Doug Soldat's Cornflakes

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Laboratory: Whitman Soil Ecology

Dr. Doug Soldat gave me a sample of algae he suspects may be the source of the dried "cornflakes" that clog the small pipes on golf courses each year. Managers' practice is purging the pipes, out of which eject white-to-yellow flakes. Are the cornflakes and algae related?

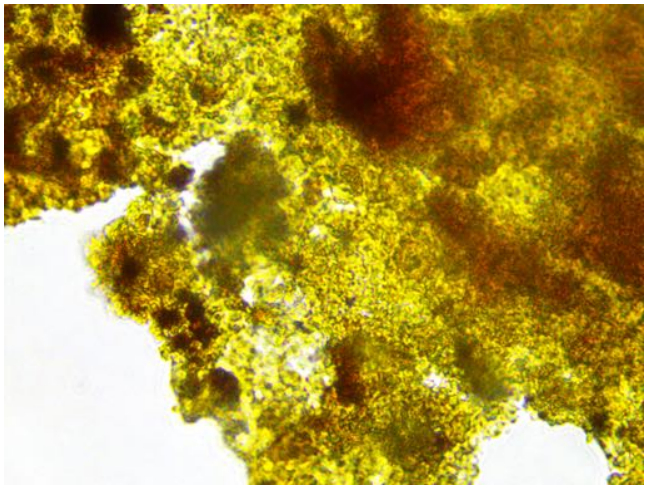
Micrographs suggest the algae is a mix of green algae (Chlorophyta: Desmodesmus, Pediastrum, Euglena, etc.) and golden algae (Stramenopiles: Fragillaria, Cymbella, Asterionella, etc.) in greatest density. Green algae leave little to no residue after decomposition, but many unicellular green algae are mixotrophic, which would persist alive in pipes. Gold algae create silica-rich armor (frustules) that persist in aqueous environments after death, but they are phototrophic. Also viewable were several protists, such as Chlamydomonas, and many motile bacteria of bacillus and spirella shapes.

A mix of gold and green algae:

Live Desmodesmus:

No frustules could be seen in the microscopic analysis of pulverized flakes in DI water. Yellow-to-orange color would suggest stable organic matter, possibly residues of bleached cellulose or fucoxanthin, the accessory pigment that gives golden algae their color. This is unlikely as it is poorly resistant to attack, but being trapped in calcite would protect these polymers from enzymatic degradation. The pale grey particles in the micrographs suggest sands and silts, and the white color of the cornflake material suggests calcite.

Thin section of partially pulverized "cornflakes":



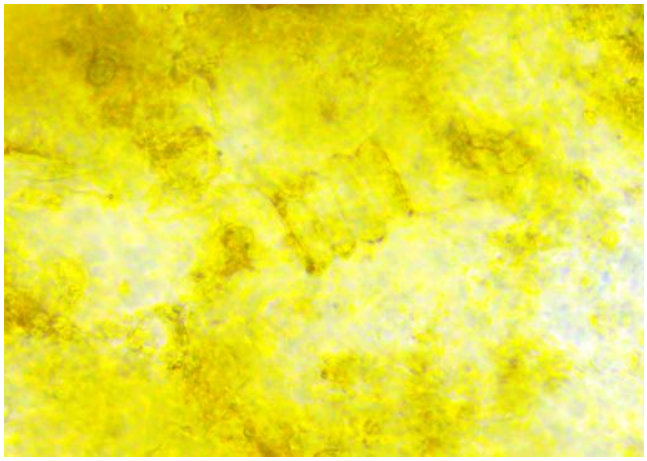
An acid bath (5% acetic acid) showed strong effervescence, suggesting a calcium-rich matrix is holding the chemically mixed material together.

Immediate reaction:

After 24 hours:

The acid bath (24 hours) did not dissolve/react all material. Micrographs from what was left behind showed a lot of organic matter, which held the flakes together despite the long-term saturation. Some bodies of algae, both greens and possibly golds, could be seen.

Remnant body of Desmodesmus:



I would conclude that the cornflakes are the product of organic matter decomposing as calcite also deposits in the pipes. Photosystems were likely still running for a few days in the thylakoids of the algal plastids as they died in the pipes, and this activity would deposit calcite by continuing to alkalize the aqueous solutions, in large part by depleting CO2.

I'd recommend adding a dilute acid solution to the water passing through the pipes when cleaning, leaving it to effervesce a few hours, then ejecting. This would likely be effective to (1) prevent the deposition of this calcite-OM material and (2) to fully clean the interior surfaces of pipes each year. Degradation of the pipes in this process is unlikely. Prevention of algal deposition is nearly impossible, given the nutrient load to the waters that feed these algae. I was most surprised that the algal sample provided had so little visible cyanobacteria, but it is possible the sampler only sampled open water and therefore only plankton and did not scrape the rocks, which would likely have yielded a typical filamentous algal-cyanobacterial mat.

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