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Waste Air Scrubbers Useful in Reducing Ammonia Emissions from Piggeries?

A two-stage waste air scrubber operating using water as a washing liquid was investigated to determine the ammonia reduction efficiency for waste air from conventional piggeries. With running nitrification a mean ammonia reduction rate of 60 % was achieved. Nitrous oxide emissions amounted to 3 % of the initial ammonia load. An nitrogen balance of the scrubber showed an efficiency reduction of only 46 %. Denitrification losses would finally lower the nitrogen efficiency to 20 %, if the washing liquid would be stored together with the liquid manure.

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Keywords

Waste air scrubber, ammonia, animal husbandry

The on-site plant extension of husbandry often results in a shortfall of minimum distances to the immediate vicinity. Authorising bodies may then demand for the use of waste gas treatment systems to lower environmental impacts. Because of ammonia emissions new animal husbandry can only be built up by keeping a minimum distance of 150 m to sensitive ecosystems (nitrogen sensitive plants, forest) in consequence of more stringent laws and ordinances (Federal Immission Control Act, Technical Instructions on Air Quality). Beyond that, animal farmers with more than 50 livestock units (LU) have to keep more stringent environmental requirements from 2007, if they are located in administrative districts with a livestock density above two LU/ha. Many questions arise for the animal farmer, if a waste air treatment is required for the plant extension. Which kind of treatment system permanently complies with the official requirements at tolerable investment and operating costs? Which amount of maintenance is required? Is the treatment process easy to check and to control? Are there sufficient experiences available for the intended system? A two-stage waste air scrubber operating with water was investigated over 259 d to evaluate the ammonia separation efficiency in view of permanent reliability. A nitrogen balance was made additionally.

Test description and methods

A scrubber equipped with two separated washing units and filled with plastic bodies was operated without pH value adjustment to clean waste air from conventional pig stables (*Fig. 3*). As filling material Envipac 2 bodies (2 • 0,25 m^3) were used. The mean gas load was 1920 $m^3/(m^2\ h)$ and the volume load amounted to 1080 $m^3/(m^2\ h)$. For irrigation, a rotating sprinkler (unit 1) and a loop nozzle (unit 2) with an irrigation density of 10.6 $m^3/(m^2\ h)$ each were applied. The irrigation resulted from separated water reservoirs with a volume of 0.56 m^3 each. As droplet separators dense plastic networks with a thickness of 0.2 m were used. The washing liquid was kept in circulation over the whole time (259 d). Evaporation losses were compensated by maintaining the level with fresh water addition. The raw and clean gas concentration results for ammonia, nitrogen oxides and nitrous oxide were determined with methods described in [1]. Ammonium analyses were carried out using the distillation method DIN 38406-E5-2. Nitrite and nitrate were measured at a wavelength of 210 nm using the ion-pair chromatography [2].

Results

Raw and clean gas concentrations from the 259 d test period were converted to mass flows and summarised (*Fig. 1*). Results show

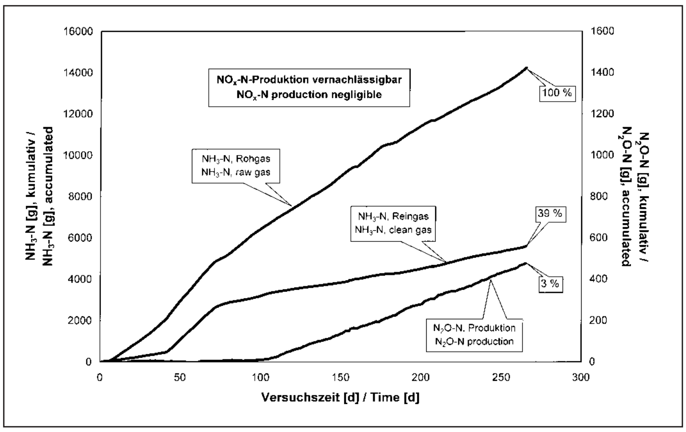

Fig. 1: Time dependent course of accumulated NH_3-N input and output as well as nitrous oxide production during cleaning of waste air from piggeries with a two-stage scrubber operating with water

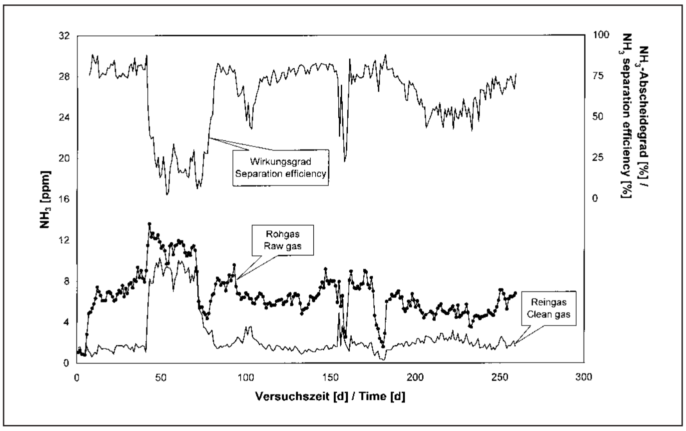

Fig. 2: Time dependent course of ammonia input and output concentrations as well as separating efficiency during cleaning of waste air from piggeries with a two-stage scrubber operating with water

that 61 % of the ammonia nitrogen input (NH_3-N) was separated from the raw gas. Beyond that a net production of nitrous oxide (N_2O-N) occurred amounting to 3 % of the NH_3-N input. The nitrous oxide production started after approximately 100 d. A net production of nitrogen oxides, however, was not detected. The ammonia reduction efficiency varied considerably during the test period (*Fig. 2*). In the first 41 d the ammonia reduction efficiency was about 80 % at pH values of 8.3 (unit 1) and 8.4 (unit 2) in the washing liquid. With increasing ammonium saturation of the washing liquid it decreased to 24 % in average at nearly constant pH values. The ammonia nitrogen concentrations (NH_4-N) in the washing liquid of both units were below 0.5 g/kg up to day 80. From day 76 a strong nitrification started in unit 2 which resulted in nitrite nitrogen concentrations (NO_2-N) of more than 1.6 g/kg.

Corresponding to that the pH value decreased to 6.2 accompanied with a regain of the ammonia reduction efficiency to 69 % in average (period 81 to 259 d) and increasing NH_4-N concentrations in the washing liquid. The pH values showed only little changes until the end of the experiment. In unit 1 it was 7.2 in average and 6.7 in unit 2. The nitrification in unit 1 started delayed on day 100. In the meantime the nitrification resulted in very high and fluctuating NO_2-N concentrations of 1.66 g/kg (unit 2, 104 d) and 2.96 g/kg (unit 1, 150 d). At the end of the experiment NO_2-N concentrations of 0.48 g/kg (unit 2) and 0.96 g/kg were detected as well. The nitrate nitrogen (NO_3-N) in the washing liquid tended to increase with the nitrification and amounted to values of 4.2 g/kg (unit 2, 162 d) and 2.7 g/kg (unit 1, 234 d) in the meantime. These results mean for the use of waste air scrubbers reducing ammonia emissions from piggeries, that satisfying separation efficiencies can only be achieved using a highly diluted washing liquid with corresponding high waste water production on the one hand or with a running nitrification on the other. The nitrification in the washing water, however, results in a production of secondary trace gases in the form of N_2O under the described conditions. The meaning of the N_2O production for the overall nitrogen separation becomes apparent, if a nitrogen balance is made for the waste air scrubbing (*Fig. 3*). From the applied nitrogen (100 % as the sum of NH_3-N, NO_x-N, N_2O-N) 54 % were released from the system in gaseous form. This complies with a nitrogen separation efficiency of only 46 %, while the ammonia reduction efficiency seems to be more favourable with rarely 61 %. In consequence of that, the nitrogen process efficiency is overestimated if only the ammonia reduction is calculated. The process is even more unfavourable concerning a sustainable nitrogen use, if the waste water is discharged into a slurry pit as usual. 43 % of the initial nitrogen load was regained in the washing water, whereas more than 52 % of this portion was oxidised nitrogen in the form of nitrite and nitrate. Oxidised nitrogen will be lost as atmospheric nitrogen (N_2) via denitrification during anaerobic storage. In the experiment a total of only 20 % of the initial nitrogen would then be recovered as a utilisable NH_4-N component. A washing water storage apart from the manure pit would be necessary, if the nitrogen should be used as a fertiliser and not be eliminated. Waste air scrubbing with a acidified washing water at a pH value of 3.5 would be a more efficient method in this regard, because more than 90 % of the ammonia is separated and predominantly regained as a solved ammonium salt [3].

Conclusions

With a two-stage packed scrubber, 60 % of the ammonia can be separated in mean from waste air of conventional piggeries without pH adjustment at a running nitrification. Conditioned by nitrification a release of secondary trace gases occurs, which affects the overall nitrogen balance adversely. During common discharge of waste water into the manure pit a large portion of the separated nitrogen is lost via denitrification. The nitrogen recovery of the whole process consequently decreased to 20 %. The use of these waste air scrubbers to separate and regain ammonia has to be estimated critically.

Literature

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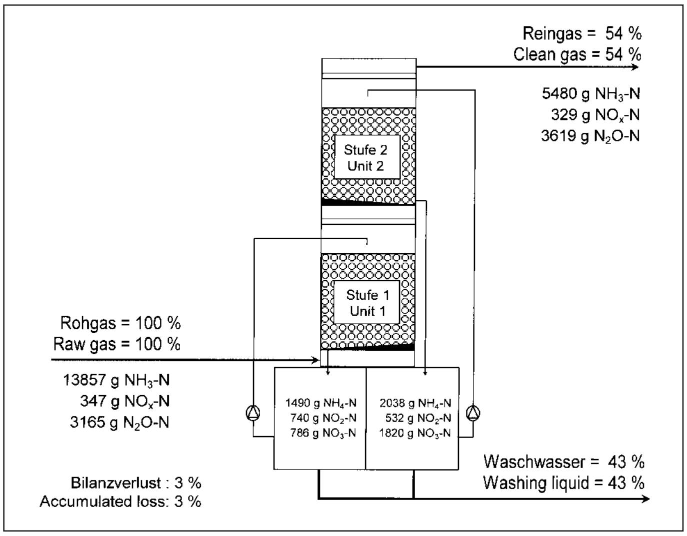

Fig. 3: Nitrogen balance of a two-stage, water-operated scrubber used for the cleaning of waste air from piggeries