ENVIRONMENTAL ASSESSMENT OF USING MEAT MEAL AS FERTILIZER - A SWEDISH CASE STUDY

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1 INTRODUCTION

The aim of organic farming is to have the agricultural system as sustainable as possible. One of the means to fulfil this principle is to keep nutrients in closed cycles and to avoid nutrients from chemically produced mineral fertilizers (IFOAM, 2006). Reasons for this are that mineral fertilizers increase the turnover of nutrients thus increasing the risk of eutrophication and also depend on a linear input of non-renewable sources, e.g. phosphorus and sulphur. The production of mineral fertilizers is energy demanding accounting for about 1.2 % of the worlds total energy consumption (IFA, 2009) and for about 20 % of the energy used in Swedish agriculture, including direct and indirect use (Ahlgren, 2009). A challenge is to find sustainable ways of supplying farms without or with only sparse access to manure with nutrients, especially for organic farms where the use of mineral fertilizers is not allowed.

One source of nutrients is animal by-products (ABP), slaughter waste not intended for human consumption. ABP Category 2 includes material potentially bearing infecting agents and also other parts of an animal not suitable for pet food production, e.g. manure and digestive tract content (European Parliament, 2002). In Sweden, fertilizers are used which are produced from ABP Category 2 waste.

The main goal of this study is to assess the total and fossil energy use and the global warming potential of using a fertilizer based on meat meal and to compare these environmental impacts with the impact from using a mineral fertilizer. Two systems typical for the conditions in Sweden are compared: In the first system meat meal is used as fertilizer and the animal fat, which is a by-product from the meat meal production, substitutes fuel oil of fossil origin and in the second system a mineral fertilizer is used and the animal by-products are combusted in the form of a slurry, Biomal, substituting bio fuel (of forestry origin).

2 MATERIALS AND METHODS

2.1 Life cycle assessment

The study was conducted using life cycle assessment (LCA) methodology. A LCA study consists of three main steps; a goal and scope definition, an inventory part and an assessment part. The study followed a so called cradle-to-grave perspective. System expansion was used in this study in such a way that avoided activities were included in the studied systems. This means that impacts from avoided activities are subtracted from impacts from the rest of the included activities. The subtraction due to the avoided activity means the resulting environmental impact for the system can be negative. In the study two different systems were compared, System MM and System CF. Harvest data were obtained from field trials conducted in the middle parts of Sweden. The field operations followed conventional production for both fertilizers, which made the fertilizers more comparable. Emissions and energy used were in this study analyzed according to the ISO standards (ISO 2006a; ISO 2006b).

2.2 Functional unit

The functional unit of the study was the harvest of one kilogram of spring wheat with a dry matter content of 85%. An additional valued function of each system was the treatment and disposal of 0.59 kg of ABP Category 2 material.

2.3 System MM

In this system, ABP Category 2 is sent from the south of Sweden to a treatment plant in Denmark where animal fat is extracted and the remaining meat meal dried and milled. Animal fat is then incinerated at industries in the vicinity of the plant. In Sweden the meat meal is bought by a fertilizer producing company that pelletizes and packages the meat meal fertilizer and sells it under the product name Biofer 10-3-0. From the production site the fertilizer is sent to the farm directly, since they wait with transport until they have a fully loaded truck. On the farm 80 kilograms per hectare of fertilizer is spread onto the field. Agricultural activities that are included are one ploughing, two harrowing, one combined drill, one field spraying and one harvest operation (Figure 1).

2.4 System CF

In System CF mineral fertilizers is used. These are produced in the middle of Finland, shipped to Sweden, packaged and transported to central supply. From here the fertilizer is transported to the farm. At the farm, the same operations are performed as in System MM.

The ABP Category 2 material, which is not used for production of meat meal, is instead used for the production of Biomal, a bio fuel produced by crushing and grinding the ABP material. The Biomal is incinerated at a plant about 45 kilometres from the production plant (Figure 2).

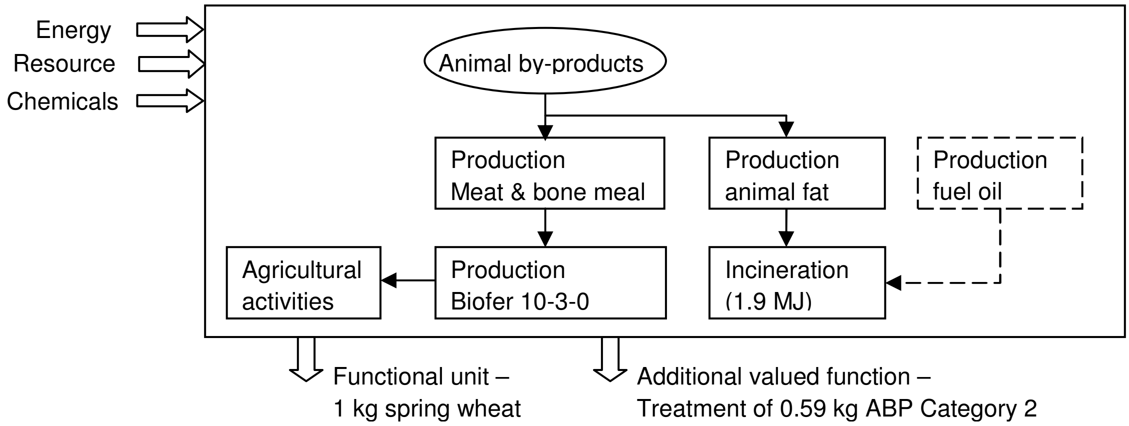

FIGURE 1 **Schematic of System MM**

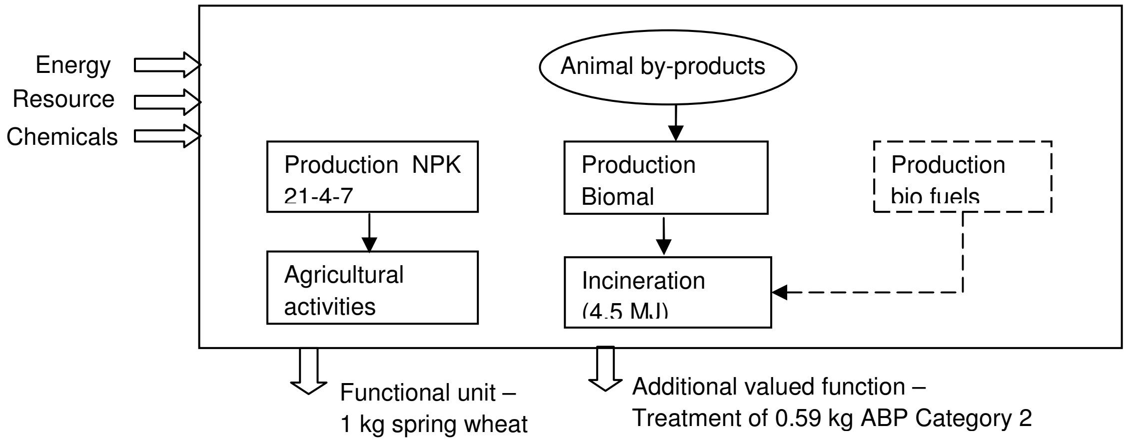

FIGURE 2 **Schematic of System CF**

2.5 System boundaries

In this study slaughter was considered the cradle of the ABP Category 2 waste, and thus the production of the livestock and the slaughter itself was not included. The harvest of spring wheat was considered the grave. Environmental impact from production of mineral fertilizers and energy carriers included all steps from the extraction of the raw material, including transports. However, the construction of buildings and machinery were not included for any of the production sites. Furthermore, only the production of the material for the big bag, but neither the sewing nor the recycling of the big bags was included in this study. Both the Biofer fertilizer and the NPK 21-4-7 are packaged in big bags. Also, use of a few chemicals in minor amounts (less than 1 kg per ton of ABP waste) at the treatment plant at Ortved was neglected. All these activities were assumed to have negligible impact on the final results. All production sites in the study (production of meat meal, animal fat, Biomal, Biofer, mineral fertilizer and spring wheat) were within the Nordic countries and the electricity used was assumed to be a Nordic average mix.

3 RESULT AND DISCUSSION

System MM had a primary energy use of 0.29 MJ and System CF had a primary energy use of -2.8 MJ per functional unit (Figure 3). The negative value in System CF was due to energy obtained from the raw ABP material.

System MM had a global warming potential (GWP) of 37 g CO_2-equivalents and System CF 138 g CO_2-equivalents per functional unit (Figure 4). The reason that the primary energy use did not correlate with the amount of greenhouse gas emissions was because the animal fat produced in System MM substituted fuel oil, while the Biomal in System CF substituted bio fuels (which can be seen correlated to the fossil fuel energy use shown in Figure 3).

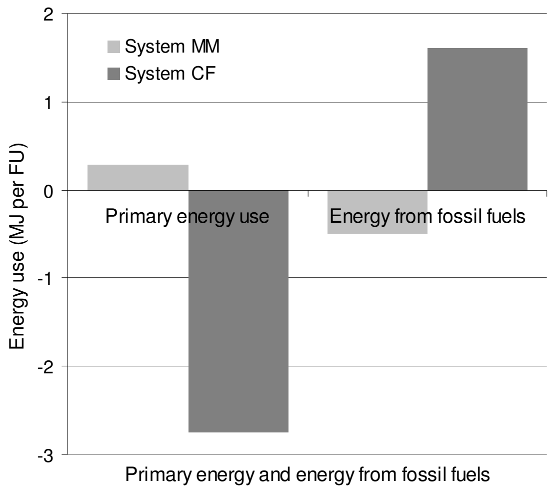

FIGURE 3 **Primary energy use and use of fossil fuel energy for systems**

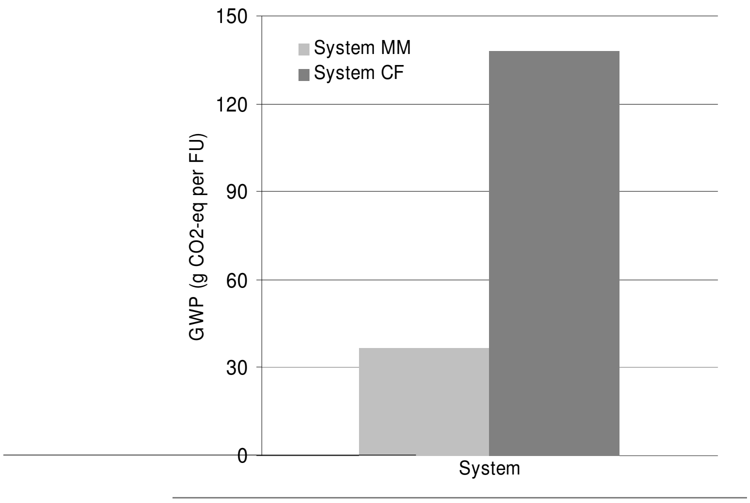

FIGURE 4 **Global warming potential, GWP, for the systems**

The meat meal fertiliser supplies the soil with about twice as much phosphorus as the mineral fertilizer at the typical application rate of 80 kilograms of nitrogen per hectare for both. The mineral fertilizer contains potassium of which the meat meal contains only minimal amounts. These factors should however not affect the yield since the soil is rich in both phosphorus and potassium.

Meat meal is an organic material with less available nutrients which increases the risk for leaching of nutrients and consequently eutrophication. Studies show that the relative N efficiency value of meat and bone meal is 80 % compared to ammonium nitrate (Gruveaus, 2003) and calcium nitrate (Jeng et al., 2004) and the relative P efficiency value around 50 % of phosphate-P in the first year with subsequent release in the following year (Jeng et al. 2006). This indicates a low risk for nitrogen leaching comparably to the application of mineral fertilizer, and a significant risk of phosphorus absorption and erosion, increased by the relatively high addition of phosphorus to the soil.

Moreover, the study shows the great importance of the surrounding infrastructure for these kinds of multifunctional systems. The result of the study greatly depends on the product that is substituted, whether it is a mineral fuels or bio fuels. In another location in Europe, the results would be different since then probably also the Biomal would replace a fossil fuel, and thus greatly decrease the greenhouse gas emissions for the CF system. From a future perspective, if there will be more bio fuels on the market, all processes would have less environmental impact where both systems would have a similar global warming potential.

4 CONCLUSIONS

ABP Category 2 material is a valuable resource of nutrients that could be recycled to the farm as fertilizer. Whether this is a more environmentally sustainable use of the material than using it as an energy source highly depends on the fuel that the animal fat and the Biomal replaces. The study shows that if fuel substituted by animal fat is a fossil fuel, here fuel oil, the greenhouse gas emissions would be around three times lower than if the ABP Category 2 material is instead incinerated as Biomal, substituting bio fuels.

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