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# Titanium dioxide nanoparticles toxic to phytoplankton in sunlight

**Titanium dioxide nanoparticles** are entering the environment in ever greater quantities as a result of their widespread use in consumer products and as a disinfectant of sewage. Researchers have recently discovered that titanium dioxide nanoparticles have a toxic effect on marine phytoplankton when exposed to normal levels of ultraviolet light found in natural sunlight.

**Phytoplankton are tiny marine organisms**, such as algae, that live in surface waters and are the primary source of food for consumers at the bottom of the marine food chain. In addition, phytoplankton play a vital role in climate regulation by removing carbon from the atmosphere.

Titanium dioxide ($TiO_2$) nanoparticles, which have a diameter of between 100 and 1 nanometres (a billionth of a metre) are used in increasing quantities in consumer products, such as sunscreens. $TiO_2$ nanoparticles are also an effective disinfectant used to purify sewage wastewater. Unknown quantities of $TiO_2$ nanoparticles are entering the environment, primarily through industrial and sewage wastewater discharges. The exposure of living forms to the nanoparticles in surface and marine waters is potentially of concern because their biological impacts are, as yet, not fully understood.

The nano-form of $TiO_2$ is an effective sewage disinfectant because the nanoparticles act as 'photocatalysts'. That is, in the presence of ultraviolet (UV) light, changes occur in the atomic structure of the nanoparticles, which cause them to react with water and oxygen to form highly reactive oxygen species (ROS). These ROS can damage the cell membranes and the DNA of bacteria in wastewater.

Until recently, laboratory experiments have used artificial light that emits little UV to assess the toxicity of the nano-form of $TiO_2$ for marine life. In contrast, this study conducted ecotoxicity experiments on four species of algae kept in seawater under conditions that simulated natural sunlight, including exposure to UV radiation levels that are similar to natural levels of UV found in coastal waters less than 1 metre deep. A number of $TiO_2$ nanoparticle concentrations were tested, ranging between 0-10mg per litre of seawater.

Under these conditions, growth was inhibited in three of the four algae species and significant quantities of ROS were produced. Although ROS can form naturally in marine waters, in the laboratory, the rate of production of one type of ROS, OH, was six times higher in seawater containing $TiO_2$ nanoparticles than is typically found in temperate coastal waters.

In addition, pictures from a scanning electron microscope revealed clumps of $TiO_2$ nanoparticles adhering to surface of algae cells. The ROS probably damage the algae by attacking cell membranes or limiting photosynthesis.

Although phytoplankton are naturally exposed to certain levels of ROS in their environment, the presence of $TiO_2$ nanoparticles increases the stress placed on the organisms, making them less able to cope with other stressors, such as high temperatures caused by climate change.

As this study has found that $TiO_2$ nanoparticles are toxic to phytoplankton when illuminated by sunlight, coastal ecosystems that support fishing and recreational activities are likely to be especially affected by high levels of $TiO_2$ nanoparticle pollution, it is suggested.

**Source:** Miller, R.J., Bennett, S., Keller, A.A. *et al.* (2012) $TiO_2$ Nanoparticles Are Phototoxic to Marine Phytoplankton. *PLoS ONE* 7: e30321..
This study is free to view at: www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0030321
**Contact:** miller@msi.ucsb.edu
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