Study of Utilization of Agricultural Waste as Environmental Issue in Romania

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Agriculture and animal husbandry produce significant quantity of solid or liquid residues and waste products. Unfortunately, some of these wastes are not dealt with properly and are causing considerable damage to the environment. Agricultural wastes (AW) in Romania amount range from 7600 thousand tons a year of which only 1400 thousand tons as animal feed and 1100 thousand tons as organic manure are being utilized. These crop waste results after harvesting in the farm of leaves stem which are characterized as coarse plant by-products and big size, chemically low in protein and fat contents, or, like other country (example: Netherlands) avoid waste as much as possible, recover the valuable raw materials from any waste that is created, try to generate energy by incinerating the residual waste, and only then dump what is left. The focus of the research paper is to investigate the importance of agriculture wastes that becomes very obvious and aggregated after the harvest crops. The most common solution is the utilizations of agricultural waste for compositing, as animal fodder, most often as a source of energy, food production, by growing mushroom on agricultural wastes such as oat straw as a substrate. This means the conversion of wastes to economic, nutritional human food. Growing vegetables on oat straw compacted bales in areas where soil disease and salinity are constrains. The implementation of most of the solutions to agricultural waste management does not meet the basic elements of sustainability like environmental protection and social progression, technical and technological improvement as well as economic improvements.

Keywords: agricultural waste, products, damage, environment, compositing

The agriculture generates significant quantities of waste that represent a risk for the human health, environment and also on animal health. In order to prevent and control this risk, different methods of waste treatment are used. When choosing the method it must be based on minimum environmental impact, maximum safety, and also on valorization of the waste and final stage consisting in the recycling of the end products. One of the main aspects of the waste management policies is to reduce the quantity of waste disposed to landfills and to recycle the organic matter [1].

Mechanical–biological treatment of the organic solid waste is now the main strategy to reduce biodegradable municipal solid waste in Europe [2]. It consists of mechanical pre-treatment followed by an anaerobic or aerobic process, so that waste impacts are reduced. These processes have attracted attention because they produce stabilized waste that can be sold as fertilizer or disposed of in landfill, in which case it will have a minimum impact on the environment [3].

Experimental part

Materials and methods

To gather the entry data for the assessment of fermentable waste types and amounts in Romania, we used a series of information sources, which we processed through desktop work. These information sources are detailed in the text, but the main ones were the 8 Regional Plans for Waste Management and the National Statistic Yearbooks, 2011-2015 [4].

Based on the identified or calculated amounts of fermentable waste, we used different sources from the literature and researches to calculate the potential of biogas generation through anaerobic fermentation. The quantity of biogas have been then integrated into energy potential calculations, based on the general supposition that 1 m^3 of biogas is equal to an average of 6 kwh of energy, which used in a HP unit with an average efficiency of 40% net electric output and 40% net thermal output and having an average of 7.500 hours of functioning in a year, would give approx. 2.4 kwh (electricity).

There have been highlighted the main economical, energetic, social and environment advantages which this technology can offer, as well as the innovative elements that contribute to advanced decomposition of organic material.

The management of agricultural waste comprises four major stages according to ISO standard (14040:2006): goal and scope definition, inventory analysis, impact assessment and interpretation.

Results and discussions

Most of Romania's land is agricultural, about 62, 60% of Romania's total area of 23.8 million hectare - some 14.9 million hectares - is agricultural (the EU average is 41%).

Arable land represents about 63% of the agricultural area, permanent crops 3% and permanent grassland 33%. In addition, 28% of Romania's land is forested [5].

The main problems facing rural areas today are agricultural waste, sewage and municipal solid waste.

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No.	Sample	Hygroscopic Humidity [%]	Ash content [%]	Low calorific value [kJ/kg]
1	Maize bran	0.16	4.63	15.535
2	Recipe of corn maize and sunflower seeds	1.04	1.81	15.192

Table 1
GENERAL CHARACTERISTICS FOR THE BIOMASS BATCHES – WATER ASH FREE MATERIAL

However, few studies have been conducted on the utilization of agricultural waste for composting and/or animal fodder, and none of them has been implemented in a sustainable form [6, 7].

Agricultural wastes (AW) can be defined as the residues from the growing and first processing of raw agricultural products such as crops, vegetables, meat, poultry, fruits, etc. This term includes both natural (organic) and non-natural wastes produced from various farming activities such as dairy farming, horticulture, seed growing, livestock breeding, grazing land, market gardens, nursery plots and even woodlands. Agricultural wastes (AW) can be in the form of solid, liquid or slurries depending on the nature of agricultural activities. Agricultural and food industry residues and wastes are characterized by seasonal production and also should be rapidly removed from the field to avoid interferences with other agricultural activities [8-13].

Agricultural activity in Romania is limited by the small size of its holdings, soil type, water scarcity and ecological constraints. This makes it harder for Romania to compete within the EU in the agricultural sector, unless some necessary actions are taken in this respect [14-17].

Agricultural Waste in Romania

The biomass supply is quite good. Statistical records group biomass in two categories: firewood and agricultural waste (accounts for 95% of the total) and wood waste from industrial processes (about 5%). Representing the target potential users of biogas polygene ration, the main sources of fermentable waste in Romania are represented by the following 5 components:

-organic waste, sludge and by-products from agriculture;

-organic waste, sludge and by-products from the food industry;

-mixed sludge from municipal waste-water-treatment-plants;

-biodegradable fraction from municipal solid waste;

-ther secondary sources: paper & pulp industry, biodiesel industry [18].

Estimation of Crop Waste

The proportion of straw to cereals varies from crop to another and according to yield level. The yield is a function of total biomass and the harvest index (the cereals to straw ratio). A harvest index of 0.5 indicates that the biomass produced is comprises 50 per cent grains and 50 per cent straw. Lower harvest production, indices means higher proportions of straw. The height of cutting will also affect how much stubble is left in the field: many combine-harvested crops are cut significant; crops on small-scale farms may be cut at ground level by sickle and the quantity of straw are less.

Two different methods can be used to calculate the amount of crop waste generated. The first one, used for woody residues from perennial crops, is based on the cropped areas. This method assumes that crops grow with a more or less standard planting density, which in practice may not be true. The type of management (traditional or advanced) as well as the crop variety (local variety, improved and/or clonal variety) can result in significant differences in the amount of crop as well as residue obtained from a particular cropping area. The second method of calculation of crop residues, often used for annual crops, is to use a residue-to-product ratio (RPR).

The experiments were accomplished using a temperature domain of 30 – 38°C and the duration for each batch extended over 45 days.

Before the experiments, preliminary determinations for each type of biomass were completed and the results are presented in tables 1, 2 and 3.

Table 1 presents the general characteristics for the two biomass batches.

General characteristics for the biomass batches – water ash free material [19].

Table 2 presents the major elements that are found inside the two batches and table 3 presents the composition in heavy metals for the two batches.

Sunflower is among Romania's traditional crops. Both from the point of view of the cultivated surface and that of production (2.129 million t), in 2014 Romania topped the rankings of the main EU agricultural states.

No.	Elements	Maize bran [mg/kg]	Recipe of corn, maize and sunflower Seeds [mg/kg]
1	Mg	1331	764
2	Al	71	61
3	Si	174	34
4	P	5855	2419
5	S	1165	925
6	Cl	370	388
7	K	9697	4359
8	Ca	1209	901
9	Mn	108	14
10	Fe	177	117
11	Zn	69	25

Table 2
MAJOR ELEMENTS FOR THE BIOMASS BATCHES – WASTER ASH FREE MATERIAL

Metal	Compost A	Compost B	Clean compost	Very clean compost
Cd	2	1	1	0.7
Cu	300	60	90	25
Hg	2	0.3	0.7	0.2
Pb	200	100	120	65
Zn	900	200	280	75
As	25	15	15	5

Table 3
THE MAXIMUM VALUES OF SOME HEAVY METALS CONTENT IN DIFFERENT COMPOST QUALITIES AS DISTINGUISHED IN THE DUTCH COMPOST DECREE IN MG/KG DRY COMPOST [26]

– Major elements for the biomass batches – waster ash free material [19].

In fact, Romania's yield is smaller than that of the main states that cultivate this crop. Variations in the reported values have been attributed to differences in seed varieties planted, moisture content of the crop residues, and method of harvesting. Table (1) gives the RPR values used by FAO in estimating crop waste in the Romania, and those given recently by R. Lai [20] for the estimation of crop waste in the world.

Utilization of Crop Residues

Crop wastes are organic and biodegradable. Utilization technology must either use the residues rapidly, or the residues must be stored under conditions that do not cause spoilage or render the residues unsuitable for processing to the desired end product.

- *Composting.* Composting is the aerobic decomposition of organic materials by microorganisms under controlled conditions. Agricultural waste is rich in organic matter. This matter is derived from the soil and the soil needs it back in order to continue producing healthy crops**.** In addition P.M. Geisel [21] reported that composting is one of the best known recycling processes for organic waste to close the natural loop. The major factors affecting the decomposition of organic matter by micro-organisms are oxygen and moisture.

In excess, however, the soluble salts are toxic and inhibit plant growth. Borates are toxic to certain plants, especially in arid regions. They are very soluble and leach out by rainfall. Cadmium and mercury serve no traditional role in plant growth [21].

Some of the factors affecting plant uptake of heavy metals are [22-25]:

- level of toxic elements in the compost/waste water and their characteristics;
- background concentration of toxic elements in the soil and their distribution;
- ability of soil chemical constituents to convert toxic elements to non-available chemical compounds - this ability is in turn affected by the nature of the toxic elements and the type of soil, for example; *p*H, Organic Matter and Clay content, phosphate level, CEC (Cation Exchange Capacity) of the soil, absorption and precipitation.

Especially Cd, Cu and Zn may accumulate in the food chain. Other heavy metals do not seem to accumulate in the edible parts of crops. Zn is more readily absorbed than most other heavy metals. The presence of Cu inhibits Zn transport through the plant.

Little is known about long-range effects of toxic elements applied to agricultural land through the continuous use of waste water and compost [23-25]. Table 3 shows the maximum values of some heavy metals content in different compost qualities as distinguished in the Dutch compost decree.

The time required for maturation depends on environmental factors within and around the composting pile. Some traditional indicators can be used to measure the degree of stabilization such as decline in temperature, absence of odors, and lake of attraction of insects in the final products.

In addition, a grower's guide [27], mentioned that aerobic composting systems can be classified as turned windrows, aerated static piles, passive static piles or windrows, and aerobic in vessel systems. In any aerobic system, composting is most rapid when microbial activity is maximized.

Concerning size of materials given by P.M. Geisel [21] concluded that material decomposes best if it is 0.5 to 1.5 inches in size. Soft, succulent tissues do not need to be chopped into very small pieces, but hard or woody tissues should be reduced to smaller pieces in order to decompose rapidly [28].

A theoretical calculation by R.T. Haug [29] suggests that for particles significant than 1.00 mm in thickness, oxygen may not diffuse all the way into the center of the particle. Thus the interior regions of significant particles are probably anaerobic, and decomposition rates in this region are correspondingly slow. However, anaerobic conditions are more of a problem with small particles, as the resulting narrow pores readily fill with water due to capillary action. These issues are addressed more fully in the section on factors leading to anaerobic conditions.

Animal feed

- *Treatment with Urea and Injection with Ammonia***.** Most developing countries, the problem is in the limited availability of protein sources although great efforts have been and are being made to find alternative supplements [30, 31]. On the other hand, Crop waste have a significant fiber content and are low in protein, starch and fat. Cell walls of straw primarily are lignin, cellulose $(C_6H_{10}O_5)_n$, and hemicelluloses.

Cellulose $(C_6H_{10}O_5)_n$ is a significant chain polymeric polysaccharide carbohydrate of betaglucose. The principal functional groups in pure cellulose are hydroxy (-OH) making cellulose a polyol with primary and secondary alcohol functional groups (-CH_2OH, -CHOH) [31].

The feeding of molasses-urea blocks is another related technology widely used for improving animal performance on fibrous crop waste bringing about [22, 26] increases in feed intake and also in digestibility [32, 33].

Pre-treatment with a source of ammonia such as urea or ammonium bicarbonate can greatly enhance both the intake and digestibility of straw, and will improve the productive performance of the animals.

GAINS sector	WASTE_AGR	NOF	Burning of agricultural waste	
Activity rate	Amount of waste burned			
Unit	Mt/year			
Data sources	RAINS database (http://www.iiasa.ac.at/web-apps/tap/RainsWeb/)			
Emission factors			Unit	
	Agricultural waste burning		kt/Mt	0.0012

GAINS =Greenhouse Gas and Air Pollution Interactions,
RAINS=Regional Air Pollution Information and Simulation

Table 4
CALCULATION OF EMISSIONS FROM BURNING OF AGRICULTURAL WASTE IN GAINS

Cow manure	Day 1	Day 5	Day 10	Day 15	Day 20
pH	6.2	6.5	7.03	7.25	7.27
TSS, %	1.17	1.07	0.74	0.51	0.23
Soluble proteins, mg· mL^{-1}	0.70	0.64	0.6	0.52	0.47
Reducing sugars, mg· mL^{-1}	4.2	3.9	3.5	3.1	2.8

Table 5
COW MANURE CHARACTERISTICS DURING THE ANAEROBIC DIGESTION PROCESS

Pig manure	Day 1	Day 5	Day 10	Day 15	Day 20
pH	6.5	6.8	7.2	7.34	7.39
TSS, %	1.26	1.22	1.14	0.97	0.71
Soluble proteins, mg· mL^{-1}	0.9	0.85	0.7	0.63	0.5
Reducing sugars, mg· mL^{-1}	4.6	4.4	4.0	3.2	3.0

Table 6
PIG MANURE CHARACTERISTICS DURING THE ANAEROBIC DIGESTION PROCESS

Food Production
Mushroom production

Application of oat straw for plantation of mushrooms is well known in Romania.

To solve the environmental troubles raised by the accumulation of these organic wastes, the most efficient way is to recycle them through biological means. As a result of other recent studies, the cultivation of edible and medicinal mushrooms was applied using both the solid state cultivation and controlled submerged fermentation of different natural by-products of agro-food industry that provided a fast growth as well as significant biomass productivity of the investigated strains [34].

Energy Production
Bio Gas

The first goal of any waste management system is to maximize the economic benefit from the waste resource and maintain acceptable environmental standards. To be practical, the system must also be affordable and suitable to the operation. If wastes are not properly handled they can pollute surface and groundwater and contribute to air pollution. Most people think of manure first when they think of farm waste. While manure is an important component, farm waste in a livestock operation can also include waste forage, dead stock, silage effluent and milk house waste [35, 36].

Manure contains about 75% of the nutrients fed to livestock including nitrogen, phosphorus and potassium. Animals use only about 25% of nutrients and excrete the rest. About 50% of nitrogen and 75% of potassium in manure is found in the liquid portion. Therefore, it is important to contain the liquids for land application. Almost all the phosphorus is in the solids [34].

Methane emissions also originate from the (open) burning of agricultural waste. A global emission factor is used for GAINS (table 4).

Removal of these nutrient-rich resources from the fields deprives the farmer of much needed fertilizer and their replacement often means the use of chemical fertilizers at a severe financial and energy cost.

Biogas technology has become therefore interesting as a way to improve the energy release from agricultural residues, save plant nutrients, and improve health conditions and quality of life in the villages [34]

In order to assess the suitability and profitability of animal manure feedstock for biogas production, the following parameters were monitored: *p*H, TSS, soluble proteins, reducing sugars, moisture and ash.

The moisture of pig manure was 84.46% and for cow manure it was 77.76%, while the determined ash was of 0.1634 g for pig manure substrate and 0.11304 g for cow manure substrate.

The optimal *p*H for methanogens is around 7.0, while it is between 5.5 and 6.5 for hydrolysis and acid genesis, as reported in numerous studies [37].

The *p*H value is the pivotal factor influencing the methane production efficiency and it has been proved that the optimal range of *p*H to obtain maximal biogas yield in anaerobic digestion is 6.5-7.5 [38].

The initial *p*H values for the tested substrates were above 6.0 in both cases. After 5 days, the *p*H values increased slightly and then stabilized and reached values above 7.0 for both tested substrates.

During the anaerobic digestion process, a slight decrease of TSS content was observed for pig manure from 1.26 to 0.71% and for cow manure from 1.17 to 0.23%, the fact that can be attributed to the presence of easily degradable compounds within the soluble fraction (table 5 and 6).

Regarding biogas production, we observed a delayed start in both cases, this phenomenon being due to the absence of inoculum in digester. The lower level of biogas produced by cow manure is also due to the lower values of reducing sugars and soluble proteins compared to those derived from the pig manure substrate.

The waste management sector in Romania is expected to develop in the coming years because as part of European Union, Romania has to meet some targets related to waste management [38-41].

Conclusions

There are a lot of recommendations that can be deducted from the experiences described above. We only want to focus on some points that are primarily addressed at decision-makers, but require partnerships with other stakeholders like donors and NGOs, private enterprises etc.:

- analyze the informal solid waste management activities, its linkages to the formal solid waste management system and its impacts;

- if significant informal waste management activities exist, foresee strategic measures for the inclusion of these activities in National Solid Waste Management Strategies, laws and regulations;
- involve representatives of the informal sector in local solid waste management planning processes;
- improve social recognition of waste recovery activities through communication campaigns, partnerships with NGOs and other actors to accompany informal stakeholders;
- facilitate the organization and formal recognition of informal waste workers (through identity cards, associations, co-operatives, enterprises, etc.);
- train informal stakeholders on health, environmental, technical and management aspects;
- provide information about recycling markets and prices to informal workers;
- create opportunities for resource recovery through the informal sector;
- in waste collection systems (e.g. (separate) collection contracts for registered informal sector, buy-back or drop-off points for recyclable materials, partnerships or franchising systems with formal private sector);
- on transfer stations or landfill sites (by providing sorting space and infrastructure, establishing agreements with waste pickers on recovery practices not disturbing landfill operation);
- analyse feasibility of upgrading informal sector recycling and initiating new recycling activities;
- establish partnerships with the private sector to improve the informal sector's linkages to industrial value chains.

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