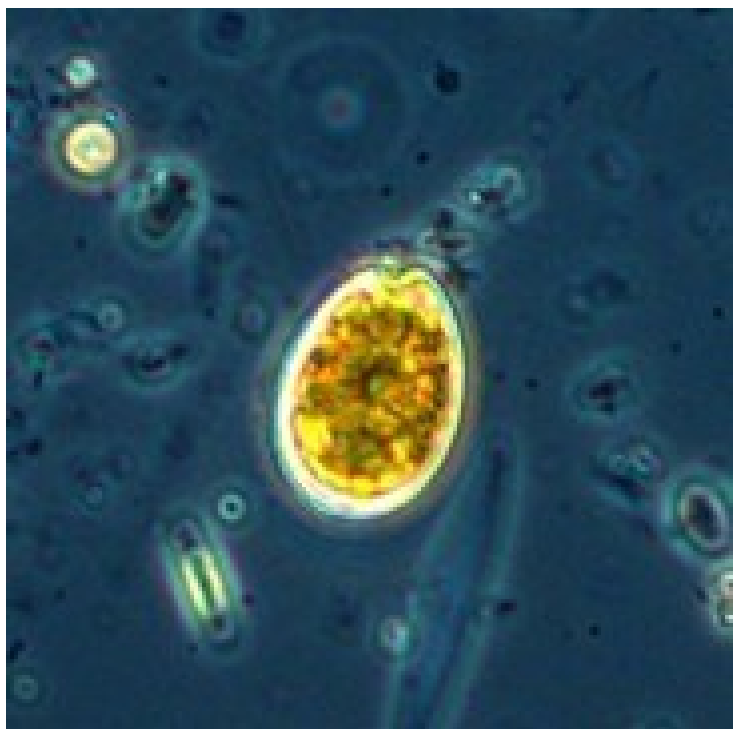


Incheon National University researchers uncover hidden toxin risks during nutrient-starved algal blooms

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Researchers from Incheon National University have discovered that prolonged nutrient depletion can significantly increase toxin production in harmful marine algae even when growth appears stable. Although nutrient starvation reduced photosynthetic efficiency, toxin levels continued to rise, revealing a hidden risk phase of harmful algal blooms.

Harmful algal blooms continue to threaten coastal ecosystems and seafood safety worldwide. Among the organisms involved, the benthic dinoflagellate *Prorocentrum lima* is a known producer of diarrhetic shellfish poisoning toxins such as okadaic acid and dinophysistoxin 1. While earlier studies have linked low nutrient availability to increased toxin production, most have examined short-term stress responses. The effects of prolonged nutrient depletion on algal physiology and toxin accumulation remain less clearly understood.

Now, researchers from Incheon National University, led by Professor Jang K. Kim have shown that extended nutrient deprivation can significantly increase toxin content per cell in *P. lima*, even when cell numbers remain relatively stable. Their findings suggest that toxin risk may increase quietly under nutrient-poor conditions without obvious bloom expansion. This paper was made available online on 21 July 2025 and was published in Volume 149 of the *Harmful Algae* journal on 01 November 2025. "We aim to observe changes in growth, photosynthetic efficiency, and toxin production in *P. lima* during the

nutrient depletion period," said Prof. Kim.

In this study, *P. lima* cultures were grown under nutrient-enriched conditions until they reached the stationary growth phase. At that point, nutrient supply was stopped, and the cultures were monitored for thirty days. The team measured changes in cell density, nutrient uptake, photosynthetic performance, pigment content, and intracellular toxin levels throughout the depletion period. Within just three hours of the final nutrient addition, the algae removed more than ninety per cent of nitrate and nitrite from the medium. Phosphate levels were also rapidly depleted. Despite the absence of further nutrient input, cell density continued to increase slightly over the following month, indicating that the algae were able to sustain growth using internally stored nutrients.

Physiological measurements revealed a more complex response beneath this apparent stability. Chlorophyll a and carotenoid concentrations showed no significant change during nutrient depletion. In contrast, key indicators of photosynthetic efficiency declined markedly over time. Maximum electron transport rate, light saturation thresholds, and relative electron transport rates were all significantly lower after thirty days, suggesting reduced photosynthetic capacity under prolonged nutrient stress. Toxin production showed the most pronounced response. Okadaic acid levels per cell increased more than threefold over the nutrient depletion period. Dinophysistoxin 1 concentrations also rose steadily, more than doubling by the end of the experiment. These toxin levels were substantially higher than those reported in many previous studies conducted under shorter or less severe nutrient limitation.

According to the researchers, the accumulation of toxins may be linked to reduced cell division during the stationary phase. As growth slows, toxins may continue to be synthesised and retained within cells rather than being diluted through cell division.