Organic solids in soil may speed up bacterial breathing

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The "mineral-breathing" bacteria found in many oxygen-free environments may be "carbon-breathing" as well.

Oxygen-free, or anaerobic, environments contain microbes sometimes described as "mineral-breathing" because they use iron oxides and other minerals in the same way we use oxygen. According to a study published online May 23 in the journal *Nature Geoscience*, this bacterial respiration may be accelerated by solid organic compounds in the soil.

Led by University of Wisconsin-Madison geoscientist Eric Roden, the new work shows that iron oxide-breathing bacteria can do the same with insoluble organic substances, formed when plants and other organic materials biodegrade in soils and sediments. During respiration, the bacteria release electrons that interact with nearby substances, a process called reduction. Reduction of large organic molecules - called humics and familiar to gardeners as part of planting soil - represents a new pathway for electrical charges to move around in the environment, with implications for understanding soil chemistry and environmental contamination.

"The reason this is so important is that when the humic substances are reduced - that is, when they go from having less electrons to having more electrons - they are very reactive with other things, in particular iron oxides," says Roden, an expert on sediment geochemistry and microbiology.

Iron is both highly reactive and very abundant on Earth, making it a key element for understanding the chemistry, biology, and geology of natural environments.

"All kinds of things follow iron oxides - organic contaminants, inorganic contaminants, energy flow, mineral transformations on Earth, speculation about possible iron-based microbial life on other worlds," Roden says. Insoluble organic compounds in the soil are a "player in that whole picture that no one had recognized before."

Similar reactions had previously been described with dissolved organic compounds, Roden says, but insoluble ones likely play a larger role in natural environments. "Most of the organic material in soil and sediment is not in solution. It's the gunk at the bottom of the lake, the dirt, the muck in the wetlands."

He and colleagues in Madison and Germany analyzed the insoluble humics by adapting existing techniques, including electron spin resonance and transmission electron microscopy, to confirm that the organic compounds receive electrons from the bacteria and pass them along to iron oxides.

In fact, the electrons shuttle more quickly from the cells to iron oxides when humics are present, Roden says. A group of Dutch scientists recently found electrical currents flowing through marine sediments. Though he has not yet tested the idea, Roden suggests that plant-derived organic compounds could act like wires to enhance the transmission of electrons through soil environments.

"The insoluble humic materials could be an integral part of this previously unrecognized pathway for electrons to move around in sediments," he says. "The bottom line is that reduction of insoluble humics may influence all the kinds of reactions that depend on the

oxidation-reduction chemistry in sediments. It's a new twist."

Provided by University of Wisconsin-Madison