In wastewater treatment, ammonia that is removed from sewage used to be discharged directly to the atmosphere. Nowadays, studies have identified that ammonia emissions are of major concern to air quality. This has led to a new way of thinking. Sulzer offers modern closed-air-loop systems for wastewater treatment that transform ammonia into a common soil fertilizer. This reuse of a waste product is sustainable and can contribute to tasty fruits as well—as the following story shows.

A multinational company with a fermentation plant in Thailand needed to remove ammonia from its wastewater stream. Wastewater from biological fermentation or from industrial, agricultural, or municipal sources often contains high concentrations of ammonia. Because it is a strong biocide, the free ammonia in the wastewater stream has to be lowered to acceptable levels (typically around 100 wt. ppm or less) before the wastewater can enter biological treatment. In the plant in Thailand, the free ammonia content reached values of up to 3000 ppm. The company’s aim was to reduce the ammonia content to 100 ppm or lower. Physical steam stripping or air stripping are common practices to lower the ammonia content to acceptable concentration levels. Shifting the ammonia from the liquid into the vapor phase, however, creates environmental issues (see infobox) and is therefore nowadays no longer an acceptable way to solve the task. If the
Water

stripped ammonia cannot be reused or recycled directly, it must be additionally treated to prevent emissions into the atmosphere.

All-in-one solution
Sulzer solves this task with an all-in-one system that combines two processes:
- Ammonia stripping process
- Ammonia chemisorption process

In wastewater, ammonium ions ($\text{NH}_4^+$) exist in equilibrium with ammonia ($\text{NH}_3$). The ratio between these two components changes depending on the temperature and pH. In the stripping process, the pH and temperature are adjusted so that a higher percentage of free ammonia is present in the liquid. The ammonia—a dissolved gas—can then move from water into air and thus be removed by air stripping. Internal packings inside the stripping column distribute the water into thin layers (films) to create a large surface area. Air is blown from the bottom of the column to the top. Ammonia is stripped from the falling water droplets into the air stream (Fig. 1).

The main parameters for efficient stripping are:
- High ratio of ammonia in the vapor phase to ammonia in the liquid phase
- Operating temperature
- Plug flow characteristic of both liquid and vapor (i.e., velocity profiles of the fluids in the packing inside the column)
- High mass transfer contact area between the two phases

In the second process step (chemisorption), the ammonia-laden vapors are treated with a diluted sulfuric acid solution. This absorbs the ammonia and produces an ammonium-sulfate solution of approx. 40 wt.% (controlled by specific gravity of the solution), which can be used directly as liquid fertilizer. The diluted sulfuric acid solution is circulated as pumparound, where the heat of reaction is removed by an external cooler. Freshly concentrated sulfuric acid is dosed by pH control directly into the circulating pipe. The virtually ammonia-free vapors are then circulated back to the ammonia stripper.

System design with advanced features
Figure 2 shows the process flow diagram of Sulzer’s closed air loop system. It consists of a single all-in-one column setup that integrates the stripper and chemisorption section into one column shell. For larger plants, it is typically made in a two-column configuration. The main features of the Sulzer system are:
- The vapor phase is circulated in a completely closed circuit and typically operated close to/atmospheric pressure without any gaseous emissions to the environment.
- The use of the high-performance packing Mellapak-Plus™ provides a high stripping and absorption efficiency with a compact design and a minimal air circulation rate. Typically, MellapakPlus™ 252Y, made of stainless steel for the stripper and of polypropylene for the chemisorber, are used (Fig. 3).

“We are committed to offering clean and complete solutions.”
Peter Fässler, Chemtech Process Technology
The Sulzer closed air loop system consists of:

- Ammonia stripper and chemisorption section, the latter designed as pumparound
- A direct fresh sulfuric-acid-dosing system
- Heat integration with simultaneous heating of raw wastewater and cooling of stripped wastewater
- Additional cooler and heater to meet specific conditioning needs of the relevant streams

A low pressure drop over the packing and vapor piping results in low operating cost. Thanks to the integrated economizer plate heat exchanger in connection with the closed air loop, only marginal additional heating and cooling is needed.

The column shell and main piping can be made of stainless steel, glass-fiber-reinforced plastic (GFP), and/or carbon steel with rubber lining.

The use of undiluted sulfuric acid is possible.

Heat exchangers are used to control the resulting concentration of the ammonium sulfate solution. An economizer heats or cools the feed to optimize the stripping temperature. A heater balances the remaining temperature gap from the economizer; it compensates heat losses in the circuit resulting from stripping the ammonia out of the liquid phase. A cooler removes reaction heat from the ammonia neutralization with sulfuric acid. It also controls the condensation of the water vapor from the saturated air loop.

Operational flexibility and low energy consumption

In addition to the stripping efficiency, one of the key points for economical plant operation is the overall pressure drop of the entire air loop system, which includes packings for both a stripper and an absorber, and adjacent piping. The low pressure drop of the Sulzer packings enables an economical ventilator design for the air circulation. Standard ventilators can be used—in the current example with a consumption of 3-5 kWh/m³ wastewater.

Operational flexibility is needed to respond to fluctuations in the ammonia concentration and the flow-rate of the feed. Sulzer’s decade-long experience ensures a reliable but also compact and thus economical plant design. The design is flexible enough to process ammonia feed concentrations within a specified range. The main operating parameter to be adapted is the operating temperature (Fig. 4).

For the chemisorption section, it is essential to avoid any carryover of liquid droplets into the absorber to avoid potential corrosion issues. For this purpose, an additional high efficiency Mellachevron™ demister, made of polypropylene, is installed on top of the liquid distributor.

The packing height in the absorber is purposely selected: It is not too high, so that it does not influence consequent stripping, and it is small enough to allow a certain slippage of non-absorbed ammonia. This neutralizes any sulfuric acid droplets that have found their way into the absorber (safety feature).

The plant in Thailand has been in operation since autumn 2012 to the full satisfaction of the client. Its
Keeping the air clean

Ammonia that gets into the air mixes with other emissions to form particulate matter. These particles can adversely affect human health because of their ability to penetrate deep into the lungs. As well as the health risks, ammonia emissions cause significant damage to ecosystems by contributing to the acidification and eutrophication of soils and water (Source: Swiss Federal Office for the Environment). With advanced wastewater treatment processes, Sulzer helps to avoid ammonia emissions.

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3 Wastewater often tends to foam, which can lead to premature flooding. Structured packing MellapakPlus™ (left: polypropylene, right: stainless steel), with its laminar flow characteristics on the liquid side, prevents or reduces potential foaming.

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operation has proven to be easy, reliable, and robust. The combination of compact column design, the use of high-efficiency packings with very low overall pressure drop, advanced heat integration, and reliable and simple plant control leads to an economical, attractive solution for both investment and operating costs. The lack of exhaust and the possibility of using the stripped ammonia directly as fertilizer in the form of ammonium sulfate is a very environment-friendly solution. Ever since the installation of the new wastewater treatment process, the local pineapple fields near the plant have been flourishing thanks to the fertilizer generated.

4 By adjusting the operating temperature, it is possible to achieve different ammonia concentrations in the stripped wastewater. The figure shows the ammonia concentration in the stripped wastewater at 500 m³ air suction volume to blower per ton wastewater @1.013 bar.