

Urea's Fate in Aquatic Environments

Introduction:

This document provides a brief summary of urea's impact on aquatic systems.

Degradation in Water:

As noted in table 1, urea degrades biotically to carbon dioxide and ammonia. The ammonia formed either:

- remain in solution (NH_3 and NH_4 species)
- convert biologically to other forms of nitrogen (NO_3 or N_2)
- volatilize into the air

The biodegradation of urea to the end products of CO_2 and NH_3 requires, in theory, the consumption of 0.27 mg of oxygen per mg of urea.¹

This oxygen demand assumes that the NH_3 does not further decompose to NO_3 . However, NH_3 produced from decomposing urea can further decompose in soil to nitrate (NO_3).

Table 1: Degradation Products in Water

Bacteria, with the help of the enzyme urease, can readily degrade urea according to the following schemes:

- $\text{H}_2\text{NCON}_2\text{H} (\text{urea}) + 2\text{H}_2\text{O} \Rightarrow 2\text{NH}_4 + \text{HCO}_3$
- $\text{NH}_4^+ \Rightarrow \text{NH}_3 (\text{g}) + \text{H}^+$
- $\text{HCO}_3 + \text{H}^+ \Rightarrow \text{CO}_2 (\text{g}) + \text{H}_2\text{O}$

Ammonia (NH_3) can further oxidize to nitrate (NO_3).

Toxicity of Ammonia:

The only degradation product with significant toxicity is ammonia (NH_3). Ammonia at very low concentrations can be toxic to aquatic animals, especially fish. For aquatic organisms, the principal toxic form of ammonia is the un-ionized species (NH_3), not the ammonium ion (NH_4^+). High pH and higher temperature promote more NH_3 formation.

The U.S. EPA has established an ammonia criterion² based on fish toxicity (coldwater fishes are more sensitive to ammonia than warmwater fishes). The EPA's ammonia criterion is often used to establish NPDES permit limits for ammonia.

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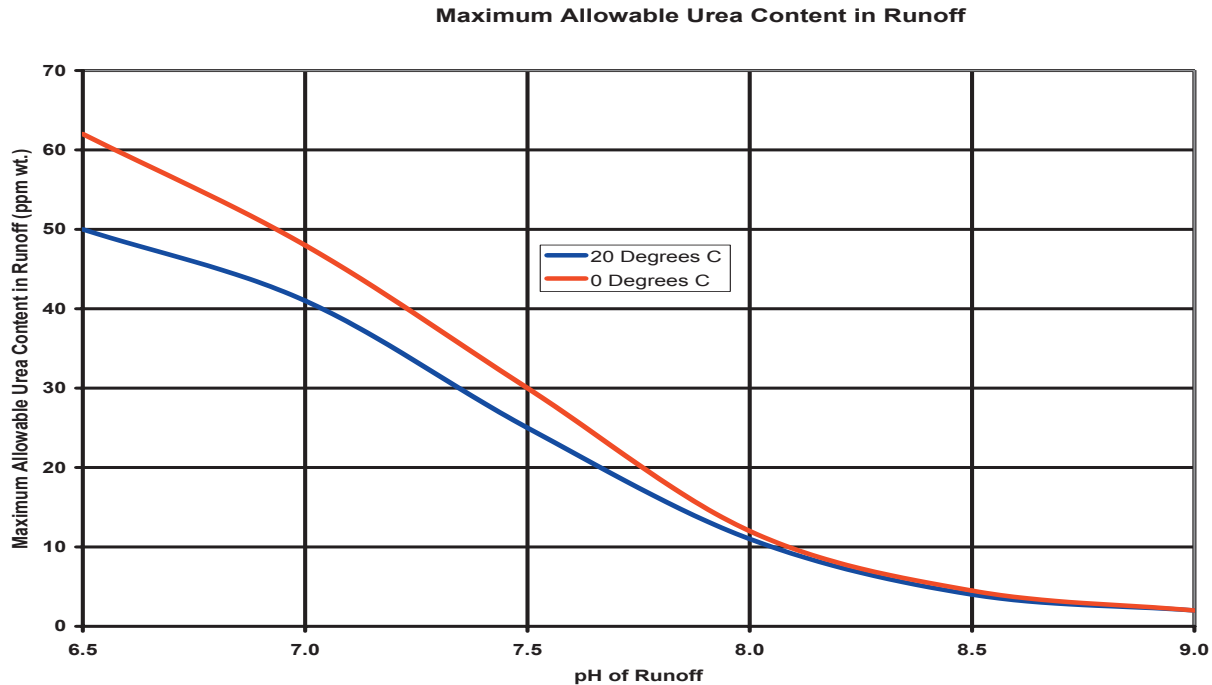


Figure 1: Maximum allowable urea content in runoff when Salmonids are present, assuming all urea decomposes to ammonia. Results derived from EPA's Maximum Ammonia Regulations. (U.S. EPA Reports 440/5-85-001.)

Figure 1 shows the maximum allowable urea content in runoff calculated from the EPA's criterion for ammonia.³ The maximum allowable urea concentration in runoff is quite low. For example, if the runoff temperature is 0°C with a pH of 7.5, the maximum allowable urea content is only 30 parts per million (ppm). Urea concentrations in runoff can exceed 1000 ppm.

Algae Stimulation:

Urea provides a key building block for algae - nitrogen. In aquatic systems that are nitrogen deficient, infiltration of urea can accelerate the formation of algae blooms. Large algae blooms can choke off oxygen fish and other aquatic animals.

Algae blooms can also lead to aesthetic problems (e.g. foul smells) for residents near the receiving waterway or lake.

Notes:

- 1: If the NH_3 further decomposes to nitrate (NO_3) the theoretical oxygen demand (TBOD) increases to 1.87 mg O_2 /mg of urea.
- 2: U.S. Environmental Protection Agency, "Quality Criteria for Water, 1986," Report No. EPA 440/5-86-001, U.S. EPA, Office of Water Regulation and Standards, Washington, DC, May 1, 1986.
- 3: This calculation assumes that all of the urea decomposes to ammonia. Studies show that urea completely degrades within 4 - 6 days in river water at 20°C, and at temperatures less than 8°C, negligible degradation occurs.