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Environmental and health impact by dairy cattle livestock and manure management in the Czech Republic

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ABSTRACT

In this study we evaluate the potential environmental and health impact of dairy cattle livestock and manure management in the Czech Republic. We present a new approach for national assessments of the environmental impact of an agricultural sector. Emission estimates are combined with a country-specific set of indicators to assess the environmental impact in nine regions with specific environmental characteristics. We estimate the contribution of emissions of ammonia (NH_3) and nitrogen oxides (NO) to acidification and terrestrial eutrophication, nitrate (NO_3) and phosphate (PO_4) to aquatic eutrophication, nitrogen oxides (NO), particulate matter (PM_{10}) and ($PM_{2.5}$) to human toxicity and methane (CH_4) and nitrous oxide (NO) to global warming. We present large regional differences in the environmental and health impact per unit of agricultural production. The regional acidifying, eutrophying and global warming impact of dairy cattle is calculated to be up to three times the national average, depending on the dairy cattle intensity. Aquatic eutrophication is found to be a problem in regions with relatively high eutrophying emissions per hectare of so-called *nitrate vulnerable zones*. Human toxicity problems caused by dairy cattle livestock and manure management are problematic in regions with a high population density in rural areas. The strength of our approach is the use of country-specific characterisation factors to assess the potential environmental and health impact of agriculture at the sub-national scale. We were able to analyse the potential environmental impact without explicit quantification of specific effects on humans and ecosystems. The results can be used to identify the most polluted areas as well as appropriate targets for emission reduction.

1. Introduction

Agriculture affects the natural environment in many different ways. For example, manure management of dairy cattle is an important source of ammonia emissions causing acidification and eutrophication (Amann et al., 2007) while enteric fermentation of dairy cattle is a significant source of methane responsible for global warming (Crutzen et al., 1986).

In this study we focus on the potential direct environmental and health impact of dairy cattle livestock and manure management. Several studies on the environmental impact of dairy cattle exist. Some of these focus on specific environmental

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problems. For example, Verge et al. (2007) and Casey and Holden (2005) analysed greenhouse gas emissions. Other studies focus on pollution of specific environmental compartments, such as the atmosphere. Brink (2003) for instance, analysed interactions between conventional air pollutants and greenhouse gases from the agricultural sector including dairy cattle. Some more complete assessments of pollution problems caused by dairy cattle can be found, for instance, in Cederberg and Mattsson (2000) for Sweden, Haas et al. (2001) for Germany and Thomassen et al. (2008) for The Netherlands. These studies differ in system boundaries. However, they all aim for an integrated analysis including an assessment of local (aquatic eutrophication) regional (acidification) and global environmental problems (climate change) caused by dairy cattle.

To our knowledge none of these comprehensive studies focus on the Czech Republic. As one of the Central European countries, the Czech Republic differs from many Western European countries. There are differences in farm structure and production intensity. For the Czech Republic, large scale farming is typical: most of the cattle are kept in large farms with >500 heads (Monteny et al., 2007). The milk yield is relatively low but gradually increasing. In addition, the specific Czech environmental conditions make an assessment of dairy cattle unique. More than 50% of the Czech land is used for agriculture. However, there are substantial differences in types of cultivated lands in the country.

Structural changes in agriculture since the beginning of 1990s ameliorated some environmental problems in the Czech Republic, mainly due to decrease in the number of cattle by about 50% between 1990 and 2005. This led to lower levels of manure application to the land and, consequently, to less environmental damage due to excessive nutrient input. However, the degradation of soil by nutrient replenishment increased substantially (Janosova et al., 2006).

Assessing the direct environmental impact of a complete agricultural sub-sector is not easy because of the complexity of the sector, and the variety of environmental issues at stake. In this paper, we follow up on an earlier study, in which we describe a method to estimate emissions from the Czech agriculture (see Havlikova and Kroeze, 2006). It builds upon the previous study by adding an assessment of the potential impact of emissions by using characterisation factors. We apply characterisation factors (e.g. acidification potential) describing the relative contribution of emissions to a certain impact category (e.g. acidification).

Two types of characterisation factors can be distinguished: site-generic and site-dependent. Site-generic characterisation factors (e.g. Wenzel et al., 1997) do not take into account spatial characteristics influencing resulted effect of emissions such as structure of sources, background concentration, or sensitivity of receiving ecosystems and human population, while site-dependent characterisation factors to a certain extent do. For acidification and terrestrial eutrophication several site-dependent methods are available (see Potting, 2000; Huijbregts et al., 2000; Hettelingh et al., 2005; Finnveden and Nilsson, 2005; Seppällä et al., 2006). This is also the case for aquatic eutrophication (Huijbregts and Seppälä, 2001; Haushild and Potting, 2004) and for human toxicity (Haushild and Potting, 2004; Finnveden and Nilsson, 2005; Van Zelm et al., 2008).

The purpose of this study is to evaluate the potential environmental and health impact of emissions from dairy cattle livestock and manure management in the Czech Republic at the sub-national level. This is done by applying a site-dependent methodology. However, applying site-dependent characterisation factors at the sub-national level is not straightforward and requires an evaluation of the available characterisation factors, their usefulness, and applicability to our case. In fact, our methodology applies selected characterisation factors while taking into account qualitatively regional differences in terms of agricultural practices and environmental characteristics. The potential environmental and health impact is assessed on the

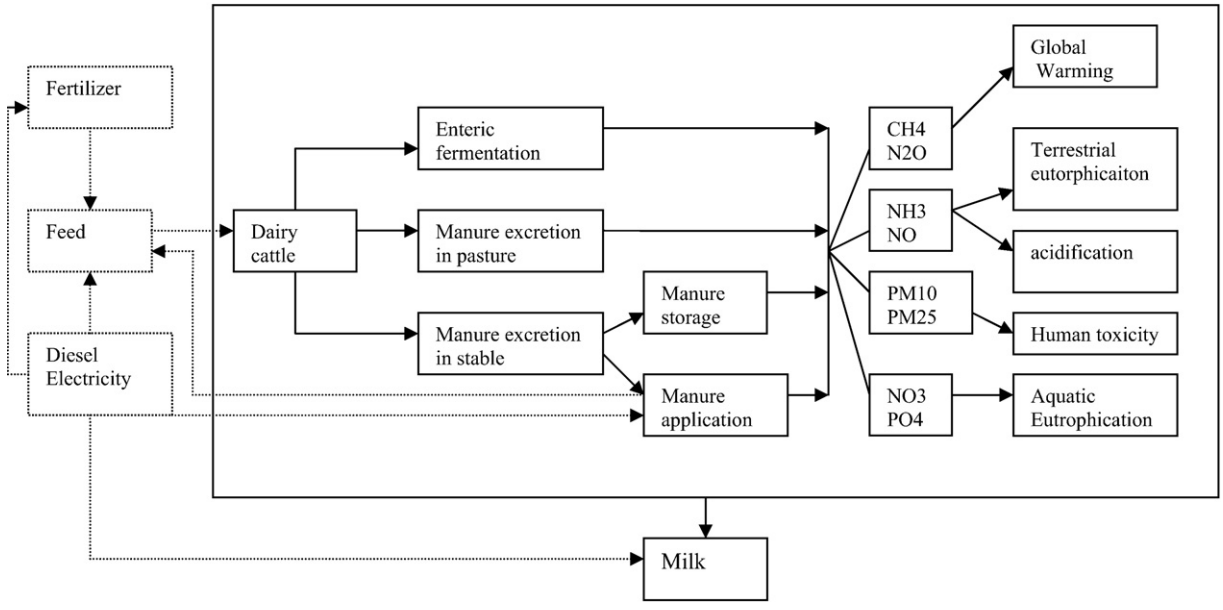

Fig. 1 – Processes, associated emissions and impact categories in dairy cattle livestock and manure management as analysed in the present study. The solid lines indicate parts that are included in the present study while dashed lines indicate parts of the system which are excluded.