SRAC Publication No. 463

Southern Regional Aquaculture Center

June 1997
Revised

Ammonia in Fish Ponds

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Ammonia is the major end product in the breakdown of proteins in fish. Fish digest the protein in their feed and excrete ammonia through their gills and in their feces. The amount of ammonia excreted by fish varies with the amount of feed put into the pond or culture system, increasing as feeding rates increase. Ammonia also enters the pond from bacterial decomposition of organic matter such as uneaten feed or dead algae and aquatic plants.

Forms and toxicity

Total ammonia nitrogen (TAN) is composed of toxic (un-ionized) ammonia (NH_3) and nontoxic (ionized) ammonia (NH^+_4). Only a fraction of the TAN exists as toxic (un-ionized) ammonia, and a balance exists between it and the nontoxic ionized ammonia:

$$H^+ + (NH_3 \rightleftharpoons (NH^+_4)$$

The proportion of TAN in the toxic form increases as the temperature and pH of the water increase. For every pH increase of one unit, the amount of toxic un-ionized ammonia increases about 10 times. The amount of toxic un-ionized ammonia in your pond can be found by measuring the TAN with a water quality test kit and then looking up the fraction of TAN that is in the toxic form on Table 1, which is based on water temperature and pH. Multiply this fraction by the TAN to find the concentration (mg/L or ppm) of toxic un-ionized ammonia present in the water. For example, if water pH is 8.6, water temperature is 30°C, and TAN is 3 mg/L (ppm), multiply 0.2422 (from Table 1) by 3 mg/L (ppm) to obtain 0.73 mg/L (ppm) toxic un-ionized ammonia.

Uptake (assimilation) of ammonia by plankton algae is important in reducing the amount of ammonia coming in contact with fish. Ammonia increases in the fall and winter because of reduced algae populations in the pond and algae populations which are not as capable of taking ammonia from the water. Additionally, lower water temperatures slow down aerobic bacterial activity, thus slowing the nitrification process whereby ammonia is converted to harmless nitrate (Figure 1). Algae die-offs can also lead to very high ammonia concentrations, but, fortunately, the low pH associated with the disappearance of the algae reduces the proportion of toxic un-ionized ammonia present.

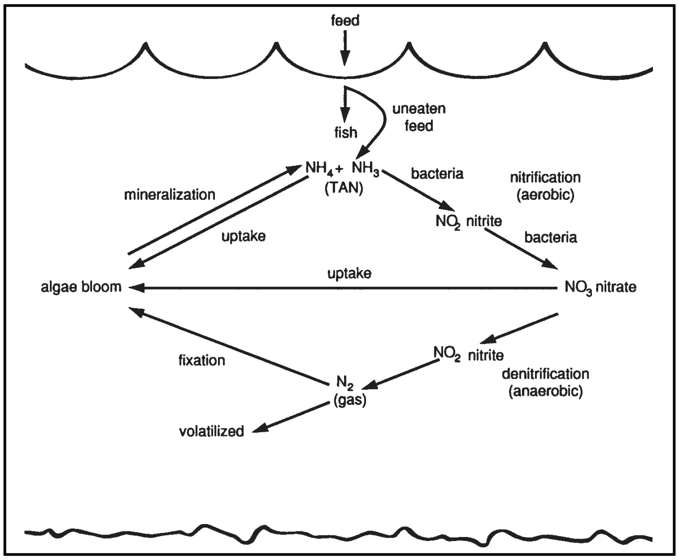

Figure 1. Nitrogen cycle in a fish pond.

Dangerous short-term levels of toxic un-ionized ammonia which are capable of killing fish over a few days start at about 0.6 mg/L (ppm). Chronic exposure to toxic un-ionized ammonia levels as low as 0.06 mg/L (ppm) can cause gill and kidney damage, reduction in growth, possible brain malfunc-

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tioning, and reduction in the oxygen-carrying capacity of the fish.

Treatments

Treatment for high TAN concentrations is difficult in large pond culture systems. Pumping fresh water into the pond is not a practical or economical means of reducing the ammonia level for the whole pond. It does, however, provide a small area near the inflowing water where fish can go to find some relief. Maintaining high dissolved oxygen levels by aeration will slightly reduce the toxic effect of un-ionized ammonia. In addition, TAN levels may be reduced through increased aerobic bacterial activity due to higher oxygen levels. Temporary reduction of feeding rates is recommended until TAN levels decrease to an acceptable level.

Prevention of high TAN is a better approach to the problem. The use of lower feeding rates and good feeding practices play a big role in keeping TAN levels low. Problems with high TAN concentrations can be expected when feeding rates exceed 100 pounds per acre per day, or when excessive feed waste is occurring. Fish should not be overfed, and the feeder should be sure that fish are consuming feed offered. This is both of practical and economic importance, since feed costs are a major portion of production costs.

With pond and tank stocking densities continually increasing, it is not often considered economically practical to reduce feeding rates. However, the organic loading in these systems is a major factor that must be dealt with. Intensive recirculating systems may be better suited to handle these excessive amounts of nitrogen, but most pond systems probably have a finite limit to the amount of nitrogen and organic loading that can be managed. Unless more efficient management methods are developed, nitrogen and organic loading may become a limiting factor in stocking and production rates in culture ponds.

Table 1. Fraction of toxic (un-ionized) ammonia in aqueous solutions at different pH values and temperatures. Calculated from data in Emerson, et al. (1975). (To determine the amount of un-ionized ammonia present, get the fraction of ammonia that is in the un-ionized form for a specific pH and temperature from the table. Multiply this fraction by the total ammonia nitrogen present in a sample to get the concentration in ppm (mg/L) of toxic (un-ionized) ammonia.)

	Temperatures (^{o}C)												
pH	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**26**	**28**	**30**
7.0	.0013	.0016	.0018	.0022	.0025	.0029	.0034	.0039	.0046	.0052	.0060	.0069	.0080
7.2	.0021	.0025	.0029	.0034	.0040	.0046	.0054	.0062	.0072	.0083	.0096	.0110	.0126
7.4	.0034	.0040	.0046	.0054	.0063	.0073	.0085	.0098	.0114	.0131	.0150	.0173	.0198
7.6	.0053	.0063	.0073	.0086	.0100	.0116	.0134	.0155	.0179	.0206	.0236	.0271	.0310
7.8	.0084	.0099	.0116	.0135	.0157	.0182	.0211	.0244	.0281	.0322	.0370	.0423	.0482
8.0	.0133	.0156	.0182	.0212	.0247	.0286	.0330	.0381	.0438	.0502	.0574	.0654	.0743
8.2	.0210	.0245	.0286	.0332	.0385	.0445	.0514	.0590	.0676	.0772	.0880	.0998	.1129
8.4	.0328	.0383	.0445	.0517	.0597	.0688	.0790	.0904	.1031	.1171	.1326	.1495	.1678
8.6	.0510	.0593	.0688	.0795	.0914	.1048	.1197	.1361	.1541	.1737	.1950	.2178	.2422
8.8	.0785	.0909	.1048	.1204	.1376	.1566	.1773	.1998	.2241	.2500	.2774	.3062	.3362
9.0	.1190	.1368	.1565	.1782	.2018	.2273	.2546	.2836	.3140	.3456	.3783	.4116	.4453
9.2	.1763	.2008	.2273	.2558	.2861	.3180	.3512	.3855	.4204	.4557	.4909	.5258	.5599
9.4	.2533	.2847	.3180	.3526	.3884	.4249	.4618	.4985	.5348	.5702	.6045	.6373	.6685
9.6	.3496	.3868	.4249	.4633	.5016	.5394	.5762	.6117	.6456	.6777	.7078	.7358	.7617
9.8	.4600	.5000	.5394	.5778	.6147	.6499	.6831	.7140	.7428	.7692	.7933	.8153	.8351
10.0	.5745	.6131	.6498	.6844	.7166	.7463	.7735	.7983	.8207	.8408	.8588	.8749	.8892
10.2	.6815	.7152	.7463	.7746	.8003	.8234	.8441	.8625	.8788	.8933	.9060	.9173	.9271

Source: Emerson, K., R.C. Russo, R.E. Lund, and R.V. Thurston. 1975. *Aqueous ammonia equilibrium calculations: effect of pH and temperature.* Journal of the Fisheries Research Board of Canada. 32:2379-2383.

The work reported in this publication was supported in part by the Southern Regional Aquaculture Center through Grant No. 94-38500-0045 from the United States Department of Agriculture, Cooperative States Research, Education, and Extension Service.