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Temperature and odour emissions from liquid manure

The ventilation and exhaust air extraction of livestock buildings rapidly leads to odours mixing with the surrounding air. On the other hand, there is hardly any gas exchange around liquid manure storage containers. In the air space over liquid manure or slurry, odour substances are also susceptible to partial pressure saturation. Where containers are open, smells diffuse into the surrounding area, mostly near ground level. Because of the concentration of its odour stream, a very much weaker mix with the surrounding air leads to a definite, mostly unpleasant, perception of odour even at greater distances.

Odours are transitory, have an odorogenic group, and are soluble in both water as in fat. In order that they are even noticeable, they have to be present in a minimum concentration. In most cases, odours comprise a number of odour substances. Depending on the partial pressure, odour substances cause different smell perceptions. Resultant effects can be compensatory, additive, but also synergetic.

As gases, the Gas Laws apply to odour substances. Henry's Law states that, with their increasing temperature, their solubility in liquid decreases. Thus, where temperatures rise, there is an increased release of odour substances. Moreover, the viscosity of the solvent reduces with rising temperature. With this, the diffusion velocity of the desorbed gases in the receiving liquid. The physical state of the molecules is also temperature related. Whereas small molecules outgas even at very low temperatures, large odour-active molecules first change-over from liquid into gaseous state when the temperature rises. Their proportion of the odour complex increases with rising temperatures. They then emit at a greatly higher rate. As a result, a rise in the solvent temperature can lead to an altered odour characteristic through changed odour substance composition.

Materials and method

To investigate the influence of temperature on the behaviour of liquid manure emission and odour characteristics, pig and cattle slurry samples were taken from the primary channels of calf rearing and pig feeding units and used for a systematic investigation. The samples were subsequently homogenised and evenly distributed between six containers in each case and then frozen. On Monday of the following week two samples each of the cattle and pigs slurry were thawed and warmed to 10 °C in a water bath. Two days later (i.e. Wednesday), odour samples were taken from the air area above containers filled with liquid manure and subsequently analysed in the laboratory with the Mannebeck TO 7 olfactometer for odour substance concentration, intensity and hedonic. In each case, this procedure was repeated after one week featuring slurry samples heated to 20 °C and 30 °C.

Odour substance concentration

The odour substance concentration is a quantitative measurement figure of the smell. Its unit of measurement is GE/m^3 (GE = odour unit). The unit represents the required dilution relationship with neutral air of an odour sample which would create an odour perceivable as clearly different from the neutral air by 50 % of the population (represented at the olfactometer by a panel of four people). An odour sample diluted to a relationship of 1:1000 and just perceived by a panel has a definition measurement of 1000 GE/m^3.

Intensity

The intensity reflects how distinctly an odour is perceived. This is a subjective odour perception. With the help of a seven-part scale a panel of eight people assesses an

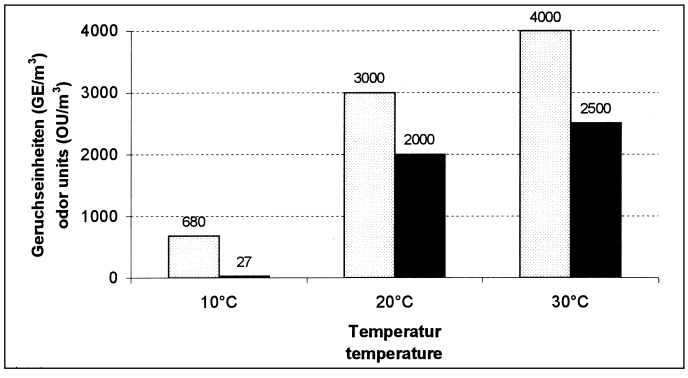

Fig. 1: Odor concentration (OU/m^3) of swine- and cattle-slurry at different temperatures

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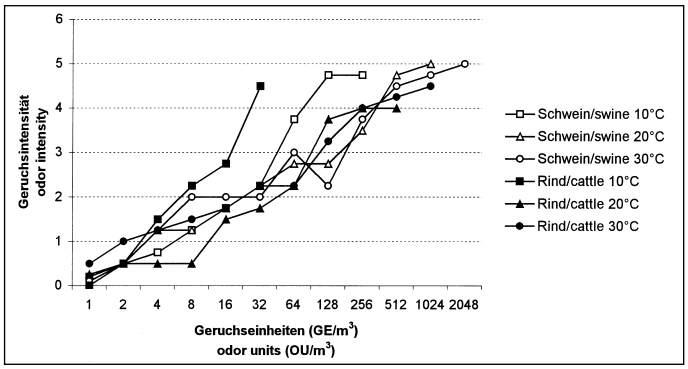

Fig. 2: Intensity of odor perception above the odour threshold of swine- and cattle-slurry at different temperatures

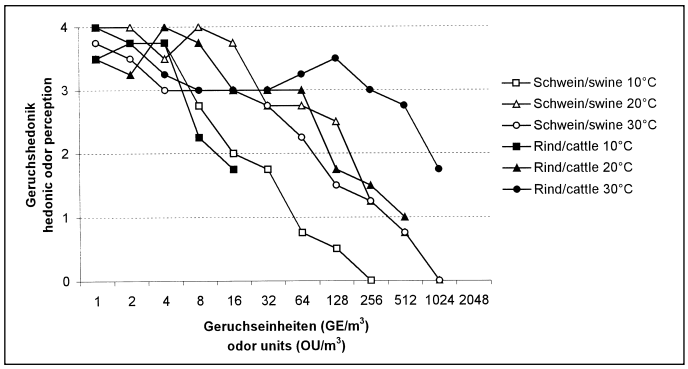

Fig. 3: Hedonic perception of swine- and cattle-slurry at different temperatures

odour sample in the area over the perception threshold. The panel members assess whether they perceive no smell, a distinct one or an extremely strong one.

Hedonic

Hedonic describes the odour perception. For this very subjective odour judgement to be justifiable and generally applicable the panel has 16 people. For odour samples in the area over the perception threshold this panel uses a nine-part scale with the extremes exceptionally pleasurable or exceptionally unpleasant to register its perceptions.

Just before the investigations the odour samples used were drawn by the olfactometer from the sample containers directly above the slurry surface. No homogenisation of the slurry samples was carried out beforehand. Because the samples were left undisturbed for a long time in a waterbath without ingress of air, it can be taken that partial pressure saturation conditions applied at the time of the sampling.

Results

Odour substance concentration

The odour substance concentration in the investigated samples from the pig slurry was clearly more than that from the cattle slurry samples (*fig. 1*). In general, a clear temperature influence was exhibited. In this context it could be determined that relatively high odour substance concentrations occurred even at low temperatures (10 °C) with pig slurry. Increasing slurry temperature to 20 °C or 30 °C only led in this case to a four or five times increase in odour concentration.

The gaseous odour material in cold cattle slurry resulted in the samples having only a very low odour substance concentration. Heating the slurry to 20 °C, however, resulted in an over-proportionately strong rise in odour concentration from 27 GE/m^3 at 10 °C to 2000 GE/m^3 at 20 °C and 2500 GE/m^3 at 30 °C. The cause for this could, on the one hand, lie with the reduced viscosity of the warmer cattle slurry and with that the increased diffusion velocity of the contained gas molecules. It could also be due to the phase transformation of individual odour substances through heating. A point to be considered is also that, with higher temperatures, the biological degradation processes in the slurry deliver gases as a decomposition by-product.

Intensity

The investigation with the olfactometer into intensity had the same result with the pig and cattle slurry in that the 20 °C and 30 °C samples produced much milder odours than samples taken over 10 °C cold slurry. Exceptionally notable in this context in *figure 2* was the 10 °C odour sample from the cattle slurry. Panel members perceived this odour very clearly, even at very low odour substance concentrations. The 10 °C odour sample from pig slurry formed a mid-position in perceptibility between the ratings of cold cattle slurry and the warmer remaining samples. The odour samples from the 20 °C and 30 °C warm cattle and pig slurry showed hardly any difference related to livestock type or sample temperature.

Hedonic

Figure 3 summarises the results of the hedonic tests. Here too, it is clearly to be seen that the odour samples taken over 10 °C slurry quickly start causing an unpleasant odour perception with rising odour substance concentration (4 = neutral, 0 = extremely unpleasant odour perception). With cold cattle slurry, reduced odour substance emissions meant that the extreme values were not reached, and this was always the case with the pig slurry. The 20 °C and 30 °C cattle slurry was, even with higher odour concentrations, only perceived as neutral or slightly unpleasant (assessment 3). Only at higher odour substance concentrations was an unpleasant odour emitted and here too this was achieved more readily from cold slurry than with the warmer odour samples. Applying in general for the pig slurry was that it emitted an extremely unpleasant odour starting from a certain odour substance concentration.

Summary

As a rule, pig slurry leads to higher odour emissions than that from cattle. The smell of the former is more intensively perceived and it rapidly emits an odour perceived as unpleasant. Odour substances emitted from warm cattle slurry were present in higher concentration but were not nearly so clearly perceived, and were assessed not as unpleasant as the odours from pig slurry. Above all, this has consequences for pig slurry containers that are uncovered. Because of the molecule size involved, the emitted odour substances remain mostly in the ground level area, are hardly mixed at all with the surrounding air and thus result in an unpleasant odour, even at greater distances.