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SUMMARY - The impact of agriculture on the environment is often discussed merely in terms of pollution due to leaching of agrochemicals or to erosion of contaminated soil particles. As a matter of fact, however, more important environmental problems are due to the imbalance or the lack of closure of nutrient cycles and to the wrong choices made to this purpose. The natural role of agriculture is the re-utilization of wastes and effluents, no more congenial today for the farmers themselves. It is necessary therefore to encourage farmers to play their environmental role. The definition of sustainable agriculture does not prescind from this role, and it is possible to stress the concept that agriculture, by playing this role, becomes the ground for a sustainable society.

Key words: Sustainability, environment, wastes, recycling.

RESUME - *"Impact de l'agriculture sur l'environnement". L'impact de l'agriculture et de l'élevage sur l'environnement est souvent traité seulement en termes de pollution causée par le lessivage de substances chimiques employées en agriculture ou par érosion de particules contaminées de sol. En effet, les problèmes ambiants plus importants sont imputables toutefois au déséquilibre ou au défaut de la clôture des cycles des éléments nutritifs et aux mauvais choix effectués à ce propos. Le rôle naturel de l'agriculture est le réemploi des déchets et des effluents, non plus ainsi inné pour les agriculteurs mêmes. Il est nécessaire donc d'encourager les agriculteurs à jouer leur rôle ambiant. La définition d'agriculture durable ne fait pas abstraction de ce rôle, et il est possible de considérer que l'agriculture, en jouant ce rôle, devient le fondement pour l'existence d'une communauté civile durable.*

Mots-clés : *Durabilité, environnement, déchets, recyclage.*

Introduction

Often, when speaking of the agricultural impact on the environment, one restricts any consideration to processes of pollution of surface and ground waters from chemicals added to the soil during agricultural practices. No doubt, such processes exist and may have even a prominent importance. They are caused either by water infiltration in soil, with the consequent possibility of nutrient and pesticide leaching, or, if water undergoes surface runoff, by erosion processes, that can lead sometimes to transport of relevant amounts of soil particles to water streams.

In a Mediterranean environment, water infiltration is less important than in northern and central European countries; an empyrical evidence may come from figures concerning consumption of fertilizers per unit of arable land, which is three or four times lower. In any case, suitable procedures of good agricultural practice are available in order to reduce potential leaching pollution risks to a minimum (e.g., Sequi and Indiati, 1996).

Huge and impressive erosion processes, on the contrary, may occur especially in a Mediterranean environment. Eroded particles in general come from the upper part of the soil profile, which is often enriched with fertilizers and treated with herbicides and pesticides; they will be theoretically free to dissolve in surface waters. As a matter of fact, however, the composition of fresh waters in rivers is far from being ideal. So, if the quality of recipient waters is poor, eroded soil particles will possibly exert an intensive purifying action rather than a polluting effect. Such a behaviour has been shown experimentally, as in the case of phosphorus in the river Marecchia flowing out into the coast of Adriatic sea near Rimini (Sequi *et al.*, 1991a).

No doubt, the approach of reviewing every possible output from agriculture to different environmental compartments, either surface and ground waters or atmospheric air or even non-agricultural soil surfaces, is justified and environmentally sound. It is a first necessary step for attaining full environmental friendship of agricultural practices and for minimizing any possible impact. However, it represents only a small part of the impact of the agriculture on the environment and does not point out the actual role that agricultural practices play in their interactions with the environment. The more important environmental problems today are due to unbalancing or to lack of closure of the nutrient cycles, and to wrong choices made to this purposes. Since all nutrient cycles lie in soil as their hearth, they can only be managed through agricultural practices. In order to afford this topic in a more general and exhaustive way, it can be useful to speak in terms of sustainability.

Although it is common today to talk about sustainable agriculture, as well as of sustainability of any human activity, the meaning of "sustainable" is seldom defined.

Sustainable is a fashionable word. So, it is possible to mistake sustainable agriculture for organic farming, or for some biological or biodinamic version of agriculture, or for the reduction of agrochemical inputs, or for the application of some recent EC directive or US EPA recommendation, and so on. As a matter of fact it is possible to realize the existence of some confusion of ideas with reference to the precise meaning of sustainability.

At a first approximation, any activity or any economic system able to maintain itself for an indefinite period of time can be defined as sustainable.

However, we must endorse the above concept in the broadest sense. An activity or a system cannot be considered separately and isolated from other activities and systems. Let us consider a breeding of trouts in mountain. There will be many problems of balanced feed supply and of veterinary precautions which must be adopted in order to prevent fish diseases. In addition, a main technical item will concern the decision of how the turnover of trouts should be regulated, i.e., how many fishes could be sold per week in function of the reproductive potentiality in the breeding. Once all technical problems are optimized, the breeding will be considered sustainable *per se*, but not economically speaking and from the environmental point of view. For instance, the resources used for the nutrition of trouts or the same trouts sold at local markets will reveal to be insufficient or excessive, or, simply, trout excrements will heavily contaminate the effluent stream.

In other words, sustainability of any activity could not be assessed without considering all the related activities. Sustainability of a human activity is a comprehensive concept, which cannot be examined apart from the whole context of other human activities influenced or interconnected with that we are considering.

Wastes and residues: Disposal and utilization

As is well known, three possible strategies are available to dispose or re-utilize any waste or residue produced by human activities, including animal wastes: incineration, sanitary landfill, and recycling. The three practices are not absolutely alternative, because they may co-exist in large part or totally, but a strong political will is necessary in order to orientate the choices that technical operators are called to make. A good policy may seem sometimes a challenge: it may reveal to be fruitful only in the medium term.

Incineration seems to be a clean technology, at least at a first glance. Disposal of wastes by incineration allows energy recovery, so that theoretically, after the initial supply of fuel, a self-sufficient energy supply internal to the cycle will occur. As a matter of fact, however, the disposal is more apparent than actual, because incineration reduces the volume of wastes substantially, but not their mass. From municipal solid wastes, for instance, about one third, and sometimes much more of the initial weight, is transformed in inorganic slags, which contain some of the less important or noxious materials, and of course will still need to be disposed. The energy recovery sometimes will remain a dream. Finally, the risk of pollution from the emissions to the atmosphere cannot be neglected: organic (e.g., dioxins) and inorganic substances (e.g., cadmium and mercury compounds) are among the most common and harmful compounds emitted. It is possible to abate the content of dioxins in the emissions by raising the combustion temperature at 1200-1300°C, but the process becomes more and more expensive. It is also possible to abate the content of heavy metals in the emissions, e.g., by washing the chimney smokes, but waters used to wash the steams will need of course further treatments. If such waters will be conveyed to a sewage treatment plant, they could heavily contaminate sewage sludges, making them unsuitable for application in agriculture.

Incineration seems to become in fashion now as a disposal treatment for the animal manures which are the richest in nutrient contents. A big plant for incineration of poultry manure has been realized in England near Eye, and the realization of at least three big plants has been at present proposed in Italy. The three plants are programmed for the incineration of about 700 thousand tons of poultry manure per year, and should yield a recovery of electric energy of about 550 millions kW. The authors of such projects stress the importance of recovering energy from hardly disposable and fully recoverable biomasses. This opinion, of course, is disputable. More disputable perhaps is the convenience of dissipating carbon dioxide and especially nitrogen oxides, gases which are considered as responsible for the so-called greenhouse effect, from animal wastes so rich in nutrients, shortly after the Kyoto Conference where many countries have recognized the importance and the urgency of reducing the emission of such gases.

Landfill is another technology which can appear even more fascinating: wastes are disposed without apparent difficulties in appropriately selected areas and at the end their volume may be utilized to re-model the areas themselves, e.g., to fill up opencast mines and to mould them pleasantly in order to give them new destinations, e.g., for recreational purpose. The first obstacle arises from the relative low availability of suitable land surface. Due to their scarcity, landfill disposal becomes expensive. Another great difficulty is caused by the slow evolution of the landfill caused by the transformation of the disposed materials: landfills undergo a slow and continuous bedding along the years, with variations of volume, emission of gases to the atmosphere in the short term, and leakage of potentially harmful percolates in the medium and long term. This requires the adoption of a number of cautions for many years, and such cautions mean additional expenses.

Animal wastes are seldom disposed of through the use of sanitary landfills, at least officially. Recently, however, some cases of disposal of animal wastes have been reported via this way, especially when liquid or semiliquid effluents were treated and the sludges which originated from treatments were not easily accepted by local farmers.

Recycling is in general the most difficult practice to face the problem, at least in the case of many wastes. For this reason, though in the past recycling represented the most important way to add fertility to soils, it is now not popular as one could expect. On the other hand, recycling is also the only totally sustainable strategy dealing with the problems of wastes. For this reason it must be encouraged enthusiastically. As stated above, for many wastes recycling is not easy and requires the highest degree of professional competences. A wise policy in matter of wastes should promote and subsidize the formation of such competences.

For every kind of materials, recycling is the technology which prevents the existence itself of wastes. Recycling transforms any material, or complex of materials which actually could become wastes if their owner should get rid of them, in useful materials or even commercial products. Recycling of organic residues may give foods, feeds, fertilizers, and many other useful materials. Stabilization of the original organic matter is the ground of any process of recycling fermentable organic residues.

So, the use of appropriate technologies is a key step to face the problem of recycling many categories of wastes. Among them, however, those concerning animal by-products, as well as manure and effluents, are probably the more important from a quantitative and qualitative point of view. So, such processes are of great benefit for the human society.

Waste recycling: Need for processing

Many animal and plant by-products that are rich in organic carbon and nitrogen, such as leather meal, ground feathers, horn and hooves, waste wool, oilseed cakes, and so on, are fertilizers as they are. They do not contain humic substances and normally do not need any fermentation process. The evolution of the organic matter of these organic fertilizers will occur directly in soil (Sequi *et al.*, 1991b).

Another group of organic residues is composed of materials sometimes also rich in organic carbon, but comparatively poor in organic nitrogen, such animal dung, agricultural residues and urban refuse. They can be applied to the soil only after a period of fermentation of organic matter, often called "maturation". If applied to urban refuse, or to urban refuse mixed with wastes arising from any possible source (e.g., sewage sludge, ash from incinerators, organic matrices suitable also for producing organic fertilizers) the process of fermentation is generally called process of composting. All these organic residues, after fermentation, are generally denominated organic amendments.

The process of fermentation of wastes is essential because the use of raw organic residues of this second group may be inappropriate for a series of reasons. The main results of a fermentation process properly carried out on organic residues to obtain organic amendments are the elimination of phytotoxic substances, the abatement of pathogenic organisms, the elimination of undesired seeds, the reduction of fermentability with the connected stabilization of organic matter, the reduction of bad odours, and the increased easiness of handling.

Since the process of fermentation of organic wastes plays an essential role in providing so many valuable properties from the agronomic point of view, it is imperative to follow its evolution both quantitatively and qualitatively. This is possible because, whereas the process proceeds, the total organic carbon content generally decreases, while the proportion of humified against non-humified carbon increases; on the other hand, the organic matter components undergo strong transformations due to the stabilization processes, which show some similarities to those occurring in soil for any organic substrate, including the organic residues or fertilizers of the first group previously cited. The use of parameters such as the degree of humification may be of help in order to follow the increase of actual amounts of humic fractions in the bulk organic material, while from a qualitative point of view the evolution of the organic matter can be monitored using electrofocusing techniques (Ciavatta *et al.*, 1993; Govi *et al.*, 1989, 1992, 1995). The last techniques can be adopted also to differentiate the different organic matrices.

The use of wastes in modern agriculture

We must debunk a myth. Organic amendments often do not fit the needs of modern agriculture. Of course soils need organic matter, especially in Mediterranean environments. In recent years the organic matter content in soils has generally decreased, sometimes to worrying levels, particularly due to the effect of increased soil tillage. However, farmers are generally reducing the intensity of tillage, at present, and may reasonably prefer to manage the organic matter balance of their soils simply by proper crop rotations and selecting different organic fertilizers.

In modern agriculture, the application to the soil of organic amendments is somewhat troublesome. Undoubtely the use of chemical fertilizers in general is more convenient for a farmer, due to the easier handling, storage, and other characteristics of feasibility. In addition, the use of organic amendments *per se* does not solve the problems of crop nutrition. The application of organic amendments to the soil is not sufficient to fit the nutrient requirements of modern crop varieties: their use must be always accompanied by that of mineral fertilization.

In addition, before the addition of organic matter to the soil, it is necessary to take into account the balance of soil organic matter. In a given pedoclimatic condition, turnover of organic matter in soil is controlled by the kinetics of mineralization rate of organic matter. Mineralization kinetics are correlated to the quality of organic matter and its humification degree. But variations in ecologically contrasted conditions can be dramatic, difficult to foresee and impossible to generalize, so that application rates and methodologies are not always simple: they take for granted an additional effort of farmers and their advisors (Sequi and Benedetti, 1995).

In a certain sense, agriculture must adapt (or re-adapt) itself to the use of organic amendments.

Needless to say, we must resolutely promote a widespread use of organic amendments in agriculture. But the use of organic amendments in agriculture is first of all an indispensable need of the human society. The primary requirement originates more in the human society than in the agricultural practice. A current reality in modern societies is that nutrient cycles are broken. Breaking of nutrient cycles occurs by neglecting the problems of organic waste recovery. In order to attain the equilibrium of nutrient cycles it is enough to follow a very simple recife: what comes from soil must be returned to the soil (Sequi, 1990).

Of course, organic amendments may play an important role in soil and improve many soil properties, including the behaviour of chemical fertilizers. According to FAO (Dudal and Roy, 1995), an integrated plant nutrition system is an approach which ensures that plant nutrition be environmentally, socially and economically viable. In this context, a judicious combination of mineral fertilizers with locally available organic sources of plant nutrients should be promoted. In fact, mixed applications are not only complementary, but synergistic, since organic inputs have beneficial effects beyond their nutritional components. The use of organic amendments, however, may also imply negative effects if their content of heavy metals and undesired elements is higher than the allowed amounts or, if maximum allowable levels have not been fixed, overcomes reasonable proportions. Sometimes the coolness of farmers, if not the full failure of the attempt to introduce the use of some organic amendments in agriculture, has been due to an ill-defined consideration of its properties. The definition of the agronomic value of organic amendments must be committed to the agronomists, on an experimental basis. Although it could seem paradoxical, however, some lists of technical parameters have been compiled in the Ministries of the Environment or even of the Public Works, at least in Italy. The lack of professional competence and of a proper institutional origin is the first step towards bad results (L'Hermite *et al.*, 1993).

Sustainable agriculture and wastes

Agriculture, like any other human activity, can be defined as sustainable by completing the definition given at the beginning of this report. In practice, agriculture is a sustainable activity if fulfils simultaneously three different requisites:

(i) It must guarantee the conservation of environmental equilibria so as to allow that productivity lasts on a permanently durable basis, i.e., should not lead in particular to dissipation of unrenewable materials or energy (sustainability of resources).

(ii) It must guarantee full safety to the farmer and any other operator, in addition to hygienic and sanitary safe conditions to the consumer (sustainability of human health).

(iii) It must guarantee economically convenient productions, i.e., a profit to farmers (economical sustainability). This last requisite is that more frequently forgiven. Sometimes it is also concealed, either with financial subsidies to farmers or, worse, by frauds against consumers.

When applying the above principles to the transformation of organic residues in useful fertilizers, the use of organic amendments in agriculture reveals to be a fully sustainable practice and also something more. In fact:

(i) For what concerns sustainability of resources, the use of organic amendments avoids both utilization of unrenewable resources and excess of energy expenses (for waste treatment, production of chemical fertilizers, and so on).

(ii) With respect to sustainability of human health, the use of organic amendments may avoid to the organic residues an improper fate, with indirect benefit for the human society.

(iii) Concerning the economic sustainability, the low cost of organic amendments is useful to the farmers, but even more to the entire human society, who does not afford different expensive solutions for the disposal of wasted materials.

First of all, in any case, organic amendments satisfy the simple recife cited above, i.e., everything comes from the soil must be returned to the soil.

Conclusions

The use of organic amendments is important in modern sustainable agriculture. However, the use of organic amendments is an essential hinge not only in sustainable agriculture, but also for the equilibria of the entire human society.

In this sense, the practice of utilizing organic amendments properly in order to improve soil fertility transcends the meaning it has as an useful practice to be recommended in sustainable agriculture. Also, sustainable agriculture cannot be considered only as a form of agriculture to be recommended to farmers and encouraged with all the possible incentives. Sustainable agriculture is something more: is a keystone for a sustainable society.

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