Digestate production in Hungary

Anaerobic digestion (AD) uses microbial organisms in the absence of oxygen to decompose organic materials as farms yard manure and/or slurry and other organic materials. As the digestion process is strongly influenced by the temperature in general two different temperature ranges are used in commercial anaerobic digestion plants as is the mesophilic (30 - 37°C) and the thermophilic (50 – 60°C) one. The volume of biogas produced is slightly affected by the temperature but the rate of material decomposition (fermentation) is strongly influenced by temperature. In mesophilic plants waste will take longer time to be processed than in thermophilic plants, however mesophilic plants tend to be more tolerant of variations in the input sources than thermophilic processes. The choice between the mesophilic or thermophilic processes depend on the composition of the manure or agricultural waste, the economic aspects, capital cost and plant environmental impact. In Hungary the majority of biogas plants use the mezophilic process as it is suited to a wide range of agricultural inputs. In addition, less heat is needed to sustain the mesophilic process, therefore more energy is available for other purposes.

The majority of plants use only the inputs from their own farms (crops, manure, feed wastes), others use animal wastes as well. The EU Animal By-products Regulations (1774/2002 EC, modified by 1069/2009 EC) allow the utilisation of animal wastes from category 2 and 3. The Regulation contain rules for the collection, storage, transport, handling, processing, use and disposal of animal by-products. They also control the marketing and export of animal by-products and products derived from them. In the first generation biogas plants usually the category 3 waste is processed. More suited for processing of the 2 category are the second generation of biogas plants using the Thermal Hydrolysis Process (THP). In most AD schemes some of the heat produced from the combustion of biogas is used in the anaerobic digestion process itself. This helps to maintain the digestion process, particularly during periods of cooler external temperature. The end product digestate can be used without separation or with separation into a liquid and a solid fraction.

From an agronomic point the utilisation of an organic material and microbiological rich digestate has several advantages as:

- increase the soil organic matter content: soil organic matter represents an accumulation of plant and animal residues as a continuous transformation by soil micro-organisms. The organic matter content is one of the most important soil quality criteria which must be renewed constantly by the addition of plant residues. Soils with higher organic matter content are typically more open and less easily compacted than a comparable soil with a lower organic matter content. Reduction in the susceptibility of soil to compaction will increase the longevity of the substrate, allowing new habitats to form and to improve soil texture.
- improve soil structure and increased water retention capacity: organic matter additions can be highly beneficial to soils with low organic material as the sandy soils. Organic matter can stabilise the poorly structured soils and increase drought resistance, furthermore prevent the breakdown of soil structure by water, encourage granulation and reduce plasticity and cohesion. Soils with a higher organic material have a higher water holding capacity.
- improve plant growth: soil physical improvement already mentioned will promote the deeper rooting and overall growth of vegetation. The deeper rooting and more vigorous vegetation growth will increase the evapotranspiration which allow higher yields and a more efficient water cycling.
- increase nutrient supply: digestate has large NH3 content which adequately managed can be valuable nutrient resources for plants. As a part exist in a mineralised state are already available to plants. Other parts are more slowly released. Digestate also contain phosphor (P), potassium (K) and

sulphur (S) which are important nutrients for plants. Phosphorus is primarily associated with root development and energy transfer within plants metabolic processes whilst K ions play an important role in water regulation.

- increase soil biological activity: the digestate will also contain a wealth of beneficial microorganisms which are able to facilitate natural nutrient cycling and disease suppression.
- soil pH stabilisation: digestate may have a neutralising value which may be used to help stabilise soil pH and reduce the acidifying effects of natural soil processes.

From economic point of view the biogas plant can be profitable if the following measures are taken: selection of cost-effective technologies to reduce investment costs and operational costs, optimization of total solids share (%) in the substrate-mix, optimization of methane production /t of biomass-input, assure stable supply of cheap biomasses of high quality for optimal mix and optimize the income from selling biogas.

Digestate properties

Digestate resulted from fermentation is a mixture of solid and liquid parts (whole digestate) which case by case during the digestate post treatment can be separated into liquid and solid fractions. Both fractions can be used as a soil conditioner/ organic fertilizer in agriculture or the remediation of poor quality lands. The amount and quality of digestates obtained will vary according to the input materials and AD system used. The use of digestates has the potential to replace and therefore reduce the production of mineral fertiliser which requires significant energy input. In addition, the sale of digestate is a potential additional source of revenue for operators of anaerobic digestion plants. It has the potential advantage over undigested manures and slurries that it is more consistent in nutrient content and availability to plants, and has lower potential for pathogens. It can also be lower in odour. Although digestate can be used without further treatment, issues such as transport, storage costs and dispersion can have several drawbacks.

The nutrient content for non-separated slurry (cattle manure and silo in this case) is 4-6% dry matter, 3-4,5 % diluted ammonia, 5-7 % total nitrogen, 1-1,5 % phosphorus, 2-5% potassium, 1-1,3 % Mg, 1-1,8% Ca, 350-450 mg/kg Zn, 80-180 mg/kg Cu, 250-350 mg/kg Mn. The pH value is 7-8 pH. For the separated slurry the figures are:

	liquid phase	solid phase
dry matter (m/m%)	1,2-1,6	25-27
nitrogen (m/m%/dm)	81000-85000	26-28000
phosphorous(m/m%/dm)	15000-17000	7000-9000
potassium (m/m%/dm)	60000-80000	7000-9000
Pb (mg/kg dm)	<3,0	<3,0
Cd (mg/kg dm)	<0,1	<0,1
Co (mg/kg dm)	<0,3	<0,3
Cr (mg/kg dm)	<1,5	<1,5
Cu (mg/kg dm)	160-190	31-34
Mo (mg/kg dm)	<1,5	<1,5
Zn (mg/kg dm)	800-1000	120-140

Utilising digestate can save several amounts of GHG emission. It is estimated that the fertilising value of digestate can save between 20 and 30kg CO2 equivalent per cubic metre of digestate used – an increasingly important consideration for retailers, who are seeking to reduce the carbon footprint of their supply chains. Digestate (in particular the separated fibre fraction) can also contribute to soil organic matter, which in turn can improve soil quality, crop health and yields over the longer-term.

The quantity and crop-availability of the nutrients in digestate will depend on the process input materials, the process itself and any post-treatment manipulation of the digestate such as de-watering. At present the whole digestate is used on the largest scale but some plants use the separation into liquid and solid phase for operational reasons. The solid phase has a dry matter content of 20- 40% and the liquid fraction between 1- 4%, although these proportions will vary depending upon the separation process or processes employed. In case of digestate separation and on source (pig or cattle) the digestate composition can be different:

In order to be utilisable as fertilizer the digestate has to have the required physical and chemical parameters. Within the chemical parameters usual the heavy metal content is a risk factor. In small quantities, some heavy metals like iron, copper, manganese and zinc (can be trace elements as well) are essential nutrients for healthy crop life. These elements can become toxic when they are not metabolized and accumulate in the tissues. The toxic levels can be just above the background concentrations naturally occurring in the environment. Digestate heavy metal content has to be reduced in the future as it is planned in the EU documents:

	Cd	**Pb**	**Hg**	**Ni**	**Zn**	**Cu**	**Cr**
EU recommendation	20	750	16	300	2500	1000	100
EU recommendation from 2015	5	500	5	200	2000	800	600
EU recommendation from 2025	2	300	2	100	1500	600	600

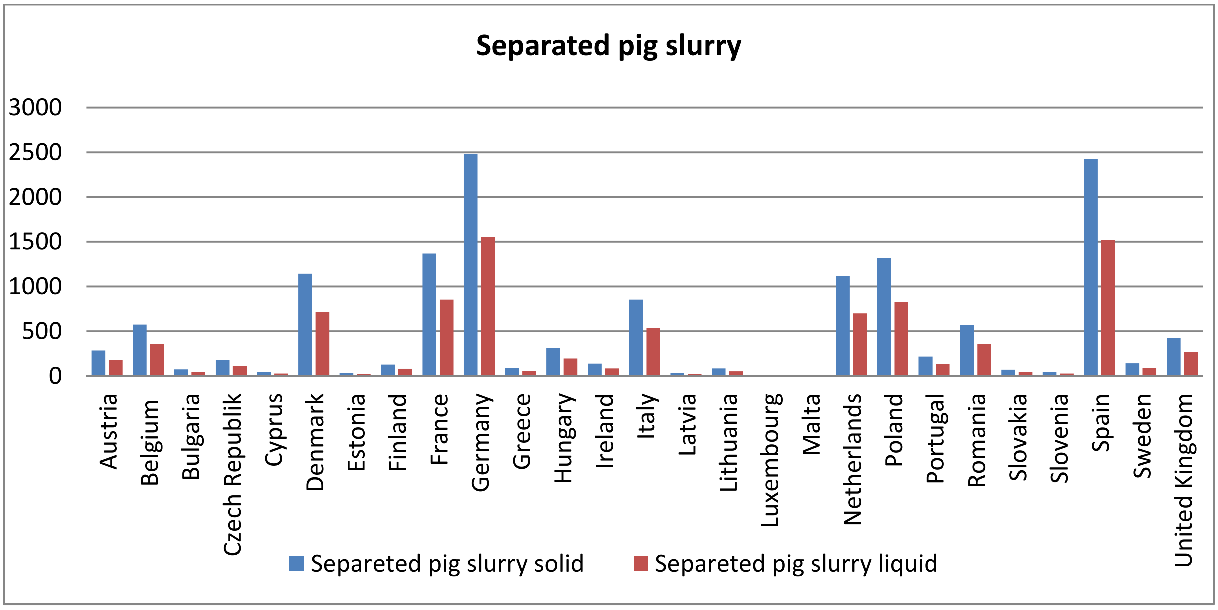
Source: WRAP, 2012

Other risk factors can be the organic pollutants containing unwanted chemical compounds mostly when beside the agricultural sources other industrial or communal wastes are used as sewage sludge, wastewaters, industrial organic wastes and even food wastes. Some of them are not biodegrade in the environment therefore has a toxicity risk. Risk factors can be the pathogens and other unwanted biological sources. Digestate used as fertiliser must pose minimal risk of transmitting bacteria, viruses, intestinal parasites, weed and crop seeds and crop diseases. The most effective bacteria are Salmonella spp., E. coli, Staphylococcus spp, Mycobacterium, coliform bacterias, the group of Streptococcus spp. The input source selection and exclusion of materials with high risk of biological contamination are vitally important measures in digestate quality. The biogas producing process has itself a sanitation effect being able to inactivate most of the pathogens present in the fermentor mixture. Depending on the input materials additional sanitation measures like pasteurisation or pressure sterilisation can be necessary, for example in case of using animal wastes (e.g 1 hour at 70°C and 1 atm) . The role of sanitation measures is to break the chain of pathogens and animal and plant diseases transmission. During fermentation the plant pest and diseases can be destroyed as Globodera spp, Fusarium spp., Plasmidiophora spp. Amoung weeds the mezophilic process can be successful for some weed but not for all

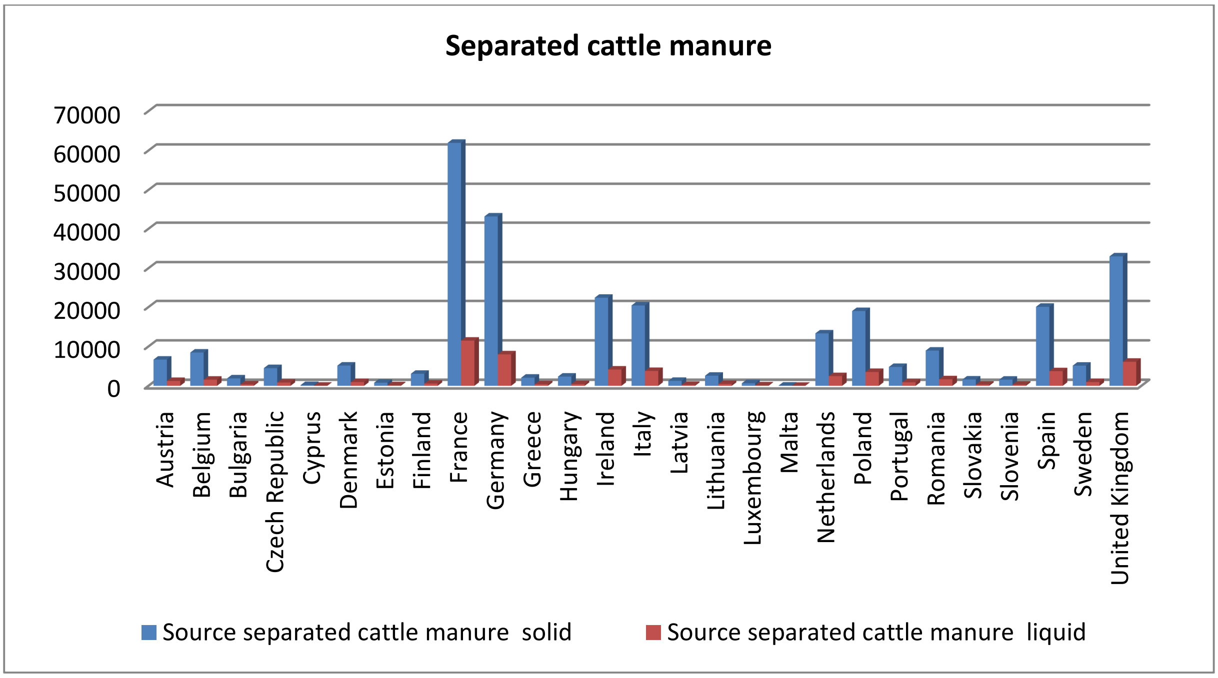
The digestate can be further processed by separation (de-watering) into solid and liquid phase. Flocculation or precipitation can be used in order to improve solid-liquid separation. Different separation technologies are available as was described in the case of slurry processing e.g. screw press or centrifuges. The solid fraction can be applied directly as fertiliser in agriculture, or can be composted, dried for intermediate storage and enhanced transportability or sold as a phosphor rich fertilizer or burnt for energy production. The liquid part containing large amount of nitrogen and potassium can be applied as liquid fertilizer or further cleaning processes as filtering, reverse osmosis or other technologies can be applied. As digestate cannot be applied to agricultural fields in the winter time (November – February) it must be stored. The storage can take 4-6 month. To prevent quality depreciation the digestate tanks should be covered by gas tight membranes, roofs or at least clay or floating straw in order to produce a surface crust.

Taking in consideration the severe animal number reduction in the last 6-8 years, and the reduced soil organic matter content of Hungarian soils there is a need to reconsider the utilisation of the farm yard manure, slurry and digestate in agriculture. The following figures show Hungary manure production (1000 tonnes) situation compared with the other EU countries:

Pig slurry



Cattle manure



Poultry manure