ORGANIC WASTE IN SPAIN: A PROBLEM THAT SHOULD BE A RESOURCE

M. Soliva
Escola Superior d'Agricultura de Barcelona - UPC. Urgell, 187. 08036 Barcelona. Spain.
montserrat.soliva@upc.es

INTRODUCTION

It is difficult to say something new about biowaste (BW); a lot of information exists and many articles have been published (Felipó, 1996; Merillot, 1998; Vallini, 2001; Crowe, 2001; Amlinger, 2002; Wasterman and Picudo, 2002; Bernal, 2002; Marmo, 2003). I would like to deal with the subject from a different point of view. It would be repetitive to talk about the amount of waste generated in Spain or in Europe, its increment or the problems it causes. I want to pose a lot of questions to try to shake up our "waste awareness".

We are conscious of the quantity of wastes generated but we are not sufficiently aware of the problems that this provokes and of our responsibility; we talk a lot about environment, about the need to conserve natural resources and how to close cycles; we also talk about sustainable development; but society is not advancing in waste reduction, nor in offering an integrated package of management options that could really solve the problems to a certain extent. Everyone is using certain words, set phrases, which have lost their real meaning. Is the interest in achieving sustainability and in protecting the environment more political than real?

The different interests that merge in waste generation, management and disposal are many (social, political, economic, technical and environmental) but they do not have a common tendency.

There are a lot of environmental experts, a lot of politicians with responsibility in environmental questions and many scientists working on projects related with the treatment or use of BW. Likewise, there are environment enterprises and relatively new groups of consultants. To what extent is the planning and solution of environmental questions only an economic or vote seeking-business? To what point do all those who in theory study and defend the environment know the real situation in depth? Or are those of us who generate waste (directly or indirectly) aware of the problems we create and which must be solved in the day-to-day management? Is there enough community participation?

The BW management is fragmented into a variety of interests and organizations, so correct treatment with a global vision becomes difficult. To overcome this difficulty it is necessary to know:

- the quantity and types of BW generated
- the possibility of reducing the quantity generated and/or improve its characteristics
- the most sustainable disposal methods and possible treatments
- how to control treatment systems to avoid environmental problems
- the energetic and environmental inventory of BW recycling system
- the possibility to re-use in the soil and to identify and control the soil quality indicators after biowaste application
- the link between BW re-use and food and fodder quality
- up-to-date results of research being carried out on the wastes

Administration and society should change their point of view about wastes. Public awareness of the waste problem and our role in solving it is very poor. Environmental quality and food safety can be achieved only with global responsibility and local action. What sort of efforts are people ready to make?

In what context are we talking about BW? In a worrying economic and environmental situation, with new legislation concerning waste management emphasizing recycling and soil protection among other aspects; but, moreover, here in Murcia, we are in a special geographical situation. It is special for its charm and also because of its pedological, cultural and climatic features, which oblige us to recycle the organic matter in a specific way. Are we to believe that regulation and management of OW, its collection and the treatment conditions have to be the same for all countries?

The climatic conditions have a double effect, both on soil and on organic wastes. The organic matter in Mediterranean soil is lost rapidly with undesirable effects on many soil properties. Organic wastes are usually humid and biodegradable, so when wastes are not correctly managed they rot quickly, causing environmental and health problems.

Nevertheless, it is not possible to change the climatic conditions, but it is possible to reduce waste production and the disadvantages associated with its management. Efficient strategies of waste management, including adequate agricultural practices, could prevent soil organic matter losses, mitigate some soil degradation problems and improve its quality.

WHAT KIND OF BIOWASTE ARE WE PRODUCING AND WHAT PROBLEMS DOES IT CAUSE?

It is necessary to know well "What kind of wastes there are and where they are generated" in order to minimize their production and associated trouble; and how to manage and treat different classes of BW adequately and reasonably.

Different kinds of BW (solid and liquid manures, sewage sludge, and organic fraction of

Table 1. *Differences between biowaste (Notes: OF organic fraction, MF mineral fertilizer, HM heavy metals)*

	Quantities	Improvements	Main characteristics: advantages/disadvantages	Proposals for reducing problems	Best recommended treatments	Reuse/Disposal
Solid manure	High	Reduction number animals	Rich in OM, N, P, K Good for direct applying or composting	-	Composting	Land application
Liquid manure	High	Reduction number animals Change systems management	Excess water and available nitrogen content Behaviour in soil similar to MF Bad odours Storage and transport difficulties Water and air pollution	Changes in farms Charges waste management	Phase separation Co-digestion Nitrification/Denitrification	Land application
Sewage sludge	Medium	Saving water or/and better treatment of waters	Rich in N and P / Poor in K Low stability High pollutant content (HM, biological and organic pollutants) Bad odours Behaviour in soil similar to MF Soil and water pollution Stabilization before application	Better control waste waters and treatments	Co-composting	Land application (with caution)
OF Mechanical Separation	Medium	Must diminish in ratio to total MSW production	Poor in OM and nutrients High pollutant content (HM, biological and organic pollutants) impurities Stabilization before application	Separate collection Biological treatment	Digestion Composting	Land application (with caution) Landfill
OF Separate Collection	Low	Must increase in ratio to total MSW production	Very humid and putrescible Stabilization before application	Biological treatment	Digestion Co-composting	Land application

MSW by mechanical separation or from selected collection) (Menzi, 2002; Soliva and Felipó, 2004) and different conditions (quantities, seasonability, possible problems, geographical situation, economic development, etc) relating to them are summarized in table 1.

Who is responsible for the production of these different wastes? Who must pay the costs generated? For example, in the case of animal waste, are only the farmers responsible or is society guilty on account of its necessities? The costs of waste management are more easily passed to the consumer for the treatment of industrial waste, waste waters and MSW, than those of farm waste.

WHY THE INTEREST IN TRANSFORMING BIOWASTE INTO RESOURCES?

There are sound economic and environmental reasons for a more sustainable approach to managing waste. The aim of waste re-use is not only to avoid waste disposal, but also to decrease the exploitation of natural resources through recycling; in the particular case of BW it is done through the soil-plant system.

There are reasons for transforming wastes into resources, but what kind of resources? How do we do it? What requirements are involved? Good quality BW contains OM and plant nutrients and it is possible to take advantage of them after an adequate treatment (mainly biological) by using them as organic fertilizers (OF), conditioners or mulches for plant production. If we want to accomplish this transformation it is necessary to take this fact into account in all steps concerning waste source and management (generation, collection, storage, treatment and reuse in local conditions).

Table 2*. Main characteristics (Bad 0/ Regular 1/ Good 2) of some composts and their possible land reuses (Agriculture A/ Private gardens, B/ Public gardens, C/ Land rehabilitation, D/ Civil engineering revegetation, E/ Substrates formulation, F/ Sportive areas, G/)*

Compost origin	pH	EC	SV	Stability	Nutrients	Pollutants	Germination Index	Aspect Odour	Uses
Manure	1-0	1-0	2	2-1	2	2	1	2-1	**ABCDEH**
Bark	2	2	2	2	0	2	2-1	2	**BCFG**
Pruning residues (PR)	2	2	2	2	1-0	2	2	2	**BCEFG**
Sewage sludge+(PR)	2-1	2	2	2-1	2-1	1-0	2	2-1	**ABCDEF G**
MSW	2-1	0	1-0	1-0	1	0	I	1-I	**DE**
OF separate collection +PR	2-1	1	2	2	2-1	2	2	2	**ABCDEG**

The possible users of these new resources must be aware that wastes are not homogeneous materials and have specific characteristics depending on their source and management practices (Table 2). Users must be able to establish the requirements for the quality of new resources. Society, as a consumer of food and user of the natural and leisure spaces should also demand a fixed quality in the products applied to soil, but accepting its own personal responsibility.

In a parallel way society, administration and waste managers must assess the way in which these requirements affect efficiency, effectiveness and cost-optimisation. Who will support the management and treatment costs and how can they be financed? Moreover, the enterprises that manage the wastes must be able to fulfil the previous demands, by being serious, specialized, competitive and careful with the environment. It is also necessary not to forget that politicians must include waste management in their programmes and afterwards adhere to their promises.

Every social group has a role to play in waste control and supervision, for example: environmentalist groups have to connect their ideals to real situations; citizens associations can propose solutions to the administration and must convince people of their responsibility; the mass media have to give verified information and avoid sensational news; marketing agencies and designers of new products must remember that poor product design and manufacturing processes add unnecessarily to industrial costs as well as creating extra household waste.

The application of transformed wastes to soil for its improvement and the use of nutrients for growing plants presents some challenges and some problems; the critics of separate collection or biological treatment usually take advantage of these problems.

Organic (OF) and mineral fertilizers (MF) are products with very different characteristics and mainly used for different purposes in crop production objectives.

OF have variable nutrient content which is relatively low compared to MF. The objective of applying OF is to furnish organic matter, although without forgetting the mineral nutrient contribution. OF is unbalanced with regard to plant needs and it is also difficult to predict availability. Not only the objectives are different, but also the way they are used and their behaviour. In order to prevent these problems adequate and continuous doses, combined with MF can be applied). (Bernat et al, 2000; Magette and O'Reagan, 2002)

The bulky nature of organic waste, which is difficult to haul and spread consistently, makes it more difficult to satisfy environmental regulations on amounts, timing, and methods of application. The costs and benefits are inherent when considering alternative management schemes for BW. It is true that its application can be expensive (time and manpower) but the benefits that it gives (environmental in the short term and environmental and economical in the long term) must not be forgotten, although they are difficult to determine. When regulations or environmental factors require additional treatment, which increases costs of production and operation, governments can offer incentives or subsidies. Where this option is considered, it is necessary for governments to assess what they are subsidising and make sure it is feasible.

There are possible environmental concerns, such as ammonia emission, odour and pathogens, which would probably be worse with bad management and disposal. (Kirchmann, Lundvall, 1998; Sommer, 2001)

Why are we always talking about the difficulties and not how to correct them? Probably, more imagination is necessary to find solutions to local problems.

It is necessary to find new ways for working with sustainable methods, minimising conflicts, engaging and involving all the actors in the waste theatre. Consensus will probably be attained with sound knowledge of the problems and acceptation of renunciations by all concerned.

MANAGEMENT AND TREATMENT STRATEGIES

The EU waste hierarchy defines the priorities in waste management (Council Resolution of February 24 1997 on a Community Strategy for Waste Management) and it gives preference firstly to waste prevention, then to recycling, after that to energy recovery and finally to disposal.

If we are aware that we are responsible (directly or indirectly) for different kinds of wastes production, we can choose either to ignore or hide the problem or find an effective solution. We can keep in mind the old Chinese saying (Miller, 2003): "Man- despite his artistic pretensions, his sophistication, and his many accomplishments- owes his existence to a six-inch layer of top soil and the fact that it rains".

To choose the best strategy we must take into account the new environmental and energy situation (White et al, 1999), the necessity to observe new legislation on waste management, as

well as the local and current conditions; however, it is necessary to check that environment companies do not put their own interests first.

But if the landfill sites are becoming scarce and we are obliged by legislation to reduce the quantities of BW going to landfill, the alternatives are different thermic treatments or land reuse. Incineration with energy production would be the most frequently used thermic treatment. Its main disadvantage is the high cost and OM and nutrients loses; although incineration does not completely solve the problems because it leaves a residue of 20-25% of the original mass, which may contain toxic chemicals and which still has to be landfilled. Neither can we forget the emission problems and the lack of public acceptance.

The choice of applicable treatment methods to divert biodegradable waste away from landfills would be based on an evaluation of infra-structural, economic and environmental conditions in a particular area. Local conditions and markets determine the most appropriate options for a particular country and region. Important for the future is the ability to develop integrated territorial strategies for all the different sources and kinds of BW; co-treatment (Amon et al, 2002) is already possible and has been widely demonstrated. It would be necessary to provide an adequate network of facilities that run correctly (with competent and convinced workers) before imposing certain legal restrictions and estimating the costs and benefits of the proposed legislation.

If we picture a map of OM distribution of European soils, we will see the low levels in Mediterranean zones. We do not always apply adequate agricultural practices; but even if the practices were correct, it would not be enough to recycle the harvest residues to prevent the OM losses. Probably, in a lot of zones it would be necessary to re-use selected BW after a strict control and an adequate treatment, because soil is not an immediately renewable resource and cannot support all BW produced. We should also remember the need to enhance carbon sequestration in the terrestrial biosphere through photosynthetic activity and increasing soil OM.

When recycling BW we are also recycling plant nutrients, saving the use of mineral fertilizers, which need energy for their production and in some cases come from non-renewable resources. Mankind cannot continue to extract resources from the natural world indefinitely.

Biological treatments are needed for BW land reuse. There are two biological treatments procedures: aerobic and anaerobic, special conditions are required for each one. It is important to recognize the special advantages of each without a confrontation between them. (Edelman et al, 1999). In both cases the application needs experts in microbiological and chemical aspects, but at present too much importance is given to the aspects of construction and engineering.

Digestion is a treatment that can be used to recover both nutrients and energy contained in BW (Cecchi and Innocenti, 2001). Digestion needs a high content of water and biodegradable OM (different levels depending on whether wet or dry treatment is used) and a balanced level of nutrients; this means it can be applied to liquid wastes, but it is not suitable for treating wastes rich in lignins. The digested product could be used directly in agriculture but the best alternative is to apply a composting post-treatment for marketing in other sectors. Treating contaminated waste can generate problems during the anaerobic process besides preventing digest reuse.

Composting is nature's own and the oldest method of BW disposal and soil fertilization because it stabilizes and can transform BW into a valuable resource; but today waste quality is not always adequate because it carries contaminants. By composting good quality BW, a more valuable resource can be obtained, but it is important for waste managers to determine the extra processing necessary to make it manageable and cost-effective, while at the same time developing markets.

The composting requirements are related with the water/air balance, the equilibrium of bio-

polymer ratios and all those conditions that permit the growth of the indigenous microbial population. The main obstacle to successful composting of BW is contamination of the waste stream; this can be avoided when source separation is incorporated as a guiding principle as in the case of MSW, or from a rigorous control of the inlet flow on treatment water plants when sewage sludge is composted.

A waste stream contamination causes loss of compost quality, can complicate the process and increase the need for space and wider production of screen-overflows. The sorting criteria specified by the municipality for households, the efficiency of citizens in sorting properly, the collection systems (including the types of domestic collection bags, and local storage bins) and finally the pre-treatment used (disc screen, screw separator, magnetic separator, etc…) prior to biological treatment are all very important for successful composting. (Figure 1)

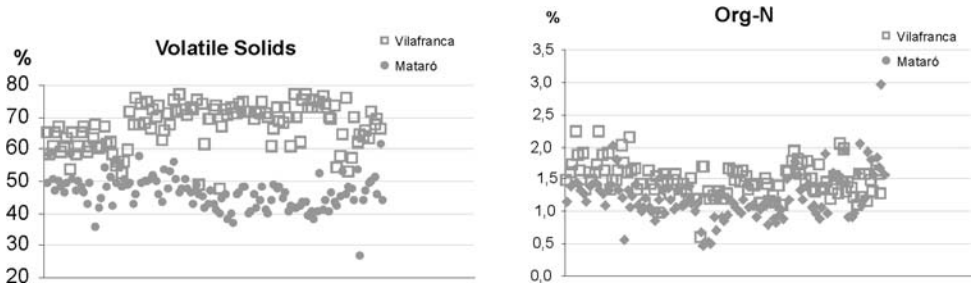

Figure 1. *Volatile solids and organic N content in MSW compost obtained in two towns from 1985 to 2003 where material selections were conducted at different stages of composting process (In Mataró, material was separated prior to entering the bioreactor; in Vilafranca, materials arriving at the plant go directly to the bioreactor) (Huerta et al, 2003)*

In Spain there are problems of application because of strong opposition from certain groups and because people are not sufficiently motivated. This means investing resources in separate collection and public education. Waste separation saves natural resources and financial running costs (Favoino and Giró, 2002). Householders have to be informed of this and the possibility of receiving a lower bill, for a smaller amount of waste, which can act as a direct incentive for recycling. Likewise, manufacturers should be encouraged to avoid the use of excessive packaging.

In Catalunya a north-eastern region of Spain, Law 6/93, regulating wastes, establishes the basis for the separate collection of biowaste (Figure 2). On the other hand in Spain in general, Law 19/1998 on waste, established for municipalities with over 5,000 inhabitants, a separate collection system of waste from the year 2001, but it is not specified that this must be done with organic waste as well (Giró, 1999).

Although, several autonomous communities and provinces in Spain have considered introducing the separate collection of biowaste in their Municipal Waste Management Programmes: Catalunya (1995), Comunitat Valenciana (1997), Madrid (1997), Aragón (1998), Castilla - La Mancha (1999), Illes Balears (1999), Andalucía (1999), Gipuzkoa (2002).

Also it is also possible to find some municipal experiences (Mancomunidad de Montejurra, Córdoba, Concello de A Coruña, Consorcio As Mariñas, Mancomunidade de Barbanza, some few municipalities in Mallorca and Menorca) which have implemented the separate collection of biowaste, with different degrees of success but some of those without conviction. (Giró, 2003)

It is necessary to have a very clear idea of what kind of problems are generated or can be generated from inadequate or bad management procedures of wastes. A difference must to be

made between immediate problems (accumulation, bad odours, aesthetics, and health) and long term problems (besides the previous ones, the need for space and a larger number of facilities; air, water, soil and food web contamination).

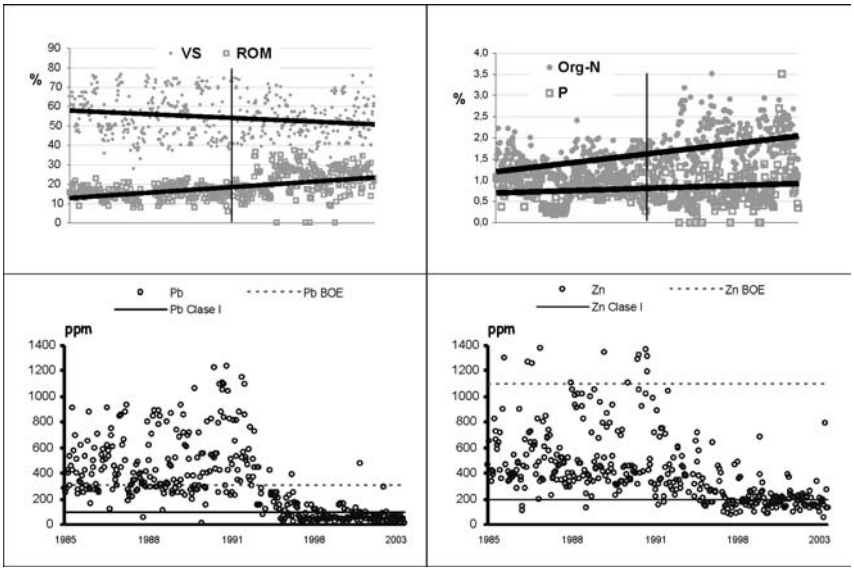

Figure 2. *Evolution from 1985 to 2003 of some indicative parameters (volatile solids, VS/ resistant organic matter, ROM/ organic nitrogen/ phosphorus/ and two heavy metals) of compost quality. Vertical line represents the introduction of separate collection in Catalonia (1997) (Huerta et al, 2003).*

In order to provide support for treatment plants and possible users of compost in many municipalities it would be necessary to provide qualified experts in biological treatments and compost use. And why do we not asses the decision makers?

To ensure linkage between waste collection, its treatment and the subsequent use of end-products such as compost, integrated waste management plans are required, at local and national level. The risks involved in pursuing a strategy of large-scale separate collection and restrictions on disposal are also worth considering. There is no sense constructing composting facilities if the compost produced cannot be put to beneficial use due to inadequate quality or lack of markets.

RESEARCH NEEDS ON WASTE IN LOCAL SCENARIOS

Even if extensive information on waste and environment interaction exists, management practices currently in use are probably not the best. We do not raise enough awareness of the fact that only with proper waste management, land and water can conserve their qualities for the future.

Waste problems may be viewed in very different ways, with no common interests. Even scientists can view them differently depending on where they work. Which kind of research must be done at the University and other research centres? Who finances this research? What kind of research are companies doing? Do they do the most adequate research for each country? Should sound science and research form the basis for decision making?

Although some countries and local governments seek the advice of scientists for environmental concerns and management of BW, unfortunately politicians do not always make decisions with an adequate input of information from scientists and engineers. (Westerman and

Picudo, 2002). And this is a vicious circle because occasionally scientists do not work on what is most necessary but on what may obtain most financial support.

This is the age of new technologies, but we must remember that there is no technology to replace losses or degradation of soil and its essential functions, to renew contaminated groundwater, or to correct global climatic changes. Thus, to avoid the main disadvantages related with BW, it is not only necessary to have new technologies to treat them, but also to study the factors that influence their behaviour during disposal, treatment or reuse, enhancing the importance of local scenarios.

A lot of research has been done on waste treatment, characterization, transformation and agricultural re-use, including effects on soils, environment and the food web in different scenarios and under diverse conditions. (Bertoldi et al, 1996; Orbit Conferences) A considerable amount of work has been done to define quality parameters of BW and the resources derived from them which are sometimes too complex to develop in practice. However, only a little progress has been made to improve the quality of the raw materials, composting and digesting systems and process control. Nevertheless, the problem is in the lack of connection and continuity; it seems that we are always beginning, the efforts are overlapping and it is not always possible to transfer the obtained information to real situations.

Community waste problems should be included as a subject in research projects; the results and technical solutions from those projects are very important for the transfer of knowledge to engineering students, decision makers, the general public and whoever else might be interested.

Certainly, more research concerning BW is still needed but as Menzi (1998) says “This is of secondary importance compared to the lack of transferring the scientific knowledge into actual farming practice”.

Decision makers, companies and researchers must be natural allies in their efforts to promote more sustainable approaches to waste management but always taking the community into account (Hueg, 1979). Why is it that research does not often reach decision makers? Why do these often ignore relevant research? Why cannot scientific results be transferred into effective policies? (ISNAR-Forum, 2000)

Research must be planned according to local conditions and consider results from previous studies. Progress in waste management, continuous cooperation and exchange of technological and organisational experiences are needed. To warrant a sustainable future a progressive transfer of knowledge is necessary, and not by the continual imposition of economic indicators on the environmental goods and services.

Given the very different contexts in which waste research, large companies, community and decision makers operate, the interface between them is bound to be complex and is often underdeveloped or otherwise functions poorly. The same issue may constitute a very different challenge for each group. Scientists may observe a management or treatment problem and examine the biological, chemical, and physical factors affecting the waste; they tend to operate in the long-term, following objective and scientific facts. For the sake of efficiency and accuracy, scientists tend to use technical terminology to describe research problems and research results.

Decision makers may frame the same issue in terms of the likely economic and political consequences of waste/ resource management decisions. They have to reconcile differing perspectives and opinions to achieve compromise, operating in the short-term, to reach their target audience. Even when scientists and decision makers have a common definition for a waste problem, they may still fail to communicate. Scientific communication and decision-making operate on very different time schedules, like private firms.

In our country and maybe in some others as well, we find problems in very different fields,

but it seems that a coordinated and imaginative approach would allow quicker progress (Miller, 2003; Soliva et al., 2004; Felipó et al., 2004). An interdisciplinary or multidisciplinary approach would help to solve real problems concerning and related:

- waste management,
- agricultural development,
- employment
- food quality,
- interrelation between real problems, teaching and research,
- availability of financing for this

and would enable projects to be carried out jointly in universities, companies and research centres, where specialists and scientists coexist in different fields.

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