involved; highly populated Municipalities in Milan Metropolitan area).

Thanks to the growing number of schemes being put in place, it is possible to assess the effectiveness of these systems, in terms of:
- quantitative effectiveness. This feature is expressed as specific capture (in grams per person per day or kilograms per person per year)
- purity of the fraction collected (table 1).
- costs of the systems and tools to cut them down.

Composting is under a fast development also in Spain. The start up of pilot schemes for source segregation of "basura orgánica" (also worded as FORM or FORSU, organic fraction of Municipal Waste) dates back to some years ago and has been developed in many Spanish Districts, both rural and urban; among these latter, an outstanding scheme – if we refer to the population covered - has already long been run in Cordoba (some 300.000 inhabitants).
Nonetheless, if we consider schemes for source segregation, Catalunya is undoubtedly becoming the leading situation, in Spain. The Catalan development takes it steps from a Regional Law (Law 6/93) setting out compulsory programs for the source segregation of organic waste in all Municipalities with a population over 5000 inhabitants. This mandate affects 158 municipalities with a population of 5.3 million inhabitants, or nearly 90% of Catalunya's population. The remaining Municipalities, those with populations under 5,000 inhabitants, are not required to comply, although they may participate - and many are doing so - on a voluntary basis.
As per November 2000, 72 Municipalities in Catalunya were reported to source separate biowaste, for an overall population of some 640.000 inhabitants (see also table 2); in the Barcelona Metropolitan Area itself, they were 21 out of 33, covering 150.000 inhabtants with a forecast development to 300.000 inhabitants within the end of year 2000.
Catalan schemes were based, till a few months ago, on collection of organic waste by means of road containers, as it had been previously done in other Spanish districts. Lately – on the spur of effective outcomes reported in Northern Italy - doorstep schemes have been introduced and developed in 3 Municipalities (Tona, Tiana, Riudecanyes) with sharply different and better outcomes, thus outlining new perspectives in growth and optimisation of strategies for composting.
As for recycling rates, these are showing to be impressively higher where doorstep schemes are put in place than in traditional schemes (figure 1).

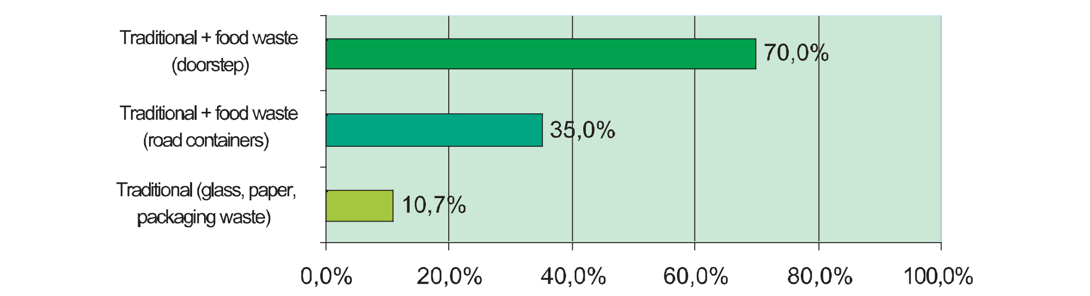

Figure 1: Average recycling rates stemming from different source separation schemes in Catalan Municipalities

Also specific captures (directly related to recycling rates) and purity show sharply different and positive trends in doorstep schemes (table 2).

These numbers are showing once again, as already shown since a long time on a broader scale in Italy, the different and much better outcomes that doorstep collection of food waste can yield. Having stressed the higher contribution of food waste to top recycling targets met in doorstep schemes, we still have to consider implications of its higher captures on the side of collection methods for restwaste, its simplified features and cost-optimisation. This can actually lead to optimised and cost-competitive schemes, as it will be shown.

Table 2: Specific capture and purity in schemes for source segregation of food waste in Catalunya. Schemes where a doorstep collection is on place are highlighted

Municipalities / schemes	Performances of source sepratаion schemes for food waste	
	Quantity (g / inhabitant . day)	Quality (% impurities w/w)
Torrelles de Llobregat	139	1,8
Molins de Rei	116	2,1
Baix Camp	175	5,2
Igualada	125	3,8
Castelldefels	292	7,2
Castelldefels (March 2000)		4,5
Gavà	223	4,7
Viladecans	128	2,8
Viladecans		3,6
Castellbisbal	254	2,1
Vilanova i la Geltrú	239	---
Sant Cugat del Vallès (April 2000)	213	2,6
Barcelona (Major de Gràcia)	52	18,7
Barcelona (Gracia Comercial) (January 2000)		5,7
Barcelona (38 markets) (January 2000)		3,7
Tona (October 2000)	265	0,9
Tiana (August 2000)	285	4,0
Riudecanyes (October 2000)	298	1,9
AVERAGE road container	177	4,9
AVERAGE doorstep	283	2,3

Source: update on Giró, 2000

The Quality Of Source Separated Organic Waste

Efficiency of collection schemes must also be considered under the point of view of the quality of collected organic waste, that affects its suitability to produce a high-quality composted product.

Numbers already shown on performances of Catalan Municipalities suggest that doorstep schemes allow a higher purity of collected food waste. This is easily understandable as road containers cannot perform an easy and effective control on behaviour of single households; thus the outcomes get negatively affected by wrong deliveries.

Here some numbers are shown stemming from surveys led in Italy

Table 3: Purity (at sorting analysis) of collected food waste in Italy (sources: Provincia di Milano, 1998; Favoino, 1999; Bigliardi, 1998)

Municipality/Area	Inhabitants	Compostable materials (percent weight)
Milan Province 17 municipalities	493.673	97.28
Monza Municipality	119.187	97.4
Area 'Padova 1' 26 municipalities	203.429	98.7
Modena Province Nonantola municipality	11.127	99.79

As Table 3 shows, random analyses of food waste, indicate the excellent quality of organic material collected in doorstep schemes. In fact usually the percentage of compostable materials inside food waste collected ranges between 97 and 99 per cent. This result is to be compared to the 95 per cent purity (5 per cent of rejects) meant to be the 'excellence' level to have high quality composted products without affording expensive pre-sorting and final refining technologies in the composting plants. This is what happens in some Central European Countries (Germany and Austria) where the purity of the material collected often varies between 93 - 98 per cent.

Good performances (as to purity and capture) of the collection of food waste in Italy and Catalunya is likely to be related to the specific features of the collection service. Among these features, the use of watertight, transparent bags (usually biodegradable) for the first delivery of the food scraps, is much appreciated by the households as a comfortable tool; this enhances "awareness" of households and their participation in the source separation programs. The watertight nature permits the delivery of most kitchen residues (including wet and/or cooked foodstuffs such as meat and fish scraps), thus reducing the percentage of fermentable waste materials inside residual waste; it strongly helps avoiding leaching and odour emissions in bins and buckets supplied to households. The transparency of the bags is meant to allow an easy quality control of the waste material and define the need for further information to be given to households (e.g. in a particular neighbourhoods).

Purity usually gets much lower (90-95 per cent and even less) where collection systems involve the use of large-volume road containers, without a door-to-door service. Anonymous delivery obviously involves a less aware behaviour by the population. See for instance the numbers referring to road container collection in Catalunya in table 2.

An evolution of the road container system is to be found with locked containers (used for instance in some districts Northern Italian Region Emilia-Romagna). In this case, each household receives a key to open the container. The overall outcome is that only most aware and responsible households will heed the “request for participation”. Purity in these cases can be very high (see Nonantola, Table 2). Nevertheless, the system is negatively affected by a delivery of yard waste much higher than that of food waste; in effect, a big container is an easy tipping site for bulky materials such as yard trimmings; on the contrary the long average distance from home hinders the will of most households to go to the container and deliver most difficult and fermentable items to be dealt with, such as food waste. We’ll dwell further upon this topic later on, in the assessment of tools to reduce collection costs.

In general, it is argued that purity of sorted food waste tends inevitably to get much lower in highly populated areas. Actually, on the contrary, it seems to be much more dependant on the system adopted for collection than on the size of towns. This can been shown through the scheme reported below (figure 2), where, with reference to main surveys led on the purity of source separated food waste (AMIAT, 1999; Provincia di Milano 1998; Favoino, 1999; Bigliardi, 1998; Lazzari, 1998), we have plotted the outcomes of sorting analysis VS. the population dwelling in towns covered by the sorting schemes.

Statistical treatment of numbers yields a very poor relation of purity to demography (R2 = 0,0015), and this is in itself a demonstration of a low dependence of purity on the size of towns running the scheme for source separation. Even at a first glance, it is easy to get aware of the presence of high purity in medium to big towns, beside low purity, sometimes, in a certain number of tiny villages. Once again, one should remark the high influence of the collection scheme, likely to affect purity much more than the urban complexity of the covered area. Though this latter could affect – along with many other factors, e.g. the presence of doorkeepers in high-rise buildings - the possibility to adopt a specific system of collection.

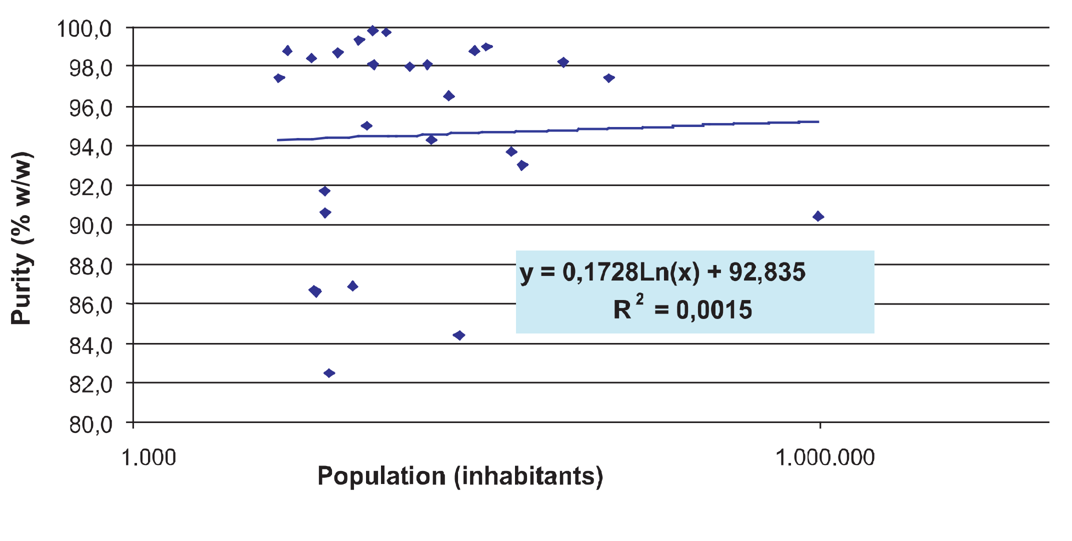

Figure 2: Purity of food waste VS population

"Biowaste", "vgf" and "food waste": relevance of a definition to performances of the waste management system

In Germany, Austria, and Central Europe the fraction targeted by the source separation system is referred to as "Bioabfall" (biowaste), that means a mixture of food scraps and yard waste; in the Netherlands, in Belgium (Flanders) and in many sites in Germany and Austria themselves, the definition "GFT" or "VGF" (vegetable, garden, fruit) is used, addressing a mixture of yard waste and the food waste portion before cooking 115(not including cooked items as pasta, meat, fish…). This choice is due to the troublesome, highly fermentable nature of cooked scraps.

On the other hand, we have to underline that the recycling of dry fractions and packaging materials (paper, glass, plastics, etc…) determines – as an undesired side-effect – the concentration of the fermentable material inside "restwaste", if food stuff is not effectively sorted by means of high-capture systems. This is what actually occurs in those Countries (Germany, Holland, Austria, etc.) even though source separation of biowaste has already gone a long way, there. That means, in those Countries separation of dry recyclables is likely to be more effective than that of food waste. For instance, in the Netherlands and Germany, food waste percentage inside "restwaste" is often reported to be at 40-50% (Wiemer, Kern, 1995; Baden Baden Amt für Umweltschutz, 1996). When transferred to warmer climates – as in the Mediterranean Area – this system would for instance keep the need for frequent collection for restwaste.

Moreover, in central Europe, in the "biobin" (bin provided to households to separate Biowaste) a large proportion of garden waste can be found (up to 80-90%, weight basis, out of the total bin content) in addition to food waste. The delivery of garden waste is much stimulated as households – even in detached houses with gardens – are provided with large-volume bins that allow the delivery of bulky materials as yard waste. This situation can also be detected in most pilot schemes in France (see table 5).

In most situations in Italy and Catalunya, source separation systems for compostable organics are often sharply different since the collection of food waste and that of yard waste are most often kept separated. One collection targets only "food waste" on the whole (including cooked scraps as meat and fish), often referred to as the "wet" fraction, by means of small volume bins and buckets; a different system targets yard waste only.
This distinction between the two collection rounds takes into account:

- the different biochemical and seasonal feature of the food scraps as compared to the yard waste. In Italy – where a door-to-door collection for food waste is adopted, and in contrast with what is generally being done in Central Europe - collection of the garden waste, that does not stink, and does not produce leachate, adopts different schemes and tools as compared to that for food waste. This in turn makes it possible an overall optimisation of the scheme, as "intensive" features of the collection of food waste (high frequencies, watertight bags) do not apply to yard waste, that doesn't need such intensive, expensive collection patterns. It is also possible to make the total bin/vehicles volume fit to the specific production of food waste, that does not show huge seasonal fluctuations as for yard trimmings; vehicles and systems used for yard waste, on the other side, can be seasonally adapted;
- the different bulk density of yard and food waste. In case of yard waste, it compels to use compacting vehicles (packer trucks) while in case of food waste compacting vehicles can be replaced by bulk lorries that are much cheaper at an equivalent working capacity. This is one of the most powerful means to optimise the operational features and cost figures related to source separation systems.

- the troublesome features of food scraps (high putrescence and moisture content). This asks for the application of specific, intensive tools, systems and collection frequencies in order to have the system clean and 'user-friend'; of course, when you let people feel comfortable, you enhance the overall participation. This leads to better quality and higher quantity collected; brings down the percentage of food stuffs inside the restwaste, making it possible to collect it less frequently. In effect, analytical measurements - where a door-to-door collection is adopted - report the content of food stuffs inside Restwaste at an average 15-20% and even less (Provincia di Milano, 1998 b), that is, much lower than in previous source separation programs across Europe.

Nevertheless, "easiness must have a borderline". A comfortable system that does not set any difference between food and yard waste is a system where a huge delivery of garden waste is to be expected. It is noteworthy that in Central Europe it has often been recorded an overall organic waste collection of some 150-200 kg $inh^{-1}y^{-1}$ and more. This is due, above all, to the easiness of delivering yard waste to the collection service (households are allowed to deliver it in the same bins adopted for food waste collection). The general outcome is a high recycling rate, but the overall MSW production figure gets often higher, as well, as deliveries of materials that had been previously home composted gets stimulated. In such situations, it happens to record an overall MSW production of some 600-650 kg $inh^{-1}y^{-1}$. The same has been already recorded in a few situations in Italy with similar collection systems adopted (table 4; Legambiente, 1997; Legambiente, 1998)

Collection schemes for yard trimmings and the importance of programs for home composting

In normal weather and cropping conditions, lawn mowing from public and private areas yield 2 to 6 kg y^{-1} grass clippings per square meter; these are roughly doubled by trees and brush pruning and leaves. The average (per person) recovery rate of garden waste collected in Italy (in those areas where the systems are well established) is often 30-70 kg inh^{-1} y^{-1}. Where garden waste is collected together with kitchen waste (in a single bin as for instance in Central European collection models), it is usual to see collection rates as high as 150 and more kg $inh^{-1}y^{-1}$ (table 4). We have already underlined that such a situation makes recycling rates rise, but also increases the overall quantity of waste to be collected and treated.

A similar assessment actually stems from the evaluation of features and performancs of pilot schemes nowadays being run in France. As a matter of fact, most of them (table 5) are based on the supply of medium-volume trolley bins also to single families in detached houses with gardens; this in Districts with a high presence of gardens leads in turn to very high deliveries of yard waste in the bins (see reported percentages of yard waste inside collected biowaste). The situation sharply improves - under this standpoint – where low-volume tools get used (e.g. little buckets).

Table 4: specific captures of yard waste in 1998 (Source: Legambiente, 1999)

Municipality	Yard waste $Kg.inh^{-1}.y^{-1}$
Forte dei Marmi	462,7
Pietrasanta	237,1
Sirtori	227,2
Seravezza	200,3
Lierna	172,3
Arese	120,5
Monticello Brianza	113,6
Rovello Porro	111,9
Burago di Molgora	108,4
San Rocco al Porto	102,5

Therefore, efforts have to be made to find suitable systems that enable high recycling rates, without implying a high delivery of yard waste and a related increase in the overall MSW collection. It is important to note that "where there are yard trimmings, there is a garden in which home composting could be performed". Our purpose is then to adopt a collection system which does not excessively promote the easiness for the households to 'get rid of yard trimmings'; nevertheless, we have to ensure the collection of yard waste by those households who have not time or conditions to run a backyard composting experience. Therefore it would be recommendable, that the collection of garden waste be kept separated from the collection of kitchen waste, as it actually happens most times in Italy and Catalunya.

The collection of yard waste should then be run through direct delivery at Civic Amenity Sites ("Piattaforme Ecologiche" in Italy, "Deixallerias" in Catalunya); in order to help people who find it troublesome to go to Civic Amenity Sites (for instance due to lack of space in their car, or whatever the problem) a door-to-door collection can be run, with a specific round ('green circuit') and a much lower frequency of collection as compared to kitchen waste (i.e. fortnightly to monthly).

We want to stress once again that a distinct collection rout for yard waste enables waste managers to plan and run a system:

- that does not involve seasonal fluctuations for the collection of food waste (that asks for much more intensive and expensive conditions)
- that is kept separated from the specific collection systems for food waste, that are fermentable, wet and with higher bulk density
- with a pretty low collection and disposal cost for the yard waste itself, thanks to simplified collection and cheaper tipping fees by composting plants
- that makes it possible to enhance home composting; as households are not provided with a specific bin, they seldom find it too easy to deliver their yard waste to the collection service, and get rather stimulated to try backyard composting, sooner or later.

Needs and tools for the collection of food waste

Running source separation for food waste, above all by households, means to find out the best way to face the specific troublesome features of such a material: its fermentable nature and its high moisture content. In this respect, a comfortable feature of the service, where households are provided with tools to avoid nuisance, will result in an enhanced participation and will thus determine higher collection quantity/quality (Favoino, 1999).
In Italy, the answer to this problematic issue – above all where a "door-to-door" collection system is adopted – has been, tipically:

- a relatively "intensive" collection schedule as compared to Countries in Central Europe; two to four times a week, seldom once weekly during wintertime in Northern Italy; it has to be noted that in Southern Italy, as in Spain, Portugal, etc. collection for mixed MSW is traditionally scheduled up to 5-6 times a week due to weather conditions; in Northern Italy the collection for MSW is usually 3 times a week
- the use, in most cases, of "door to door" collection systems so as to have them more "user-friend" and enhance the participation rate
- the use of watertight, transparent tools to hold the waste ("Biobags")

Table 5: Features and main performances of pilot French schemes for source separation of biowaste ("biodechets")

Scheme	Covered population	Biodechets Kg/ inhab.yr	Reported % of single family dwellings	Reported of yard waste inside Biowaste	% Type of tool
District des trois Frontieres	24.000	153	80	80	Trolley bins 120-240-340
District des Sud Bassin	30.500	159	88	95	Trolley bins 140-260
SITCOM Coté Sud des Landes	5.360		92		Trolley bins 240 + paper bags 15l
Communauté d'Agglomeration d'Agen	1.500		100		Trolley bins 240, a few 120-180
SITCOM Nord-Allier	2.800	221	100	75	Trolley bins 120-240
SIVOM du Pont Fort de Saint Lò	13.100	178	100	75	Trolley bins 120-240
SITCOM de Buxy-Saint Gengoux-le-National	2.720	136	97	65	Trolley bins 120-240
Communauté Urbaine de Creusot Montceau	70.000	89	80	0	plastic bags 20 l
Communauté de Communes					
de la Region de Guegnon	9.897	72	85	98	plastic bags 50 - 100 l
SITCOM de la Region de Rambouillet	29.000	70	100	87	Double-compart trolley bins 180-260-340 l
SAN de Cergy-Pontoise	25.800	87	100	90	Trolley bins 140 l, bags 80 l
Ville de Beziers	3.000	67	100	75	Trolley bins 120-240
SITCOM de l'Ouest Audoi SYDOM de l'Aude	2.681	28	100	10	Trolley bins 330-660 l, buckets with biodegradable bags
SYNTOMA	2.380	64	100	20	buckets 10 - 35 l
SIVOM de Coursan Narbonne Rural	4.008	107	100		Containers 660 l, buckets 15 l
Communauté de Communes du Bassin de Pompey	9.000	93	83	70	Trolley bins 120 l
SISOV	1.118	138	95	70	Trolley bins 120-240
SIVOM de Bapaume	23.667	211	100	70	Trolley bins 120 l
SIRFAG SIRDCGUTOM	57.326	155	91	80	Trolley bins 120-240
Lillé Metropole Commonauté Urbaine	233.629	94	100	85	Double-compart trolley bins 180-260 l
SIRTOM du Laonnois	3.830	0	72		Trolley bins 120-240
Communauté de Communes de la Vallée de l'Oise	100	90	99	10	Bins 35 l
Communauté de Communes de la Region de la Villedieu du Clain	13.000	46	100		Aerated trolley bins 120 l
Communauté de Communes du Pays Santon	2.000	155	100		Trolley bins 120-240
Ville de Niort	32.271	140	65	90	Trolley bins 120-240
Communauté de Communes des Duyes et Bléone	270	30	100	5	Trolley bins 120 l
Communauté de Communes du Canton de Clelles	1.460	178	100	35	Trolley bins 120-240

The use of the bags:

- substantially prevents pest attraction (insects) and leachate production and keeps the bins clean. This, in turn, makes it possible to cut down the frequency for washing rounds. Actually, in many cases, bins are considered a "personal" equipment and are washed by households themselves but for a few washing rounds in the warm season supplied by the waste collection service.
- Avoids nuisances generally related to delivery of "loose" material inside the bin, makes it possible to collect even meat and fish scraps along with vegetables and fruit residues.
- Increases captures that, in turn, allow a significant reduction in collection frequency for "restwaste"
- the small bag size prevents the delivery of bulky materials (e.g. bottles, cans), allowing higher biowaste purity.

The 'bio-bag' is placed:

- directly on the roadside on the collection day, usually inside the family small bin (6.5 to 10 litres) or inside "buckets" (20 to 30 litres). This system is often under adoption in small towns and villages to reduce the pick-up time for each dwelling (loading is manual) and to prevent households from delivering garden waste inside the bins
- or in a bigger bin whose capacity usually ranges from 80 to 240 litres for 10 to 20 families depending on the collection frequency. This system is under adoption where households dwell in flats in high-rise buildings.

Cost analysis: a proposal

One of the major concerns in Mediterranean Countries – as it is actually throughout Europe - is the lack of cost-competitiveness of source separation system with high recycling rates as compared to the traditional mixed MSW collection. Operators in general think that sorting food waste leads to higher costs of the overall collection scheme.

Hence, it is useful to analyse main source separation systems currently in operation. Cost analyses carried out so far have usually expressed the costs per kilogram (or per ton) for a single waste material collected. However, there is evidence that this distorts the true picture, because the more the waste collected, the lower the costs of the collection service per kg. This distortion hides some important outcomes of integrated source separation and waste management:

- the reduction of total waste delivered as a consequence of effective waste reduction policies
- the contribution of home composting programs to the overall reduction of organic waste collected

Furthermore, the evaluation of a single waste flow, does not allow one to compare advantages to collection costs for other materials, flowing from operational integration. In effect, the collection of food waste allows important changes in the collection scheme of other waste materials, by reducing, above all, collection frequencies for residual waste ("restwaste").

Moreover, it has to be stressed that the cost of the system (collection plus transport) is not paid for according to the amount of the waste collected, but to the general operational scheme (the number and frequency of collection rounds, the number of workers, vehicles, pick-up points, etc). It is therefore incorrect to express the cost of this service per unit mass, rather it should be expressed as cost per person. This permits a fair comparison of the competitiveness of different systems covering a different population (in terms of cost, quantity and quality of materials recycled).

An overview of collection costs

In order to allow a comparison among different collection systems, our Research Group on Composting and Integrated Waste Management at Scuola Agraria del Parco di Monza led a survey on the costs of different collection systems in Italy.

The three systems might be described as follows:

- traditional source separation, based on the use of plastic bags or road containers (up to 3.3 m^3) for mixed MSW and source separation through road containers only for dry recyclables (paper, glass, plastics). The food waste is not sorted and it's delivered along with the mixed waste; this holds pretty fermentable (actually, food waste gets concentrated in it due to the withdrawal of paper, board, glass, plastics) and has to be collected frequently.
- intensive source separation, including that of food waste, based on road containers (up to 3.3 m^3) both for food waste and dry recyclables; collection of the residual waste through road containers. This is usually referred to as the 'double container' collection (beside that for residual waste, households find the one for food waste).
- intensive source separations, including that of food waste, with door-to-door (DtD) collection for food waste and residual waste. In general, also some high-yield dry recyclables are collected with a DtD system (usually paper and board, due to the much higher capture per person than with road containers).

Outcomes of the survey follow.

Traditional collection systems

Table 6 reports on the costs of such a collection. The data shows that the total waste management costs (including disposal) fluctuate widely because of the different disposal fees charged in different regions. Therefore, in order to evaluate the competitiveness and draw reliable conclusions it is necessary to focus on collection and transport costs, disregarding disposal costs, at least until the National and European Regulations (e.g. the lately issued EC landfill Directive) will affect evenly the cost of disposal in different sites.

The results also indicate once again that data expressed in cost per unit mass (ITL/kg, with 1 Euro = some 2000 ITL) penalise municipalities with less waste production. The average collection and transport costs of the three municipalities with waste arisings below 350 kg.person-1year-1 is ITL 253/kg, while municipalities with more than 500 kg.person-1year-1 have costs of ITL 134/ kg. But in absolute terms, these must dispose of more waste; overall waste collection costs tends to be higher. The per capita cost collection + transport (without disposal) averages some ITL 66.000.

Table 6: Municipalities with a 'traditional' source separation system only for dry recyclables

Municipality/ District	Population	Average annual MSW production (kg/inh)	Collection + transport cost (ITL/inh. year)	Disposal cost (ITL/inh. year)	Total cost (ITL/inh. year)	Collection + transport cost (ITL/kg)	Total cost (ITL/kg)
VE 4 District (3 municipalities)	n.a.	408	62.157	46.286	108.443	152	266
TV Cons. Priula (3 municipalities)	36.575	412	45.064	54.203	99.267	109	241
VR province (38 municipalities)	n.a.	439	61.090	51.287	112.377	139	256
VR town	254.000	470	n.a.	n.a.	159.123	n.a.	339
Caravaggio (BG)	14.180	453	112.065	75.609	187.674	247	414
BG province (3 municipalities)	8.224	536	63.405	96.095	159.499	118	298
Cinisello B. (MI)	78.000	n.a.	59.751	n.a.	n.a.	n.a.	n.a.
Pescara	122.236	436	73.743	48.006	121.749	169	279
Cepagatti (PS)	7.870	478	65.082	51.970	117.052	136	245
Popoli (PS)	5.855	443	44.309	18.043	62.352	100	141
Vasto (CH)	5.000	409	45.000	n.a.	n.a.	110	n.a.
Cupello (CH)	3.500	275	63.000	n.a.	n.a.	229	n.a.
Macerata	41.936	407	63.338	40.101	103.439	156	254
Termoli (CB)	30.100	520	65.620	18.765	84.385	126	162
Campobasso	51.518	412	79.310	34.532	113.842	193	277
Alghero (SS)	40.477	508	104.726	54.352	159.078	206	313
Quartu (CA)	61.500	505	87.138	46.732	133.870	172	265
Guspini (CA)	13.400	349	45.522	20.896	66.418	130	190
Montagnareale (ME)	1.800	194	52.633	9.779	62.412	271	321
Librizzi (ME)	2.020	379	73.855	12.376	86.231	195	227
S. Piero Patti (ME)	3.664	396	62.901	15.881	78.782	159	199
AVERAGE		421	66.485	41.272	112.373	156	261

NOTE: the average of the sums (average total cost) doesn't match with the sum of average values (average collection and transport + average disposal cost), as they are slightly affected by data not available.

Collection systems with source separation of food waste

As mentioned above, these systems can be grouped into two categories:
- door to door (DtD) - or "doorstep" - collection systems
- road collection systems

The study focused on mature experiences (run for at least two years), mainly concentrated in Northern Italy. Tables 7 and 8 summarise the costs of the service. As previously noted, what matters is the average cost for collection + transport per person; we have highlighted it in both tables with a bigger letter body.
The results also indicate that collection schemes based on the use of road containers (whether for mixed MSW or separate food waste) show a higher specific waste production than schemes where small waste bins and buckets are given to single households (DtD collection). Many other surveys are focusing now on this trend – mainly due to tipping of industrial waste inside road containers - that has been corroborated by many more numbers (Tornavacca, Favoino, 2000).

Table 7: Systems with source separation of food waste by means of road containers

Municipality/ District	Population	Average annual MSW production (kg/inh)	Collection + transport cost (ITL/inh. year)	Disposal cost (ITL/inh. year)	Total cost (ITL/inh. year)	Collection + transport cost (ITL/kg)	Total cost (ITL/kg)
VE 4 District (6 Municipalities)	n.a.	445	54.417	44.060	98.477	122	221
VR Province (7 Municipalities)	41.167	447	66.407	47.369	113.776	149	255
AVERAGE		446	60.367	45.714	106.126	135	238

Table 8: Systems with DtD separation for food waste

Municipality/ District	Population	Average annual MSW production (kg/inh)	Collection + transport cost (ITL/inh. year)	Disposal cost (ITL/inh. year)	Total cost (ITL/inh. year)	Collection + transport cost (ITL/kg)	Total cost (ITL/kg)
VE 4 District (4 Municipalities)	n.a.	321	53.733	31.558	85.291	167	266
VR Province (7 Municipalities)	63.697	310	61.389	25.013	86.402	198	279
PD 1 Bacin (26 Municipalities)	206.000	322	52.500	25.182	77.682	163	241
Province Bergamo (7 Municipalities)	20.013	n.a.	45.821	62.954	108.775	n.a.	n.a.
Calcio (BG)	4.765	393	31.266	61.032	92.298	80	235
Caravaggio (BG)	14.181	n.a.	38.079	n.a.	n.a.	n.a.	n.a.
Cinisello B.. (MI)	78.000	422	55.620	n.a.	n.a.	124	n.a.
Treviglio (MI)	25.294	457	n.a.	n.a.	158.310	n.a.	346
Cameri (NO)	9.567	382	n.a.	n.a.	83.521	n.a.	219
Castiglione (LO)	4.691	234	48.658	n.a.	n.a.	208	n.a.
Cupello (CH)	3.500	275	52.000	n.a.	n.a.	189	n.a.
AVERAGE		346	48.401	41.148	98.897	161	264

The traditional collection systems based on separation of dry recyclables by means of road containers (table 6) surprisingly shows a higher cost per inhabitant than systems with a source segregation of food waste; this is partly due to higher collection frequencies in Southern Italy (up to 6 times weekly) that affect average costs in table 6, as many case studies from Southern Italy are included, there. But the most surprising outlet is that the average collection and transport costs (per person per year) tends to be lower in schemes where source segregation of food waste uses doorsteps systems, than where road containers are used; this goes against what is generally expected, due to the much higher number of pick-up points in doorstep schemes.

Cost comparison in homogeneous areas

One might think that lower costs of the DtD systems are due to the relatively small number of councils examined; and this could in turn be important in the evaluation of specific features related to weather conditions (e.g. more frequent collection or bin washing), type of dwelling etc.

Therefore, in order to get further evidence, costs of different collection systems run in the same area have been evaluated. Data from district "VE4", close to Venice (Figure 3), also show that source segregation of food waste with DtD schemes can be run with no substantial increase in overall cost, and sometimes costs are even lower than with traditional collection (no segregation of food waste) or with food waste segregation by means of road containers.

To understand the unexpected outcomes of the survey, we must underline that if source separation of food waste is added to, with no modification in the previous scheme for MSW collection, total costs are bound to rise; this actually happens with food waste segeregation by means of road containers. But this does not happen when food collection is integrated into the overall collection scheme: namely, when DtD schemes are implemented.

The trick is that intensive DtD schemes for food waste yield high captures. This brings down the percentage of food waste in the residual waste, which can then be collected less frequently. Furthermore, food waste on its own needs no compaction – letting operators use cheaper collection vehicles.

Tools to optimise costs

Collection frequency for residual waste

Obviously collection frequencies for residual waste can be cut only when an effective separation of foodstuffs, yielding high quantities is run. Under such a viewpoint we have to mention (See Table 9) that DtD schemes enable much higher performances. Some 170-250 grams per person per day have been reported for food waste. Large road containers yield much lower quantities; well, their capture is sometimes similar, but a high percentage of yard waste contributes, and actual capture of food waste is low.

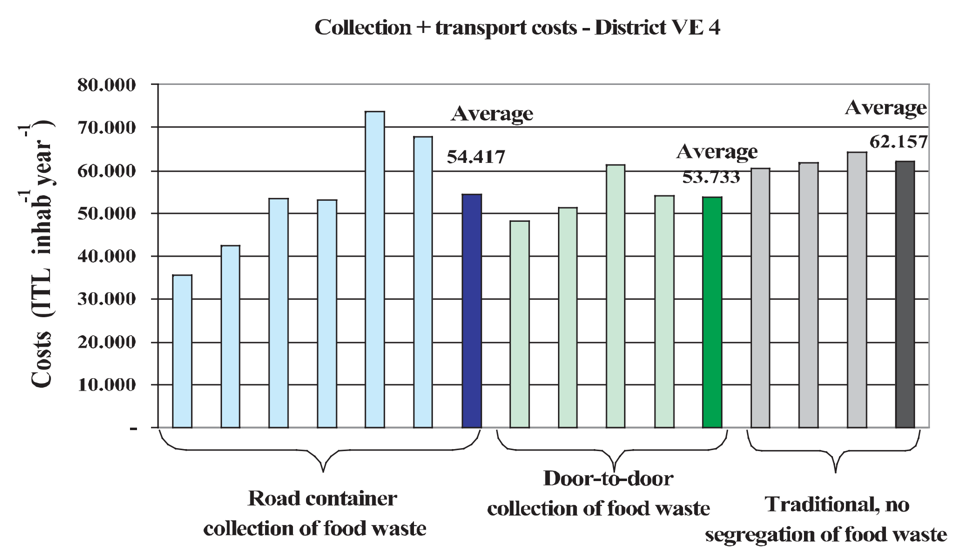

Figure 3: Cost comparison (ITL.inhab-1.year-1) for different collection schemes in a single District

Table 9: Performances of different collection schemes for biowaste in Italy

System	Overall yield (typical)	Yard waste %	Yield: food waste
Door–to-door	170-250 $g.inhab^{-1}day^{-1}$	0% (where delivery is banned) –10 % (maximum, due to low available volumes)	160-220 $g.inhab^{-1}day^{-1}$
Road containers	150-200 $g.inhab^{-1}day^{-1}$	40-70% (seasonal)	60-120 $g.inhab^{-1}day^{-1}$

Sources: Favoino, 1999; Provincia di Milano, 1998; Cocchi, 1997

We could assume that "collection using road containers results in a lower participation rate".

Cutting down collection frequencies for residual waste constitutes in itself one of the most important tools to optimise schemes for source segregation of food waste. Its use is particularly effective in those areas where high collection frequencies are in place for traditional, mixed MSW collection (above all Southern Europe).

Diversifying the fleet of collection vehicles

Where DtD schemes for food waste is in place using small bags, to be then delivered in bins (for high-rise buildings) and small buckets (for single families in houses with gardens), a material with a high bulk density (0.5-0.7 kg.litre-1) is targeted, which can be collected using non-compacting vehicles.

These are suitable only when schemes effectively prevent delivery of yard waste along with food waste. So it is advisable to limit the size of containers supplied to households where gardens are available (6-10 litres for a single family; up to 30 litres for groups of 3-4 families); bins (80-240 litres) have to be supplied only to high-rise buildings.

Households can manage yard waste through:
- home composting, promoted effectively by the municipality
- delivery to local recycling centres (Civic Amenity Sites, frequently named "Piattaforme Ecologiche" or "Ecocentri" in Italy, "Deixallerias" in Catalunya)
- DtD garden waste collection with low frequencies (e.g. 1-2 times per month, only in the growing season, in general April through October).

An evaluation of mature and optimised schemes

We have to underline once more that with a cost assessment in cost per kg, the comparison would not be fair to evaluate the collection of food waste. This is because the quantity collected is obviously lower than that of residual waste (60-80 kg per person per year, versus 100-200 kg per person per year); but this latter (residual waste, also referred to as "restwaste") gets collected at a much lower cost than with traditional mixed collection, thus the overall cost of the integrated sorting scheme is similar or lower.

An effective segregation of food waste allows an overall number of collection shifts (for different waste fractions) that tends to equal the previous schedule (for mixed collection). For example, one can collect food waste twice weekly and residual waste once per week in Northern Italy - where mixed MSW collection used to be run three times per week.

The following scheme shows typical collection frequencies for mixed MSW collection and for "integrated" collection systems that sort food waste in Italy. Frequencies applied in Southern Italy could perfectly work in many Spanish situations, as well, where mixed collection is traditionally run 6 times weekly.

Frequencies for the collection of:				
AREA	Mixed MSW	Food waste (both with DtD schemes and road containers)	Restwaste in DtD schemes (frequencies cut down, thanks to high capture of food waste)	Restwaste in road container schemes (no difference from previous mixed collection)
Northern Italy	3 times weekly	2 times weekly (sometimes once weekly during wintertime)<	1-2 times weekly	3 times weekly
Southern Italy	6 times weekly	3-4 times weekly	2-3 times weekly	6 times weekly

Also schemes run in Spain (above all in the Catalan situation where the strategy is being fully developed and can thus well be said to be pretty "mature"), show same trends in the comparative assessment of doorstep schemes and schemes with road containers:

Frequencies for the collection of:				
AREA	Mixed MSW	Food waste (both with DtD schemes and road containers)	Restwaste in DtD schemes (frequencies cut down, thanks to high capture of food waste)	Restwaste in road container schemes (no difference from previous mixed collection)
Medium to big towns [29]	Daily	6-7 times weekly	No example to date	3 times weekly
Small towns[30]	3-4 times weekly (up to 6 times weekly)	3-4 times weekly (up to 6 times weekly)	1-2 times weekly[31]	3 to 6 times weekly

Furthermore we could say that some collection shifts – namely those aimed at collecting food waste - will have costs reduced through the use of tiny vehicles. In our surveys, we calculated and found out that a two-shift scheme for food waste collection using bulk lorries tends to equal the cost of a single-shift collection for residual waste with packer trucks.

Table 10: Costs of collection routes ($ITL.inhab^{-1}.year^{-1}$) for food waste and restwaste in Door-to-door schemes

Municipality (Province)	Population (inhabitants)	Cost for collection of food waste (once per week, with compactors)	Cost for collection of Restwaste (twice per week, with lorries)
Calcio (BG)	4.765	9.956	8.143
Caravaggio (BG)	14.181	10.578	11.635
Consorzio Cremasco (CR)	63.751	17.000	16.000
Sommacampagna e Sona (VR)	26.036	14.100	17.195

[29] Information from Cordoba and Barcelona was available
[30] Catalan schemes
[31] Tona, Tiana and Riudecanyes in Catalunya

This is due to two main reasons:

1. the lower cost of use of tiny lorries instead of packer trucks
2. the possibility to have a much faster specific loading time where food waste is not mixed up with yard waste, and therefore low-volume, hand-picked tiny buckets request a much faster time for each pick-up point. Mechanical loading will of course still be kept for trolley bins supplied to high-rise buildings and big producers, but there the longer specific loading time is meant to serve many families and/or high quantities at a single pick-up.

Cost evaluation is for instance confirmed, as we consider numbers reported for Consorzio Cremasco and some municipalities in Bergamo and Verona Provinces (table 10). Amazingly enough, the cost of twice weekly collection for food waste (using non-compacting vehicles) is comparable to a weekly collection of residual waste with compacting vehicles.

Conclusions

According to the numbers shown, it is clear that the main mistake made when planning sorting schemes, is the added feature of the scheme. That means, a new collection scheme is run in addition to the previous mixed MSW collection, and cannot therefore yield savings to fund a new scheme. It is vital – on the contrary – that the new separate collection is integrated into the established waste management system, e.g. changing frequencies and volumes to collect residual waste.

In turn, we have to consider that collection frequencies of Restwaste can be cut only where a high capture of food waste reduces the fermentability of Restwaste. From such a standpoint, the use of comfortable tools such as door-to-door schemes and biodegradable bags have proven to be very effective. This is why an "intensive" collection, run through door-to-door schemes, notwithstanding a much higher number of pick-up points, has unexpectedly shown to be less expensive than collection of food waste through road containers, thanks to the integration of the system and much lower collection costs for restwaste.

Moreover, door-to-door collection of food waste allows Municipalities to perform much higher recycling rates (topping even 60% and more in Municipalities with around 10.000 inhabitants, 50% in Monza, 120.000 inhabitants) and a much better quality of collected food waste.

A further tool to optimise the scheme is the use of suitable vehicles to collect food waste, due to its high bulk density when yard waste is kept away from the collection scheme. One of main lessons to be learned from these astonishing outcomes is that "the more flexible and varied the fleet of collection trucks, the better it is". This goes against some tendencies that we have unfortunately recorded across Europe (and in some Italian and Spanish Regions themselves), where huge expenditures have lately been done to buy only packer trucks for side-loading road containers. This is fighting against optimised schemes for high-yielding collection of food waste; the lack of flexibility doesn't allow optimisation at all.

In such respect, we also have to consider the troublesome situation regarding smaller municipalities with direct responsibility for MSW collection (a situation still much diffused in Mediterranean Districts), as they often own a single collection truck, that constitutes a problem when planning changes and "integration" of the system. Nevertheless, higher institutional levels (e.g. the Districts or Provinces), can help. They could, for instance, buy appropriate vehicles and lend, or lease them to single municipalities. Such a system is already being run in two provinces in Central Italy (Chieti and Pescara).

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Success Stories on Composting and Separate Collection. Only a Question of Luck?

(Simon Aumonier Environmental Resources Management Oxford)

Introduction

In 1999, the Directorate General for the Environment of the European Commission commissioned a study into success stories on composting and separate collection. The objectives of the study were to provide information to local authorities across Member States to assist in introducing cost-effective home composting and biodegradable waste-separation schemes. The dissemination of information from successful separation and home composting schemes will help other local authorities and municipalities meet the diversion targets for landfill.

This presentation is structured as follows. I will firstly describe some background to the project, including the drivers for composting and separate collection. I will then outline the structure and approach to the study and what key success factors have been identified. I will finish with conclusions on whether composting and separate collection really is just a 'question of luck'.

Key Drivers for Composting and Separate Collection

The European Community waste strategy sets out the 'Waste Hierarchy' for waste management options. The top of the hierarchy, or the preferred waste management option, is the minimisation of waste at source. This is followed by material or waste reuse, recycling, energy recovery and finally waste disposal. In some European Countries, a substantial proportion of waste is landfilled and it is necessary to move up the hierarchy to more sustainable waste management practices.

The Landfill Directive was introduced in 1999. It has two broad aims: firstly, to ensure high standards for the disposal of waste in the European Union and secondly, to stimulate more sustainable waste management practices. It specifically includes provisions to reduce the volumes of biodegradable waste which is sent to landfill. Biodegradable waste which is landfilled causes environmental damage as it decomposes by releasing landfill gas, containing methane, and leachate.

A key driver for increasing composting is the avoided waste disposal costs which are incurred when waste is landfilled. Increasing public awareness of waste and recycling issues is resulting in an increase in public demand for more composting facilities and services. Public acceptability for composting schemes is high compared to other technologies such as incineration or landfilling of waste.

A key driver for separate collection is that clean feedstock material produces high quality compost products. Although the biodegradable fraction of waste can be extracted from mixed waste this is expensive and produces a lower quality feedstock material for the composting process.

Constraints to Separate Collection

There are a number of issues which constrain the ability to collect biodegradable waste separately. The public need to be involved and need to be motivated to separate their waste in the home. Overcoming inertia is a constraint which needs to be overcome at the beginning of any scheme and maintaining levels of public participation is fundamental to the success of any separate collection schemes. Other issue are outlined below.

Waste Management Industry Failure. The waste management industry needs to be ready to adapt to the new challenges and changes in their market place. The key role to be played by industry is the provision of facilities and services for local authorities and the community. Clearly, there is no point separately collecting biodegradable waste if there are no composting or biodegradable waste treatment plants to accept it.

I*nstitutional Failure.* Local authorities may need to innovative or change practices which have existed in a local community for many years. They need the support of national government and clear and practicable strategies to move forward waste management thinking.

Lack of Infrastructure. Separate collection of biodegradable waste may require investment in new vehicles or modification to refuse collection vehicles. New collection receptacles also may be required. Facilities for the treatment of biodegradable waste need to planned to ensure their size and location are suitable for the incoming waste materials.

Perceived Costs. Establishing a new system for treating biodegradable waste is likely to require capital outlay at the beginning. There are inherent risks in changing waste management services and the costs may appear prohibitive, but it is important that the long-term view is taken. Costs of alternative scenarios, including the 'business as usual' scenario, need to be compared.

Low Participation Rates & Public Awareness. The public play an extremely important role, and their participation, or lack of participation, can be a constraint in ensuring the success of any scheme. If the public are not educated and informed of the benefits and reasons for the scheme, a scheme can fail. Engaging the public throughout the process and maintain awareness of the service will help ensure a successful scheme.

Member States Covered

The study covered a range of initiatives found throughout the Member States and is reported in the form of case studies. The case studies are taken from countries which have relied predominately on landfill as a waste management option.

The study has identified a number of successful centralised and home composting initiatives in six Member States: France, Ireland, Italy, Portugal, Spain and the UK. A search for successful schemes in Greece was also carried out although this work had limited success.

Type of Scheme

The initiatives highlighted in the study cover a range of different scenarios, yet each has been successful in increasing the volumes of biodegradable waste which is composted in their area.

Home composting is demonstrated successfully by Arun District Council in the UK.

Separate Collection and Centralised Composting is carried out by a large number of local authorities across all six member states.
Central Collection, Shredding and Composting requires members of the public to take their separately collected biodegradable waste to a central collection point. In Cork, Ireland, the

local authority runs a mobile shredder service which allows residents to drop off their garden waste for shredding.

The success of a scheme is not dependant on the number of participants. The case studies highlight a range of initiatives which have from 2000 to 200 000 inhabitants. Likewise, the volumes of waste collected in the schemes range from 250 tonnes by the small Wyecycle scheme in the UK, to 36 000 tonnes by the Gironde scheme in France. As a result, the volumes of composted product varies from 70 tonnes to 24 000 tonnes per year.

Success Criteria

In establishing any new composting or source separation schemes the following criteria do need to be met.

Reliable waste management route - Is there a reliable route for the waste once it is separately collected? Is the facility suitable for dealing with the type and volumes of waste. For home composting schemes this is not an issue, as the householders themselves provide the waste management route.

Diversion of Wastes from Disposal Routes - There will be a reduction of waste which requires disposal and, as a result, collection and disposal costs will be reduced. In the planning stages, it is important to consider the impact on the general refuse collection services.

Affordable Management Costs - Whilst capital and operational costs associated with setting up and running the scheme cannot be avoided, opportunities to minimise costs should be pursued wherever possible. For example, many composting schemes share collection vehicles (and associated costs) with schemes to collect dry recyclables.

Participation Rates - In all of the case studies, the overriding factor of importance for a successful scheme is good publicity and information which maximises acceptance and ensures high participation rates. Composting schemes tend to be popular with the local population, creating jobs and a 'feel good' factor. Publicity campaigns can emphasise these key points.

Plans for Continuation or Expansion - In planning a new initiative to separately collect biodegradable waste from householders, it may be appropriate to begin at a small or pilot scale with a small number of residents. However, plans for expansion need to be in place in terms of additional properties, additional waste and additional compost product.

Product Use or End Market - Ensuring the composted waste material can be sold or supplied as a viable new soil conditioner or compost product is vital to the success of a scheme. Standards for compost material derived from waste are being developed in some countries and in the European Commission's biowaste paper. It may not be necessary to meet a standard if a local outlet can be found for the material.

Common Themes Behind Success (1)

The case studies have highlighted some common themes for successful composting initiatives.

Publicity and Information. The general public need to be involved from an early stage to help maximise acceptance and increase participation rates. The message must be clear and consistent, and, where possible, provided continuously. Using a range of media channels has shown to increase awareness - this includes TV, radio, newspapers and leaflets. Many schemes have been running for a number of years and commitment is shown to grow over time: clearly patience is important. Clean source-segregated material will result in a clean feedstock which is more readily marketable. The general public need to understand the positive impacts such as jobs, reduced waste pollution, reduced costs etc. The use of local champions and local community events have helped spread the message.

Publicity Material from Padova

In the region of Bacino Padova in Northern Italy, the municipalities formed a consortium which deals both with waste and waste water management. The consortium runs a door-to-door collection scheme for biodegradable waste. It is a very convenient service for local residents. Householders now receive a bimonthly publication - Pollution. It contains information on performance of the scheme and new projects which are being developed. It also encourages two-way communication by requesting feedback from residents.

Common Themes Behind Success (2)

Successful schemes can also combine the collection of biodegradable waste with other recyclables. In the Montejurra scheme in Spain ,the scheme combines the kerbside collection of biodegradable waste and two different containers for the collection of plastics, paper and metal packaging. The scheme was one of the first schemes in Spain. It started in 1986 with the composting plant coming on stream in 1993.

Flexibility and convenience will help a scheme succeed. In the Gironde scheme in France, householders can voluntarily deliver their garden and green wastes to public areas or can have their waste collected directly from their household on a weekly basis.

Composting is a robust, viable and flexible management technique for biodegradable wastes. All schemes target the biodegradable waste fractions of household waste, which can include kitchen waste, such as vegetable and fruit peelings, and garden waste, such as grass and plant clippings. Some schemes also allow card and newspapers.

Common Themes Behind Success (3)

Established end markets will help schemes succeed. Sales of the end product can provide revenue to assist in funding the scheme. Obtaining a recognised standard for the product, while not necessary, can increase customer confidence in the compost. In Italy, the compost produced in the case studies all comply with the Italian law on fertilisers and in the Padova scheme farmers were also encouraged by offering free samples of the product.

The Cork Shredder Scheme in Ireland is successful partly due to the fact that public demand for the service is high and other schemes have been able to sell compost back to the residents.

The majority of schemes have received financial assistance, often partial funding from local or national government. The Barcelona scheme in Spain received funding from the European

Commission. However, many of the schemes highlighted have realised substantial cost savings through avoided disposal costs and taxes.

Conclusions

n conclusion, the case studies showed that Success in Separate Collection and Composting was not only a question of luck, but was dependant on the influence of a number of important, and manageable, factors, as follows:
Infrastructure and Convenience. The whole chain from waste producer to composting plant needs to be easy and convenient.
Product Quality. Ensuring the compost is of a high standard requires good quality feedstock, but will help sell the product at the end of the treatment process.
Waste Management and Planning Context. Successful schemes require detailed planning and design, incorporating local market conditions and specifications. The separate collection and composting scheme needs to complement the other waste management services offered in the municipality.
Avoided Costs and Revenues. The costs and revenues need to be balanced and it needs to be recognised that 'up front' costs can be balanced with long term revenues and cost savings from avoided disposal.
However, above all, public education and awareness raising is critical. Public participation needs to be fostered through clear, consistent and sustained communication.

The Report
A full copy of the report including all the case studies can be obtained from the European Commission.

Success Stories on Composting and Separate Collection
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Compost quality and market perspectives - the case of Portugal

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Summary

Only 11% of arable land in mainland Portugal is well provided with organic matter (OM), while around 87% is at risk of erosion. This situation is a result of unsound farming practices and climatic and topographical conditions.
Using analyses of the soil from six of mainland Portugal's seven agricultural regions and statistical data from 1997 it is possible to estimate the amount of dry organic matter needed to increase the OM content of arable land in classes "Very low" and "Low" to levels which would put them in the "Medium" class. It has been calculated that around 116 million tonnes of dry organic matter would be required.
In order to combat this depletion sound cultivation practices need to be introduced, as well as incentives for the recovery of organic waste which could be used to enhance soil quality, such as animal waste (livestock excreta), the organic fraction of municipal solid waste and sewage sludge from urban waste water treatment plants. We have estimated the amount of organic matter these types of waste could provide.
In Portugal, composting plants have, generally speaking, been marketing everything they produce, even though the quality of some compost is poor. However, it is expected that in the near future competition will increase and the quality of the products will improve.
A proposal for a standard has been drawn up relating to the use of compost in agriculture which defines classes of quality and lays down certain restrictions.

The importance of stabilised organic matter or humus in the soil-plant system

The current state of knowledge leaves us in no doubt that organic matter (OM) improves the soil characteristics and plant growing (Allison, 1973; Russel, 1961; Soltner, 1986; Stevenson, 1982; Mustin, 1987; Wallace and Terry, 1998).
The benefits basically derive from the stabilised fraction of OM in the soil - humic compounds - the structure and characteristics of which can explain some of their effects on soil properties and plant growth, namely:

- The fact that the aromatic nuclei of humic and fulvic acids do not bond linearly - thus giving rise to structures which are more or less compact and homogeneous but which constitute relatively big, approximately spherical basic units (Allison, 1973; Dudas and Pawlick, 1970; Schnitzer and Kodama, 1975; Senesi and Loffredo, 1998) - makes humus porous (enabling it to absorb and retain water).
- The contribution of humic compounds to the formation of aggregates is due to their colloidal properties and, more specifically, the action of the salts they constitute with soil cations, which, when they precipitate, form stable aggregates with the mineral particles of the soil (Allison, 1973; Kononova, 1966).
- Their very high specific surface (between 600 and 800 $m^2 g^{-1}$), much higher than that of montmorilonite (175 $m^2 g^{-1}$), makes them extraordinarily reactive, so they promote most of the reactions that occur at the solid-liquid interface (Sequi, 1983).
- The presence of many functional groups, such as COOH and OH, on the side chains of humic compounds gives them the following properties: i) high cation exchange capacity (higher that that of type 2:1 clays) which enables them to adsorb some mono and bivalent cation nutrients, such as Ca^{2+}, Mg^{2+}, K^+ and NH^{4+}, keeping them available for plants; ii) the ability to form chelates with polyvalent metals such as iron, zinc, copper and manganese, preventing precipitation or occlusion of these nutrients (Kononova, 1966;

Schnitzer and Skinner, 1963); iii) the ability to bond, across cation bridges, such as calcium and iron, with clays (Stevenson and Ardakani, 1972; Tisdall and Oades, 1982), forming clay-humic complexes.

- Their ability to form phospho-humic complexes minimises the retrogradation of phosphorous (Mustin, 1987).
- They are rich in polyphenols, which act as reducing agents, and this may explain their effect on the mobilisation of iron, reducing it from Fe (III) to Fe (II).
- The capacity of humic colloids to retain, like clays, hydrogen ions, aluminium ions and other cations, enable it to act as a buffer, protecting the soil from sudden variations in pH, caused by the uncontrolled application of fertilisers and phytosanitary products.
- The dark colour, due in particular to quinone-nitrogen compound bonds on the aliphatic chains, helps the soil absorb and retain heat (Stevenson, 1982; Soltner, 1986).
- Because they are rich in energy and mineral nutrients, they support a diverse and beneficial microbial population, which improves the physical and chemical characteristics of the soil, helps plants absorb nutrients and can even protect them from some diseases caused by pathogenic microorganisms and parasites whose vegetative cycle takes place in the soil (Hoitink et al., 1996; Mustin, 1987).
- With regard to the effect of organic matter on plant physiology, the humic and fulvic fraction affects the permeability of the cellular membranes, the active transport of ions and mineral nutrition as well as activity relating to protein synthesis, (Benedetti et al., 1996); it also promotes the production of plant enzymes and regulates osmotic pressure, thereby increasing resistance to drought (Kononova, 1966).

Once any farming system/soil combination tends to reach a certain balance with regard to humus content, it is not possible to establish universal optimum (or critical) levels for this important component of the soil (Johnston, 1993). However, the relevant literature contains references to desirable levels, depending on the characteristics of the soil, especially texture, clay content and percentage of carbonates.
In Portugal, the Instituto Nacional de Investigação Agrária/Laboratório Químico Agrícola Rebelo da Silva (INIA/LQARS) has defined five classes of OM content for two different soil types (Dias et al., 1980): Very Low (VL), Low (L), Medium (M), High (H) and Very High (VH), as follows:

Class	Coarse textured soil	Medium and fine textured soil
V L	OM £ 0.5%	OM ≤ 1.0 %
L	0.6 % ≤ OM £1.5%	1.1% ≤ OM £ 2.0%
M	1.6 % ≤ OM £ 5.0%	2.1 % ≤ OM £ 7.0%
H	5.1% ≤ OM £ 7.0%	7.1 % ≤ OM £ 10.0%
V H	OM ≥ 7.1%	OM ≥ 10.1%

The organic matter content of soil on mainland Portugal

The organic fraction of decomposing waste (especially in the soil) behaves differently depending on the characteristics of the organic compounds it is made up of. In animal and vegetable waste with a low carbon/nitrogen ratio (such as "green manure"), the organic matter is mineralised in a short time, contributing little to humus production; in waste which does not easily biodegrade (with a high ligno-cellulose content) the organic matter decomposes more slowly, adding a large amount of stabilised material to the humus in the soil. This, in turn, is very slowly mineralised, the mineralisation coefficient (k2) depending on several factors, in particular temperature, humidity and aeration of the soil.

In Portugal, especially in the south, climatic conditions favour high humus mineralisation coefficients. The Mediterranean climate, with hot summers and mild winters, enables the microorganisms responsible for mineralisation to carry out their activity with a high level of production the whole year round, provided there is enough moisture in the soil. The mineralisation coefficients might, often, be over 2%, especially in irrigated areas and areas where there are greenhouses or other types of shelter.
Climatic and/or topographical conditions combine with farming practices to deplete the OM content of the great majority of Portuguese soils. Such practices include the failure to systematically incorporate organic soil improvers into the soil, the practice of monoculture instead of crop rotation which puts organic matter back into the soil, the reduction of wooded areas, the extension of irrigated areas, deeper ploughing, increased use of mineral fertilisers, etc.
These factors have contributed to the current situation: only 11% of Portuguese soil has an optimum OM content, while 87% is at risk (high or intermediate) of erosion, and, also, to the reduced soil formation rate (between 0.3 and 1.5 mm per year1) (DGA, 1994). The risk of erosion is generally higher in the south and in the interior of the country.
The impoverishment of Portuguese soils is underlined by studies carried out using the results of soil testing for fertiliser recommendation purposes. We refer to those carried out by Dias et al. (1989), Leandro et al. (1989) and Gonçalves et al. (1995 n.p.). The first study summarised the general state of fertility of arable land in the agricultural regions of Beira Litoral, Beira Interior, Lisboa e Vale do Tejo and Alentejo. The second and third studies looked at the soil of Entre Douro e Minho and the Algarve. The results for the organic matter parameter are summarised in table 1. The classes of OM content were defined using the INIA/LQARS criteria, set out above.

Table 1: Percentage distribution by class of OM content of soil in six agricultural regions.

AGRICULTURAL REGION	Number of samples	Class				
		VL	L	M	H	VH
Entre Douro e Minho*	29 245	0.8	2.9	59.0	36.8	0.5
Beira Litoral**	36 365	4.1	20.2	63.0	12.1	0.6
Beira Interior**	13 773	11.1	39.8	41.3	7.4	0.4
Lisboa e Vale doTejo**	44 189	27.4	50.9	20.8	0.8	0.1
Alentejo**	24 988	24.1	53.8	21.3	0.7	0.1
Algarve***	4 379	26.8	44.5	28.7	0.0	0.0

VL: Very low; L: Low; M: Medium; H: High; VH: Very high.
Sources: * Leandro et al. (1989); ** Dias et al. (1989); *** Gonçalves et al. (1995, n.p.).

The table shows that the OM content of 24.5% of arable land in the Beira Litoral is below critical levels (classes VL and L) and the same is true for 50.9%, 78.3%, 77.9% and 71.3% of the soil in the Beira Interior, Ribatejo e Oeste, Alentejo and Algarve respectively.
The level of depletion of the OM content of arable land is significant in the Beira Litoral, worrying in the Beira Interior and it reaches alarming proportions in the southern half of the country, where the Mediterranean climate has a more marked influence.

Estimating the OM requirements of soil in mainland Portugal

Using the results obtained from the studies we have been interpreting, available statistical data on the occupation of the soil in the agricultural regions concerned (INE, 1998) and several presuppositions (which are of course debatable), it is possible to estimate the amount of organic matter needed to correct the soil in the regions concerned. Clearly, in principle, the larger the area considered, the more the results will diverge from the true values: an estimate for a region with a uniform climate, soil characteristics and agricultural history - knowledge of the latter is important for calculating the humification coefficient (K1) representing waste returned to the soil by crops - will correspond more closely to real needs than an estimate for a large area encompassing different climatic conditions, land cover and soil types, with a varied agricultural history. However, if we assign average values to the variables which come into play, we can at least estimate approximately how much organic matter needs to be applied to arable land on mainland Portugal.

We are not including the region of Trás-os-Montes and Alto Douro, since the data available (Martins e Coutinho, 1988) does not allow us to perform the type of calculation used for the other agricultural regions. However, it should be noted that this region, with a utilised agricultural area of 462 230 ha (INE 1998), has a significant percentage of soils with a low and very low OM content, and is also an area with a high risk of erosion.

The estimate covers the area comprising the regions of Entre-Douro-e-Minho, Beira Litoral, Beira Interior, Lisboa e Vale do Tejo, Alentejo and the Algarve (figure 1). The details are as follows:

Area considered

We consider, as the basis for our calculation, the utilised agricultural area (UAA), that is the crop covered area, in each agricultural region, in accordance with the publication "Inquérito às Explorações Agrícolas do Continente" [Survey of agricultural holdings in mainland Portugal] (INE, 1998).

Areas with class VL and L soils in each agricultural region

The areas with class VL and L soils are estimated by multiplying the UAA of each agricultural region by the percentage distribution of OM content for those classes of soil (see table 1). For example, in the Entre-Douro-e-Minho region, the area occupied by class VL and L soil is as follows:

- Class VL soil: 243 451 x 0.8% ≈ 1 950 ha
- Class L soil: 243 451 x 2.9% ≈ 7 060 ha

Average OM values in classes VL and L and values to be attained (assigned for the purposes of the calculation)

As stated above, the INIA/LQARS has established OM content classes and their limits for different types of soil: for coarse textured soil, classes VL, L and M correspond to soil with an OM content lower than 0.5%, between 0.6 and 1,5% and between 1.6 and 5%, respectively; for medium and fine textured soil, classes VL, L and M correspond to soil with an OM content lower than 1.0%, from 1.1 to 2.0% and from 2.1 to 7.0%, respectively. Since we do not know the percentage of the two different soil types for each agricultural region, we choose, for calculation purposes, to use the following average values for OM content: 0.3% (class VL) for coarse soils and 0.6% (class VL) for medium and fine soils; 1.0% (class B) for coarse soils and 1.5% (class B) for medium and fine soils. Generalising, for both soil types, this gives an average value of 0.45% [(0.3 + 0.6)/2] for class VL soils and 1.25% [(1.0+1.5)/2] for class L soils. Similarly, the minimum value for class M (which we aim to achieve) is:
[2.1 (lower limit for class M for medium and fine soils) + 1.6 (lower limit for class M for coarse soils)/2] = 1.85%.

Depth of the arable layer

Let us suppose that the arable layer of the soil is 20 cm deep.

Bulk density

Since we do not have detailed knowledge of the characteristics of the soils concerned and considering that the great majority are poor in organic matter, we opt for an average apparent density of 1.3.

Humification coefficient (K_1) of the organic matter applied

Let us suppose that the humification coefficient of the organic matter applied is 40%.
From the variables given it is possible to estimate, grosso modo, the amount of organic matter that would have to be added to raise the OM content of the soil in each agricultural region to 1.85%.
To do this, we calculate as follows:

1) Dry OM requirement per ha
- Class VL soils

$$\text{OM: } \frac{10000\ m^2 \times 1.3 \times 0.2\ m \times (1.85\% - 0.45\%)}{40\%} = 91\ t$$

- Class L soils

$$\text{OM: } \frac{10000\ m^2 \times 1.3 \times 0.2\ m \times (1.85\% - 1.25\%)}{40\%} = 39\ t$$

2) Amount of OM (dry material) needed to raise the OM content of the soil in the agricultural regions concerned to 1.85%:

E.g. for the soil in the Entre-Douro-e-Minho region:

- Class VL soils:
  243 451 (UAA) x 0.8% x 91 t ≈ 177 232 t
- Class L soils:
  243 451 x 2.9% x 39 t ≈ 275 343 t
  Total: 452 575 t

For the Beira Litoral: 2 088 425 t; Beira Interior:11 147 337 t; Lisboa e Vale do Tejo: 22 142 913 t; Alentejo: 75 413 590 t and Algarve: 5 332 501 t.

In view of the above, we can conclude that, theoretically, approximately 116 million tonnes of dry organic matter are needed to correct the soil in the six agricultural regions.
This is an enormous amount, so it would have to be added to the soil over a period of many years. We also have to consider the humus mineralisation coefficient (K2) which, for the regions concerned, should be around 2% per year, which corresponds to a soil OM loss of about 2.3 million tonnes/year. This coefficient was not taken into account in the estimate because the return of organic waste to the soil by crops was not considered either. However, it is important to mention that the amounts of humus lost through mineralisation were greater than those produced by the return of OM to the soil by crops and this is proved by the fact that the humus content of the soil continues to decrease.
In order to counteract the depletion of organic matter in the soil, in addition to alternative growing practices which could help, we should promote the use of organic waste whose characteristics allow it to be used as corrective material, such as municipal solid waste (MSW,

sewage sludge, livestock waste and agro-industrial waste. MSW could, in the next few years, provide around 600-800 thousand tonnes of organic matter per year, if the entire organic fraction were recovered, and sewage sludge could provide up to 100 thousand tonnes per year, if the entire mainland population were served by waste water disposal systems and treatment plants. We have also estimated that in 1999 the amount of organic matter contained in livestock waste (cattle, pigs, sheep and poultry) on mainland Portugal is around 3 million tonnes. Up to now, it has not been possible to estimate the quantities of other types of organic waste which could be biologically treated for agricultural use. However, the incorporation into the soil of the above mentioned waste (properly treated) could at least compensate for the OM loss resulting from the annual mineralisation of the above estimated amount of OM to be added to correct the soils from the crop covered area of Portugal.

Potential agricultural market and quality of compost

Given, as shown above, the depletion of the OM content of most arable land in mainland Portugal and farmers' awareness of the benefits, for the soil and crop production, of organic soil improvers use, composting plants in Portugal have, generally speaking, been marketing everything they produce, although many of the composts sold (mostly deriving from solid municipal waste or the co-composting of sewage sludge and agro-industrial waste) are of poor quality. However, soon it will probably become more difficult to market poor quality compost because:

(i) farmers are becoming increasingly aware of environmental protection and public health;
(ii) there will be increased competition between composts and several kinds of non-composted soil improvers which are not regulated in Portugal;
(iii) the supply will increase, since one of the priority aims of the Instituto dos Resíduos for 2006 is to promote the use of biologically treated organic waste(Gonçalves, 1999; INR, 2000).

With regard to MSW compost, annual production is currently around 65 000 - 70 000 tonnes (table 2) but is very likely to rise by 150% in the near future, for the reason given in (iii) above. In order that composts may be used in agriculture without harming the soil, plants, humans,

Table 2: MSW biological treatment plants in operation or scheduled to start operating in the near future

Treatment plant	Location	Type of biological. treatment (system)	Compost production (t/ha)	Situation
LIPOR**	Ermesinde	Composting (Windrow)	19 000	In operation
AMTRES	Trajouce	Composting (Agitated bed / Koch)	12 000	In operation
C.M. Setúbal - - Koch	Setúbal	Composting (Agitated bed / Koch)	5 000	In operation
AMAVE	Riba de Ave	Dano type + windrow	29 000	In operation
A. M. Cova da Beira	Fundão	Composting (Agitated bed / Siloda)	15 000 (scheduled)	Will start in 2001
VALORSUL*	Amadora	Anaerobic digestion followed by composting	15 000 (scheduled)	Tender selection
LIPOR*	Ermesinde	Composting	24 000 (scheduled)	Tender selection

*Will process organic waste from selective collection.
** Will close as soon as the new plant begins to operate.

animals or the environment in general, the INIA/LQARS has prepared a proposal for a standard establishing specifications for compost, defining classes of quality and laying down restrictions on its use.

In preparing the proposal, we took account of the present situation, in particular the fact that the percentage of MSW waste selectively collected is still very low, and that in the near future only good quality compost should be allowed on the market. We begin with specifications imposing a minimum permissible level of quality. After 8 years, stricter requirements are introduced for certain parameters so that only compost of appropriate quality can be used for the intended purpose. This eight-year period will give producers time to improve the quality of their composts.

The document will be presented for examination by the parties concerned (composting plants, State laboratories, universities, the Ministries of Agriculture and the Environment) and some amendments may be made.

Contamination of the soil by heavy metals in compost is the most controversial item and the relevant specifications, quality classes and restrictions on compost use are set out below (tables 3, 4 and 5):

Table 3: Maximum permissible values for normalised total heavy metal content (dry matter basis) in compost.*

ELEMENT	CLASS I	CLASS II
CADMIUM (MG/KG)	1,5	5
LEAD (MG/KG)	150	400
COPPER (MG/KG)	200	500
CHROMIUM (MG/KG)	150	300
MERCURY (MG/KG)	1,5	5
NICKEL (MG/KG)	50	200
ZINC (MG/KG)	500	1500

* standardised to a basis of 40% organic matter.
note: until 31 december 2008 the marketing of both classes of compost will be permitted; from 1 january 2009 only the marketing of class i composts will be permitted for crops intended for human and animal consumption. this standard may be amended in the future to include new quality classes (high quality), and the laying down of maximum permissible levels of organic micropollutants.

Table 4: Maximum permissible values for total heavy metal content in soils to which compost will be applied.

ELEMENT	Maximum permissible values (mg/kg)		
	5 ≤ pH < 6	6 ≤ pH < 7	pH ≥ 7
cadmium	0.5	1	1.5
lead	70	70	100
copper	20	50	100
chromium	30	60	100
mercury	0.1	0.5	1
nickel	15	50	70
zinc	60	150	200

note: compost may only be applied to soils with a ph< 5 if authorisation is obtained from thecompetent authorities.

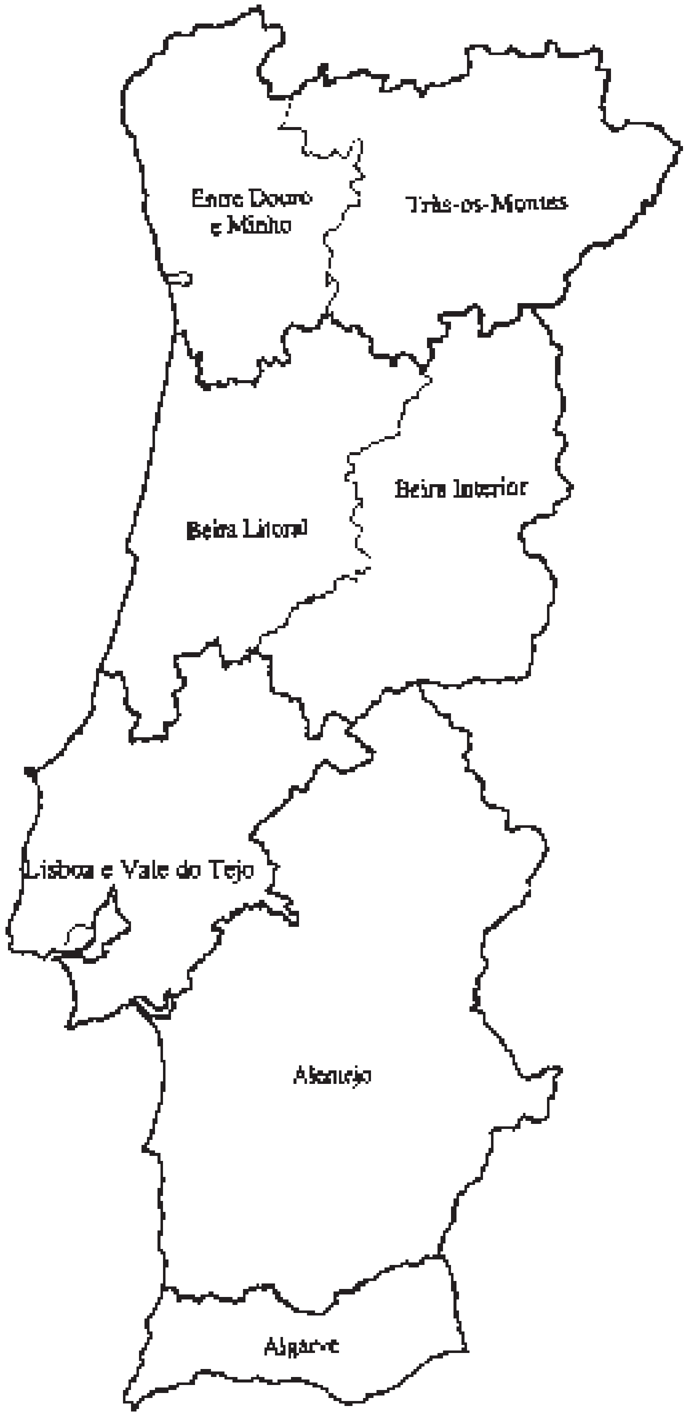

Figura 1: Regiões agricolas de Portugal continental

Table 5: Maximum quantities of heavy metals which may be applied to the soil per year

ELEMENT	MAXIMUM QUANTITIES (G/HA/YEAR)	
	UNTIL 31/12/2008	FROM 1/1/2009
CADMIUM	50	25
LEAD	5000	2250
COPPER	5000	3000
CHROMIUM	5000	3000
MERCURY	50	25
NICKEL	1500	900
ZINC	15000	7500

*Some stakeholders' representatives have suggested deleting this table and specifying a maximum annual application rate of 10 t/ha for class B compost and 25 t/ha for class A compost.

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From Waste to a Valuable Product - Quality Assurance Schemes for Compost Production

(J. Barth, Informa Compost Consultants, Germany)

Abstract

Investigations in Europe indicate that quality and marketing of the end product are the most crucial composting issues. Both producers and users are of the opinion that sustainable recycling of organic wastes demands clear regulations with regard to what is suitable to be recycled and how it should be managed and controlled. Around 15% of the estimated total recoverable potential of 60 million Mg of organic waste is presently treated biologically in Europe. The re-use has to meet environmental and market requirements. Therefore, the trend in Europe goes definitely towards source separation of the organic residues from gardens and households. Quality requirements for composts regarding heavy metals, organic pollutants and hygiene allow no other alternative. There is no longer a market for mixed-waste compost. The introduction of source separation and composting must go hand in hand with the introduction of a quality assurance system for compost plants. Assuring compost quality entails more than just fulfilling a number of heavy metal limits. Levels and ranges of the quality criteria for compost differ very much in Europe. In most countries, independent monitoring of sampling and analysis takes place or is in preparation. A quality label or certificate will be given to compost, which meets the monitored quality criteria.

Keywords: Compost application, European compost production, quality assurance, quality criteria, source separation, waste policy

Introduction

Recent years have seen a phenomenal increase in the biological waste treatment in Europe. Looking ahead, we must assume that at least 32% of urban waste and a large proportion of industrial waste - approximately 40% of the total waste production in Europe - could be biologically treated via composting and anaerobic digestion. The final products from the treatment are usually used as soil improvers or as fertilisers. They have to meet environmental and market requirements which will lead to an improvement of the compost quality produced in Europe in the future.

Waste quantities and source separation in the EU member states

The collected and treated amounts of organic material differ much in the EU countries. Around 34 percent representing 17 million Mg (table 1) of the estimated total recoverable potential of the 50 million tons bio- and green waste is presently separately collected. This results in a compost production of around 9 million Mg in Europe.

Table 1: Amount of separately collected and composted bio- and green waste in EU

Country	Sep. collected + treated organic waste [in Mio Mg]		Recovery potential of organic waste [in Mio Mg]		Theoretical potential[1])
	Biowaste	Greenwaste	Biowaste	Greenwaste	Total [in Mio Mg]
A (1996)	0,88 +0,58 industrial organics	0,85	1,22	1,02	2,24 in 2000
B (1998) Flanders	0,33	0,39			1,3
	A potential of 0,9 Mio Mg can be collected and composted in reality				
B (1994) Wallonia	0,12				0,16 in 2002
D (1998)	7,0				9
	A potential of 8 Mio Mg can be collected and composted in reality				
DK (1997)	0,028	0,49	0,05	0,55	0,6 in 2004
F (1998)	0,08	0,76	5,25	3,5	8,75
Fi (1998)	0,1				0,6
GR (1995)					1,8
I (1999)	1,5				9
IRE (1998)					0,44
Lux (1998)	0,03				0,06
NL (1996)	1,5	0,8	2,5	1	3,5
P (1995)		0,01			1,3
ES (1998)	0,06 (Catal.)				6,6
S (1997)	0,13	0,15	0,98	0,53	1,5
UK (1998)	0,039	0,86			3,2 in 2006
Sum	12,4	4,3			50
Treated Bio- + Greenwaste 16,7 Mio. Mg			Theoretical recovery potential 50 Mio. Mg		

[1]In most of the European countries no statistical data about the home composting are available, so an estimation of the full extent of the potential of organic waste is very difficult.

The composting of mixed municipal solid waste (MSW) is no longer state of the art and becomes more and more unusual and can be seen only in the few countries in southern Europe. In these countries, however, a change in the waste management also begins because it is obvious that in future there will be no market for composts with bad qualities - such as e.g. mixed municipal solid waste composts. Compost products based on source separated organic waste show only 10 to 20 percent of the heavy metal contents compared to MSW compost and can reach the same quality level as the one produced in private gardens. This suits the requirements especially to those of professional compost users.

Waste policy in Europe

Concerning their organic waste activities Europe can be divided into 4 categories (Figure 1). In Austria, Belgium (Flanders), Germany, Switzerland, Luxembourg, Netherlands, Sweden, Italy the policy is nearly countrywide implemented. These countries of the first category recover more than 80 percent of the, at present, separately collected and treated (mostly by composting) organic waste fraction in the EU. Digestion plays a minor part at the moment. Denmark, Spain (Catalonia) and Norway form the second category of the implementing states.

These countries have built up parts of the political, quality and organising framework for separate collection and composting. Finland, France and the United Kingdom form the third category. These countries have developed strategies and are at the starting point. In the fourth category we find countries where no effort on composting of source separated organic waste can be detected like parts of Spain, Greece, Ireland and Portugal. These countries still compost mixed urban wastes.

Figure 1: Development of source separation and composting in Europe

As a summary the policy in Europe shows an extensive trend and a fast development towards source separation of organic waste. In most countries home composting is part of this policy.

Compost quality and quality assurance

Many investigations in Europe indicate that quality and marketing of the end product is the most crucial composting issue. Both producers and users are of the opinion that a sustainable recycling of organic wastes demands clear regulations regarding what is suitable to be recycled and how it should be managed and controlled. A well-founded quality assurance programme would definitely increase sustainable recycling of organic wastes.
Marketing analysis over recent years shows that all users of compost demand a standardised quality product that is supervised by independent organisations. A study in the south of Germany showed that 94% of the commercial users made this a precondition. In another German study among citizens of Cologne and Düsseldorf 80% of the participants would have

a more positive attitude towards compost and food grown on arable land with compost application, if they were sure that a quality control system for compost exists.
The introduction of separate collection and composting must therefore go hand in hand with the introduction of a quality assurance system. Assuring compost quality is more than just fulfilling a number of heavy metal limit values. It plays a central role and influences all stages of the treatment of organic residues:

- Separate collection

Quality assurance can be used to draw conclusions on the quality of the source separation and can introduce measures for improvement.

- Plant engineering

Errors in the plant engineering can be quickly identified via quality controls. In the hygienic sector quality assurance also serves to guarantee worker protection.

- Compost production

Only constant quality and product checks avoid errors in compost production.

- Marketing

Consumers want a standardised quality compost. Only a quality assurance system guarantees this. The quality sign as a symbol helps the marketing efforts.

- Public relations work

A good image for compost can be built up with assured quality and a quality label.

- Application

The analytical results form the basis for the declaration and the recommendations for use and consequently for the correct and successful application of compost.

- Product range

Only by precisely knowing the constituents and their width of fluctuation several compost products can be developed.

- Politics/legislature

Through statistical evaluation of the test results the legislator is familiar with the present standard of compost and the possibilities of the composting plants and he can issue directives that are appropriate for the current practical situation of the compost quality.

- Certification

A quality assurance system is a pre-condition for certifying the composting plants to e.g. the EU-Standard EN ISO 9002.

The central role of quality assurance is seen in the countries with developed composting system like Austria, Germany, Denmark, the Netherlands and Belgium. These countries have established extensive quality management for the composting plants, in which around 400 composting plants take part at the moment. Several other countries like Sweden, Norway, Italy and France are at the stage of the conceptual design.

Elements of quality assurance systems

Depending on intention, philosophy, political or functional approach, the quality assurance systems for compost comprise different elements:
- Raw material
- Intake control
- Limits for harmful substances
- Quality criteria for the valuable constituents in the compost
- Composting production
- External control (product and/or production)

- In-house monitoring
- Quality label for the product
- Certificate for the plant and/or the product
- Declaration of the properties of compost
- Recommendations for use and application
- Training and qualification of the operator
- Management and operation of plants (plant assessment)
- Annual certificates

Quality of compost and quality management

When considering the introduction of composting, the end product should merit equal or even more attention than the composting process and the composting technique. Quality assurance of compost plays therefore a central role. It links the end product to all the elements of the organic treatment and cycle and forms the first step to a comprehensive quality management of the composting plants.

Table 2: Survey on compost quality efforts in various countries

Country	Status of quality assurance/certification of compost
Austria	Fully established quality assurance system
Belgium	Fully established quality assurance system in the Flanders region, the Wallonia and the Brussels region will probably follow the Flanders example.
Denmark	Just started with quality assurance system for compost (Criteria, standardised product definition, analysing methods)
France	Proposal for quality criteria, research program for a quality management system
Germany	Fully established quality assurance system
Italy	Successful source separation system
Luxembourg	Some plants according to German Quality Assurance System
Netherlands	Fully established quality assurance and certification system
Spain	Proposal for "Bill on the Quality of Compost" in Catalonia
Sweden	Just started with quality assurance system for compost
UK	Proposal of quality standard by the Composting Association TCA
Finland	No official efforts until now
Greece	No official efforts until now
Ireland	No official efforts until now
Portugal	No official efforts until now
Other Countries	
Norway	Criteria and requirements for 3 quality classes
Switzerland	Product definition and analysing methods
USA	- Published analysing methods - Plans for product definitions for MSW compost
Canada	Final step of discussion of a quality assurance system for source separated organic waste
Australia	Proposal of quality criteria and analysing methods

Status of Quality assurance in EU

Table 3: Status of quality assurance of European composting plants (1998)

Country quality assurance1)	Plants with quality sign or certificate	Plants with
Austria	ca. 18	2
Belgium (FL)	ca. 21	5
Germany	ca. 340	ca. 300
Netherlands	22	2

[1]The table includes plants that have applied for a quality sign/certificate but the process is not yet finished

Type of control systems

An essential difference between the European countries lies also in the amount in which the compost production is included into quality assurance. The RAL-quality sign of Germany has the philosophy to assess the quality of the end product. In the Netherlands and in Belgium there is an aspect of two different attitudes. Here the control of the end product is combined with a production control. In Belgium the period for application of a new compost plant for the quality sign is two years, whereas in the first year a continuous production monitoring is made. The second year of application follows only the control of the produced compost.
The certification for the quality sign in the Netherlands describes a very large internal quality monitoring of the compost production with weekly tests of parameters from each compost charge. Similar tendencies can be observed in Austria where the quality sign demands a product/process diary with nearly a hundred positions.

Table 4: Range of control systems

Range of Control Systems for Composting Plants in Europe		
	Production control	Product control
Austria	Indirect	Austrian compost quality association KGVÖ
Belgium (FL)	Compost promotion organisation VLACO in the first year of production	Compost promotion organisation VLACO in the second year of production
Denmark	-	Plant Directorate
Germany	German compost quality assurance organisation on hygienic issues BGK	German compost quality assurance organisation BGK
Netherlands	Certification organisation KIWA	Certification organisation KIWA

Quality criteria

The quality criteria for compost vary in the European countries concerning the amount, the requirements and the limited values. Direct quality classes based on heavy metal limits exist only in Austria (class I and II such as the types "A" fresh and "B" matured compost) and in the Netherlands (Table 5). The Dutch requirements for the class "very good compost" are so high that they can only be reached in exceptional cases; thus the compost plant association is trying to obtain an alteration of the parameters. A quality standard with two steps in Belgium, with composts for arable land and for other areas, did not prove to be practicable, thus composts can be distinguished only on a raw material basis.
Evidence has been made by diversified compost qualities based on heavy metal content that only the best will be asked for. The large quantity of good quality compost which is sufficient for various uses will fail to be used in most cases.

Quality classes based on raw material (Belgium/Fl), on the properties or the ranges of utilisation (Germany) will more effectively meet the requirements of the compost market.

Table 5: Classification of compost quality in Europe

Country	Type of compost/quality class
Austria	Quality Class I and II, Type A (mulch) and B (matured) compost
Belgium/Fl	Yard and Vegetable, Fruit and Garden VFG Compost
Denmark	Organic household waste compost with no classification up to now.
	No quality criteria for green/yard waste compost necessary.
Germany	Fresh and matured compost, mulch and potting soil compost
Netherlands	Compost and very good compost

Heavy metal content
With the stipulation of the quality criteria various philosophies are to be observed. Here we have countries such as Austria or the Netherlands with relatively severe guidelines e.g. concerning heavy metals on the one hand and on the other hand relatively high deviations (40 to 50%) from the guide values which are allowed for the single case. These are confronted with the German guide values with relatively moderate values, but relatively little deviations of only 15%.

Table 6: Heavy metal limits and allowed deviations (mg/kg dm)

Country	Chrome	Nickel	Copper	Zinc	Cadmium	Mercury	Lead
Austria							
Class 1	70	42	70	210	0,7	0,7	70
+ 50 %[1]	105	63	105	315	1,05	1,05	105
Belgium							
Agri. Min.	70	20	90	300	1,5	1	120
Denmark							
Stat. Order No. 823	100	30	1000	4000	0,8[2]	0,8	120[3]
Germany							
RAL and Biowaste	100	50	100	400	1,5	1	150
Ordinance							
+ 25 %	125	75	125	500	1,875	1,25	187
Netherlands							
High quality	50	10	25	75	0,7	0,2	65
x 1,43	72	14	36	107	1,0	0,3	93

[1]Basis: 30% organic matter; To compare these values with others based on dry matter, they have to be reduced by 10%.
[2]0,4 mg/kg dm after the year 2000
[3]60 mg/kg dm in private gardens

The guide values have been proved in practice to be more efficient than the stipulation of absolute limited values resp. cut-off values. Compost plants have little influence on the input material so that a certain deviation of the quality criteria in the single case and after control should be allowed. Especially with very low limited values the compost plants are producing a compost quality which is ranging at the limit. After the composting is finished it can be analysed finally whether the compost end product fulfils the requirements or not. Only a possible deviation for the single case gives the compost plant a certain security for their production.

Organic pollutants
At the moment only Denmark is worried about organic pollutants in compost and has fixed limits. The other countries have detected very low levels, so they don't analyse the contamination

(Netherlands, Belgium) or they do a kind of observation in suspicious cases (Austria) or on a voluntary basis (Germany).

Hygienic requirements
In Austria the composting process has to be controlled after the first running of the plant and after each essential change of the equipment. During the regular decomposition process the temperature in the composted material has to reach 64°C over 4 days. In Germany the selected decomposition process must lead to a sanitised, hygienically irreproachable product and assure the exclusion of germs. The compost plant must be able to prove the hygienic effectiveness which is normally done by a daily temperature recording. The temperature level has to show in open composting systems more than 55°C over two weeks or 65 °C over one week, in closed systems one week with more than 60°C is sufficient. With the new German Biowaste Ordinance (BioAbfV – Oct. 98) the epidemic and phytohygienic clearance of products from biological waste treatment are stated by a direct and an indirect process control together with end product tests (on salmonella).

No hygiene standards exist until now in Belgium. Denmark defines two standardised process types which should guarantee sanitation. Controlled composting has to show the over 55°C during more than two weeks, controlled deactivation takes place after one hour at 70°C. Because of the variations in the technology of the composting plants a new regulation for hygiene aspects was laid down in the Netherlands in 1998. The former standardised general process parameters (minimum 8 weeks composting, and from these 4 weeks intensive with aeration and re-stacking twice, 50 - 60°C temperature) which guarantee hygiene efficiency are replaced by an individual solution for every composting plant. The Dutch independent certification organisation KIWA strongly supervises the strict adherence to the therefore required process parameters.

In future an extension of the hygiene requirements in Europe can be expected. Thus the latest draft of the new German compost ordinance asks for a hygiene process test of the total compost plant every two years. Austria is likely to follow this example and plans according to a draft version of the new Austrian compost decree an additional hygiene control of compost bags at the point of sale.

Additional quality aspects
The fulfilment of the requirements for heavy metals, organic pollutants, hygiene requirements and further characteristics are the preconditions for the award of a certificate (Netherlands) or of a compost quality label (Austria, Belgium/FL, Germany, Sweden).

These additional quality criteria concern impurities (plastics, metals, glass, stones), organic matter, plant compatibility, degree of decomposition, salt and water content. The detailed declaration of the contents of the compost to be sold is of a great importance in all countries. Only with the exact knowledge of the characteristics compost can be used successfully.

Actual compost qualities in Europe

Table 7 shows the results of compost analysis executed in Austria, Belgium/FL, Denmark, Germany and the Netherlands. Not all results are fully comparable because of different analysing methods in the countries.

Table 7: Comparison of the current compost qualities (1997 – 1998)

	Unit	A Median	Belgium Median		D Median	DK Mean		NL Mean	
Parameter		Bio- and Greenc.	VFG- [1]) ccompost	Green- compost	Bio-and Greenc.	VFG- compost	Green-. compost	VFG- compost	Green- compost
Organic matter	% dm [2])	38,7	35	35	36	55	20	38	27
(dry)	-	7,6	8,5	8,0	7,7	8	8	7,7	7,8
pH (H_2O)		($CaCl_2$)							
Total Nitrogen	mg/kg dm	1,5	1,9	1,3	1,35	2,3	0,7	1,59	0,57
(dry)	% dm	0,9	0,57	0,30	0,66	1,1	0,7	0,66	0,32
Total P_2O_5	% dm	1,5	0,83	0,53	1,1	-	-	088	074
Total K_2O	% dm	9,9	1,93	1,42	4,06	-	-	2,12	2,20
Total CaO	% dm	2,2	0,30	0,25	0,71	0,7	0,6	0,29	0,42
Total MgO									
Soluble N	mg/l	-	476	113	230	600	100	-	-
Soluble P	mg/l	-	492	277	918	800	500	-	-
Soluble K	mg/l	-	4107	2271	3344	2200	900	-	-
Soluble Ca	mg/l	-	4250	2995	-	-	-	-	-
Soluble Mg	mg/l	-	524	354	266	-	-	-	-
Cadmium	mg/kg dm	0,7*	0,9	0,9	0,5*	0,4	0,4	0,3	-
Chrome	mg/kg dm	28,5*	17	14	24*	12	9	17	19
Copper	mg/kg dm	66,5*44	33	44,7*	44	50	29	28	
Mercury	mg/kg dm	0,2*	0,2	0,1	0,15*	0,13	0,12	0,12	0,1
Lead	mg/kg dm	60,5*	66	61	53*	36	27	57	49
Nickel	mg/kg dm	22,5*	12	8	14,3*	10	7	7	9
Zinc	mg/kg dm	229,5*	237	183	190*	165	141	157	134
Arsine	mg/kg dm	5,7*	-	--	--	3,6-	3,3-5	4	
Impurities > 2 mm	% weight	-	0,1	0,1	0,09	0,1	0,06	0,19	0,06
Ø	% weight	-	0,5	0,8	1,48	2	6	1,00	0,83
Stones > 5 mm Ø	#/l	-	0	0	0	0	0	0	0
Germinating seeds									
Decomposition:									
- Rotting degree	-	-	-	-	V	III -	IV -	IV - V	IV V
- NO_3-N / NH_4-N	-	28	0,4	1,0		IV			
		(CaCl²)	(H_2O)	(H_2O)					
EOX	mg Cl/kg	0,6							
AOX	dm	67,0							
DEHP	mg Cl/kg					22,2	0,29		
LAS	dm				72,5	-			
NPE						2,9	-		
Sum of PAH						0,5	0,7		

[1] VFG compost = Vegetable fruit and garden compost
[2] dm = dry matter
* Basis: 30 % organic matter; To compare this values with others based on dry matter, they have to be reduced by 10 %

<u>Sources of information:</u>

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The quality of composts can not be improved that much in these countries. Statistical data from the German Compost Quality Assurance Organisation FCQAO show a reduction of e.g. the heavy metal content of zinc and cadmium only of two or three percent over the last six years despite composting plants' many efforts. So it can be expected that the compost quality has reached the inevitable background level.

Compost quality and marketing/public relations

Public relations and marketing of compost requires a standardised quality product too. Composts which have been tested in a quality assurance system meet these requirements because:

- Quality assurance is a good basis for sales promotion, for public relations work and a good argument for the building up of confidence in compost.
- The quality label allows the establishment of a branded "quality-tested compost" and a positive compost image.
- Regular analyses during compost production guarantee a quality-assured product.
- Standardised analyses carried out in accordance with specified methods enable a nation-wide objective assessment of the compost.
- The investigation results form a basis for the product declaration and the application recommendations.

The result is a compost of defined quality which is therefore marketable and saleable on a large scale.

Further marketing activities are necessary, as compost with a quality label or a quality certificate will not be sold by itself. With this qualification, however, the compost plants have an excellent start because quality products always have advantages in the market. In order to compete with the activities of the peat-, soil- and bark industries the compost plants need to undertake common efforts in their marketing activities on a similar level.

The quality assurance organisations (e.g. the compost quality assurance organisation in Germany, KGVÖ in Austria, VLACO in Belgium, VVAV in the Netherlands) support the compost plants in their joint marketing activities. It is neither necessary nor financially sensible that each compost producer develops its own marketing instruments.

The marketing measurements in the individual EU countries vary decisively in size and volume. There are only actions in countries with a developed compost management. An advantageous start of a marketing strategy is to build up a quality assurance/certification with recommendations for the use of compost for the most important ranges of product sales. (User brochures of the German Compost Quality Assurance Organisation, 2-volume guidelines for practical use of compost of VLACO in Belgium, 6 user information sheets of the KGVÖ in Austria). The Belgium VLACO supports additionally a row of tests for the use of compost.

Compost use and markets

Significant differences on the market situation are to be recognised also in the EU countries. Generally it can be recognised that even in the developed countries with a circumstantial compost production like Germany the feared problems with compost sales did not occur. In all the countries hobby gardening, horticulture and landscaping is a successful market and has a good chance of developing.

Table 8: Market shares of compost sales and market size

	Market shares in selected EU countries (in %) 1998					Market size
	Austria					
	Belgium					
	Germany					
	Denmark					
	Netherlands					
Landscaping	30	24	33	19	30	Large
Landfill + Restoration	5	5	4	13	-	Small
Agriculture	351)	5	21	10	40	Very big
Horticulture	5	6	7	3		Medium
Earth works	5	33	10	-		Medium
Privat gardens	20	18	19	48	20	Large
Export		9	-	-	-	Very small
Miscellaneous		-	6	7	10	

[1]60% of the Austrian VFG and green waste is on-farm-composted

Compost marketing shows several trends in Europe. Green compost is an organic fertiliser and soil conditioner accepted by the markets all over Europe. It can be produced in a good quality without much technical equipment. The biocompost market shows two contrary developments: By means of the decreasing or low tipping fees, some of the composting plants try to minimise their treatment and marketing costs which results mostly in delivering the compost free of charge to farmers without additional marketing efforts. On the other hand a lot of composting plants start to add value to their compost products and produce mixtures or special products according to customers' needs and market requirements. They co-operate with earthworks or build one by themselves. The quality assurance organisations support these tendencies in organising research projects for compost application and for new compost products.

Conclusion

The European compost market requires best quality like the development in Belgium, Denmark Germany, Netherlands, Austria and Switzerland show, as these countries already have a highly developed compost management. The quality standard of the composts must stand the competition on the market with peat-, earth- and bark products. This is only possible with organic raw materials from separate collection and via a distinct quality assurance programme to be handled by the compost sites.

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Use of sewage sludge in agriculture Presentation of an opinion from the Economic and Social ommittee of the EU

(Staffan Nilsson Member of the ESC, Member of the Board of the Federation of Swedish Farmers (LRF))

Introduction

First of all, I want to express my thanks for the invitation and the possibility for me, as member of the EU Economic and Social Committee, to present our opinion, adopted on 19 October 2000 under the title "Use of sewage sludge in agriculture". Let me also express my real estimation for this initiative between the Commission and the Italian Environment Protection Agency.

The role of the ESC

I want to briefly explain the role of the Economic and Social Committee (ESC). The Rome Treaty set up the ESC. We have an institutional role beside the Parliament and the Committee of the Regions. We can express our role in three different ways:

- To advise the three big institutions (European Parliament, Council and Commission);
- To promote a greater commitment/contribution from civil society to the European venture;
- To bolster the role of civil society organisations and associations in non-Community Countries and, to this end, foster structured dialogue with their representatives and promote the establishment of similar bodies in the CEEC, Turkey, the EUROMED, ACP and MERCOSUR countries etc ("institution building").

To achieve these objectives, the Committee can issue three different kinds of opinion:

- Opinions on matters referred by the Commission, the Council and from the European Parliament. The Treaty provides for Committee referral in a wide range of areas; these are thus "automatic" referrals based on proposals from the European Commission;
- The Committee may also draw up exploratory opinions;
- The Committee may also express own-initiative opinions.

The 222 members of the ESC represent organisations for workers, employers and other groups like farmers, consumers, environmentalists and others from the organised civil society.

The ESC opinion on sewage sludge

This opinion on sludge is an own initiative of the ESC, and the intention is to influence the Commission in their work to renew the Directive from 1986.
The focus is expressed in the title: the view is from the agricultural side and in full respect and harmony with the consumer, agrifood-industry and agri-co-operatives. The document describes the sewage system for collecting waste from urban areas and the possible use of sewage sludge in agriculture. Sludge and other organic waste contains nutrients for plants, which are a key resource for sustainable agriculture and society. However, in urban sludge the nutrients are mixed with numerous metals and organic pollutants.

Background

The organic waste produced by society mainly comes from the country's own farm produce or imports of plant or animal origin. This waste naturally contains the nutrients plants need. They are a major resource for agriculture. In addition to organic waste containing nutrients, other substances are introduced as a result of domestic use. A large number of different chemical substances are also added. These substances have no place in agriculture or food production and compromise the sustainability of arable soil and food quality. Researchers and environmental and farmers' organisations also question whether, under the current system, the waste

water treatment plant manages to remove both metals and hazardous organic substances sufficiently when purifying the waste water. In the years ahead more waste water treatment plants will be built, and more sludge produced. Often this is accompanied by the introduction of taxes and bans in order to stop the deposit of organic waste on landfill sites. As a result waste producers will step up their efforts to persuade agriculture to use larger quantities of sludge.
The precautionary principle, the "polluter pays" principle (PPP) and pro-active measures are the guidelines to be followed for reuse of nutrients for plants in agriculture. The ESC particularly stresses the importance of applying the PPP to sewage and to the production of sewage sludge. Regulations should be adopted to promote new systems which facilitate the use of non-pollutant forms of waste in agriculture, and the recovery of valuable components in waste water and other organic waste.

Nutrients

Among the nutrients for plants, phosphorus has a special signification. Phosphorus is an element contained in the Earth crust, which is currently extracted from phosphorus-rich calcium phosphates. It is vital to plants and must be added to the soil if harvests are to produce optimum yield. The growing need for food over the next fifty years can clearly be expected to boost demand for supplies of phosphorus for crop cultivation purposes. In this sense this element can become no longer economically viable and must be managed prudently by society and recycled with a view to promoting sustainable agriculture and a sustainable society.
There is also a solidarity dimension. The Member States will probably be able to afford to buy the phosphorus they need even in fifty years' time. When costs rise, the poorer countries are the ones which will have to content themselves with poorer quality and dwindling supplies. Since phosphorus is an element (like metals such as mercury or cadmium), it is not degradable and will not disappear. Phosphorus contained in agri-foodstuffs will, unless recycled in agriculture, gradually spread to watercourses and groundwater. There is therefore a risk that phosphorus that is not returned to arable land will leak into the environment in a way which has hitherto not become apparent and will cause environmental damage.
When we separate sludge from the water, we also get on average nearly up to 90% phosphorus in the sludge. But little advantage is taken of important nutrients in waste water such as nitrogen and potassium. But for the plants we should need to built a circle where we can get back clean nutrients, if we want to build what we talk such a lot of, the sustainable society and sustainable agriculture.

Heavy metals

Well, what is then the problem? Let us focus on metal content of soil and waste. Technology-linked environments contain three times more cadmium, fifteen times more lead and twenty times more copper than arable land. When these metals erode, they must not be allowed to disperse into farmland, even if copper sometimes needs to be added to soil with a low copper content.
For the past twenty years, six to seven metals have been regularly analysed on the instructions of the authorities, as provided for in the Sewage Sludge Directive 86/278/EEC. There are historical reasons, such as widespread industrial use, for controls on these metals. In recent decades a large number of new metals and other raw materials have come into use. They too should be checked in organic waste. Certain tests on the silver content of sludge and soil, show that levels in the soil have doubled within a period of between five and ten years in normal sludge spreads. The content of certain other metals (wolfram, gold, platinum, uranium) has doubled in the space of decades.

The Sludge Directive indicates metal concentration in mg metal/kg dry matter. This measurement criterion has certain limitations:
1. Metal concentration can be diluted by mixing sludge from treated sewage with lime, sand, peat, animal manure etc, thereby obtaining concentrations below the mg metal/kg dry matter limit value;
2. The degree of decomposition/digestion plays a role; a more digested or composted material will have a higher metal concentration per kg dry matter;
3. This measurement gives no indication of the element's origin. For instance, sludge and animal manure can have roughly the same metal concentration. In the former case, 95% of these metals will stem from technology-related environments and, in the latter, most metals will derive from foodstuff and the farmer's own land.

A supplementary method of measurement is to indicate the content of certain metals in relation to the phosphorus level, e.g. in mg cadmium/kg phosphorus. This method offsets the shortcomings of the mg/kg measurement.
Two basic principles are used by scientists to determine the acceptable level of metal concentration in arable land:
1. Metals can be added to the soil up to a certain limit considered harmless to land, crops or human health (Often this is interpreted as implying that anything up to that limit is permissible. Once the arable land has reached this ceiling, spreading must move elsewhere.);
2. Fertilisation must be reduced so that a balance is established between the introduction and loss of metals in the particular area concerned. (Here the precautionary principle is interpreted more strictly, but a given increase in metal concentration in the soil - possibly 2 times (+100%) over 10,000 years can be accepted, i.e. an increase of 1.0% every year over the first 10 years, 0.3% over the next 90 years and 0.001% over the next 9,900 years.).

Organic pollutants

We have also other problems related to sewage sludge, let me state our comments on hazardous organic substances, which occur more often in waste water and sludge from waste water treatment plants than in other types of organic waste. The reason is quite simply that they are often contained in effluents or, as a result of wear, are evacuated with the water collected in the sewage system.
Although thousands of substances can be analysed, they are merely a fraction of the 100,000 or so substances contained in waste. Many of them decompose during processing in the waste water treatment plant, while new substances are probably being created at the same time. Only for a few of these substances is the environmental impact known.
Methods of analysis for organic and inorganic pollutants need to be developed.
In order to reduce the quantity of undesirable substances, water from certain sources of waste must be closed off or purified before release into the sewage network. Such sources include industrial activities, run-off water and leachates from landfills and car maintenance plants.
Another step is to curb the use of hazardous substances for domestic or industrial purposes. Progress on the EU's policy and rules on chemical products need to be speeded up so that manufacturers document all ingredients and replace unsuitable or undocumented products by a set deadline.
A third way to reduce pollutants in organic liquid waste is to introduce separated systems, and so avoid mixing organic waste with other forms of waste and consequently deal with each component individually. As a third aspect we can focus on contamination risk.

Pathogens

Waste containing faecal matter and other organic waste includes pathogenic organisms such as bacteria, viruses and parasites. All organic waste must be carefully inspected and treated appropriately so as to avoid contamination. The need for preventive measures and control has increased.
The use or elimination of waste from urban areas must not involve any risk of epidemics in people, livestock or wild animals. Farmers suffer considerable financial loss when disease strikes their herds. If organic waste from urban areas is to be used in agriculture, the product must be safe, particularly with reference to salmonella and E. Coli O157. For certain diseases, that also presupposes that waste may not be used on arable land or as fertiliser, and that it must not be landfilled until the risk of contamination has been eliminated.
But the use of sludge is not only a question for agriculture and society, we need also consumers' confidence in agriculture. Consumers are entitled to demand, and receive guarantees, that the foodstuffs on sale comply with established food safety regulations. The producer and the salesperson of the food should provide such guarantees. The consumer's evaluation of food quality plays a decisive role in the value of such products and determines which products he/she chooses. The food market is sensitive to alarms regarding various risks and high standards of food safety must be guaranteed so as to foster confidence. This also influences farming methods, and the use of sewage sludge.
Whether or not the use of sludge is acceptable will be influenced by the food products' measurable quality but will above all depend on the general public's confidence in the use of sludge in agriculture and in the waste water system's capacity to supply non-pollutant nutrients. In most Member States there is an ongoing debate on whether it is appropriate to use sludge and other organic forms of waste on arable food-producing land. There are a number of reasons for the low acceptance. The sludge contains a number of pollutants. Knowledge about the function of sewage systems, the influence of individual human activities and the need to return nutrients to agriculture is generally low.

Commission Report on the implementation of Community waste legislation

In its Report on the situation regarding implementation of Community waste legislation, COM(1999) 752, the Commission states that the use of sludge on arable land is considered to be the most environment-friendly option, and that no reports have been received of damage to people, animals or crops caused by the use of sludge on farmland.
The ESC does not agree with the Commission's intention and is critical of this over-simplified approach. As this own-initiative opinion shows, there is every reason to have doubts about the use of sludge on farmland in view of its present quality. Few of the metals, which pollute sludge, have been analysed. The metal concentration allowed in sludge is far too high for sustainable use. Certain sludge spreads, which are accepted in the Sludge Directive, involve a doubling in the metal concentration in soil after one or two single spreadings. Too little is known about all the organic pollutants mixed into sewage sludge, or about the health risks.
A number of research surveys also challenge current limit values (e.g. cadmium in foodstuffs) and indicate that the risks to human health could be greater than researchers have thought to date. The same holds for dioxins. The Report shows no recognition of the problems and does not spell out the need for healthy soil to be able to produce healthy food for thousands of years to come. The Report indicates that the use of sludge is regarded with increasing suspicion, though it states that this distrust is not scientifically justified. According to the "precautionary principle", action should be taken even if sound scientific proof of the danger is not available.

In the ESC's view, the decisive factor for agriculture and the food industry is consumers' confidence in their raw materials and products. So the potential use of sewage sludge in agriculture is to be decided by farmers and consumers

Regulatory aspects

In our opinion we also have a chapter with some important comments related to the legislation and with some important regulatory aspects.
We underline the need that the revised Directive take into account the guidelines of the Communication on the precautionary principle. The Committee wishes to see evidence of an integrated approach, as the Commission has recently tabled several documents referring to a series of principles and guidelines governing the future of its legislation, also applicable to the subject under analysis.
Water is protected under the forthcoming Water Framework Directive. In addition, the ESC highlights the absence of any Community minimum requirements regarding soil protection and urges the Commission to trigger procedures to this end.

Conclusions

Nutrients for plants are transported to urban areas through agri-foodstuffs. Nutrients remain in food waste and toilet water and can be channelled back into agriculture without added pollutants so that agriculture and society can be sustainable.
Over the next 10,000 years a doubled content of most metals in soils might be acceptable. That means that sludge can be used when the amount of metals added in the next 10-20 years does not exceed 10-15% and that it is to be reduced to almost zero within a generation. Hazardous organic substances are in the long run to be avoided all together. A model for risk assessment and methods for analysing the effects of key chemicals in biological systems is needed now. Use of sludge in agriculture must not generate increased risks of contamination in agriculture or among the general public.
Little advantage is taken of important nutrients in waste water such as nitrogen and potassium. However, 90% of the phosphorus content is captured in the sludge. People are sceptical not only about sludge quality but also about the capacity of the sewage system in its present state to purify sewage, and hence to contribute to a sustainable society.
As a result, doubts regarding the use of sludge in agriculture exist in most countries. Often there is little understanding from sludge producers and authorities regarding this problem. The questions need to be identified and proper targets and actions should be defined in order to change the situation.
EU consumers are entitled to demand safe food and to influence the production methods and resources used in agriculture. Many groups, including the chemical industry, consumers, sludge producers, building firms, planners and decision-makers, are responsible for ensuring that society develops in a way that allows nutrients to be recycled. Agriculture has the task of maintaining soil quality and bears ultimate responsibility for what is spread over arable land. The environmental impact cost from any use or disposal of sludge should be internalised in the costs for water use and pollutant products. In the ESC's view, agriculture should in the long run only use nutrients from organic waste kept separate from other pollutant waste which increases the metal content or introduces hazardous organic substances. Hence the use of sludge as agricultural fertiliser is highly dubious, and in most cases manifestly unsuitable unless the sludge and the system delivering it are greatly improved.

Recommendations

The revised Directive should indicate clearly that the overall long-term aim is to channel back non-pollutant nutrients from the Community's sewage into agriculture. It must specify that the precautionary principle and PPP are applicable in evaluating sources connected with the sewage system and the production and use of sewage sludge.
The revised Sludge Directive must adopt a holistic approach to all effluent waste from waste water treatment plants and other urban waste sources. It should preferably encompass all waste and discharges which are not covered by the forthcoming Water Framework Directive.
Though water protection legislation exists, there is currently no Community minimum requirements regarding soil protection. The ESC urges the Commission to draw up such legislation.
The origin of waste, the substances introduced into it and the processes it has undergone must be reported to the authorities and to the user. As a back up to the mg/kg measurement, the quantity of certain metals could be indicated in relation to the volume of phosphorus (e.g. mg cadmium/kg phosphorus). This measurement offsets shortcomings of the mg/kg criterion.
Responsibility for environmental damage caused by sludge use should be specified in the Directive. The national authorities should report regularly on the use made of sludge, its quality and the quality of other types of waste so as to help authorities and users to make both national and international comparisons. The EEA has a natural role to play in collating such information to be notified by the Member States.
Systems for tracing sludge use, reliable testing methods and permanent monitoring systems need to be developed. Ways in which the Member States manage risks connected with the use of organic waste should be reported and published on a regular basis.
The ESC stresses the need for the waste committee to liase closely with the Commission's scientific services in order to ensure objective risk evaluation.
Since one of the EU's aims is to create a sustainable society, greater priority must be given to environmental sustainability and steps must be taken to facilitate investment in new technologies that reduce the environmental impact of organic waste management in general, and the re-use of non-pollutant nutrients in particular.
The amended Sludge Directive should state that metal content in sludge can only be used when the amount of metals added in the next 10-20 years does not exceed 10-15%, to be reduced to almost zero within a generation. Hazardous organic substances are in the long run to be avoided all together. A model for risk assessment and methods for analysing the effects of key chemicals in biological systems is needed now. Use of sludge in agriculture must not generate increased risks of contamination in agriculture or among the general public. The Commission is requested to consult the ESC in its future work on the Sludge Directive and other regulations governing the production and management of organic waste.

PANEL DISCUSSION: the Development of a Market for Compost

Glòria Colom i Puigbò (Organic Waste Department of Cepa Catalonia)

The development of a market for compost depends on:

1. Its requirements
2. Its quality
3. Its price

Requirements

- They can increase if the use of chemical fertilisers decreases. In this sense, it's necessary to make a promotion effort and to have a distribution method.
- If a region has a surplus of organic materials, those must be relocated to other deficient places. Just remember that: Sicily loosed its fertility into Roman sewers, as happened with North Africa nutrients during first century a.D. This contributed to an environmental and economic failure of this region on the half III century a.D. (Justus von Liebig)

Who makes the marketing of compost:
- Marketing based on own workers.
- Engage brokers.
- Take a private contractor to market in bagged form to chains of stores.

Promotion policies:

- In many countries there is a bad experience (compost with impurities, weeds, diseases, pesticides, unsteadiness of compost...) due to compost coming from unsorted municipal solid wastes (MSW). It's hard to get a first-time customer but it's three times harder to get them back. It's necessary to give credibility.
- To give specialized advice (dose of application, application method, moment of application). Researches in this subject are very interesting.
- Supply transport and field application.
- Be aware about customer interests. For ex: landscapers preferences in EEUU have changed to a larger compost particle size to help aerate soils.
- It's important to have a steady supply of uniform product.
- Give compost to show it's a good product for free.
- Choose some types of customers (for ex. Landscape contractors, garden centers and homeowners) as the primary markets, and get other types since them.
- It's very useful to make information pass by word of mouth.
- Offer a bagged product to reach a broader audience. In this specific composting business, competition becomes harder. Bagging compost also allows you to advertise your product when you are selling it.
- To diversify the offer by adding other products like topsoil, wood chips, and several types of mulches.
- No overstimulate the market because it can run out of product and the valued customers would start buying compost from other sources.
- The location of composting facilities is also important. For ex. Near a hot market for lawn and garden sales, close enough to a metropolitan area.

Quality

- It's the most important aspect.
- It's the easiest aspect to touch upon it.

Legislative measures that would help the compost market:

It should be a maximum of impurities allowed for the incoming food residuals. This implies:

- The source separation of the organic fraction of MSW must be mandatory.
- An increase of environmental education.
- The use of composting bags (Image 1).
- Choose a good collection model for source separation schemes.

It should be a minimum quality of the final product.
Possibility to introduce organic pollutants analyses.

Eco-labels and quality assurance schemes:

- They can be the solution to change the negative image and to give credibility.
- It's necessary to do enough analytic control.

Improve the management of the facilities:

- Control the managers of the collection and transport as well as the managers of the composting facilities.
- Assure a convenient period for the composting process.
- Handle contamination of the material as soon as possible (preventive management instead of finalist management of the composting facilities). The compost of Image 2 has past by a complicated post-treatment, and has still some little impurities. The compost of Image 3 has past by just a trommel, and has no impurities. Real solution for impurities is based on a clean separate collection fraction and pretreatment.

Gravity separators are not the solution for all the impurities.

Price

- In Catalonia, the price of compost ranges between 9.01 and 54.09 €/tm.
- It is possible to touch upon this aspect by, for example, aiding agricultural use of compost

Silvia Calamandrei

(Head of Division of the Section of "Agriculture, rural development and environment protection of the Economic and Social Committee of the European Union)

.First of all my compliments to the organisers of this highly qualified conference, paying attention to waste management aspects that have been left aside in the building up of the European waste strategy, that had to focus first on priority subjects concentrated in the industrial sector. This strategy, based on prevention, recycling and recovery of waste, has achieved great results, and thanks to its success we are now able to conceive new targets and to involve new stakeholders: not only industry and consumers, but also the farmers, who are paying greater attention to sustainable agriculture and agro-environmental measures and are potential users of new recycled and recovered materials.

Staffan Nilsson, a representative of Swedish farmers, has already illustrated the reasons and the contents of the ECOSOC Opinion on sewage sludge and has underlined the interest of farmers in an improved dialogue with society on preservation of soil and natural resources, preventing harm to the environment and promoting sustainable rural development.

Organic waste produced by society and properly collected and separated can be used by farmers as a nutrient; but as users and producers of consumer goods the farmers want to be guaranteed that hazardous substances (especially heavy metals) are properly removed, avoiding damage to water and soil and preventing an impact on food products. So the farmers are involved as stakeholders in the use of recycled materials resulting from the collection of waste: to develop this new market their point of view has to be taken into account.

For this reason the ECOSOC is pushing for the revision of the sewage sludge directive and is looking forward to other measures in the same direction; this is part of the effort to integrate the environmental dimension and a high level of consumer protection into all policies, as well as an important issue in the food safety policy. At the Economic and Social Committee we are dealing with agricultural questions, food safety and environment within a single consultative structure, the Section for Agriculture, Rural development and the Environment; this is an interesting experiment in dialogue and consensus building between different stakeholders, allowing a better mutual understanding and opening up agriculture to the new demands of society.

We are looking forward to the results of the present debate and to the future initiatives of the Commission and we are prepared to give our contribution in connection also with the discussion of the new Environmental Programme and the debate on the future of Agriculture Common Policy.

Agostino Braga
(Council of European Municipalities and Regions)

Separate collection of organic waste is a necessary step in order to reach significant values of separate collection and to meet the EU targets.
Especially in southern European countries, there is extensive need of compost but, possibly because of the poor quality of this product in the past years, the demand is limited and there are few composting plants.
In Greece, for example, about 50% of the municipal solid waste is composed of organic material and 8,3% of the GNP arises from agricultural activities: this is 2-3 times as high as in the other southern European countries. Furthermore, compost could reduce the waste problem also with regard to the Greek islands, providing an economical solution that could be useful to enrich the soil with humus. But, for the moment, not one composting plant is operating (like in southern Italy).

More generally, separate collection has had difficulties in getting under way in southern Europe, both because it requires several types of competence, that the local authorities often do not possess, in order to be successful, and because of the lack of a productive system which provides for the treatment and recovery of whatever could be separately collected. Furthermore the transport costs to distant treatment plants are often prohibitive.
There are simply not enough paper factories, glass works, steel plants and compost plants able to usefully use recovered paper, glass, iron and organic waste.

So we have to face two problems: the first concerning the organization of separate collection, which is the task of the local authorities, and the second concerning facilities, that is the lack of plants for recovering the waste separately collected.
The solutions that I foresee require a precise commitment of the European Union and of the central governments in order to train and to educate the local authorities and the citizens.
In particular, in the case of compost, the educational aspects also concern the users: if the students of the agricultural schools begin to use compost during their studies, they will better appreciate its utility, also in their future professional lives.
In my city (Brescia) an agreement has been in effect for several years, which establishes that the local utility supplies compost free of charge to an agricultural school and co-operates with it on research for optimum utilization.

The other fundamental aspect is quality, that has been extensively discussed during this conference. The industrial sector, which is the recipient of paper, glass, metals selected from waste, is very well organized from the quality point of view and is more easily controllable. The agricultural sector, on the other hand, is not sufficiently committed to quality.
Low quality composts have a negative effect not only on agricultural products, but also on the soil and on water bearing strata.
The concept of quality, for compost, has to be applied starting from the conferment of the biowaste through appropriate information to the citizens, in order to ensure an adequate level of purity.
There is also the collection stage, which has to be optimized in order to keep costs within bounds and increase the percentage of the humid organic waste collected.
At this stage, and in the final treatment stage, recourse to certification such as ISO, EMAS and ECOLABEL for the compost is desirable.

The European Union is preparing a Directive for biological treatment of biodegradable waste,

which is awaited with great interest and expected to provide everyone with a common framework.
Indeed, it is essential to ensure that, in view of application of the Ladder Principle and thus of the residual use of landfills, compost does not become a disguised disposal, causing long-term damage to the soil and polluting the water bearing strata.
This is an aspect that worries the local authorities very much, as they are the first defenders of their territory. And they are right to worry, because the work document ENV.E.3 for biological treatment of biodegradable waste (20.10.2000 version) establishes five environmental quality classes for compost and stabilised biowaste, with values that are not acceptable for the lower classes.

I conclude with a recommendation, which may sound banal, but that could lead us to significant results in waste reduction: we have to promote home composting wherever possible. A composter costing 30-60 euro will eliminate conferment, collection, transport and treatment stages.
In spite of this, there has been little interest in developing this option, also because in the official separated collection percentages of several member countries (including Italy) the data relative to domestic compost are not included (although assessable and controllable by sample) and thus do not contribute to achieving the separate collection targets.
That is undoubtedly why this useful solution appears less interesting to the local authorities.
That is not the case, for example, in Switzerland, where 2/3 of the biowaste is treated in domestic composters.