The Fertilizer Institute

Nourish, Replenish, Grow

HEALTH EFFECTS of AMMONIA

contents

INTRODUCTION

Ammonia: An Essential Chemical

Ammonia is a naturally occurring chemical in the atmosphere, as well as an essential man-made chemical. It is represented by the chemical formula NH_3. Ammonia in this form is also known as ammonia gas or anhydrous ("without water") ammonia. At room temperature, ammonia is a colorless, pungent-smelling gas and is lighter than air.

At minus 28 degrees Fahrenheit (-33 degrees Celsius), ammonia becomes a liquid. Ammonia easily dissolves in water. In this form, it is also known as liquid ammonia, aqueous ammonia or ammonia solution. In water, most of the ammonia changes to ammonium ions, NH_4^+.

Ammonia is an essential element for plant, animal and human life. It is found in water, soil and air, and is a source of much needed nitrogen for plants and animals. Most of the ammonia in the environment comes from the natural breakdown of manure, dead plants and animals. Man-made sources of ammonia include fertilizers, power plants, mobile sources and other manufacturing emissions. Due to its widespread presence in the environment and its many uses, questions often arise about its potential impact on human health.

Summary of Health Effects

The human body has several ways to process the ammonia it produces and is capable of clearing large levels of ammonia from its system.

- Ammonia levels in the air as low as 5 parts per million (ppm) can be recognized by odor. An average person detects ammonia by odor at around 17 ppm.

- According to the World Health Organization (WHO), continuous exposure to 25 ppm of ammonia in the air does not result in a significant increase in blood levels of ammonia in the body.
- According to the Occupational Safety and Health Administration (OSHA), the least amount of ammonia which is found to be irritating to the eyes, nose and throat of the most sensitive individuals is 50 ppm.
- There is no evidence that ammonia causes cancer.
- There is no evidence that exposure to the levels of ammonia found in the environment causes birth defects or other developmental effects.
- Because ammonia is present in the human body at all times, no long-term health effects from inhalation exposure to low levels of ammonia would be expected.
- Because ammonia is a respiratory tract irritant, persons who are hyperreactive to other respiratory irritants, or who are asthmatic, may be expected to be more susceptible to inhalation of high concentrations of ammonia.

Uses of Ammonia

Ammonia contributes to the nutritional needs of living organisms, and serves as a feedstock in the production of many fertilizers and other important chemicals. Ammonia is one of the most widely used industrial chemicals. It is prepared industrially from natural gas, steam and air. More than 80 percent of manufactured ammonia is used as fertilizer. Some of this ammonia is chilled to a liquid form for direct injection into croplands as a fertilizer. A large amount of industrial ammonia is reacted with carbon dioxide to make urea fertilizer or used to make nitrate fertilizers.

Most people are familiar with its use in a variety of household products, including cleaning products and smelling salts. Ammonia is also used in large-scale refrigeration systems; to make synthetic fibers, plastics and glues; in the treatment and refining of metals; and in a variety of other chemical production processes and foods. Another important use of ammonia is in selective catalytic reduction during which ammonia is added to a stream of exhaust gas and absorbed into a catalyst, a technology which is utilized in power plant stacks, cars and trucks to remove nitrogen oxide and sulfur oxide.

Sources of Ammonia

Metabolism

The term metabolism refers to the ways in which chemicals are changed to other chemicals by living organisms.

Ammonia is a unique industrial chemical because it is also produced by the body and used by all mammalian species. It is produced by the breakdown of the proteins in food and from amino acids. Ammonia is essential to the synthesis of DNA and proteins, which are the basic building blocks of life. In addition, bacteria in the digestive tract break down other food compounds to form ammonia.

About 17 grams (≈ 0.5 ounces) of ammonia are produced by the body every day, of which approximately 4 grams are absorbed into the body's circulation system. The rest is excreted through urine.

External Sources

External Exposures – The average human intake of ammonia from external sources is about 18 milligrams per day (mg/day).

- Exposure to ammonia from sources outside the body come from eating proteins and certain foods containing ammonium salt additives and from air, water and direct contact with the skin. Ammonia is used in food preparation as a stabilizer, leavening agent and food additive.

- Estimates of the average global atmospheric ammonia concentration range from 0.6 - 3 parts per billion (ppb). Concentrations of ammonia in the atmosphere vary across the United States, with geography, altitude, season and man-made activities contributing to the difference. In general, concentrations are higher in the Midwest compared to either the west or east coasts, with a nationwide average of 3.3 ppb. Typical large cities have estimated airborne ammonia levels of approximately 0.03 ppm, which means that an individual will typically breathe in about 0.4 mg/day of ammonia.
  In rural areas, a person will take in about 0.1 mg/day.

- Ammonia concentrations in water vary seasonally and regionally, and are also affected by surrounding land use, temperature and pH. The average human intake from drinking water is about 1 mg/day in cities and less than 0.4 mg/day in rural areas.

- Cigarette smokers inhale an additional 0.8 mg/day of ammonia (based on 20 cigarettes per day).

[See Daily Ammonia Intake Table on right.]

DAILY AMMONIA INTAKE

Total Production by the Body		17,000 mg
Continuously Breathing 25 ppm		379 mg
Eating a 7 ounce Steak		13,000 mg
Food Additives		18 mg
Drinking Water		
	City	1.0 mg
	Rural	0.4 mg
Normal Breathing		
	City	0.4 mg
	Rural	0.1 mg
Cigarette Smoking (one pack per day)		0.8 mg

HOW DOES THE BODY PROCESS AMMONIA?

Because ammonia is very water soluble, inhaled ammonia dissolves into the lining of the nasal passages and is swallowed. Consequently, very little inhaled ammonia reaches the lungs. According to WHO estimates, continuous inhalation of low concentrations of ammonia – 25 ppm, equivalent to about 379 mg/day – would only result in a 10 percent increase in blood-ammonia concentration.

It is important to note that individual blood ammonia levels vary considerably due to dietary fluctuations. For example, eating a meal rich in protein will produce changes in blood ammonia levels considerably higher than 10 percent.

The Liver Converts Ammonia to Urea

Human bodies use ammonia in a number of ways, including for the maintenance of the normal pH balance necessary to sustain life. Ammonia is processed in the liver, kidneys and skeletal muscle. The two main modes for the body to process ammonia involve its conversion to urea and to glutamine.

The human liver has the capacity to convert as much as 130 grams of ammonia into urea each day although it normally operates at less than one eighth of that capacity. Thus, the human body has a large capacity for handling any excess ammonia that may be introduced from a protein-rich meal or from environmental exposures.

Elimination and Excretion

While ammonia is mainly eliminated in the urine, ammonia is also present in exhaled air. Humans exhale between 0.1 and 3.2 ppm of ammonia through their breath.

HEALTH EFFECTS ASSESSMENT

In order to assess how exposure to ammonia might affect human health, changes in various organs; decreases in lung function; changes in cilia beating in the trachea; effects on nerve conditions; and the ability to fight bacterial lung infections have been evaluated during laboratory studies and from observation of people exposed to ammonia. Carcinogenicity, mutagenicity – damage to the genetic material of cells – and damage to the reproductive system or fetus have also been studied. The following sections discuss the major findings on ammonia from several human and animal studies conducted by the WHO, the Agency for Toxic Substances and Disease Registry (ATSDR), the Environmental Protection Agency, the Occupational Safety and Health Administration, the American Conference of Industrial Hygienists (ACGIH), and TFI.

Acute Health Effects

Ammonia, in both its gaseous and liquid form, can be irritating to the eyes, respiratory tract and skin due to its alkaline nature. The biological effects of ammonia in humans after acute exposures are dose-related – they depend on the ambient concentration, the amount taken in by the body and the duration of exposure.

- Ammonia levels in the air as low as 5 ppm can be recognized by odor. An average person detects ammonia by odor at around 17 ppm. Most people can taste ammonia in water at levels of about 35 ppm.

- ACGIH recommends a threshold limit value (TLV) of 35 ppm as a short-term exposure limit (STEL) and 25 ppm on a time-weighted average (TWA) to avoid irritation of the eyes, nose and throat. ACGIH develops TLVs as guidelines to assist in the control of occupational health hazards. While TLVs are recognized guidelines around the world, they are not law and carry no legal enforcement.
- In addition, other applicable exposure limits are required by specific states, and other organizations have developed alternate ammonia exposure limit guidelines for specific scenarios, such as public health assessment and emergency response.
- According to OSHA, the smallest amount of ammonia that has been found to be irritating to the eyes, nose and throat of the most sensitive individuals is 50 ppm.
- Without personal protective equipment (PPE), the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action is 100 ppm.
- OSHA also sets 300 ppm as the exposure concentration of ammonia causing no escape-impairing symptoms and no irreversible effects.
- Without protective equipment, the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 30 minutes without experiencing or developing life-threatening health effects is 500 ppm.

- Breathing 700 to 1,700 ppm results in coughing, bronchospasm and chest pain along with severe eye irritation and tearing.
- At levels greater than 5,000 ppm, ammonia causes chemical bronchitis, fluid accumulation in the lungs, chemical burns of the skin and is potentially fatal.
- Based on information provided by ATSDR, permanent lung damage has not been associated with acute ammonia exposures unless the exposure concentrations were near lethal levels.

Chronic Toxicity

Few studies of longer duration – chronic studies – have been conducted with animals primarily because there is no scientific belief that persistent, low level exposure to ammonia would be harmful, as ammonia is naturally present at relatively high levels in humans.

A study conducted on workers exposed to ammonia for 10 to 15 years at levels up to and exceeding 24 ppm did not find adverse effects. In additional occupational studies, no relationship was found between exposure to ammonia and cancer or carcinogenicity.

According to the ATSDR and TFI studies, chronic exposure to ammonia did not result in harm to genetic material or damage the reproductive system or a developing fetus.

Table 1: Concentration/Duration/Effect (without protective clothing)

Concentration / Time	Effect
10,000 ppm	Promptly lethal
5,000 – 10,000 ppm	Rapidly fatal
700 – 1700 ppm	Incapacitation from tearing of the eyes and coughing
500 ppm for 30 minutes	Upper respiratory tract irritation, tearing of the eyes
134 ppm for 5 minutes	Tearing of the eyes, eye irritation, nasal irritation, throat irritation, chest irritation
140 ppm for 2 hours	Severe irritation, need to leave exposure area
100 ppm for 2 hours	Nuisance eye and throat irritation
50 – 80 ppm for 2 hours	Perceptible eye and throat irritation
20 – 50 ppm	Mild discomfort, depending on whether an individual is accustomed to smelling ammonia

Table 2: Effects of Ammonia Exposure for “A Few Minutes” (without protective equipment)

Concentration (ppm)	Symptoms	Signs	Consequences
Less than 5000	Stinging in eyes and mouth, pain when swallowing, hoarseness, tightness of throat, cough	Reddening of conjunctivae, lips, mouth and tongue, swelling of eyelids, edema of throat	Usually recovery without pulmonary complications
5000 – 10,000	Exaggeration of above symptoms, tightness in chest, difficulty swallowing, loss of voice, cough with sputum and sometimes blood	Distress, increase in pulse and respiration rates, swelling of eyelids, burning of mucous membranes	Fatalities due to obstruction of airways
Greater than 10,000	Similar to above symptoms, persistent cough with copious frothy sputum	Shock, restlessness, distress, rapid pulse of poor volume, cyanosis, difficulty breathing	Death as result of asphyxiation; survivors may die later a result of complications

Effects on Sensitive Individuals

There is no scientific consensus that children are more susceptible to the effects of ammonia than adults. Persons who suffer from severe liver or kidney disease may be more sensitive to exposure to higher concentrations of ammonia, because of the importance of these organs in transforming and excreting ammonia. However, levels likely to be encountered normally in the environment, with the exception of those resulting from high-level accidental exposures, are not generally of concern, due to the low absorption rate compared with levels produced within the body. Because ammonia is a respiratory tract irritant, persons who are hyperreactive to other respiratory irritants, or who are asthmatic, would be expected to be more susceptible to inhalation of high concentrations of ammonia.

Particulate Matter

Questions are sometimes raised regarding ammonia's role in the toxicity of airborne particulate matter. Particulate matter, also known as particle pollution or PM 2.5 and PM 10 depending on particle size – with 2.5 being the smaller value – is a complex mixture of extremely small particles and liquid droplets including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles.

Particle pollution contains microscopic solids or liquid droplets so small that they potentially could get deep into the lungs and cause serious health problems. The size of particles is directly linked to their potential for causing health problems – the smaller particles, PM 2.5, can travel deeper into the lungs.

Inhalable coarse particles, such as those found near roadways and dusty industries, are larger than 2.5 micrometers and smaller than

10 micrometers in diameter. Fine particles, such as those found in smoke and haze, are 2.5 micrometers in diameter and smaller. These particles can be directly emitted from sources such as forest fires, or they can form when gases emitted from power plants, industries and automobiles react in the air.

Because ammonia is found naturally in ambient air, as well as emitted from industrial and agricultural sources, it can interact with other airborne gases, especially sulfates and nitrates, to produce particulate matter. The amount of ammonia in air may be a factor in determining the final form of particulate matter in a geographic area by influencing the conversion of acid gases to their ammonium salts.

Current scientific research into the toxicity of particulate matter is focused on the effects of combustion byproducts, such as carbon and volatile organic compounds, on human health. While there are no definitive answers, there is little evidence to indicate that ammonia contained in particulate matter increases the risk to human health beyond those effects discussed earlier in this document.

Short-term exposures to particles (hours or days) can aggravate lung disease, causing asthma attacks and may also increase susceptibility to respiratory infections. In people with heart disease, short-term exposures have been linked to heart attacks and arrhythmias. Healthy children and adults have not been reported to suffer serious effects from short-term exposures, although they may experience temporary minor irritation when particle levels are elevated.

Long-term exposures to particulate matter, such as those experienced by people living for many years in areas with high particle levels, have been associated with problems such as reduced lung function, the development of chronic bronchitis and even premature death. Ammonia may also contribute to regional haze and reduced visibility in parts of the United States.

HOW TO PROTECT YOURSELF

Before working with ammonia, personnel should review the material safety data sheet. Personnel handling anhydrous or strong aqua ammonia where skin or eye contact is likely to occur should wear gloves, shoe covers and aprons impervious to ammonia. Unless eye and face protection is afforded by a respirator hood or face piece, chemical goggles and face shields should be worn at all times. The National Institute for Occupational Safety and Health recommends wearing gloves made of Butyl, Teflon or Viton for up to eight hours of exposure and Nitrile gloves for up to four hours of exposure.

Any personnel required to enter atmospheric ammonia concentration likely to be more than 10,000 ppm must wear a self-contained breathing apparatus with a positive pressure in a full face piece under an impervious full body suit or other combination of continuous-flow supplied air, and impervious suit. When the worker is using the impervious suit over a self-contained breathing apparatus, stay-time in the area should be limited due to consideration of the heat stress factors involved.

Treatment of Burns and Blisters

Most material safety data sheets state that burns should be treated by flushing with water for a minimum of 20 to 30 minutes, while removing contaminated shoes, clothing and constrictive jewelry once the person has been removed from any additional exposure. If the skin surface is damaged, apply a clean dressing and seek immediate medical attention. If the skin surface is not damaged, cleanse the affected area(s) thoroughly by washing with mild soap and water.

Never apply salves or ointments to chemical burns. The application of these products can worsen the burn by holding in chemicals not washed off of the skin that need to be released from the wound. If salves or ointments are applied, there is a greater potential for causing more severe burns. Once the wound is fully cleansed, a doctor or burn specialist may apply one percent silver sulfadiazine cream directly to the skin.

Shelter-in-Place Procedures

What should you do if there's been an ammonia release from a retail or manufacturing facility in your area and it's coming your way? Because ammonia is primarily an acute health hazard which rapidly disperses in the atmosphere, sheltering is almost always the best short and long-term response. Shelter-in-place means to get inside a building (even a car if no building is available) and take certain steps described here. In almost all fatalities involving ammonia releases, those killed or even seriously injured were in the immediate area of the release and were most often affected by the impact of sudden pressure, rather than by exposure to ammonia. Those nearby who quickly found shelter were usually spared serious long-term effects.

Only when deemed appropriate by the public emergency response official in charge, evacuation can be appropriate in three circumstances before evacuating. Otherwise, you could mistakenly move into or towards an ammonia vapor cloud. The first such circumstance might be in those areas not directly downwind of a large scale release, but close enough that shifts in wind direction could create problems. The second would be those areas far enough downwind of a major release that time is adequate to permit an orderly and safe evacuation. Officials, based on an understanding of many factors, should make such a decision. The third evacuation circumstance would involve trained emergency responders who would enter homes to remove people in the unlikely event that unusual weather conditions hold very high ammonia concentrations over an area for an extended period of time.

If an accidental release of ammonia occurs at a nearby facility that is significant enough to pose a threat, plant neighbors within a two mile radius will typically be notified by a phone call usually advising them to shelter-in-place. These phone calls are made using an automatic dialing message service that accesses multiple phone lines at once, so the calls should be prompt. All persons receiving this call should go inside their home or business, close all doors and windows, and shut off any devices that circulate air from outside (such as heating/air conditioning, window or attic fans, fireplace flues, etc.). Tune into local radio stations for information on the specific areas affected and steps to take if you are in these areas.

Every home and most businesses have the elements necessary for a shelter. These include a single room (or two adjoining rooms) containing a radio and/or television, telephone, as few windows and doors as possible, and a supply of water. An ideal example would be a bedroom with an adjoining bath. The windows and doors should be sealed using whatever materials are available from tape to garbage bags to wet towels, bedspreads, etc. Wet towels or other fabric can also be used to cover the face as a temporary mask if necessary. Water absorbs ammonia and thus provides a temporary barrier. Individuals should evaluate their home or place of business to identify the most effective sheltering area.

Most releases will be corrected in less than 15 minutes. Since ammonia rapidly disperses, the threat to human health should not last much longer than the release.

An all-clear message will be sent using the automatic dialing service. Once the emergency is over, if the ammonia odor outside is not as strong as it is inside, move outside the shelter. Generally if you can tolerate the smell outside without severe reaction, the concentration represents no threat to health even though it may be irritating. Tolerance levels for ammonia vary widely from person to person. People with respiratory problems may be more sensitive and should take extra precautions.

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