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SOME SUSTAINABLE DEPOLLUTION STRATEGIES APPLIED IN INTEGRATED ENVIRONMENTAL PROTECTION MANAGEMENT IN AGRICULTURE

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Abstract

The global problems of humanity are closely related to the problems of the environment. At the same time as the development of the society, various imbalances appeared that led to significant environmental pollution. Activities regarding the protection and conservation of the environment and the stability of ecological systems are vital for supporting the process of sustainable development and ecological management in contemporary society. A sustainable agricultural environmental protection management program involves optimizing integrated methods of ecological reconstruction, increasing biodiversity, restoring biotope factors, maintaining fertility and controlling soil erosion. In this context, the purpose of this paper was to review some sustainable depollution strategies, emphasizing the organic farming, phytoremediation and waste management. The first of these strategies, organic farming, has a positive impact on the environment, because it promotes the responsible and sustainable use of energy and natural resources and preserving biodiversity. On the other hand, the phytoremediation can be applied for the environmental elimination of pesticides, solvents, and seepage from landfills. In terms of agricultural waste management, the waste composting is a sustainable solution of environmental pollution prevention, for the real contribution in bioremediation, weed control, erosion reduction and increasing of biodiversity, all these benefits being doubled by the use of compost as an organic fertilizer, of course.

Key words*: *sustainable, management, agriculture, depollution, environmental

INTRODUCTION

The agricultural production activity has experienced, over time, a continuous process of updating to the increased requirements of food for an increasingly numerous human population and with increasing demands towards the diversity and quality of food.

The agriculture practiced in Romania is mostly polluting, and the pollution phenomenon is known by the specialists in the field of environmental protection. On the other hand, pollution, as a process of degradation of the quality of environmental factors, vital for human health, has not always been recognized by political factors and there is still a lack of the resources necessary to highlight all the aspects that pollution entails [1].

In according to Voicea et al. (2020), some issues of environmental pollution caused by agricultural activities in Romania are: evacuation of wastewater, untreated or incompletely treated, from the animal's industrial breeding complexes, into the surface waters and into the drainage network; the excessive use of manure (over 100 t/ha), at intervals of 2-3 years, which results in the accumulation of nitrates in feed, as well as leaching into the groundwater table; he intensification of the phenomenon of soil erosion on sloping lands and the degradation of the soil structure as a result of the decrease in the content of organic matter, etc. [36].

Pesticides (especially fungicides and insecticides) but also fertilizers are chemicals commonly used in agriculture but are also the elements that make agriculture to be one of the biggest polluters of the environment [26]. The long-term effects are, in addition to damaging environmental health, the deterioration of the primary consumers health as well as the decrease of biodiversity [17].

In this context, the objective of this study was to review some sustainable depollution strategies applied in integrated environmental protection management in agriculture, emphasizing the organic farming, phytoremediation and waste management.

MATERIALS AND METHODS

The research method consisted in identifying, accessing and selecting of several scientific results in proposed topic, published in various journals indexed in WOS, Clarivate Analytics, Scopus and Springer databases. Some articles from specialized online magazines, such as Agrimedia and Biz, were also taken into account. Certain results have been compiled into tables and figures respectively.

RESULTS AND DISCUSSIONS

Agricultural pollution generally occurs due to chemical fertilizers and pesticides used for fertilization and protection of agricultural crops against diseases, pests and weeds. However, these extremely toxic substances with great chemical stability over time are spread in low concentrations on the field, but the very large extent of treated cultivated surfaces contributes to a worrying pollution of the environment and especially of soil and water.

In 2019, share of emissions from the non-food and agri-food sector in global greenhouse gas emissions was of the 69% and 31% respectivelly (Figure 1). The first three categories of chemical compounds that showed the highest emissions were nitrous oxide (N_2O), methane (CH_4), and carbon dioxide (CO_2) [18].

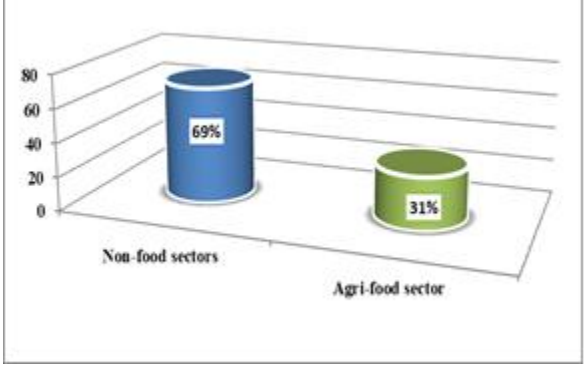

Fig. 1. Share of emissions from the non-food and agri-food sector in global greenhouse gas emissions (2019).
Source: Own design based on [14].

The largest share of the activities that lead to water pollution is the inefficient use of fertilizers in agriculture, along with the improper storage of manure. The meteoric waters wash the fields and carry the chemical substances from the fields that they introduce directly into the surface waters or the groundwater table. An essential characteristic of these waters is that they cannot be collected, concentrated and purified.

Also, agricultural pollution appears today due to the wastewater discharged from animal husbandry complexes, which contain large amounts of organic substances, viruses and bacteria.

In the case of underground water resources, pollution occurs through the infiltration of solid and liquid impurity substances due to meteoric waters that wash away the garbage deposited in the soil and sewage waters that enter the soil through the leaks in the pipeline network.

Nitrogen used in agriculture is the main source of water pollution. This is precisely why mitigation strategies are needed to minimize global N pollution and to implement agricultural management practices for sustainable environmental protection [26].

Nitrogen that pollutes groundwater, as well as surface water, can have many sources. Thus, the point sources are those that can be well located, represented by a single objective. The point pollution from agricultural sources can be caused by semi-liquid and liquid animal manure, solid manure and effluents from silos, untreated or insufficiently treated wastewater and runoff from mineral and organic fertilizer deposits.

The impact of agricultural production to environment is of concern to the globally level [4, 26]. Therefore, the concept of sustainable development should become the main concern of farmers [16, 22, 31]. However, there are some difficulties about seek temporary, material, and intellectual resources [16].

Protecting the environment is the only way that life can continue to thrive, and from this point of view, three of the most sustainable technologies applied within the concept of

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integrated environmental protection in agriculture can be exemplified below.

1. Organic farming

Organic farming produces plant and animal raw materials by using natural substances and processes. The biodiversity is a key strategy for pest control. For example, instead of synthetic chemical pesticides, organic farmers can introduce natural predators, helpful insects, and crop rotation. Also, organic farming has been promoted to restore soil health and fertility status through the addition of organic matter [12]. Another advantage of organic farming that shows its sustainability in environmental protection is the potential for reducing greenhouse gas emissions and improving organic carbon sequestration [18, 30].

Organic farming is full of promise and benefits too: animal health and welfare; protection of biodiversity (organic farmers can provide food and homes for wild species, maintain healthy soils, and reduce water pollution); combating soil erosion by crop rotation, intercropping and minimum tillage; water conservation, etc.

Therefore, organic farming has a limited impact on the environment, because it promotes the responsible and sustainable use of energy and natural resources and preserving/increase biodiversity. Also, organic farming promotes long-term environmental protection in particular due to the certification rules that certain inspection bodies check for compliance. Some of these rules include banning pesticides, due to their adverse effects on human beings.

According to many studies in the field, other positive effects of organic farming on the environment are the following:

- Restoring of natural balances by using crop rotation [40], associated and interspersed crops, agroforestry curtains and hedges [25], the application of green manure [2, 23], mulching [34], as well as the application of biotechnological methods of plant protection [21];
- Organic farms use 45% less energy compared to conventional ones [33]. Less energy means fewer fuels being burned which slows the production of greenhouse gasses. In addition, using organic pesticides has reduced the amount of nitrous oxide that gets introduced into the atmosphere. Nitrous oxide is considered one of the most damaging greenhouse gasses and one of the main ingredients in chemical pesticides [33];
- Reducing global environmental problems such as global warming and desertification;
- Reduce or eliminates the use of pesticides and highly soluble forms of nitrogen;
- Because fossil fuel-based fertilizers and most synthetic pesticides are prohibited in organic farming, this agricultural sistem has a significantly lower carbon footprint. The production of these farm chemicals are energy intensive. According to Walling et al. (2020), the elimination of synthetic nitrogen fertilizers alone, as is required in organic systems, could lower direct global agricultural greenhouse gas emissions by about 20% [37] Therefore, organic farmers are already controlling pollution.

The analysis of the greenhouse gas emissions from plant production can be carried out by examining the carbon footprint of a product from the extraction of raw materials and energy to the harvesting within the system from ″cradle-to-farm-gate″ and ″gate-to-gate″ (Figure 2) [18].

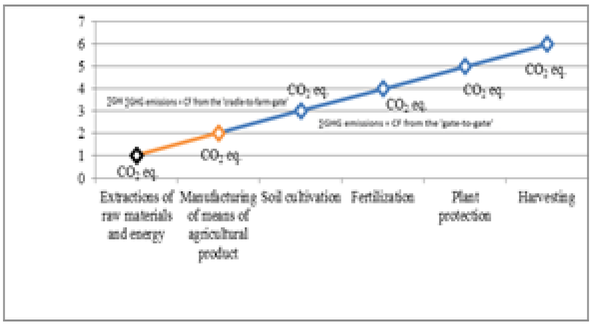

Fig. 2. The greenhouse gas emissions from plant production by examining the carbon footprint.
Source: Own design based on [18].

According to a recent report of IFOAM Organics Europe (2022), from the point of view of organic agricultural crops, forecasts show an increase of more than 25% by 2030, such as legumes, which increase to 73%, and permanent pastures, which increase from 12% to 32% in this scenario. Other crops, however, are well below the average share of the 2020 organic area, including cereals, oilseeds, potatoes and total arable, which would increase from 7% to 20% [13].

In the case of animal and poultry breeding, the current global situation already ensures a 7% reduction in the number of ruminants per unit area and forecasts for 2030 are for a further reduction of 11% of the total number of animals in the EU27. However, this reduction will be more pronounced in the category of pigs and poultry and smaller in ruminants [13].

In the 25% organic area growth scenarios at the EU level, the top of countries are represented by Germany, Spain, France and Italy but also Austria and Sweden (Figure 3). Thus, Germany, from 10% UAA (Total utilisable agricultural area) in 2020 would reach 15% UAA (in 2030 linear growth scenario) and even 30% UAA (in 2030 higher linear growth scenario); Spain, from 10% UAA in 2020 would reach 14% UAA (in 2030 linear growth scenario) and 25% UAA (in 2030 higher linear growth scenario); France, from 9% UAA in 2020 would reach 18% UAA (in 2030 linear growth scenario) and 30% UAA (in 2030 higher linear growth scenario); Italy, from 16% UAA in 2020 would reach 20% UAA (in 2030 linear growth scenario) and 40% UAA (in 2030 higher linear growth scenario), etc. [13].

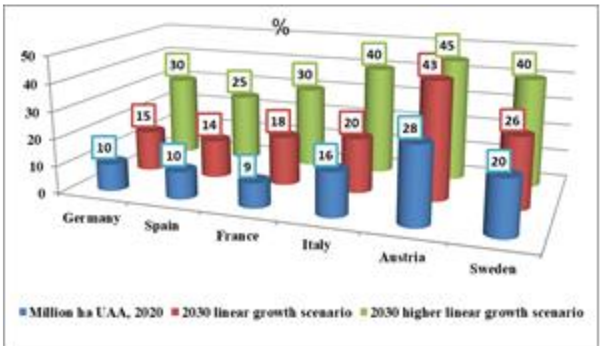

Fig. 3. The 25% organic area growth scenarios at the EU level.
UAA=Total utilisable agricultural area.
Source: Own design based on [13].

Romania has a strategy for sustainable development, a set of indicators that show where we are in terms of sustainability, but also a circular economy strategy, the first strategy on this subject, which is also relevant for the agricultural sector. Moreover, Romania has at its disposal almost 100 billion euros until 2027, to achieve sustainability objectives by building partnerships. Private companies are the main players, including banks [32].

2. Phytoremediation

Phytoremediation is a sustainable strategy that involves the use of plants to remove organic or inorganic pollutants from the soil [6, 20] and even water [3]. The phytoremediation can be applied for the environmental elimination of pesticides, solvents, crude oil and seepage from landfills. The mechanisms of this strategy include phytoaccumulation, phytodegradation and phytostabilization expressed by degradation through metabolism by plants or enhanced microbial action; vaporization as the plant transpires; extraction-accumulation, then collection, recycling or disposal; containment by adsorption or otherwise reducing movement or availability [9, 20, 15, 24].

In practical terms, plant roots assimilate pollutants and transfer them to the stem and leaves. Pollutants then degrade in the plant tissues; from this point of view, plants produce certain enzymes (dehalogenase and oxygenase) [5, 7, 28] that help to catalyze degradation (Table 1), as well as chemical compounds that determine the immobilization of pollutants when the roots come into contact with the soil [21].

Table 1. Applications of some microbial enzymes to phytoremediation

Enzymes	Applications
Pseudomonas putida	Degradation of synthetic dyes
Streptomyces cyaneus	Oxidation of BPA, DFC, and MFA micropollutants
Anoxybacillus gonensis	Bioremediation of wastewater
Bacillus subtilis	
Pseudomonas sp.	Degradation of halogen acid
Ancylobacter aquaticus	
Pseudomonas sp.	

Source: Own compilation based on [7, 11, 39, 41].

There are many plant species that have the ability to store various pollutants in their roots. These plants can be transplanted to contaminated sites and when the roots become loaded with pollutants, these plants can be removed. Thus, plants that accumulate large amounts can remove or store significant amounts of pollutants. For example, lead

concentrations in plant tissues are directly proportional to lead concentrations in the soil.
Plants with high phytoremediation potential can be species from the spontaneous flora that grow in polluted places or cultivated plants that have specific traits, determined by the polluting environment. Some of the most commonly used plant species for phytoremediation are shown in Table 2.

Table 2. Plants with high phytoremediation potential

Species	Remarks
Populus sp.	Decontamination of soils contaminated with nitrates
Nicotiana tabacum	Cd higher in stems and leaves
Zea mays	Chelators induced the phytoextraction of Pb and Ti
Brassica juncea	Decontamination of soils contaminated with Pb
Solanum nigrum	Polyaspartate or liquid amino acid fertilizer enhance the extraction process
Pelargonium hortorum	EDTA enhanced Pb and Cd phytoextraction
Commelina communis	Hyperacumulator species of *Commelina* had Cu concentration >1000 μg/g

Source: Own compilation based on [9, 19, 20, 27].

Phytoremediation is a long-term remedial process. Although it has undeniable advantages, however, there are also a number of disadvantages, such as: high concentrations of hazardous substances can be toxic for plants; sometimes it can only be done in certain seasons, depending on the locations; can transfer pollutants between environments (from soil to air); the toxicity and bioavailability of degradation products are not always known; the products can be mobilized in underground waters or bioaccumulated in animals, etc.

3. Waste management

The world's rapid population growth increases the challenges of sustainable waste management to keep up with the demands of modern life. This involves adopting new practices to protect and conserve resources and moving to a circular economy. By introducing circular economy principles into waste management strategies, the level of environmental pollution can be reduced, while promoting economic growth [10].
The need to protect the environment and maintain people's health required the discovery and implementation of appropriate solutions to successfully collect and recycle hazardous and non-hazardous waste. Romania's accession to the European Union also attracted the emergence of a new policy carried out in this sense by the Romanian authorities, according to European trends.
To ensure the sustainability of waste management in agriculture, the link between economic growth and the environmental impact associated with waste generation must be broken [8].
Waste management involves: identifying the categories of waste that a company generates, making monthly records, annual reports, handing over waste to collection centers, capitalizing on resources by reusing recoverable parts. The record of the management must be made by companies and specialized persons, trained in this regard.
The management of agricultural waste involves the management of compostable residues, the separate collection of biodegradable waste, the recycling of waste from pesticide and/or fertilizer packaging (paper, glass, plastic and metal), green waste, etc. It is necessary to create a waste management plan of this type in order to collect and recycle it. Very often the burning of vegetable remains was used, but it is a polluting method, which should no longer be considered a viable solution. The most recommended way to manage some of this waste is composting and using the compost as an organic fertilizer [38].
Improper management of agricultural waste can lead to the release of pollutants into the environment, contamination of water and soil, threats to the health of the population and animals, so certain methods and appropriate sustainable solutions must be considered.
From this point of view, the steps for sustainable agricultural waste management are as follows: consultancy (specialists must propose the best methods for waste disposal); pre-collection of waste (in different containers, of different colors depending on the type of waste they contain); waste transport (it is mandatory that the transport is carried out very quickly, with special vehicles from the customer to the final recyclers); intermediate processing (by selecting,

shredding or compacting residues); continuous information (companies specialized in waste management constantly inform their collaborators about changes in the legislation in the field, so that there is no risk of non-compliance with the law).

Agricultural waste composting is a sustainable solution in the context of integrated management of environmental pollution prevention, for the real contribution in bioremediation [35], weed and plant disease control [29], soil erosion management, increasing of biodiversity and reduces environmental risks involved of synthetic fertilizers [38].

The management of agricultural waste in the correct way must become a permanent practice of all the factors involved, because only in this way there are real chances of reducing environmental pollution. However, there is a constant need for the help of waste management specialists, who can find the best solutions in a short time, for a sustainable management of agricultural waste management and beyond.

CONCLUSIONS

Globally, the agriculture system has changed significantly during the past decades and for sure, will continue to change in the future. The intensive chemicalization in agriculture offers marketing advantages and mostly lower unit cost of production compared to smaller sized operations. However, increased farms size brings new management challenges for environmental protection.

Sustainable agriculture strategies have a hight impact worldwide because of their healthier crops and food product. For the sustainable protection of the environment is needed the implementation of cost-effective environmental technologies and make the transition from the applied technologies toward environmentally oriented ones. From this point of view, organic farming is one of the sustainable strategies to environmental protection and the mitigation of climate changes.

Strategies and decisions about environment protection must be made together with farmers, through education and partnership, because every day they work in the environment, with the environment and take care of it because they want profitable and resilient agricultural productions.

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