Ammonia and Nitrite in a Koi Pond

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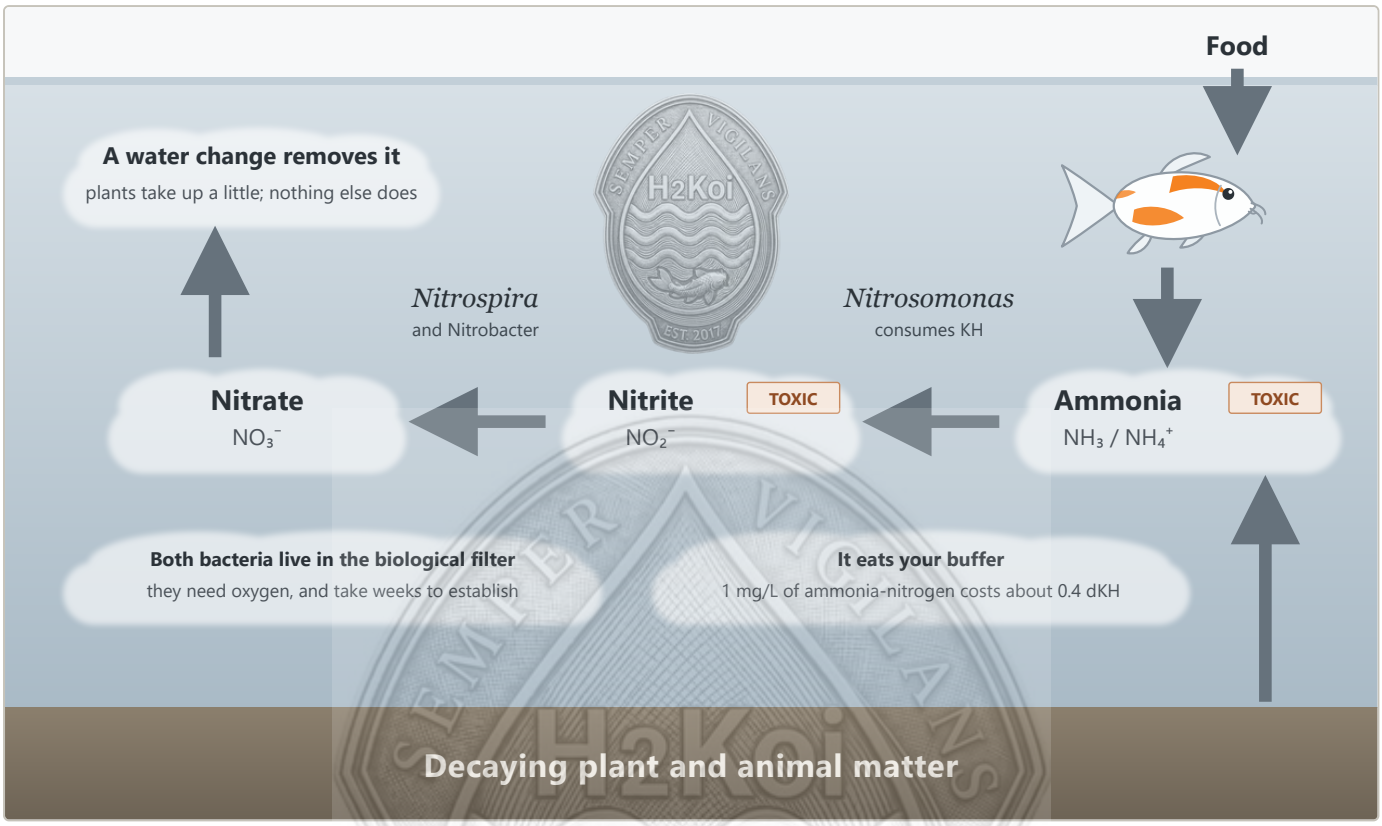
WATER CHEMISTRY

Ammonia and nitrite are the two numbers that can kill fish in a weekend. They are also the two most commonly misread, because an ammonia result on its own tells you almost nothing until you know the pH and the water temperature that go with it.

In short

- Fish excrete ammonia. Filter bacteria convert it to nitrite, then to nitrate. Both intermediate steps are toxic to koi.
- Your test kit reads total ammonia. Only part of that is free ammonia (NH3), the toxic form, and that share climbs steeply with higher pH and warmer water.
- The same 1.0 ppm reading is a non-event at pH 7.0 and 59 °F, and an emergency at pH 8.5 and 82 °F.
- Nitrite should read zero. It blocks the blood from carrying oxygen, and salt at the correct dose is the recognized protective measure while the filter recovers.

Where ammonia comes from, and what the filter is supposed to do with it



Where ammonia goes, and what it costs your buffer on the way.

Koi excrete ammonia continuously, mostly across the gills, as the direct waste product of digesting protein. Uneaten pellets and decaying organics add more. In a pond with a mature biofilter, two groups of bacteria handle it in sequence: one oxidizes ammonia to nitrite, a second oxidizes nitrite to nitrate. Nitrate accumulates until you dilute it out with a water change.

That chain only works if the bacteria are there in sufficient numbers, sitting on media with flow and oxygen across it. They are slow-growing. A new filter takes roughly four to eight weeks to build a population large enough for the stock in the pond, and that population is sized to the current feeding rate, not to what you might feed next month. The first step of that chain — ammonia to nitrite — consumes alkalinity, roughly 7 mg/L as calcium carbonate (about 0.4 dKH) for every 1 mg/L of ammonia nitrogen oxidized; the nitrite-to-nitrate step consumes none. That is why a hard-working new filter can quietly pull your buffer down toward a pH crash at the same time it is fighting an ammonia problem.

The number that matters is free ammonia, not total ammonia

This is the single most useful idea on this page. Total ammonia in water exists as two species in equilibrium: ammonium (NH4+), which is relatively harmless, and free or un-ionized ammonia (NH3), which is highly toxic. Your kit reports the sum of the two, usually as total ammonia nitrogen in ppm or mg/L. The split between them is set by pH and temperature, and it shifts far more sharply than most keepers expect.

Higher pH pushes the equilibrium toward free NH3. So does higher temperature. The two stack. The table below shows what percentage of a total ammonia reading is actually the toxic form.

PH	59 °F (15 °C)	68 °F (20 °C)	77 °F (25 °C)	82 °F (28 °C)
7.0	0.3%	0.4%	0.6%	0.7%
7.5	0.9%	1.2%	1.8%	2.2%
8.0	2.7%	3.8%	5.4%	6.5%
8.5	7.9%	11%	15%	18%
9.0	21%	28%	36%	41%

Work an example. Your kit reads 1.0 ppm total ammonia. At pH 7.0 and 59 °F that is about 0.003 ppm free ammonia, below the level anyone worries about. The same 1.0 ppm at pH 8.5 on an 82 °F August afternoon is about 0.18 ppm free ammonia, roughly sixty times higher, and firmly in the range that damages gills within hours. Nothing about the ammonia changed. The water around it did.

There is a seasonal trap hidden in this. Ponds with heavy plant or algae growth swing in pH across the day, often peaking mid-afternoon as photosynthesis strips carbon dioxide out of the water. If you test at seven in the morning at pH 7.6 and the pond runs to pH 8.7 by four in the afternoon, your morning result understated the afternoon risk by a wide margin. Stable carbonate hardness is what keeps that daily swing narrow, and US kits usually label it total alkalinity in ppm CaCO3 rather than KH. Around 100 to 150 ppm, or roughly 6 to 8 dKH, keeps most ponds steady.

Reading your kit without fooling yourself

Once you have converted total ammonia to free ammonia, the interpretation is straightforward.

FREE AMMONIA (MG/L)	WHAT IT MEANS	WHAT TO DO
Below 0.02	Background. A healthy filter keeps you here.	Normal running. Keep testing on your usual schedule.
0.02 to 0.05	Gill irritation over days. Growth and appetite suffer before you see anything.	Stop feeding. Find the cause. Partial water change.
0.05 to 0.20	Real gill and skin damage over hours to days.	Treat as urgent. Aerate, dilute, re-test every few hours.
Above 0.20	Acute. Expect visible distress and losses.	Emergency response. Large staged water changes.

Two practical notes on kits. First, ammonia test kits come in two chemistries, and they behave differently if you have dosed an ammonia-binding product: a Nessler reagent will still show the bound ammonia, while a salicylate kit generally will not. Neither is wrong, but you should know which one is in your hand before you panic or relax. Second, liquid reagents expire. A kit that has been in a shed through two summers is not a reference standard.

> The classic misread runs like this: a keeper sees ammonia present, reads that low pH reduces its toxicity, and deliberately drops the pH. It does reduce free ammonia, but it also slows the nitrifying bacteria that are your only real way out, and if alkalinity is already thin the pH will not stop where you wanted it. Dilute the ammonia with clean water instead of chasing pH downward.

Nitrite, brown blood, and why salt buys you time

Nitrite is the middle step, and the target is zero. It crosses the gills and binds to hemoglobin, converting it to methemoglobin, which cannot carry oxygen. The blood turns brown, which is where keepers get the name brown blood disease. The fish suffocates in water that may test perfectly well for dissolved oxygen, because the problem is not the water, it is the blood. Fish gasping at the surface with a good DO reading and no visible parasites should send you straight to the nitrite test.

Salt is the recognized protective measure. Chloride competes with nitrite for the same uptake pathway at the gill, so adding sodium chloride blocks nitrite from being absorbed while your filter catches up. Around 0.1% (roughly one pound of pond-grade or solar salt per 120 gallons) is the usual protective level, calculated against your actual measured volume, dissolved in a bucket first and added over several hours rather than dumped in. Salt does not remove nitrite or fix the filter. It protects the fish while you do.

Two honest caveats. Salt at higher doses stresses the same biofilter you are trying to rebuild, and it interacts with some medications and with most pond plants. And because salt does not evaporate, it only leaves through water changes, so track how much is already in there before you add more.

Nitrate, and why it is a different kind of number

Nitrate is the end of the chain and is far less toxic than either precursor. Koi tolerate levels that would be alarming for ammonia by two or three orders of magnitude. It is still worth watching, because a slowly climbing nitrate is an honest record of accumulated load: how much you are feeding, how many fish you carry, and how little fresh water you have put in lately. Water changes are the only practical way down. If nitrate is climbing and you have not changed water in a month, the pond is telling you something before any emergency shows up.

What causes a spike

Ammonia and nitrite almost never rise for mysterious reasons. In practice it is one of a short list, and knowing which one tells you how long the recovery will take.

TRIGGER	WHAT YOU TYPICALLY SEE	NOTES
New or immature filter	Ammonia rises first, then falls as nitrite rises, then both clear	Four to eight weeks. Feed lightly and stock slowly.
Filter media rinsed in tap water	Ammonia within a day or two of the cleaning	Chlorine kills the bacteria. Rinse in pond water only.

TRIGGER	WHAT YOU TYPICALLY SEE	NOTES
Medication or a heavy salt dose	Ammonia mid-treatment or shortly after	Many treatments are hard on the biofilter. Test daily during any course.
Overfeeding	Gradual rise, often after a warm spell or a new food	The filter is sized to the old feeding rate, not the new one.
A dead fish or trapped organics	Sudden rise with no change in routine	Check skimmers, bottom drains, and under rocks and liner folds.
Power outage or pump failure	Rise starting hours after flow stopped	Media without flow goes anaerobic and dies back quickly.
Adding several fish at once	Rise within days of the new arrivals	Bacteria populations take weeks to scale to a new bioload.

What to do when the reading comes back high

1. Stop feeding entirely. No ammonia goes in that does not come from food. Koi are comfortable without feeding for a week or more.
2. Test pH and temperature alongside the ammonia, and convert to free ammonia. This is what tells you whether you have hours or days.
3. Increase aeration. Damaged gills work less well, and nitrite compounds the shortfall. An extra air stone or a redirected return costs nothing.
4. Do partial water changes with dechlorinated water, matched for temperature. Twenty to thirty percent, repeated, is safer than one dramatic change.
5. Leave the filter alone. Do not clean it, do not backwash aggressively, do not swap media. You are trying to grow the bacteria, not remove them.
6. If nitrite is present, bring salt to a protective level as described above.
7. Re-test every few hours at first, then daily, and keep going until you have two clean results in a row.

> Any water you add must be dechlorinated. Chloramine, used by many US municipal systems, is not removed by standing water or aeration and requires an appropriate conditioner. Adding untreated tap water during an ammonia event kills the surviving bacteria and turns a bad week into a much longer one.

Why testing on Saturday morning leaves a gap

Most keepers test on a schedule, and a good schedule is genuinely valuable. The difficulty is what happens between tests. A pump that fails Monday evening, a fish that dies behind the skimmer on Tuesday, a filter rinsed a little too thoroughly on Wednesday: all of these have several days to develop before the next test strip goes in the water. By then you are not catching a rising trend, you are managing a mature event with visible fish behavior.

The pH and temperature problem compounds this. A single weekly result records one moment in a parameter that moves through every day. Two ponds with identical logbooks can be running very different afternoon risk, and the logbook will not show it.

> **What H2Koi does, and what it does not.** The sonde sits in the pond and measures continuously. Directly measured: temperature, pH, dissolved oxygen in mg/L and percent saturation, conductivity, turbidity, ammonium (NH4), and nitrate (NO3). ORP is available as an option. Derived from those measurements: free ammonia (NH3), nitrite, carbonate hardness on a 0 to 20 dKH scale, salinity, TDS. That distinction matters on this page in particular. NH3 is computed from the measured ammonium together with pH and temperature, which is exactly the calculation this article asks you to do by hand, run continuously instead of weekly. Nitrite and KH are likewise derived figures, not titrations, and general hardness (GH) is not reported at all. A self-cleaning wiper keeps the optical sensors clear. What this gives you is continuous early warning from industrial-grade sensors. It does not detect disease or parasites, and it will not stop a spike from occurring. It shortens the time between something going wrong and you knowing about it. We also build bespoke automated water change systems for ponds that need them; we have never found another system that does it, and neither have our clients.

Common questions

What should ammonia and nitrite be in a koi pond?

Both should read zero on a normal test kit in an established pond. Any detectable nitrite is worth acting on. For ammonia, convert your total reading to free ammonia using pH and temperature before deciding how urgent it is; below 0.02 mg/L free ammonia is the range you want to live in.

Is 0.25 ppm ammonia bad for koi?

It depends entirely on your pH and temperature. At pH 7.0 and 60 °F, 0.25 ppm total ammonia is well under 0.001 mg/L free ammonia and is not an emergency, though it does tell you the filter is not keeping up. At pH 8.5 and 82 °F, the same reading is about 0.045 mg/L free ammonia and needs attention that day. This is why 0.25 ppm on its own is an unanswerable question.

How long does a new pond take to cycle?

Typically four to eight weeks with fish present, longer in cold water because the bacteria are temperature-dependent. Expect ammonia to rise and fall first, then nitrite to rise and fall, then both to settle at zero with nitrate appearing. Stock lightly, feed sparingly, and test daily through the process.

Why did my ammonia spike right after I cleaned the filter?

Almost certainly because the media was rinsed in chlorinated tap water, which kills the nitrifying bacteria living on it. Filter media should only ever be rinsed in pond water, and only enough to restore flow. The same happens if you replace too much media at once, or if a pump outage left the media without oxygenated flow for several hours.

How much salt do I add for nitrite in a koi pond?

Around 0.1%, which is roughly one pound of pond-grade or solar salt per 120 gallons, calculated against a genuine measurement of your pond volume rather than an estimate. Dissolve it in pond water first and add it in stages over several hours. Salt protects the fish from nitrite uptake; it does not remove nitrite or repair the filter.

Do ammonia detoxifiers actually work?

Binding products convert free ammonia to a less toxic form and can be a reasonable bridge during an emergency, but the nitrogen is still in the pond and your filter still has to process it. They are a way to buy hours, not a solution. Be aware that a Nessler-type test kit will still register the bound ammonia while a salicylate kit typically will not, so check which chemistry you are using before you read the result.

My koi are gasping at the surface. Is it ammonia?

It may be, but gasping has several causes and they need separating. Check dissolved oxygen first, then nitrite, then free ammonia, then look for gill parasites. Nitrite is the one that catches people out, because it starves the fish of oxygen while the water itself tests as well oxygenated. Red or inflamed gills, clamped fins, excess slime, and fish hanging near the returns all point toward a water quality cause rather than a disease cause.
