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Exhaust air cleaning system from corn stover for reducing ammonia emissions from livestock housing

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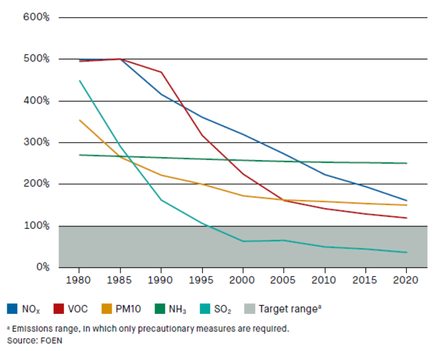
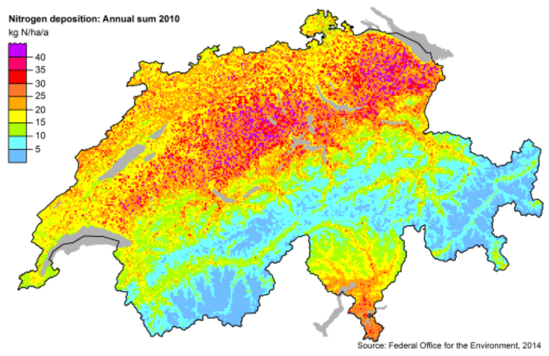
Ammonia emissions affect biodiversity

The air in Switzerland has become considerably cleaner over the last 25 years except for ammonia. These emissions are allocated to 90% to agricultural activities, mainly by livestock farm. Ammonia emissions are due to biological decomposition of manure. Since ammonia has a negative impact on animal health, poultry and swine production facility are ventilated to maintain indoor ammonia level below 25 parts per millions. Gaseous ammonia combines then with the acidic gas species in the atmosphere to form PM2.5 and PM10 particulate matter which can affect human health. Ammonia can also be carried by wind over long distances and contributes to over-fertilization. The consequences are eutrophication and acidification of soils and biodiversity loss. Ammonia emissions from agriculture are estimated at 48,000 tons per year. The soil nitrogen cycle has important losses which must be compensated by the use of industrial fertilizers. If Switzerland has reached the 2010 targets of the Gothenburg Protocol for the reduction of ammonia emissions (-17% as compared to 1990), progress remains insufficient to achieve the new objectives for 2020. For this, the Swiss Federal Council defined the goal to reduce ammonia emissions by about 40% compared to 2005.



Air pollutant emissions

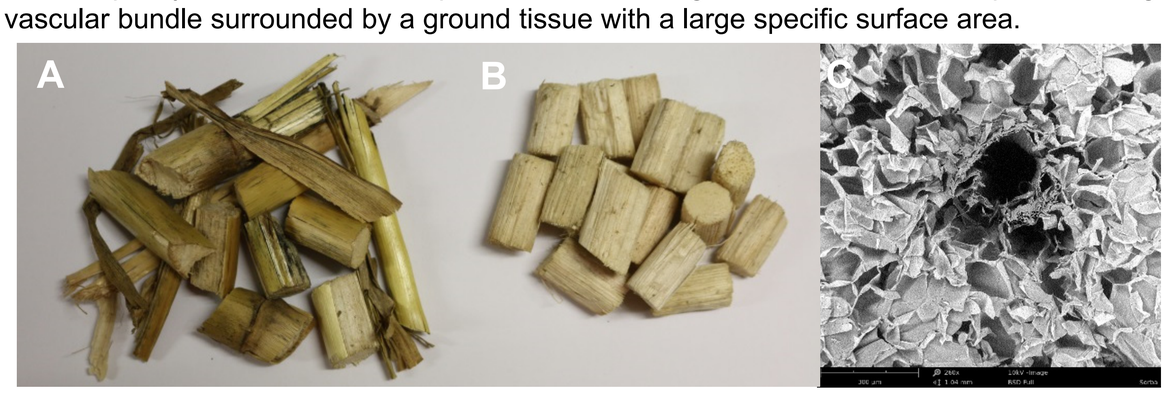


Map of nitrogen deposition

Actually the Ordinance on Air Pollution Control (OAPC) states that emissions shall be limited as far as is technically and operationally feasible and economically acceptable (art. 4 OAPC). Nowadays, the exhaust air cleaning system available on the market works as a chemical scrubber. Exhaust air is treated by sprinkling and the washing water is continuously acidified with sulfuric acid to maintain a pH of about 3. This method offers a partial solution. The system allows the reduction of ammonia emissions with efficiency up to 70%, but it is expensive, cumbersome, requires a lot of maintenance and produces a large amount of sludge to be recycled.

Innovative filter from corn stover

BABS™ (BioABSorber) produced by Sorba Absorber GmbH, is the spongy body obtained after removing the bark of maize stalks. It is a biosourced and biodegradable material which has a capacity of water retention up to 40 times its weight. Maize stalks is composed of large vascular bundle surrounded by a ground tissue with a large specific surface area.



(A) Row corn stover, (B) BABS™ after removing lives and bark, (C) Cross section of BABS™ by scanning electron microscope

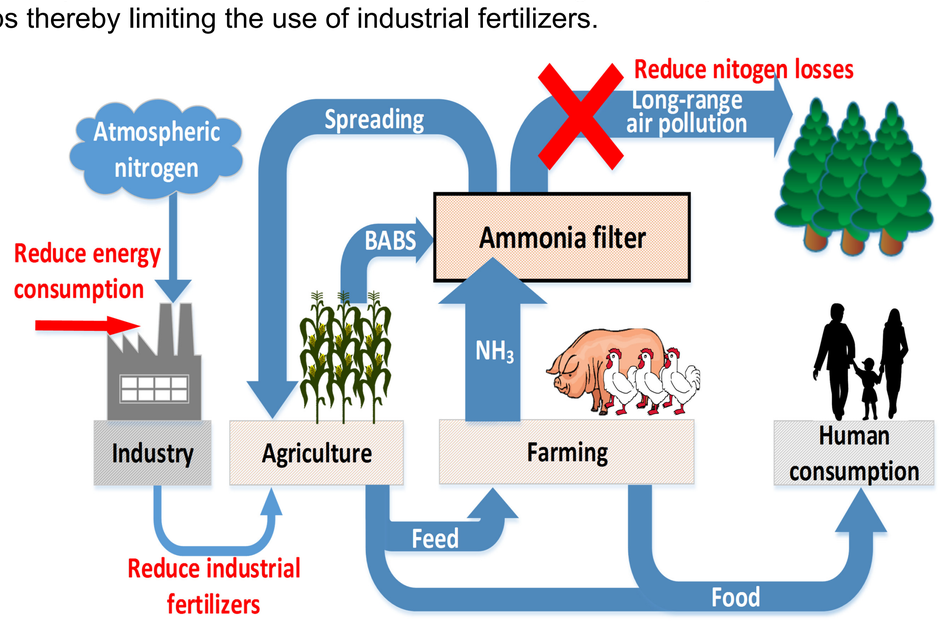
BABS™ is impregnated with a solution of sulfuric acid and is used as a filter on the output of an air extractor of a livestock facility. Ammonia concentration before and after the filter was measured simultaneously using two calibrated chemical sensor, model Libelium Smart Environment PRO with temperature, humidity, pressure sensors and calibrated ammonia sensor (ref 9378-P, range 100ppm, accuracy ±0.5ppm, resolution 0.1ppm). The filter is designed for a residence time of 0.5 second.

BABS 1m³ filter connected on extracting air of a poultry farm

Used filter material impregnated with ammonium sulfate that can be used as fertilizer

Reduce nitrogen losses

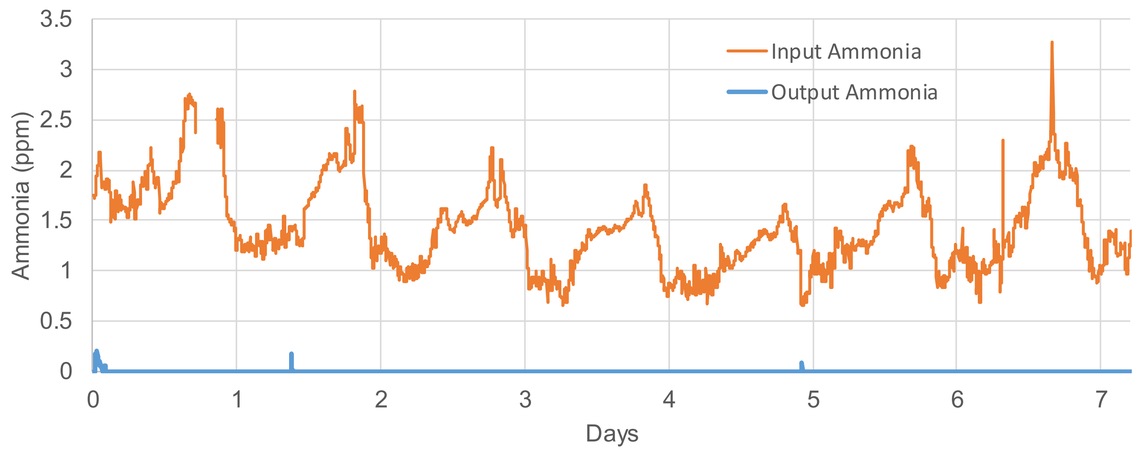
In order to solve this problem, the company Sorba Absorber GmbH and the School of Engineering and Architecture of Fribourg, with the collaboration of the Canton of Fribourg (CleanTech Fribourg) and the Federal Office for the Environment (FOEN), develop a new air cleaning system from corn stover impregnated with phosphoric acid or with sulfuric acid. Because ammonia is highly soluble in acidic medium, it is washed out and trapped chemically to give ammonium phosphate or ammonium sulfate, two fertilizers commonly used for crop production. The used filter material might be recycled as a source of nitrogen for crops thereby limiting the use of industrial fertilizers.



The reduction of long-range ammonia emissions and the use of filters material as fertilizer is a great way to close the broken nitrogen cycle.

Over 95% of efficiency

BABS 1m³ filter was connected to an air extractor of a poultry farm in Kerzers FR. An exhaust fan of 5'000m³/h is used for stripping of ammonia and for temperature control in the livestock housing. The fan is switched off during the night which explains the daily ammonia fluctuations (orange plot). The ammonia measured at the output of the filter is less than the detection limit of the measuring system (blue plot). Spot measurements with Dräger tubes does not detect any traces of ammonia. According to the resolution of the measuring system, the filter efficiency is greater than 95%.



Evolution of the ammonia before and after the filter at a poultry farm. The ammonia at the outlet is kept at a minimum level.

This strategy of ammonia emission reduction offers an economically acceptable solution for agriculture. It can be apply for poultry, swine farms and manure storage facilities. As the substrate is fully biodegradable, spreading of used filter material on crops can reduce industrial fertilizer consumption and limit losses in the nitrogen cycle.

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