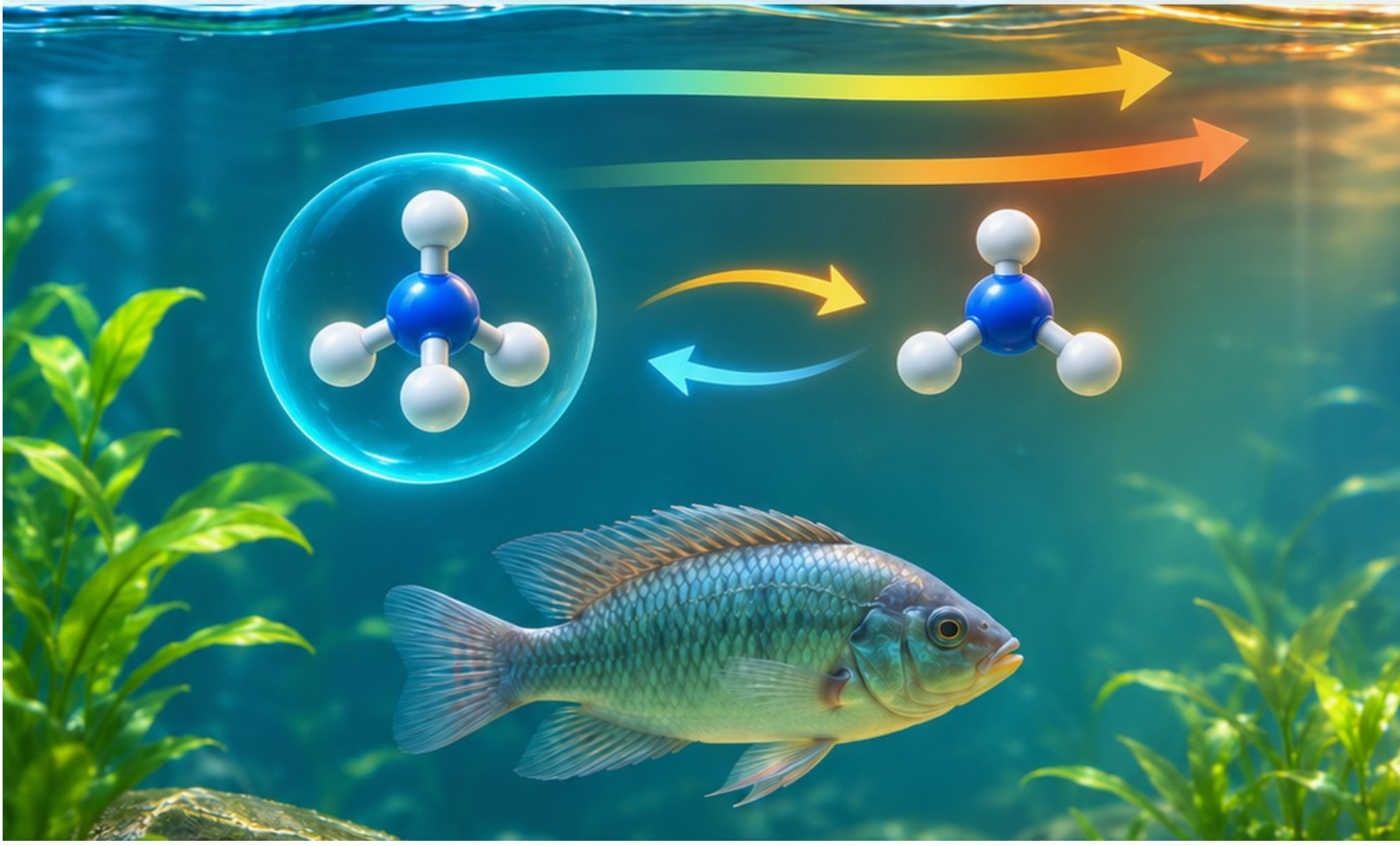
PUROXI WATER SERIES

UNDERSTANDING AMMONIA

Why pH and Temperature Change Its Behaviour in Water

PWS-012



CHAPTER 1

Ammonia Is More Than One Number

Ammonia in water exists mainly as un-ionized ammonia, NH3, and the ammonium ion, NH4+. Tests often report the two together as total ammonia nitrogen, or TAN.

The result cannot be interpreted responsibly until the reporting basis, pH, temperature, salinity, application and exposure conditions are known.

- TAN is commonly reported as milligrams of nitrogen per litre, mg N/L.
- Some reports use mg/L as NH3 or another basis; these values are not numerically identical.
- Always record the method, unit and reporting basis.

PUROXI INSIGHT **An ammonia number without its reporting basis can be misunderstood before interpretation even begins.**

CHAPTER 2

Ammonia and Ammonium Exist in Equilibrium

NH3 and NH4+ continually shift between forms in water. The balance is controlled primarily by pH and temperature, with ionic strength also influencing the equilibrium.

Un-ionized NH3 crosses biological membranes more readily and is generally the more toxic form to aquatic organisms.

- Increasing pH increases the fraction present as NH3.
- Increasing temperature also increases the NH3 fraction.
- A stable TAN result can become more hazardous if pH or temperature rises.

PUROXI INSIGHT **The total may remain unchanged while the biologically important fraction changes.**

CHAPTER 3

Where Ammonia Comes From

Natural decomposition, animal excretion and microbial activity release ammonia. Human sources include sewage, manure, fertilizers, food processing, industrial discharges and landfill leachate.

In closed or recirculating systems, ammonia can accumulate when production exceeds biological conversion, plant uptake, water exchange or treatment capacity.

- Uneaten feed and excessive protein loading increase nitrogen input.
- Sludge and oxygen-poor sediment can release ammonia.
- Treatment upset, cold temperatures or toxic shocks can slow nitrification.

PUROXI INSIGHT **Source control begins with understanding how nitrogen enters and moves through the system.**

CHAPTER 4

Reporting Units Must Be Confirmed

Laboratories and meters may report total ammonia nitrogen, ammonia-nitrogen, ammonium-nitrogen, NH3 or NH4+. Conversion requires molecular-weight relationships and a clear definition of what was measured.

A value reported as nitrogen is lower than the numeric value of the equivalent full compound because only the nitrogen mass is counted.

Report wording	Interpretation
TAN or NH3-N + NH4-N	Combined ammonia forms expressed as nitrogen.
NH3-N	Un-ionized ammonia expressed as nitrogen.
NH3	Un-ionized ammonia expressed as the full compound.
NH4-N	Ammonium expressed as nitrogen.
NH4+	Ammonium expressed as the full ion.

PUROXI INSIGHT **Do not compare ammonia results until the reporting bases are confirmed.**

CHAPTER 5

pH Changes the Risk

At lower pH, a larger share of total ammonia is present as NH4+. As pH rises, equilibrium shifts toward NH3. This is why an algae-driven afternoon pH increase can raise risk even when TAN changes little.

Ammonia management should therefore include measurements taken at the times when pH is highest, not only convenient morning samples.

- Record pH at the same time and location as the ammonia sample.
- In productive ponds, check late-afternoon pH as well as morning conditions.
- Avoid sudden pH increases when ammonia is elevated.

PUROXI INSIGHT **A pH change can alter the meaning of the same TAN concentration.**

CHAPTER 6

Temperature Also Changes the Balance

Warmer water increases the fraction of TAN present as NH3 and can intensify biological oxygen demand. Temperature also affects feeding, metabolism, microbial conversion and the oxygen available in water.

A result acceptable under cool conditions may require a different response during a heat event or seasonal warming.

- Measure temperature with every ammonia sample.
- Review daily and seasonal maximum temperatures.
- Reduce assumptions based on a single annual laboratory result.

PUROXI INSIGHT **pH and temperature must travel with the ammonia number.**

CHAPTER 7

Nitrification Connects Ammonia Oxygen and Alkalinity

Nitrifying microorganisms oxidize ammonia to nitrite and then nitrate under suitable aerobic conditions. The process consumes dissolved oxygen and alkalinity and can lower pH.

Low oxygen, inadequate alkalinity, unsuitable temperature, insufficient biofilm area or inhibitory chemicals can reduce conversion and allow ammonia or nitrite to accumulate.

- Monitor ammonia, nitrite, nitrate, dissolved oxygen, pH, temperature and alkalinity together.
- Provide adequate oxygen where nitrification is expected.
- Protect the biological treatment community from sudden toxic or hydraulic shocks.

PUROXI INSIGHT **Nitrification is a biological process with oxygen and alkalinity requirements—not an automatic reaction.**

CHAPTER 8

Nitrite and Nitrate Complete the Picture

Nitrite is an intermediate product and can be toxic even when ammonia begins to fall. Nitrate is generally less acutely toxic but can accumulate, contribute nutrients and create discharge or reuse concerns.

A falling ammonia value is not proof that the nitrogen problem has been resolved; it may have shifted into another form.

- Follow the complete nitrogen pathway.
- Check nitrite during startup, loading changes and treatment upset.
- Manage nitrate through plant uptake, denitrification, water exchange or other suitable treatment.

PUROXI INSIGHT **Successful ammonia conversion must be verified beyond the first step.**

CHAPTER 9

Aquaculture and Hatcheries

Fish and shellfish continually release nitrogenous waste. Feed, stocking density, temperature, pH, biofilter performance and water exchange determine whether ammonia accumulates. Species and life stages differ greatly in sensitivity.

Behaviour, feeding response and gill condition can provide warnings, but testing is essential because harmful conditions may exist before obvious signs appear.

- Use species-specific guidance and current local requirements.
- Increase sampling during heat, heavy feeding, biofilter startup or mortality events.
- Interpret TAN with pH, temperature, oxygen and salinity.

PUROXI INSIGHT **The correct limit belongs to the species, life stage and water conditions—not to a universal chart.**

CHAPTER 10

Wastewater and Effluent

Ammonia in wastewater reflects urine, proteins, industrial nitrogen and decomposition. Treatment performance depends on loading, sludge age, temperature, oxygen, alkalinity, pH and inhibitory substances.

Effluent impact depends on receiving-water pH, temperature, flow, dilution and sensitive aquatic life. Permit limits and compliance methods are jurisdiction-specific.

- Trend influent, process and effluent locations separately.
- Use oxygen and alkalinity data to diagnose nitrification decline.
- Do not substitute a field screening value for a required compliance method.

PUROXI INSIGHT **A treatment plant and its receiving water form one nitrogen-management pathway.**

CHAPTER 11

Agriculture Livestock and Irrigation

Manure, fertilizer and organic matter can contribute ammonia to water and soil. Ammonium may be retained by soil particles, converted by microbes, taken up by plants or lost through volatilization and runoff.

For livestock, ammonia results should be interpreted with nitrate, nitrite, sulfate, salinity, microbial quality, species, age and diet. Irrigation decisions also require soil, crop and nutrient-management context.

- Prevent manure and fertilizer entry into wells and surface water.
- Use laboratory nutrient analysis when water contributes meaningful nitrogen.
- Coordinate water results with agronomic and animal-nutrition advice.

PUROXI INSIGHT **Ammonia can be a nutrient, a process indicator or a hazard depending on concentration and context.**

CHAPTER 12

Drinking Water Sources and Distribution

Ammonia can enter source water naturally or through wastewater, agriculture and industrial activity. Some drinking-water systems intentionally use chloramination, where ammonia is combined with chlorine under controlled conditions.

Unexpected ammonia can increase disinfectant demand, complicate chloramine control and support nitrification within distribution systems. Safety and compliance decisions require the complete treatment context and applicable regulations.

- Distinguish intentional chloramination from uncontrolled ammonia intrusion.
- Monitor disinfectant residual, nitrite, nitrate and microbial indicators as required.
- Follow jurisdiction-specific drinking-water guidance.

PUROXI INSIGHT **The meaning of ammonia changes when it is part of a controlled treatment process.**

CHAPTER 13

Sampling and Measurement Practice

Ammonia can change after collection through biological activity, volatilization, contamination or improper preservation. Follow the laboratory's container, preservation, cooling and holding-time instructions.

Field kits and online sensors support screening and trends, while laboratory methods provide the basis needed for many regulatory and design decisions.

- Sample representative locations and record time, depth and operating condition.
- Measure pH and temperature at the sampling location.
- Use blanks, calibration checks and duplicate samples when data quality matters.

PUROXI INSIGHT A precise result is useful only when the sample still represents the water of interest.

CHAPTER 14

Treatment and Management Options

The correct response depends on source, concentration, flow, pH, temperature, salinity, biological sensitivity and discharge requirements. Treatment often combines source control, biological conversion and operational management.

Approach	Primary role and caution
Source control	Reduce feed, manure, sewage or process nitrogen entering the system.
Nitrification	Biologically converts ammonia; requires oxygen, alkalinity and suitable conditions.
Ion exchange	Can remove ammonium in selected waters; competing ions and regeneration matter.
Air stripping	Can remove NH3 at elevated pH; off-gas, safety and pH control require design.
Break-point chlorination	Oxidizes ammonia in controlled treatment; chemical demand and by-products matter.
Membranes	Some processes reject ammonium or ammonia depending on chemistry; concentrate remains.

PUROXI INSIGHT Treatment selection follows the nitrogen form, water chemistry and required outcome.

CHAPTER 15

Aeration Nano Bubbles and Oxygenation

Puroxi Nano Bubble Nozzles can improve gas transfer, circulation and oxygen distribution when correctly designed. This can support aerobic nitrification where oxygen transfer is limiting.

Aeration does not automatically remove TAN. At ordinary water pH, most ammonia nitrogen may remain as NH4+. Raising pH to promote stripping can also increase NH3 toxicity and requires engineered off-gas and safety control.

- Size oxygen transfer against actual demand and hydraulic conditions.
- Do not claim ammonia removal without before-and-after nitrogen testing.
- Combine oxygenation with appropriate biological treatment, solids management and monitoring.

PUROXI INSIGHT Oxygenation can support the biology that converts ammonia; it is not a universal ammonia-removal claim.

CHAPTER 16

Common Ammonia Myths

Ammonia is familiar, but shortcuts can create unsafe conclusions.

Myth	More accurate interpretation
One ammonia limit fits every water	Criteria depend on reporting basis, pH, temperature, species, duration and jurisdiction.
Ammonia and ammonium are identical	They coexist in equilibrium but differ in charge and biological behaviour.
A low TAN result is always safe	The NH3 fraction can rise as pH and temperature increase.
More aeration removes all ammonia	Aeration supports oxygen transfer; biological conversion or engineered stripping may be needed.
Falling ammonia means treatment is complete	Nitrite or nitrate may be accumulating.
A field meter replaces laboratory analysis	Field tools support operations but may not meet design or compliance requirements.

PUROXI INSIGHT **Ammonia is a system condition, not a stand-alone number.**

CHAPTER 17

A Practical Ammonia Decision Framework

Begin by defining the application and consequence of exposure. Then confirm the result before changing treatment.

- Confirm the analyte, unit, reporting basis and method.
- Measure pH, temperature, dissolved oxygen, alkalinity, nitrite and nitrate.
- Identify source, loading pattern, flow, depth and time of day.
- Use species-, process- and jurisdiction-specific criteria.
- Correct source and biological-process limitations before adding equipment.
- Select treatment for the actual nitrogen form and required outcome.
- Verify improvement with consistent post-treatment testing and trends.

PUROXI INSIGHT **Understanding Always Comes Before Recommendation.**

KEY LESSONS

- Ammonia in water exists mainly as NH3 and NH4+.
- TAN commonly measures both forms together as nitrogen.
- The reporting basis must be confirmed before values are compared.
- Higher pH and temperature increase the fraction present as un-ionized NH3.
- Nitrification consumes dissolved oxygen and alkalinity and produces nitrite then nitrate.
- Aquatic criteria depend on species, life stage, exposure and water conditions.
- Nano bubble oxygenation can support aerobic biology but does not automatically remove TAN.

The ammonia number becomes meaningful only when its form and water conditions are understood.

TECHNICAL REFERENCES

- U.S. Environmental Protection Agency. Aquatic Life Ambient Water Quality Criteria for Ammonia Freshwater 2013.
- U.S. Environmental Protection Agency. CADDIS Ammonia. https://www.epa.gov/caddis/ammonia
- U.S. Geological Survey. Ammonia or Ammonium What Is the Difference. 2025.
- Environment and Climate Change Canada. Guideline for the Release of Ammonia Dissolved in Water Found in Wastewater Effluents.
- Food and Agriculture Organization of the United Nations. Aquaculture Water Quality and Ammonia Management.
- APHA AWWA WEF. Standard Methods for the Examination of Water and Wastewater ammonia methods.

Criteria, sampling methods and compliance requirements vary by jurisdiction, species and application. Current local requirements should be confirmed before targets or treatment decisions are established.

ABOUT THE PUROXI WATER SERIES

The Puroxi Water Series is an educational publication created to improve understanding of water through science, practical experience and thoughtful discussion. Each edition focuses on one important measurement or process and explains what it means, what it does not mean and how it should be interpreted in real applications.

PWS-012 Understanding Ammonia connects nitrogen chemistry with pH, temperature, dissolved oxygen, alkalinity, biological treatment and responsible water management.

UNDERSTANDING ALWAYS COMES BEFORE RECOMMENDATION.

Puroxi Pure Water Global Inc.
British Columbia, Canada
www.puroxi.com
info@puroxi.com