TECHNOLOGIES FOR REDUCING THE ENVIRONMENTAL IMPACT OF AGRICULTURAL AND LIVESTOCK PRODUCTIONS

ENVIRONMENTAL IMPACT OF ELECTRICITY FROM ANAEROBIC DIGESTION PLANTS: LIGHTS AND SHADOWS

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Key words: Life Cycle Assessment, Anaerobic Digestion, environmental sustainability, renewable energy

In the last 20 years, thanks to remarkable public subsidies for the production of electricity from renewable sources, the anaerobic digestion (AD) of agricultural biomass has grown. In 2013, in Italy, according the CRPA, about 7450 GWh of electricity was produced by 1713 agricultural AD plants. Although the agricultural feedstock AD (animal wastes, in particular) has been recognized as an effective solution to reduce greenhouses gases (GHG) emissions, general conclusions about the environmental sustainability of this biomass-to-energy process cannot be drawn. A careful assessment of several environmental concerns must be carried out.

The aim of this study is to evaluate, using Life Cycle Assessment (LCA) approach, the environmental performances of 10 AD agricultural plants. LCA, defined by specific ISO standards, is a holistic method for the assessment of the environmental load related to a production. The 10 AD plants, located in Lombardy and Piedmont regions, are characterized by an electrical power ranging from 100 to 999 kW. Built since 2009 to 2013, they are fed by cereal silages (maize, triticale), animal wastes (pig and cow slurry) and agro-food industry by-products (tomato skins and peels).

The selected functional unit is 1 kWh of produced electricity. The system boundaries involve production, transport and storage at the AD plant of the feedstock, anaerobic digestion, biogas treatment and conversion by a cogeneration system (CHP, i.c. reciprocating engine). Animal slurries and agro-industry by-products are considered wastes coming from other production processes; therefore, no environmental burden is accounted for their production. For the AD plants fed by animal wastes, considering that the energy generation process substitutes the traditional slurry management in open tanks, environmental credits have been taken into account. Inventory data, collected by mean questionnaires to the plant manager as well as by direct surveys, refers to the period 2012-2014.

Eleven environmental impacts, accounted considering the characterization factors provided by ILCD, were evaluated: climate change (CC), ozone depletion (OD), particulate matter (PM), human toxicity (HT), photochemical ozone formation (POF), terrestrial acidification (TA), terrestrial eutrophication (TE), freshwater eutrophication (FE), marine eutrophication (ME), freshwater ecotoxicity (FEx), and mineral and fossil resource depletion (MFRD).

The results show a huge variability among both the 10 plants and different impact categories. Cereal silage production (when used), methane losses and digestate emissions are the main contributors for the environmental impacts taken into account. Building, maintenance and disposal of digesters and CHP are responsible for a little impact but cannot be neglected in small plants, for HT in particular.

The AD plants fed by slurries and agro-industry residues show a lower impact compared to the ones fed by energy crops For CC, the small power plants, fed with animal slurries and by-products), show negative values (*i.e.* environment benefits) while the bigger ones, fed mainly by cereal silages, have GHG emissions close to the Italian electric mix. For acidification and eutrophication impact categories, the plants fed with cereal silages present a severe higher impact (2-4 times) respect to Italian electricity mix.

COMPARISON AMONG DIFFERENT TECHNIQUES FOR SLURRY SPREADING: EFFECT ON THE ENVIRONMENTAL PERFORMANCE OF MAIZE CULTIVATION

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Key words: Life cycle assessment, slurry spreading, environmental impact mitigation.

Greenhouse gases emissions from human activities are considered the major causes of global warming. Among the production sectors, agriculture plays an important role on greenhouse gases emissions. Although most of these are due to enteric fermentation, mainly caused by cows, slurry management is also responsible for a considerable environmental impact. In Italy, mainly in Northern Regions, intensive livestock holdings are much developed. Slurry management should aim to the selection of spreading techniques able to reduce ammonia and other nitrogen compounds emissions.

In this paper, the environmental impacts of different pre-sowing fertilisation schemes for the cultivation of a maize hybrid FAO Class 700 have been evaluated using the *Life Cycle Assessment* (LCA) methodology. The assessed scenarios are:

- Scenario A, urea spreading;
- Scenario B, superficial slurry spreading and injection after more than 48 hours;
- Scenario C, superficial slurry spreading and injection within 2 hours;
- Scenario D, direct slurry injection in 7-cm deep furrows.

The selected Functional Unit (FU) is 1 ton of maize silage. The system boundaries include the production of inputs consumed during the life cycle till the farm gate, where silage is stocked in horizontal silos. From the analysis are excluded all processes that consider the silage use. The impact categories evaluated using the ILCD characterisation method are: climate change (CC), ozone depletion (OD), human toxicity (HT), particulate matter (PM), photochemical oxidant formation (POF), terrestrial acidification (TA), freshwater eutrophication (FE), terrestrial eutrophication (TE), marine eutrophication (ME) and mineral, fossil and renewable resources depletion (MFRD).

LCA results obtained from the comparison among the different scenarios are not univocal:

- For CC, scenario A shows the worst environmental performance, followed by scenario D (-11%) and scenarios B and C (-16%);
- For OD, scenario A shows again the worst performance followed by scenario D (-33%) and scenarios B and C (-40%);
- For HT, scenario A is the worst, whereas the other three scenarios report similar results, with an environmental impact reduction of about 32%;
- For PM, direct soil injection (scenario D) shows the lowest environmental impact, fast injection has similar results (-77% and -71% compared with scenario A, respectively);
- For POF, scenario D is the worst, while mineral fertilisers use (scenario A) has a lower environmental impact;
- For TA and TE, the highest environmental impact is associated with scenario D, while remarkable reductions are associated with sce-

nario A (-24%) and mostly with scenarios B and C (-88% and -81%, respectively);
- For FE, scenarios B, C and D show similar impacts and scenario A is the best (-54%);
- For ME, the lowest environmental impact is associated with scenarios B and C and the highest with scenario D;
- For MFRD, scenario A has the highest environmental impact, similarly to B (-3%), while scenario D shows the best results (-7%).

PROTOTYPE OF A CO_2 FLEXIBLE PLANT FOR COLD STORAGE AND CONDITIONING OF FOOD PRODUCTS

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Key words: Carbon dioxide, refrigerant, refrigeration plant, food

Recently the European Union has focused its attention on the effect that some emissions from industrial processes on the environment, attempting to reduce, and then eliminate, the use of third-generation refrigerants. Main aim of this paper is to provide a low environmental impact CO_2 refrigerant system, to investigate the use of this fluid in food refrigeration and storage applications. The study is part of a wider research program on a pilot plant aimed at testing the use of this fluid with regard to product quality, cost and environmental impact. To this end a network of different sensors was developed: temperature, pressure, CO_2 and flow rate, all controlled on LabVIEW platform.

The experimental measurement system was designed to control the key parameters of the prototype system. It is a pilot plant realized in the laboratory and equipped with: a compressor and related gas-cooler, an intermediate heat exchanger and two liquid-gas separators, all of them located outside in an partially covered area near the laboratory, while three cold storage modules (1.0 mx 0.70 mx 2.0 m each) were installed in the closed area of the laboratory.

In each module there are: a humidifier, an extractor fan and radiant heating panels on the side walls. Each module is also equipped with a different evaporator: in the cold store 1 a static type evaporator, in the cold store 2 a bi-flow evaporator with suction from the bottom and discharge along the side walls, in the cold store 3 a traditional evaporator with front fan and rear suction. In the laboratory there is also the electrical panel and the control computer.

During the trial, despite the storage conditions and the outside temperature it was often unfavorable compared to those of common industrial CO_2 plants, the refrigeration system worked with high efficiency.

The flexibility of the prototype is highlighted by the temperature and relative humidity trends in the cold stores during the experimental tests: it was noted that the thermo-hygrometric regime was very stable in the ventilated storage modules. In fact, the thermal hysteresis is on the order of ± 0.5 ° C and, under saturation conditions, excluding the peaks due to the opening of the doors, the hygrometric hysteresis can be considered absent in the cold store 2 and of the order of ± 2 % in the cold store 3. These results also confirm the greater efficiency of ventilation established in the cold store 2, also supported by specific qualitative and microbiological evaluations on the products.

DISTRIBUTION PATTERN OF ORGANO-MINERAL FERTILIZERS IN LOCALIZED APPLICATIONS

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Localized fertilization with granular fertilizers is an agronomic practice of great interest, because it is often associable with other farming operations (eg. planting, weeding, etc.) and because it achieves a greater adherence with the nutritional needs of the crop, thus saving product and causing less pollution. The application quality of the product depends on several factors, which include, on the one hand, the characteristics of the equipment used and the working parameters and, on the other, the physical and mechanical characteristics of distributed fertilizers. For the organo-mineral fertilizers (OMF), which are a rather new group of fertilizers, there is a certain lack of information about the quality of their distribution, although the assessment of the distribution performance of the machines is a prerequisite for the application of precision farming techniques. Therefore, the present work aimed at verifying, for two OMF, the horizontal (*i.e.* transversely to the forward direction of the machine) and the longitudinal (*i.e.* parallel) uniformity of distribution, expressed in terms of coefficient of variation (CV). Granular urea was used as reference fertilizer, to compare the studied OMF with a widely employed and efficient fertilizer in terms of distribution ease. Firstly, all fertilizers were investigated for their main physical characteristics. The OMF showed: a bulk density varying from 830 and 990 kg m^{-3}; a particle size distribution with a median diameter from 1.0 to 1.3 mm; a relative humidity from 1.5 to 1.8%. The tests were carried out with the following three machines: a pneumatic precision seed drill; a cultivator-fertilizer spreader; a fertilizer spreader for orchards and vineyards. Depending on the machinery, static or dynamic tests of distribution were carried out. The data obtained in the tests underwent to an ANOVA statistical test to individuate significative differences among treatments. Preliminary results show that the average CV measured both on horizontal and on longitudinal distribution with the three fertilizers, were similar. OMF showed a slightly better performance (i.e. more uniformity) with respect of urea. In conclusion, results indicate that the studied fertilizers are suitable for localized fertilization. In the future, we plan to expand the survey to other formulated fertilizers and fertilizer spreader machines.