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Yes, they can! First proof of bacterial manganese(IV) oxide use for survival near H₂S “dead zone”

The Black Sea, with its permanent stratification, large oxygen-free water masses and extensive zones of toxic hydrogen sulphide (H₂S), is an excellent natural laboratory to study survival strategies of specialised organisms in such a hostile environment. Microbiologist Jan Henkel from the Leibniz Institute for Baltic Sea Research Warnemünde (IOW) and colleagues have investigated how bacteria are nevertheless able to grow there. The researchers now for the first time present proof in the renowned scientific journal PNAS that a bacterium that frequently occurs near the “dead zone” specifically uses manganese(IV) oxide to gain metabolic energy from H₂S and convert it into non-toxic sulphate.*

90% of the Black Sea is uninhabitable to life that depends on oxygen respiration. Only the uppermost 100 to 150 metres of the water column, which is on average 1250 metres deep, can be supplied with oxygen from the atmosphere via mixing. Underneath lies the world's largest anoxic sea basin, in which all dissolved oxygen is consumed by decomposition processes and highly toxic H₂S is formed. Such extensive hostile environmental conditions have developed, because twice as much freshwater flows into the almost completely landlocked sea via rivers as oceanic salt water from the Mediterranean Sea via the narrow connections of the Bosphorus and the Sea of Marmara. As a result, an extremely stable stratification is formed in which lighter, low salinity surface water (approx. 17 ‰ salt content) lies like a lid on saltier and thus denser deep water layers (with 38-39 ‰ salt content) and thus largely prevents vertical exchange.

At the upper boundary of this huge lightless “dead zone”, in the so-called suboxic zone, which is often many meters thick and no longer contains oxygen but is free of toxic H₂S, a surprising amount of life “rages”: Here a high metabolic activity of bacteria can be detected, which build up their own organic cell material from carbon dioxide and other inorganic substances – thus carrying out primary production. However, the type of energy metabolism that makes this possible under the given environmental conditions has been unknown until now. Scientists have long suspected that in the absence of oxygen or other electron acceptors, such as nitrate (NO₃⁻), manganese dioxide (MnO₂) plays this role and enables the transformation of H₂S into sulphate (SO₄²⁻), thereby providing the necessary energy for cell growth. Nevertheless, all attempts have failed to cultivate microorganisms from the suboxic layer of the Black Sea that indeed oxidise H₂S with MnO₂.

Jan Henkel from the IOW's geomicrobiology working group and his colleagues have now succeeded for the first time to isolate a bacterium from a water sample of the suboxic zone that was taken at a depth of 105 metres during a Black Sea expedition in 2013 with the research vessel “Maria S. Merian”. The bacterium performs exactly the long assumed but never proven metabolic reaction. Genetic analyses showed that it belongs to the genus *Sulfurimonas*, which typically occurs with high cell numbers in the immediate vicinity of sulfidic environments. Its closest relative is the bacterium *Sulfurimonas gotlandica*, which uses nitrate to oxidise toxic H₂S to obtain energy and is commonly found at the edge of the oxygen-free dead zones of the Baltic Sea.

“The newly isolated bacterial strain was named after its discovery site ‘*Sulfurimonas marisnigri*’, which means ‘*Sulfurimonas* from the Black Sea’,” Jan Henkel explains the naming of his newly discovered ‘lab pet’. “For me, it is especially fascinating that after 30 years of unsuccessful searches, with a little luck, these special bacteria could be found exactly where researchers suspected them to be even before I was born,” the young scientist continues. *S. marisnigri* has very specifically adapted to the conditions close to the Black Sea dead zone, which is so harmful to higher organisms, and has thereby succeeded in tapping into a very rich energy source that no one else uses, Henkel explains. “So far, no other bacterium is known that is able to oxidise H₂S in the absence of oxygen, nitrate or light. Furthermore, compared to other manganese-reducing bacteria that depend on organic compounds, we are possibly also dealing with a completely unknown system of electron transfer.” The aim of future studies will be to investigate this system in more detail in order to better understand the enormous efficiency, with which these bacteria oxidise H₂S. “We may be dealing here with an ecological key metabolism that contributes significantly to the formation of the suboxic zone and the H₂S detoxification of the Black Sea, so that it remains habitable for higher organisms,” Henkel concludes.

Original publication:

Jan V. Henkel, Olaf Dellwig, Falk Pollehne, Daniel P. R. Herlemann, Thomas Leipe, Heide N. Schulz-Vogt (2019): *A bacterial isolate from the Black Sea oxidizes sulphide with manganese(IV) oxide. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, <https://doi.org/10.1073/pnas.1906000116>

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