European Commission

Science for Environment Policy

Changes in soil carbon, biodiversity and ecotoxicity should be considered when assessing environmental impact of dairy products

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Considering the impact on soil carbon, biodiversity and ecotoxicity is important when assessing the environmental footprint of dairy products, suggests a new study, which explored the impacts of organic and conventional milk production in three types of system established in Western Europe. The study found that organic milk production had a significantly lower impact on ecotoxicity and biodiversity than conventional milk production, and suggests that including soil carbon changes in the assessment would result in greater reductions in the carbon footprint of organic, rather than conventional, milk — in some cases by up to 18%.

European climate policy has stipulated that agriculture should contribute to climate change mitigation by protecting and enhancing organic carbon in the soil, among other measures, while the EU 2020 Biodiversity Strategy calls for initiatives to halt the loss of biodiversity throughout Europe.

This study used life cycle assessment (LCA), a framework for assessing the potential environmental impact of goods and services, to explore the importance of including a broader range of impacts — namely changes in soil carbon, biodiversity and ecotoxicity (the toxic effects of natural or synthetic substances on ecosystems) – in LCA.

There is evidence that these three factors may be affected very differently under organic and conventional agricultural management, but they have not been considered together in LCA before due to concerns around the limitations of LCA methodology and a lack of data on the magnitude of these impacts in various systems. Recently, however, methods have been proposed that could characterise the three factors for inclusion in LCA. This study, therefore, investigated the importance of including the methods in environmental LCA, and applied its methodology to the organic and conventional production of milk in Western Europe.

The researchers modelled three basic European dairy systems: mixed crop-livestock lowland systems (as found in Denmark); lowland grassland-based systems (as found in the United Kingdom); and mountainous systems (as found in Austria). They logged the characteristics of each type of system, including information on herd breed, culling rate, per-cow milk production rate, days at pasture, farm area, type of feed, use of manure and pesticides, crop yields and per-cow feed intake of concentrates and roughage. Each system was modelled using typical data based on national production conditions, statistics, and regulation; the farms investigated were constructed for the purpose of the study, and do not represent data gathered from actual farming systems.

Their LCA approach considered the impacts up to the farm gate — i.e. the consumption and disposal of products were not considered — and broke the life cycle of each system into components: 'enteric fermentation' (breakdown of substances within the cows' intestines, associated with methane emissions), 'electricity at the dairy farm', 'home-produced feed and manure management', 'transport', and 'bought-in feed'. It identified foreground (home-grown feed, milk production) and background processes (the production and transport of inputs such as concentrate, fertilisers, pesticides, fuel, seeds and electricity). The study's LCA approach covered eight categories for assessing the footprint of dairy products: climate change (within which carbon sequestration was included), acidification, marine eutrophication, terrestrial eutrophication, freshwater ecotoxicity, land use, impact on biodiversity[1], and mineral, fossil and renewable resource depletion. Water resource depletion was omitted due to a lack of relevant data. The total environmental impact was split across three areas: milk production, calves for meat and culled cows.

1. It should be noted that the biodiversity assessment was based on plant species diversity, and captures arthropods, birds etc. only indirectly.

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Overall, the assessment showed that across production systems, the environmental impact per kilogram of milk produced was similar or slightly lower for organic than conventional milk in terms of climate change, terrestrial eutrophication[2] and acidification, but clearly lower under organic management in terms of resource use, biodiversity and ecotoxicity.

In terms of **soil carbon**, systems with more grass — such as grassland-based organic systems — showed higher rates of carbon sequestration, given that grass is more efficient at storing carbon in the soil than arable crops. Including soil carbon changes within the LCA reduced the carbon footprint of milk production by 5–18%.

The impact of organic milk production was one-third of that for conventional milk in terms of **biodiversity**[3] (due to the generally richer biodiversity seen in organic crops and grass, and the higher proportion of grass used in the feed rations for organic cows). Ecotoxicity impacts were calculated based on the use of pesticides on home-grown and imported feed: organic systems used none, while conventional used varying combinations of herbicides, insecticides and fungicides. This differing pesticide use was the dominant factor in terms of organic vs. conventional freshwater ecotoxicity – with organic milk production reporting just 2% of the impact of conventional management. Organic systems had a slightly higher impact on land use and methane emissions from enteric fermentation, given that they have a lower milk yield per cow, but just one-fifth of the conventional impact on resource depletion due to their avoidance of fertiliser. The higher methane emissions were compensated by reduced emissions of other greenhouse gases and enhanced carbon sequestration in the soil.

The researchers suggest that the main options for improvement would be to increase the amount of grass in feed, replacing the use of imported feed: this would both increase carbon sequestration rates and decrease the negative impacts on biodiversity and freshwater ecotoxicity. It is important to include estimates of these factors within dairy LCA, they say, to get an accurate representation of a product's footprint and help with the future management of the carbon cycle in the context of European animal husbandry and agriculture.

2. Although not explored in this study, the issue of eutrophication is higher in conventional than organic farming systems for numerous reasons. For example, the permitted livestock stocking rate is limited for organic farming, but only the nitrogen manure application per ha is limited for conventional farming in zones vulnerable to nitrates. Intensive conventional animal rearing in these zones produces large amounts of manure, raising subsequent issues around its disposal.

3. This was measured using the 'Potentially Disappeared Fraction' (PDF) (as the name suggests – potential reduction in biodiversity per sq. metre compared to natural conditions). PDFs are lower in general for organic than conventional farms, as organic farms rely on rich/varied biodiversity to help with resilience to pests and climate change and avoid pesticides, etc.