



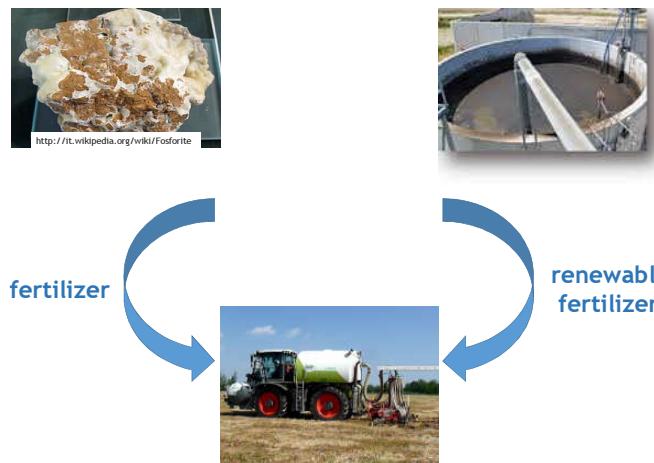
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Anaerobic digestion (AD) plays a key role in the increasingly sustainable management of livestock manure through the production of renewable energy (biogas). Nevertheless, the excessive content of nutrients in the digestate, N and P in particular, did not find, at the moment, a real solution. The solid-liquid separation system is one of the treatments most often used in the management of the digestate. Treatment yields two fractions: a clarified liquid fraction and a solid fraction both rich in nutrients, especially nitrogen and phosphorus. Aim of this work was the characterization of the digestate and its fractions liquid (LF) and solid (SF), coming from 15 full-scale plants located in the Lombardy Region (Northern Italy) operating anaerobic digestion and successive mechanical separation of the digestate. The mineral composition of different samples of digestate, and relative liquid and solid fractions, was assessed. In particular, the study was focused on nitrogen, phosphorous and heavy metals content, to better understand their suitability, agronomic and environmentally, to be used in place of chemical fertilizers. Heavy metals have been investigated in the digestates, as usually occurs for biomasses originated by waste (i.e. compost and sewage sludge), for their potential impact on soil and plants. Generally, in fact, biogas plants co-digest manure and slurry with other wastes such as agro-residues or organic fraction of municipal solid waste, possible sources of heavy metals. Data obtained were compared with an organic NP fertilizer (dried pig manure) for which the minimum requisite (Italian Law) is 25 g kg⁻¹ and 20 g kg⁻¹, respectively, for nitrogen and phosphorus (P₂O₅).

Characteristics of the anaerobic digestion plants studied

Plant	Infeed biomasses	Rated power (kWh)	Separator type
1	Pig slurry + energetic crops	999	screw press
2	Pig slurry + energetic crops	999	screw press
3	Pig slurry + energetic crops + cornmeal + milk whey	999	screw press
4	Pig slurry + agro-industrial residues	999	screw press
5	Pig slurry + energetic crops	999	screw press
6	Cow slurry + energetic crops	999	screw press
7	Energetic crops + milk whey	340	screw press
8	Energetic crops	650	screw press
9	Cow slurry + energetic crops	999	screw press
10	Cow slurry + cow manure + energetic crops + molasses	999	screw press
11	Cow slurry + pig slurry + poultry manure + molasses + middlings	999	centrifuge
12	Cow slurry + pig slurry + poultry manure + molasses + middlings	999	centrifuge
13	Cow slurry + energetic crops	999	screw press
14	Cow slurry + energetic crops + poultry manure	380	screw press
15	Cow slurry + energetic crops	999	screw press



Chemical characteristics of the samples

Samples	DM	TKN	N-NH ₄	N-NH ₄ /TKN	P ₂ O ₅ tot
	% FM	g kg ⁻¹ DM	%	g kg ⁻¹ DM	
D average (n=15)	6.02±1.18 a	47.50±24.52 b	79.76±17.99 b	55.50±7.77 b	36.19±10.39 a
LF average (n=15)	4.23±1.09 a	62.87±20.53 b	101.98±21.60 b	60.20±9.15 b	37.35±11.93 a
SF average (n=15)	21.04±3.16 b	10.06±3.25 a	29.39±5.84 a	34.41±8.65 a	31.27±10.42 a

Heavy metals content

	Samples	Ni	Co	Zn	Cu	Pb	Cd	Cr tot	As
		mg kg ⁻¹ DM							
	D average (n=15)	9.98±3.39	1.58±0.79	345±199	68.93±31.01	1.88±0.91	0.37±0.17	8.76±1.86	0.86±0.44
	LF average (n=15)	10.05±4.49	1.47±0.58	273±132	61.61±30.33	1.74±0.78	0.30±0.18	11.32±5.87	0.80±0.46
	SF average (n=15)	8.24±3.89	1.27±0.72	215±123	45.98±35.70	1.64±1.22	0.30±0.22	9.73±4.80	0.66±0.37
EU, recommendations ¹	Ni	Co	Zn	Cu	Pb	Cd	Cr tot	As	
	300	//	2500	1000	750	20	1000	//	
	200	//	2000	800	500	5	600	//	
EU, recommendations starting 2015 ¹	100	//	1500	600	300	2	600	//	
	100	//	1500	600	300	2	600	//	
	100	//	1500	600	300	2	600	//	

¹ Al eadi and Lukehurst, 2012. Source EU (2000) 3rd Working Document of the EU Commission on Sludge management; (Sludge defined by EWC Codes covering agri-food processing, animal by-products, fruit and vegetables, dairy, baking and drinks residues); ENV.E3/LM, 27 April. Available from: <www.ec.europa.eu/environment/waste/sludge/pdf_en.pdf>

The results provide evidence that in digestate, LF and SF the values of nitrogen and phosphorus are higher than the minimum value required for the product taken as reference. As a consequence it can be assumed that the digestate, and the liquid and solid fractions obtained by mechanical separation, can be compared to common commercial organic fertilizers. Through anaerobic digestion it would be possible generate not only renewable energy, but also fertilizers to be used in agriculture. Further studies should investigate, by chemical and spectroscopic techniques, the effect of anaerobic digestion on P-form in digestates with the aim, at the same time, to optimizing P removing from liquid digested fraction by insoluble P-salt formation, i.e. struvite.

In this context, the adoption of a normative is necessary in order to regulate the use of digestate as renewable fertilizer, as in recent years has been done for nitrogen (see EU Nitrates Directive) preserving, at the same, soil and water by excessive inputs of nutrients.