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New Directions: Significant contributions of dimethyl sulphide from livestock to the atmosphere☆

Concerns for the atmospheric impact from biogenic sources of dimethyl sulphide (DMS) have focused on oceanic sources, and their possible relationship to radiative forcing resulting both from cloud formation and modification by production of cloud condensation nuclei (CCN), and from aerosol backscattering of solar radiation. Terrestrial biogenic sources of DMS have previously been identified as being very small. We have determined, however, that ruminants contribute DMS as well as methane to the troposphere. Methane emissions from the rumen of farmed livestock account for 25% of the UK total. These were determined when studying the energy losses from the digestive system of the dairy cow.

Our preliminary studies reveal that the formation and exhalation of DMS is the means by which ruminants expel excess sulphur. Dairy cows in the developed world are generally fed a surplus of protein, and our conservative estimates show that animals may be contributing to the atmospheric flux of DMS. Contributions by ruminants to the global flux of DMS were evaluated by means of measurement and by dietary studies of lactating matter, which contains 19.2 g d^{-1} of sulphur. At peak lactation 16.8 g d^{-1} of sulphur will be excreted in the milk, and this will decline with the possibility that at least 2.4 g d^{-1} of sulphur may be exhaled as DMS from the rumen. We have determined that the breath of cows contains between 0 and 25 ppm(v) DMS at various stages of the reproductive cycle, with an average of 9.4 ppm (v) (or about 3.5 g of sulphur d^{-1}). Assuming the emissions of other ruminants is proportional to body weight, then farmed ruminants contribute 0.42 Tg S yr^{-1} of sulphur to the global atmosphere in the form of DMS from breath. The global flux of sulphur to the atmosphere as DMS from biogenic sources was estimated to be between 2.1 and 5.5 Tg S yr^{-1} (O. Badr and S.D. Probert, Applied Energy 47, 1–67, 1994) but there was no recognition of a possible contribution from livestock. Ruminant exhalation would not be of interest if it were not for DMS being an agent that regulates the global climate, and that contributions vary on a regional or smaller area basis.

Whilst this source may be considered minor in terms of total global amounts there are some reasons for considering the potential impact of this source. Firstly, it will partially negate the positive forcing effect of methane from cattle on radiative solar energy in the atmosphere. This would primarily be by oxidation of DMS to methanesulphonic acid and then to sulphuric acid, which forms cloud condensation nuclei (CCN). Secondly the impact of DMS is more important in less polluted or remote environments. In a global model Langmann et al. (Atmospheric Environment 32, 2757–2768, 1998) noted that about 30% of the sulphate burden and its short-wave radiative climate forcing over Europe was caused by sulphate burden and its short-wave radiative climate forcing over Europe was caused by sulphate from natural sources, which includes DMS and volcanoes. They are identified as coming from outside of the model domain and contribute on a regional basis. Complications may arise from substantial ammonia emissions that occur from cattle (B.F. Pain et al., Atmospheric Chemistry 32, 309–313, 1998) that can readily form aerosols with sulphate. Langmann et al. suggested that information for limited-area models be investigated in more detail. Continental air sources contain larger concentrations of ozone, sulphur dioxide and CCN than oceanic air sources and this can relate to the oxidation of DMS by ozone during the daytime. Nagao et al. (Journal of Geophysical Research 104, 11675–11693, 1999) identified that nighttime oxidation of DMS that is predominated by nitrate was small. Could it be that DMS from cattle has a greater influence on forcing continental air mass than currently thought?

The role of DMS in atmospheric chemistry has another aspect, as the rate at which DMS is converted to CCN is dependent on background ozone concentrations. DMS from livestock could reduce oxidising compounds

☆Contributions to New Directions are welcome as is correspondence on this or previous columns. Please see http://www.uea.ac.uk/ ~ e044/newd.html for further details, or contact Dr. W.T. Sturges at new.directions@uea.ac.uk.

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in an ozone event. However, the contrary is apparent, as rural areas have greater ozone concentrations than urban areas. Little is known of how other emissions from agriculture affect an ozone event in localised atmospheric or rural conditions subject to high pressure. Acetone has been identified as present in ruminant breath and is photochemically active producing oxidising species in the troposphere. This is not significant in terms of a global acetone flux of 40–60 Tg yr^{-1}, but with an average sub-clinical breath concentration of 3 ppm(v) farmed cattle contribute 0.1 Tg yr^{-1} to the atmosphere.

Research principally by dietary composition is currently being undertaken to develop strategies to reduce the impact of cows on the global climate by reducing methane emissions. The quantification of DMS in cow's breath opens the possibility that we may be better able to predict the impact of ruminant livestock on the atmospheric environment.

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