Detecting Ammonia in Poultry Housing Using Inexpensive Instruments

If humans can smell ammonia, that means it’s over the recommended levels. Use simple instruments to measure ammonia before it reaches significant levels.

What about that sensation of ammonia smell upon entering a poultry house for the first time today? Unfortunately, this is likely bad news for the birds. Because once we clearly identify ammonia odor, it is likely already above recommended levels.

Our human nose will not recognize ammonia until about 20 to 30 parts per million (ppm) has been reached. But poultry health guidelines suggest that ammonia be kept below 25 ppm for most birds. Ammonia below 25 ppm is required for achieving success with most poultry certification programs. Producers who have frequent exposure to poultry facilities with recognizable ammonia gas levels are known to lose their sensitivity to smell ammonia gas concentration. Often they can no longer detect even irritatingly high ammonia at 50-100 ppm. Even the casual visitor to a poultry barn will acclimate to an ammonia odor within about 20 minutes, similar to a guest who no longer recognizes the fresh baked smell of a pie after being in your kitchen for the same duration.

But the implications of not being able to detect threshold levels of ammonia are more impactful than being unable to smell the pie. Elevated ammonia levels are proven to be detrimental to bird respiratory function, leading to disease challenge, and at higher levels ammonia decreases bird productivity and farm profit. Research* has shown a one-half pound body weight reduction at 7-weeks of age for broilers raised in 25-50 ppm ammonia environment versus those birds kept in surroundings below 25 ppm.

Where does poultry ammonia come from?

Ammonia is a natural byproduct of manure, but we strive to minimize its generation and release in order to maintain suitable air quality in the poultry house. The decomposition of nitrogen compounds in manure results in ammonia (NH\(_3\) \(+\) ) and ammonium (NH\(_4\) \(-\) ) formation. These two products are in equilibrium related to manure pH. Lower pH will favor the ammonium form, which is not released as a gas (ammonia) but stays in solution in the manure (manure with bedding is referred to as litter in poultry houses). It has been well established that decreasing litter pH, moisture and temperature will likewise decrease ammonia release. Typically, only the first two options, reduction of litter moisture and pH, are readily available management techniques since poultry house temperature is dictated by bird comfort and heath. Even a slight 5% increase in litter moisture from 20 to 25% at 75 o F can result in a 140% increase* in ammonia release!

How to monitor ammonia?

Fortunately, easy-to-use and relatively inexpensive instruments are available for measuring ammonia level in poultry environments. It is now common for company advisory personnel to have these instruments for spot checks or sharing with producers to troubleshoot a poultry house environment control system. More accurate and sophisticated instruments are also available at greatly increased cost.

The lowest cost ammonia instrumentation that offers reasonable accuracy (about 20% of reading) is an instrument group called **Colorimetric Tube** (also known as Detector Tube). The pen-sized glass tube changes color along its length after exposure to ammonia gas as the contents of the tube react with the gas. The length of the color change in the detector tube indicates the...
concentration of ammonia, like reading a glass thermometer. The ammonia concentration is determined by reading a scale along the tube at a location where the tube color has stopped changing. There are two main types of colorimetric tubes: Pull tubes and Diffusion tubes.

**Pull Tubes**

A portable, quick, and relatively inexpensive way to detect ammonia gas levels is with a pull tube inserted into a hand-held sampler pump (pump cost $400-700). This manually-operated, piston-type pump (Figures 1 and 2) draws an accurate volume of sample of ambient air through the colorimetric tube once both ends of the glass tube are broken off. This offers a one-time spot-check of ammonia level at a location of interest. The pump draws air through the tube for about 60 seconds. It is very important to hold the pump so the air pulled in through the tube comes from the location of interest. For example, this means holding it near the bird breathing zone during the sampling period if animal welfare measurements are the goal. Options exist for partially automating the process with an array of tubes that are sampled at prearranged intervals.

![Figure 1. Example of a gas sampling pump with pull-tubes for quick assessment of ammonia concentration. (Source: William Moyer)](image)

![Figure 2. Example of pull tube ready for gas concentration detection in the sampling pump. (source: Eileen Fabian)](image)
Diffusion Tubes

Diffusion tubes (also known as Passive tubes or Dosimeter tubes) offer an even less expensive colorimetric option to monitor ammonia gas in the animal environment since the sampler pump is not needed. Another advantage is that diffusion tubes provide an average ammonia level over a period of hours rather than the spot check of the pull tube. One end of the diffusion tube is broken off, time of deployment written on the tube, and then the tube is positioned in the environment of interest. As the name implies, ambient air slowly diffuses into the tube's contents offering a change in color due to the chemical reaction with ammonia in the air. A diffusion tube gathers information over 2 to 10 hours as ppm-hr. A scale is provided on the side of the tube for the direct reading. This concentration-time reading is divided by the number of hours of exposure to the barn air to get the average ppm over that monitoring period. The tube can be positioned near (but out of reach of) the animals for welfare concerns or building ventilation exhaust as part of an emission calculation. A disadvantage of the diffusion tube process is the need for two visits to the animal environment, hours apart, to place the tube and retrieve the concentration reading.

Example calculation: Maintaining ammonia below about 25 ppm is a goal in poultry housing so that good air quality is maintained for bird heath and productivity. A diffusion tube is deployed at 9:15 am at a location near the feed line to monitor air quality near the animal breathing zone. At 3:30 pm the tube is retrieved. The color change of the contents indicates 50 ppm-hr. The time the tube was exposed to the poultry barn air was 6 hours and 15 minutes, which is 6.25 hours. Calculation is 50 ppm-hr/6.25 hr = 8 ppm average ammonia level over this timeframe. The accuracy of colorimetric readings is noted as about 20-25% by the manufacturer so the actual ammonia level in this barn over that time period can be considered about 6 to 10 ppm.

![Passive or diffusion tubes appear very similar to the pull-tubes but do not need the pump to take a time-weighted average ammonia reading over several hours](source: Eileen Fabian)

Gas Detection Colormetric Tube Options

The thin glass colorimetric tubes are offered for dozens of different types of gases. The tube content is specifically reactive with the type of gas that is being measured, including those that may be found in farm animal environments such as ammonia, hydrogen sulfide, and carbon dioxide. Several types of sampling pumps are available but the pump and pull tubes must be from the same manufacturer to match the volume of ambient air drawn through the tube with the reaction rate of the tube contents. As with other instruments, the pumps need to be periodically checked for problems such as leakage of older worn seals (tube instructions offer a quick test for leakage).

Pull tubes and diffusion tubes come in a choice of measurable ranges so that suitable analysis is possible. Tubes cost about $8 to $12 apiece sold in boxes of ten. These tubes come in scales, for example, from 2 to 10 ppm or 5 to 100 ppm. The latter recommended for most poultry houses, particularly those with in-house manure storage (high-rise layer or broiler with built-up, multiple-cycle litter). Tubes are stored in a cool (32-77°F) and dark place and need to be used prior to the expiration date indicated on the box (typical shelf life of one year). As an aside, within a poultry manure storage environment, ammonia monitoring is needed up to 500 ppm.
Getting a Good Measurement

Where's the ammonia? Although ammonia ($\text{NH}_3$) is lighter than air (composed of roughly 80% nitrogen, $\text{N}_2$) the ammonia level will typically be higher near bird level, particularly for floor-raised birds, than at our human head level in poultry barns. This is because of the dilution of ammonia from the ventilation system air exchange while recognizing that ammonia level near its source, the manure, will accumulate. This is important as floor raised birds are exposed to higher ammonia levels than human caretakers. This requires that ammonia be measured at bird level to document the conditions under which they are living.

![Image](image.png)

Summary

Colorimetric tubes offer reliable and proven technology for roughly estimating ammonia gas concentration in animal environments. They are relatively low cost, compared to other ammonia detection instrumentation, and are widely available. Pull tubes offer a quick snapshot of ammonia levels in various locations around the barn while passive, diffusion tubes provide a time-weighted-average ammonia evaluation at a location over several hours.

Suppliers

Dräger (Draeger) Sensidyne, Kitagawa, MSA and Gastec manufacturer colorimetric tubes and pumps available from several sources, including the following suppliers:

- Grainer
- Premier Safety and Service, Inc.
- SKC Inc.

*Research Cited*

