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THE ECO-EFFICIENCY OF RECYCLING ORGANIC WASTE FOR AGRICULTURE PURPOSES

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ABSTRACT

One of the problems of the cities is the raising of household waste, with polluting effects on the environment. On the other hand, in agriculture, through specific activities necessary to ensure food, fertilizers are needed, which could be used for the commands of sustainable development. Depending on environmental conditions, the negative impact can be indicated that they have on the human population by affecting plants, animals and, not least, people. Developed countries, such as the Netherlands, UK, Germany, France, Switzerland, have invested in technologies for the transformation of household organic waste into biofertilizers with low impact to the environment. The present article tries to analyze and underline the eco-efficiency of transforming organic waste into biofertilizers.

KEYWORDS: sustainable development, eco-development, organic waste, green development, eco-management, eco-efficiency

1. Introduction

The theme of this paper is important in terms of increasing the quality of life, so superficially treated for methodological and procedural aspects. Essentially, the mismanagement of waste is an important cause regarding environment pollution and threats to human health, at the same time reflecting the inefficient use of natural resources. Therefore, one of the highest risks for people is represented by ineffective and irresponsible collection and recycling of waste which pollutes the environment. For example, waste management technologies, such as land filling and incineration, do not represent a complete solution to existing problems. Some organizations have one of the most important tasks, i.e., the continuous improvement of waste disposal usage. Additionally, in order to protect the environment, it is necessary to eliminate waste or to transform it into useful products. In the same time, it may be required to review the identification of waste. The main focus of the present article is waste elimination, to ensure that the manufacturing sector progresses towards ecoefficient production processes and a hazard-free workplace environment. For example, in agriculture recycling organic wastes can preserve finite phosphate resources and the embodied energy from industrial nitrogen fixation, thus helping to increase sustainable food production. Some waste, such as wood waste and paper sludge, offer organic alternatives to animal use. The agricultural uses of wastes ensure the protection of human health and of the environment.

2. Literature Review

"Most countries have traditionally utilized various kinds of organic materials to maintain or improve the tilth, fertility and productivity of their agricultural soils" [2].

Recycling organic wastes in agriculture can reduce the need for fertilizers and even restore organic carbon deficiency in the soil.

Recycling of organic wastes (such as biogas residues and sewage sludge) to agriculture has been a widely-discussed subject for decades [5].

"Organic agriculture augments ecological processes that foster plant nutrition yet conserves soil and water resources. Organic systems eliminate agrochemicals and reduce other external inputs to improve the environment and farm economics. Among the benefits of organic technologies there are higher soil organic matter and nitrogen, lower fossil energy inputs, yields similar to those of conventional

systems, and conservation of soil moisture and water resources" [6].

Despite the economic crisis, people focus on buying organic products that do not harm health, the organic farming sector is increasingly popular because it is benefic to human health.

Additionally, it should be noted that a significant share of the whole quantity of waste is represented by non-biodegradable materials (plastic, glass, metal, etc.) that were considered by European legislation as agents of soil pollution and contaminants that are to be eliminated.

"Everyday waste consists of 45% food waste, 24% plastic, 7% paper and 6% iron. Approximately 95-97% of waste collected is taken to landfill for disposals. Wastes which remain are sent to small incineration plants, or diverted to recyclers/re-processors or is dumped illegally. Actually, *only 5% of waste is recycled, however the government aims to reach a ceiling of 22% in terms of waste recycled by 2020"* [9].

The good practice we teach is that the best strategy for guaranteeing high standards of waste is to separate at collection in new developments and restoration areas e.g. "*at door-to-door waste collection".*

"As global environment and climate change are challenges the world faces today, there is an increasing need to evaluate the impact of waste management on environmental quality and greenhouse gas emissions" [3.]

Currently, there are various treatment methods that can be applied to a good management of natural resources and ecological recycling options are a priority for the recovery of organic waste.

It additionally shows that *"current waste management practices in relation to composites are dominated by landfilling*" [12] *"which still is a relatively inexpensive option for industry in comparison to alternatives. However, it is the least preferred option according to legislation*" [7].

In addition, the approaches to eco-efficiency and resource development can be combined. This article may have implications on how eco-efficiency can be quantified in waste management.

"Sustainable consumption behavior occurs when consumers have two positive attitudes: firstly, as regards sustainability and environment and, secondly, when there is a greater personal responsibility and involvement displayed" [4].

Recycling included feeding vegetable waste to livestock and using eco-waste as fertilizer.

3. Research methodology

3.1. European Directives on Waste Management

a. Waste Framework Directive 2008/98/EC sets the basic concepts and definitions related to waste management, such as definitions of waste, recycling, recovery. It explains when waste ceases to be waste and becomes a secondary raw material (so called end-of-waste criteria), and how to distinguish between waste and by-products. The Directive lays down some basic waste management principles: it requires that waste be managed without endangering human health and harming the environment, and in particular without risk to water, air, soil, plants or animals, without causing a nuisance through noise or odors, and without adversely affecting the countryside or places of special interest. Figure 1 presents briefly the main features of waste management that must be taken into account,: (i) *waste prevention*, by application of "clean technologies" in waste generating activities; (ii) *reduction of waste quantities*, by implementing best practices in everyday waste generating activity; (iii) *valorification*, by reuse, material recycling and energy recovery; (iv) *disposal*, by incineration and landfill.

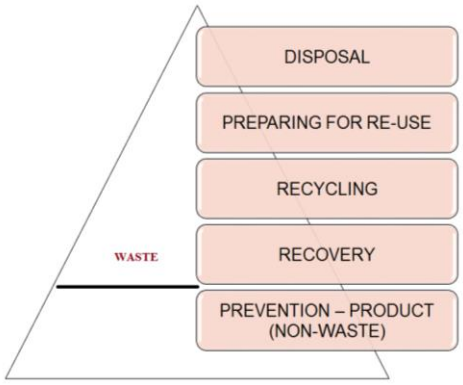


Fig. 1. *Waste recycling*

This Directive introduces the ***polluter pays principle*** and the "extended producer responsibility". It incorporates provisions on hazardous waste and waste oils (old Directives on hazardous waste and waste oils being repealed, in force since 12 December 2010), and includes two new recycling and recovery targets to be achieved by 2020: 50%.

Preparing for re-use and recycling of certain waste materials from households and other origins similar to households, and 70% preparing for re-use, recycling and other recovery of construction and demolition waste.

***b. Directive 2000/76/EC of the European Parliament* and of the Council of 4 December 2000 on incineration of waste.** The European Union imposes strict operating conditions and technical requirements on waste incineration plants and waste co-incineration plants to prevent or reduce air, water and soil pollution caused by the incineration or co-incineration of waste. Emission limits are introduced for certain pollutants released to air or to water.

c. The Landfill Directive

Council Directive 1999/31/EC on the landfill of waste (the Landfill Directive) was agreed in Europe at Council on 26 April 1999 and came into force in the EU on 16 July 1999. The Directive aims to harmonize controls on the landfill of waste throughout the European Union, and its main focus is to achieve common standards for the design, operation, and aftercare of landfill sites. It also aims to reduce the amount of methane, a powerful greenhouse gas, emitted from landfill sites.

3.2. Specific responsibilities for waste

The issue of responsibility for waste management implies an inherent hierarchy from individual and family responsibilities at the institutional, legal and community levels. Generally speaking, everybody is responsible regarding waste recycling. Additionally, it is important to understand that as the quantity of waste increases, there is also an accumulation of effects, some of which are evil because they lead to pollution and decrease in comfort, others are beneficial as they create a natural source of raw materials and recyclable materials. It is also essential to have clarity regarding the action of factors acting as producers of waste. Therefore, the legislation on waste management clearly imposes certain responsibilities incumbent upon the waste producer but not on processing such material. If reference is made to the guidance about `Waste Management: The Duty of Care - A Code of Practice` these responsibilities for the producer can be defined as: (i) "*the person who made the substance become waste e.g. by breaking or contaminating it"*; (ii) "*the person who decided that a substance was unwanted and therefore waste"* [10].

3.3. Indicators of eco-efficiency

Eco-efficiency indicators are used to illustrate whether there is a decoupling of environmental impact and the sectors' economic activity or not.

Quality of economic growth represents the making the green concept of growth operational for public policies, which requires a measurement that would capture the pattern.

The main indicators of eco-efficiency are the following: (i) measure the eco-efficiency of different sectors within the country; (ii) compare the eco-efficiency of economic growth of different countries; (iii) identify policy areas for improvement in achieving economic benefit.

The eco-efficiency indicators of the World Business Council for Sustainable Development are: *"(i). minimize the material intensity of goods and services; (ii) minimize the energy intensity of goods and services; (iii). minimize toxic dispersion; (iv) enhance material recyclability; (v) maximize the use of renewable resources; (vi). extend product durability; (vii) increase the service intensity of goods and services"* [11].

If reference is made to the economic instruments, for example user charges for managing municipal waste (e.g. 'pay-as-you-throw' schemes), landfill taxes and product charges can play a significant role in diverting waste from landfill if they are designed in such a way that they regulate the behavior of households, waste companies and producers effectively.

3.4. Comparative analyses

In Romania, currently there is still no system collecting organic waste separately from other waste categories even though there have been important steps towards selective waste selection.

Furthermore, there are no technology firms that would take over, process and transform organic household waste into compost and then into organic fertilizer. However, there is no legislative framework to stimulate and encourage initiative in this area. Therefore, studies should be carried out to evaluate the environmental impact of both domestic organic waste disposals in landfills and combustion (CO_2 emissions in conjunction with other sources, transport, industry, etc. that amplify the greenhouse effect and global climate change) and salting excess land and underground water sources compromised.

Generally, diverting waste from landfill has relied on combinations of policies aimed at households, waste companies and producers. And countries have progressed or plan to progress further towards the Landfill Directive targets by strengthening several alternative waste treatment paths, rather than focusing on just one. The strategies usually include a combination of recycling, incineration, and/or mechanical-biological treatment. On the other hand, the quality of the compost derived from separately collected biodegradable waste is not always sufficient.

"Countries with high dependence on landfill can take positive action against climate change by landfilling less biodegradable waste. Likewise, in

countries that have very low landfill rates, waste recycling and energy recovery can help avoid greenhouse gas emissions from the production of virgin material or energy" [1].

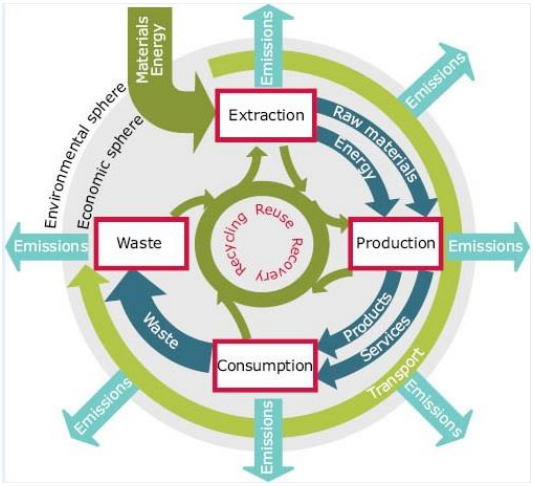


Fig. 2. *Life-cycle chain: extraction - production - consumption - waste (EEA, 2012)*

Figure 3 below exemplifies methods of waste treatment in several states; as for Romania, it can be noticed that recycling and disposal in landfills are most frequent [8].

According to Eurostat (2012), Figure 2 below shows that between 2004 and 2012 progress has been made in terms of waste recycling by using methods of incineration, but also reuse, especially in 2008, in European countries [8].

Figure 3 lists the quantities of waste from various sources of business, and in our country the highest amounts of waste resulting from mining and quarrying / mining and other economic activities similar and / or complementary.

In developed countries, such as Germany, UK, Sweden, the Netherlands, etc., materials and resources must be used to their full potential, and this has propagated a culture of reuse, repair and recycling.

Also, there are three main methods in which organic waste can be used: (i) soil improvement, (ii) animal raising and (iii) provision of source of energy.

	Total	Recycling	Energy recovery	Backfilling	Incineration	Disposal
EU-28	2 302 560	838 960	101 140	213 790	36 650	1 112 020
Belgium	41 328	30 237	4 612	0	3 331	3 148
Bulgaria	158 752	1 789	172	0	14	156 777
Czech Republic	18 263	8 420	959	5 137	76	3 670
Denmark	14 070	8 147	3 255	0	0	2 668
Germany	352 996	152 807	33 953	91 469	11 017	63 750
Estonia	20 610	7 903	349	4 196	0	8 162
Ireland	8 033	827	403	1 985	13	4 805
Greece	71 334	2 928	118	5 440	21	62 827
Spain	108 475	48 745	3 269	8 194	7	48 259
France	315 147	151 724	11 637	39 591	7 153	105 042
Croatia	2 999	994	39	42	0	1 923
Italy	130 460	98 809	2 593	160	5 814	23 084
Cyprus	2 077	409	2	232	7	1 429
Latvia	1 573	808	153	0	1	612
Lithuania	4 221	999	106	0	1	3 115
Luxembourg	10 302	4 691	36	1 934	134	3 507
Hungary	12 964	4 637	960	436	90	6 842
Malta	1 351	116	0	46	6	1 183
Netherlands	119 962	61 796	8 997	0	1 612	47 556
Austria	32 122	14 272	3 305	2 795	75	11 675
Poland	160 697	80 941	3 567	35 103	328	40 757
Portugal	10 188	4 598	1 735	0	70	3 785
Romania	264 647	18 849	1 708	1 037	182	242 871
Slovenia	5 068	2 965	326	1 102	36	639
Slovakia	7 052	2 651	270	0	71	4 059
Finland	90 478	31 700	10 317	0	445	48 015
Sweden	151 225	18 732	6 712	774	43	124 964
United Kingdom	186 163	77 467	1 585	14 114	6 102	86 895
Iceland	521	344	14	3	0	160
Norway	10 103	4 303	4 271	143	86	1 300
FYR of Macedonia	9 023	68	19	0	41	8 896
Serbia	55 023	793	49	0	0	54 180
Turkey	983 046	307 467	440	0	44	675 095

Source: Eurostat (online data code: env_wastrt)

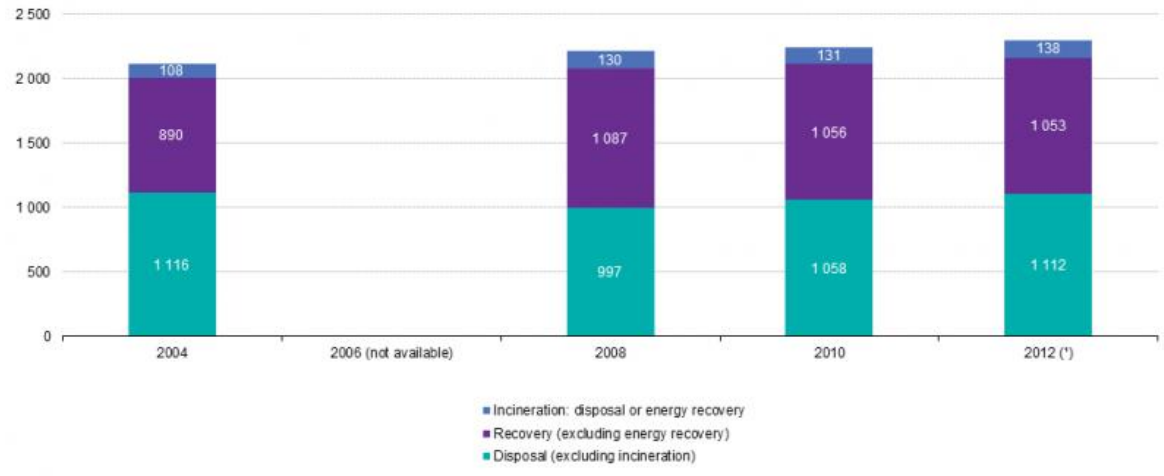
Fig. 3. *Waste Treatment (Eurostat, 2012)*

In Figure 6 (diagram) the differing levels of processing required can be observed and in this section, we will take a brief look at just some of the common approaches to using organic waste.

The agricultural potential that Romania has may lead to the use of organic waste that allows the development of organic farming. Environmental policies are necessary to educate citizens / employees of companies on corporate responsibility actions involving recycling promotion. Ecological agriculture offers a modern alternative that helps reduce organic waste, thereby leading to the reduction / elimination

of pollution, better soil fertility and food production and providing a source of income for farmers.

Bio-fertilizers are an essential component of ecological agriculture and involve the preparations containing live or latent cells of efficient strains of nitrogen fixing, phosphate solubilizing or cellulolytic micro-organisms used for application to seed, soil or composting areas with the objective of increasing number of such micro-organisms and accelerate those microbial processes which augment the availability of nutrients that can be easily assimilated by plants.



(*) Estimates.
Source: Eurostat (online data code: env_wastrt)

Fig. 4. *Recycling methods used in Europe (Eurostat, 2012)*

	Total	Mining and quarrying	Manufacturing	Energy	Construction and demolition	Other economic activities	Households
EU-28	2 515 110	733 980	269 690	96 480	821 160	380 390	213 410
Belgium	67 630	115	17 736	1 314	24 570	18 891	5 004
Bulgaria	161 252	141 083	3 009	9 533	1 033	3 841	2 755
Czech Republic	23 171	167	4 376	1 063	8 593	5 739	3 233
Denmark	16 332	18	1 610	893	3 867	6 216	3 727
Germany	368 022	8 625	56 596	8 050	197 528	60 752	36 472
Estonia	21 992	9 355	4 121	6 258	657	1 165	436
Ireland	13 421	2 025	4 599	396	366	4 379	1 657
Greece	72 328	47 832	4 183	12 259	813	2 383	4 859
Spain	118 562	22 509	14 594	5 772	26 129	28 333	21 224
France	344 732	2 477	21 431	2 100	246 702	42 024	29 996
Croatia	3 379	5	425	108	682	968	1 191
Italy	162 765	720	34 142	3 616	52 966	41 708	29 613
Cyprus	2 086	218	98	2	965	353	451
Latvia	2 310	2	396	133	8	558	1 213
Lithuania	5 679	26	2 551	29	419	1 477	1 177
Luxembourg	8 397	131	509	2	7 079	426	249
Hungary	16 310	91	2 991	2 872	4 038	3 638	2 681
Malta	1 452	45	9	2	1 041	201	155
Netherlands	123 613	179	14 115	1 342	81 354	17 758	8 864
Austria	34 047	51	3 636	622	19 471	6 247	4 020
Poland	163 378	68 035	31 135	20 706	15 368	18 809	9 324
Portugal	14 184	243	3 188	422	928	4 672	4 731
Romania	266 976	223 293	6 029	9 043	1 325	22 638	4 647
Slovenia	4 547	14	1 345	1 069	535	941	641
Slovakia	8 425	311	2 516	1 046	806	2 090	1 657
Finland	91 824	52 880	14 531	1 011	16 034	5 635	1 734
Sweden	156 367	129 481	6 218	1 852	7 656	6 967	4 193
United Kingdom	241 922	24 044	13 596	4 965	100 230	71 580	27 506
Iceland	529	0	93	2	11	191	233
Liechtenstein	467	29	12	0	107	2	316
Norway	10 721	470	2 639	89	1 881	3 205	2 438
Montenegro	386	1	33	351	0	0	0
FYR of Macedonia	8 472	802	1 304	6	0	6 360	0
Serbia	55 003	47 896	760	5 744	364	238	0
Turkey	1 013 226	950 587	13 141	18 424	0	289	30 785
Bosnia and Herzegovina	4 457	72	1 213	3 171	0	0	0
Kosovo	1 167	177	80	151	0	268	490

Source: Eurostat (online data code: env_wasgen)

Fig. 5. *Sources of provenance of the waste (Eurostat, 2012)*

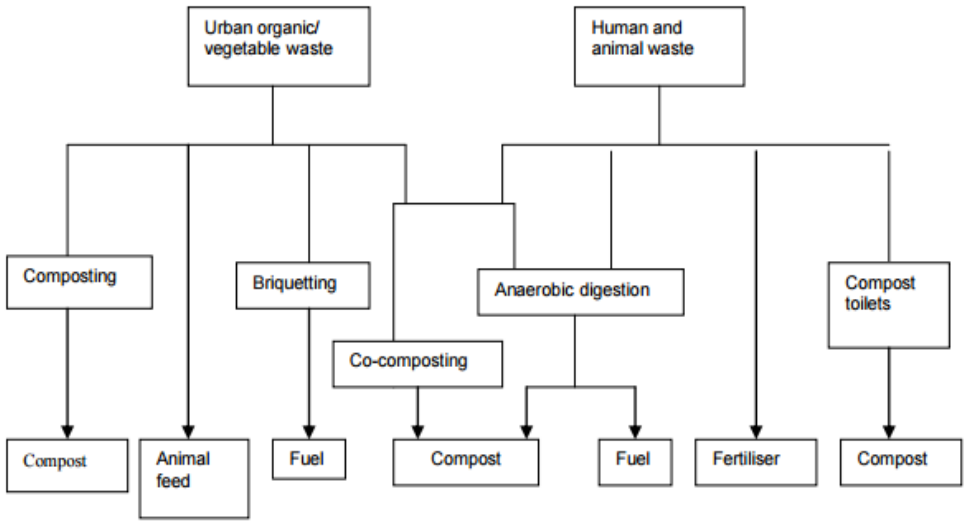


Fig. 6. *Structure of organic waste*

The importance of bio-fertilizers results from the following: (i) increase the yield of plants by 15-35%, (ii) bio-fertilizers are effective even under semi-arid conditions, (iii) farmers can prepare the inoculum themselves, (iv) improve soil texture, (v) bio-fertilizers do not allow pathogens to flourish, (vi) produce vitamins and growth promoting bio-chemical's, (vii) are non-polluting.

4. Conclusion

In conclusion, the difference between recycling methods in European countries is obvious. Finally, it may indicate that the responsibility of the government or municipality is waste collection and disposal. Also, in many cases the municipality is unable to fulfil this role either due to financial constraints, lack of will or lack of organizational skills. It has been noted that it is of great help if the organic and non-organic waste is separated at source. Many successful methods are only successful because of community participation in the activities on a day-to-day basis. Where waste is separated at source, this lessens the risk of contamination from items such as batteries, meaning that the organic waste is cleaner (and will therefore fetch a higher price), it is easier to sort and the incidence of injury and disease related to sorting is decreased. There is a number of good examples of community recycling or resource recovery schemes in developing countries.

The commonly used methods of recycling in Europe are landfills and incinerators, that is precisely why we need an ecological recycling.

Also, recycling organic waste plays an important role in agriculture through bio-fertilizers on soil that have beneficial properties.

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