December 2021

Monosulfidic black oozes are anoxic and alter nutrient cycles

Image - Left: Monosulfidic black ooze in a sediment core sample from the Coorong South Lagoon (Photo: Luke Mosley)
Right: Unhealthy Monosulfidic black ooze sediments in the Coorong (Photo: Luke Mosley)

Monosulfidic black oozes are black, organic and sulfide rich sediments. They have formed over large areas of the Southern Coorong under anoxic sediment conditions that are created when thick algal mats and dead phytoplankton decompose.

Decomposing algal mats have very high levels of organic carbon and nitrogen. Bacteria use all the oxygen to decompose the organic matter and so the sediments become anoxic. Monosulfidic black oozes (MBOs) form when there is no oxygen for aerobic bacteria to break down organic matter and instead anaerobic bacteria convert iron oxide and sulfate in the sediment and water to hydrogen sulfide and iron monosulfide. Hydrogen sulfide is a foul-smelling gas, often referred to as “rotten egg gas” and is often smelled when sediment in the Southern Coorong is disturbed.

When monosulfidic black oozes form, the sediments can become completely uninhabitable for aquatic plants and macroinvertebrates. The high sulfide concentrations can cause sulfide intrusion into the roots of aquatic plants, reducing plant growth rates and contributing to die-off events. Low dissolved oxygen and high hydrogen sulfide levels also make conditions inhospitable for most benthic (bottom-dwelling) macroinvertebrates. Aquatic plants and macroinvertebrates can help to oxygenate sediment, but because they cannot inhabit monosulfidic black oozes, the impacts to the nutrient cycle are further fuelled by their absence.

Monosulfidic black oozes have formed in large quantities because the Southern Coorong has persisted in a hyper-eutrophic state. Excessive organic matter and anoxic conditions, coupled with very high salinity, impair nutrient cycling and make the sediment uninhabitable for many organisms, which further fuels eutrophication. Project Coorong is investigating the ways in which export of nutrients, algae and salt can be increased to restore a desired healthier state.

Further reading:

Mosley, L., S. Priestley, J. Brookes, S. Dittmann, J. Farkas, M. Farrell, A. J. P. Ferguson, M. Gibbs, M. Hipsey, J. Huang, O. Lam-Gordillo, S. Simpson, P. Teasdale, J. Tyler, M. Waycott, and D. Welsh. 2020. Coorong water quality synthesis with a focus on the drivers of eutrophication. Goyder Institute for Water Research, Adelaide.

Acknowledgements

The Healthy Coorong, Healthy Basin Action Plan is part of the South Australian Government’s overarching Project Coorong initiative.

This project is part of the South Australian Government’s Healthy Coorong, Healthy Basin Program, which is jointly funded by the Australian and South Australian governments.

The Goyder Institute for Water Research is the delivery partner for research components of Healthy Coorong, Healthy Basin, providing independent research to inform future management decisions for the region.

Glossary

Ammonium — A dissolved form of nitrogen readily taken up by algae and aquatic plants.

Anoxic — Lacking oxygen.

Aquatic plants — A phrase used to describe the mixed submerged aquatic plant community that includes *Ruppia tuberosa, Ruppia megacarpa* and *Althenia cylindrocarpa*. Where otherwise stated, the phrasing will be referring to either species independently or the genus.

Bacteria — A unicellular microorganism with simple internal structures.

Bioturbation — The reworking of sediments by animal activities including burrowing, ingestion, and defecation of sediment grains. It has a profound effect on sediment condition and the environment.

Connectivity — A mechanism that allows for the movement of water, materials and animals between areas, including between the north and south lagoons of the Coorong, between the sea and the Coorong through the Murray Mouth, and from the River Murray or south east flows to the Coorong (but not typically vice versa). It is an important element of hydrodynamics, has a strong influence on water quality (through exchange of salt and nutrients) and is essential for some ecological processes, such as migration of fish at different times of year and for the transport of zooplankton from freshwater inflows to support food webs of the Coorong.

Detritivore — An animal that feeds on dead material, especially plant parts.

Denitrification — The process by which nitrate is converted to nitrogen gas bubbles, which are released to the atmosphere. If the sediment is anoxic, then nitrification-denitrification cannot occur and the nitrogen remains in the nutrient cycle.

Eutrophication — The process of nutrient enrichment and the increase in the supply of organic matter. Eutrophic systems typically have excessive plant and algal growth, which become internally produced organic matter loads as they decay. They grow excessively in response to nutrient enrichment such as nitrogen and phosphorus inputs. Eutrophication has cascading effects for the entire ecosystem. The hyper-eutrophic state in the Southern Coorong is characterised by high concentrations of chlorophyll-a (>50 mg/L), total nitrogen (>4 mg/L) and total phosphorus (>0.2 mg/L) in the water.

Evapo-concentration — The concentration of solutes such as salt and contaminants as water evaporates. The effects of evapo-concentration increase with increasing water residence time, and at higher temperatures in summer.

Filamentous algae — The green filamentous algal community which occurs in the Coorong, consisting of *Ulva paradoxa, Rhizoclonium sp*. and *Cladophora sp.*.

Herbivore — An animal that eats plants.

Hyper-eutrophic — An extremely high-nutrient state due to eutrophication.

Hyper-saline — Salinities that are greater than that of normal seawater.

Macroinvertebrate — Invertebrate fauna that are greater than 0.5 mm.

Mesotrophic — Intermediate levels of nutrients, common in healthy estuaries. A mesotrophic Coorong would be fairly productive (with plant and animal life), but could be at risk of having water quality problems.

Millennium Drought — An Australian drought which impacted the Murray-Darling Basin over the period 1996–2010, and substantially impacted the Coorong over the period 2001–2010. The period from 2007–2010 was particularly extreme with extended periods of no flow through the barrages to the Coorong.

Monosulfidic black oozes — Monosulfidic black oozes (MBOs) form when there is an excess of organic matter, and sediments become anoxic as the bacteria consume all the oxygen to decompose the organic matter. Iron (III) and sulfate are converted by bacteria to iron (II) and hydrogen sulfide, because there is no oxygen. The iron typically comes from iron oxide minerals in the sediment that are reduced, whereas sulfate comes from water (it is plentiful in seawater and saline groundwaters)

Nitrogen — A nutrient that is essential to plants and animals and forms compounds such as amino acids and proteins. Nitrogen can be found in aquatic environments in dissolved, particulate, inorganic, organic and gaseous forms. Too much nitrogen can be associated with eutrophication.

Nitrate — A dissolved form of nitrogen.

Glossary

Nitrification — Nitrification is the process by which ammonium is converted to nitrite and then nitrate. It can also take place in the sediment and requires oxygen. Denitrification is the process by which nitrate is converted to nitrogen gas bubbles, which are released to the atmosphere. If the sediment is anoxic, then nitrification-denitrification cannot occur and the nitrogen remains in the nutrient cycle.

Nutrient cycle — The movement or exchange of nutrients, such as nitrogen, from inorganic and organic forms into organic matter, including plants and animals, and back again.

Oxygenate — Supply or enrich with oxygen. Sediments in aquatic systems need to be oxygenated in order for healthy nutrient cycling and nutrient exchange from sediment to water and to the atmosphere to occur. Oxygenation of sediments can occur through biological processes (e.g. animal movement, pumping through plant roots), or physical processes such as water turbulence and currents moving sediments around.

Phosphorus — A nutrient essential to life and strongly influencing water and sediment quality in the Coorong. Phosphate is the dissolved form of phosphorus, which is uptaken by plants and algae.

Photosynthesis(e) — The conversion of light energy to organic compounds, can be referred to as carbon fixation.

Phytoplankton — Small plankton algae that is essential to aquatic food webs.

Respiration — Respiration is a chemical reaction which takes place in all livings cells and releases energy from glucose. Anaerobic respiration occurs without oxygen and releases less energy but more quickly than aerobic respiration.

Ruppia — A genus of aquatic plant, referring to the species *Ruppia tuberosa* in the Southern Coorong.

Salinity — Salinity can be defined as the concentration of dissolved mineral salts present in waters and soils on a unit volume or weight basis.

Southern Coorong - The Southern Coorong is defined here as the area ranging from Parnka Point in the north and south to 42 Mile Crossing, approximately 65 to 105 km from the Murray Mouth that connects the estuary to the sea.

Turion — Reproductive structure of *Ruppia tuberosa* (Type I and Type II) and *R. polycarpa* (Type I) produced underground that is capable of forming into a new plant

Water quality — The condition of water or some water-related resource as measured by biological surveys, habitat-quality assessments, chemical-specific analyses of pollutants in water bodies, and toxicity tests.

Zooplankton — Animals (often microscopic) that either move by water currents or are weak swimmers in the water column.

Acknowledgements

The Healthy Coorong, Healthy Basin Action Plan is part of the South Australian Government's overarching Project Coorong initiative.

This project is part of the South Australian Government's Healthy Coorong, Healthy Basin Program, which is jointly funded by the Australian and South Australian governments.

The Goyder Institute for Water Research is the delivery partner for research components of Healthy Coorong, Healthy Basin, providing independent research to inform future management decisions for the region.