**Ammonia**

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| NH3, Ammonia Gas, is extremely soluble in water. It is the natural product of decay of organic nitrogen compounds. Although it is widely used and common in our society, ammonia can be both hazardous and caustic. Ammonia is present in almost all waters to some degree. In many cases, it is deliberately added to chlorinated feedwaters to reduce THM precursors. It is well removed by deionization processes but not by softening. Ammonia is a colorless, pungent gaseous compound of hydrogen and nitrogen that is highly soluble in water. It is a biologically active compound found in most waters as a normal biological degradation product of nitrogenous organic matter (protein). It also may find its way to ground and surface waters through discharge of industrial process wastes containing ammonia and fertilizers. Ammonia has been used in municipal treatment systems for over 70 years to prolong the effectiveness of disinfection chlorine added to drinking water. The addition of ammonia enhances the formation of chloramines (which may create objectionable tastes), and it reduces the formation of chlorination by-products which may be carcinogenic. Partial adsorption of chloramines (from city supplied water) by GAC may liberate ammonia. When dissolved in water, ammonia (NH3) reacts to form ammonium (NH4 + ) and hydroxyl (OH- ) ions. When the pH is above 7.2, some free NH3 remains and this increases with increasing pH. The equilibrium for these chemical species can be expressed by the following: NH3 + H2O ↔ NH4OH ↔ NH4 + + OHOxidation of ammonia results in the formation of nitrite and nitrate. HEALTH EFFECTS There is no EPA mandated Maximum Contaminant Level (MCL) for ammonia. However, it has been known, since early in this century, that ammonia (NH3) is toxic to fish and that the toxicity increases with pH and temperature.  **What is Ammonia**? Ammonia is a nutrient that contains nitrogen and hydrogen. Its chemical formula is NH3 in the un-ionized state and NH4 + in the ionized form. Total ammonia is the sum of both NH3 and NH4 + . Total ammonia is what is measured analytically in water. Why is it Important? Ammonia is the preferred nitrogen-containing nutrient for plant growth. Ammonia can be converted to nitrite (NO2 ) and nitrate (NO3) by bacteria, and then used by plants. Nitrate and ammonia are the most common forms of nitrogen in aquatic systems. Nitrate predominates in unpolluted waters. Nitrogen can be an important factor controlling algal growth when other nutrients, such as phosphate, are abundant. If phosphate is not abundant it may limit algal growth rather than nitrogen. Ammonia is excreted by animals and produced during decomposition of plants and animals, thus returning nitrogen to the aquatic system. Ammonia is also one of the most important pollutants because it is relatively common but can be toxic, causing lower reproduction and growth, or death. The neutral, unionized form (NH3 ) is highly toxic to fish and other aquatic life. Trout and salmon are more sensitive to ammonia than warm water fish such as bluegill. Fish tend to be more sensitive than invertebrates.  **What is ammonia**?  Ammonia (NH3) is a colorless, alkaline gas at ambient temperature and pressure, with a distinct pungent odor. Ammonia is very soluble in water and forms the ammonium cation (NH4 + ) on dissolution in water. In the pH range of most natural waters nitrogen exists principally as NH4 + . Ammonia may be present in groundwater as a result of the degradation of naturally occurring organic matter or manmade sources. Natural ammonia levels in groundwater and surface water are usually below 0.2 mg/L, but many regions throughout the world have high levels of naturally occurring ammonia. Ammonia may also originate from nitrogen-fertilizer application, livestock operations, industrial processes, sewage infiltration, and cement mortar pipe lining. During 1998 to 2010, samples from 393 private water wells in Saskatchewan were analyzed for ammonia and it was detected in more than 87% of the samples with an average value of 1.19 mg/L.  **Major uses Ammonia** is used in fertilizer and animal feed production and in the manufacture of fibres, plastics, explosives, paper, and rubber. It is used as a coolant, in metal processing, and as a starting product for many nitrogen-containing compounds (3). Ammonia and ammonium salts are used in cleansing agents and as food additives (1,4), and ammonium chloride is used as a diuretic.  **Water solubility** 421 g/litre at 20 °C; 706 g/litre at 0 °C Vapour pressure 882 kPa at 20 °C Organoleptic properties The threshold odour concentration of ammonia in water is approximately 1.5 mg/litre A taste threshold of 35 mg/litre has been proposed for the ammonium cation (1).  **ENVIRONMENTAL LEVELS** AND HUMAN EXPOSURE Air in urban areas contains up to 20 µg of ammonia per m3 . Air in areas where farm animals are intensively reared may contain levels as high as 300 µg/m3 (7).  Water Natural levels in groundwaters are usually below 0.2 mg of ammonia per litre. Higher natural contents (up to 3 mg/litre) are found in strata rich in humic substances or iron or in forests (8).  Surface waters may contain up to 12 mg/litre (1). Ammonia may be present in drinking-water as a result of disinfection with chloramines. The presence of ammonia at higher than geogenic levels is an important indicator of faecal pollution (5). Taste and odour problems as well as decreased disinfection efficiency are to be expected if drinking-water containing more than 0.2 mg of ammonia per litre is chlorinated (9), as up to 68% of the chlorine may react with the ammonia and become unavailable for disinfection.  Natural factors that can affect the concentration of ammonia include: algal growth, decay of plant or animal material, and fecal matter. Other aspects of nitrogen cycling can also affect the amount of ammonia present. Ammonia can also come from domestic, industrial or agricultural pollution, primarily from fertilizers, organic matter or fecal matter. What are Acceptable Ranges? The toxicity of ammonia is critically dependent on pH and temperature. The un-ionized form (NH3 ) is more toxic than the ionized form ( NH4 + ). As pH increases, NH4 + is converted to NH3, and the toxicity increases. Higher temperatures also favor the more toxic form. It is very important that you compare values of ammonia correctly. |  |
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| **Removing Ammonia From Water**  Ammonia is difficult to remove from water. It can be removed by cation exchange resin in the hydrogen form, which requires use of acid as a regenerant. Degasification can also be effective. Neither of these methods is easily adapted to residential use.  it can be effectively and economically reduced in public and private water supplies by zeolite ion exchange regenerated with salt. Using sodium alumino silicate zeolites, reduction from 20 to 1 ppm can be achieved with flow rates of 4 gpm per square foot of resin.  The natural zeolite clinoptilolite, also regenerated with salt, is also an effective ammonia treatment.  For drinking water, distillation is an effective treatment.  Ammonia can be destroyed chemically by chlorination, but the resulting product is chloramine, which is also difficult to deal with. | |
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| **Below is an interesting piece about ammonia reduction from Pure Water Products' main website:**  Chloramine, which more than 30% of US cities now use as a disinfectant, is more difficult to remove from water than free chlorine. It can be removed with exactly the same treatment strategies that are used for chlorine, but greater contact time is needed.  Activated carbon is the best remover of free chlorine, and with enough residence time it removes chloramine effectively. However, when chloramine is involved in an oxidation-reduction reaction, ammonia is left behind, and ammonia is a severe problem for aquarium owners.  Reverse osmosis units with at least two carbon prefilters should remove chloramine nicely, but ammonia must still be dealt with.  Ammonia can be present in water in two forms, either ammonium hydroxide (NH3) or as the ammonium ion (NH4).  When the pH of the water is less than 7 the ammonia is present as the ammonium ion. As pH increases above 7, more of the ammonia is present as ammonium hydroxide.  The ammonium ion is readily removed by cation resin. Good removal capacity can be expected in waters low in hardness. Waters that are high in hardness will have decreased capacity due to the simultaneous affinity and removal of calcium, magnesium and the ammonium ion.  What this means is that an RO postfilter cartridge containing standard water softener resin should remove ammonia nicely.  Reverse osmosis removes the hardness and decreases the pH, assuring that the ammonia exists in the ammonium ion state that is readily removed by standard cation (water softening) resin.  Here is a clip from another article on ion exchange which throws light on the same concept:  **Ammonia**  The general approach to ammonia removal would be primary and polishing softeners. Ammonia is removed preferentially to sodium by cation resin, but is displaced by calcium and magnesium. Therefore, a single softener will remove ammonia during the initial part of its cycle but will then release the ammonia as it becomes exhausted with hardness.  Softening can be used effectively for ammonia removal if the primary softener is allowed to load to a hardness endpoint and a polishing softener is used to remove ammonia. In this case, the primary softener must not be operated to hardness breakthrough, as this would cause an ammonia spike and lead to elevated ammonia levels in the final product water. | |
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**Environmental fate:** On dissolution in water, ammonia forms the ammonium cation; hydroxyl ions are formed at the same time. The equilibrium constant of this reaction, KB, is 1.78 × 10-5 (3). The degree of ionization depends on the temperature, the pH, and the concentration of dissolved salts in the water. The environmental cycling of nitrogen relies mainly on nitrate, followed by ammonia and the ammonium cation, which predominates. The ammonium cation is less mobile in soil and water than ammonia and is involved in the biological processes of nitrogen fixation, mineralization, and nitrification (2).

**How is it Measured**? Ammonia is analyzed by chemical titration. The method used in most test kits is called the salicylate method. Always measure pH and temperature when you measure ammonia. Without these other measurements it will be difficult to know the toxicity of the ammonia. The careful reporting of ammonia test results is very important. Do not simply tabulate your results as "NH3" because this abbreviation is used for both total and unionized ammonia. Be sure you indicate which you are reporting. Results can be expressed as: ο total ammonia (mg/l), ο un-ionized ammonia (mg/l), ο total ammonia (as N, mg/l), ο un-ionized ammonia (as N, mg/l). Ammonia (page 2) If you measure pH and temperature, you can convert total ammonia values to unionized ammonia using the attached table. Example: Your total ammonia (mg/l) = 2.0 pH = 8.0 Temperature = 25 Degrees C Your sample is from a freshwater stream. Find pH = 8 at the left side of the table, find 25 Degrees C and FW (freshwater) at the top of the table. Their intersection gives the percent un-ionized ammonia. The value is 5.28% Un-ionized ammonia (mg/l) = total ammonia x percent un-ionized = 2 x 0.0528 = 0.106 mg/l (un-ionized NH3) The "as N" values are based only on the nitrogen component of the molecule. To convert readings, use the equations in the table.

ANALYTICAL METHOD Ammonia and ammonium cation at concentrations between 0.025 and 3 mg/litre can be determined by the indophenol reaction. An ammonia-selective electrode can also be used, as can titrimetry, which is less sensitive.