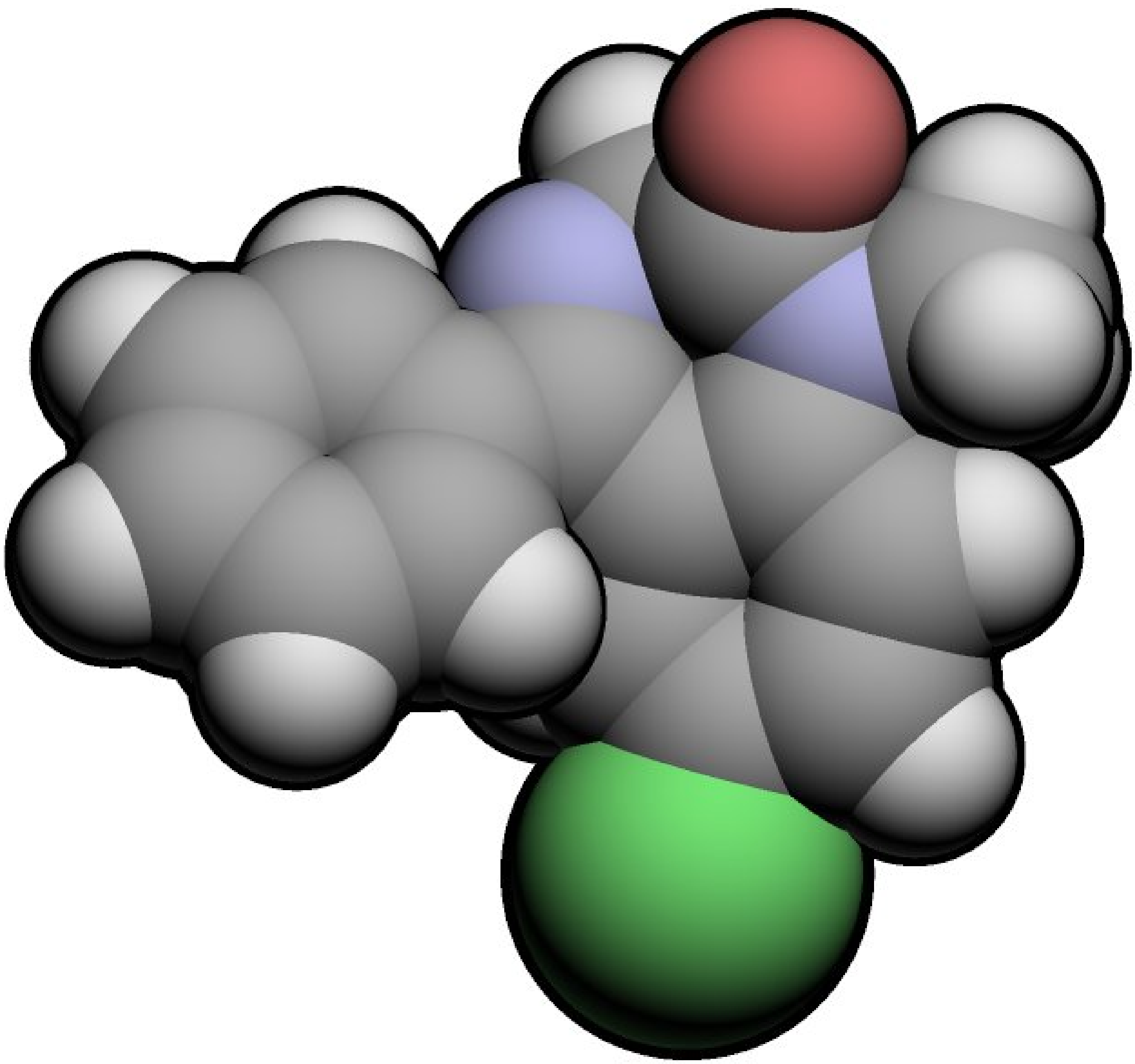
Removing globally-used anxiety drug from wastewater at low cost

February 21 2018



The globally-used anxiety drug Diazepam can now be removed from recycled water and wastewater, using low-cost titanium dioxide nanofibers, says Prof Vinod Gupta from the University of Johannesburg. First marketed as Valium, Diazepam is available in hundreds of brands. The drug is one of three benzodiapezines in the World Health Organisation list of essential medicines, but is also widely abused as an addictive prescription drug. In cities running out of water, removing pharmaceuticals from wastewater in a simple, low cost way is becoming a priority. This 3D image shows Diazepam's molecular structure. Credit: CC Roberts, Wikimedia

A low-cost, one-step method to remove the anxiety drug Diazepam from recycled water and wastewater, using titanium dioxide nanofibers has been developed by researchers headed by University of Johannesburg's Prof Vinod Kumar Gupta. Diazepam is used worldwide and is a member of the benzodiapezine drug group.

Prescription drugs like Diazepam tend to slip through traditional wastewater treatment plants. These plants are not designed to remove the thousands of different pharmaceuticals in use globally. As drug use increases, legal and illegal pharmaceuticals enter the environment through treated sewage and wastewater discharged from drug manufacturing.

"Existing processes that can remove Diazepam and other drugs at large scale from wastewater are expensive, time consuming, inefficient, or all three. Some also consume a lot of energy in multiple steps, or use toxic and hazardous compounds unfriendly to the environment," says Prof Gupta, from the Department of Applied Chemistry at the university.

"Also, Diazepam is not easy to remove from wastewater using traditional methods. It is partially soluble and has a small particle size. For efficient, targeted removal, advanced hybrid nanomaterials are needed," he says.

Used everywhere

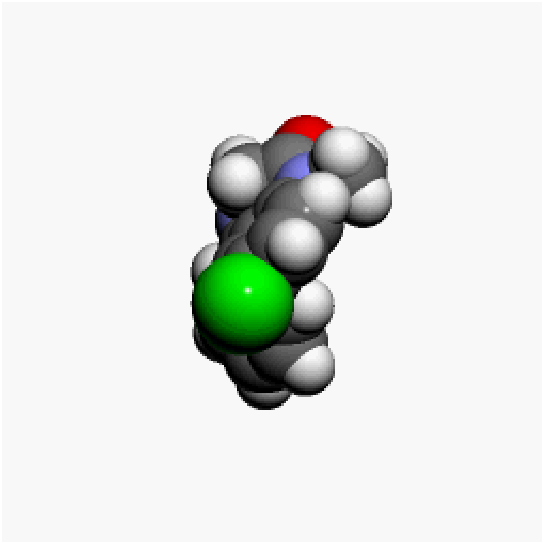
Benzodiazepine drugs are used all over the world for anxiety disorders, as anticonvulsants and anti-epileptics, and for terminally ill people as part of essential medicines list from the World Health Organisation (WHO). The WHO list includes Diazepam, first marketed as Valium, as well as Midozolam and Lorazepam. All three are psychoactive drugs, which affect the way a person thinks and feels.

Diazepam, which can be addictive, is available in over 500 brands globally. It has become a widely-abused prescription drug.

In 2017, a team headed by a researcher from New York State University, announced a new method to simultaneously test for 89 legal neuropsychiatric pharmaceuticals and illicit drugs in unfiltered wastewater and freshwater. Diazepam and several other benzodiapezines are included in the list.

Also, in 2017, a review of seven psychoactive drugs, and to what extent they show up in the aquatic environment, was published by Rio de Janeiro State University (UERJ). The review analysed research about Diazepam and five other benzodiapezines.

The researchers found that the presence and concentration of psychoactive drugs (such as Diazepam) is roughly the same in treated wastewater and untreated wastewater. They found that lower-income countries are worse affected. Also, in surface water, psychoactive drugs tested for were "mostly within the range that caused measurable toxic effects in ecotoxicity assays."



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As the world rapidly urbanizes, city populations grow significantly in short timescales. In some regions this means that fresh water resources become more constrained. In Cape Town, South Africa, residents dread the imminent Day Zero, when authorities will have to turn off the taps because there will be too little water left in the city's dams and reservoirs.

As a city's options for fresh water become more limited, re-using waste water, even for drinking purposes, becomes a more important option. However, for a city in a developing country, removing pharmaceuticals from wastewater needs to happen in an efficient, cost-effective way. The treated water can then be added back in low volumes to the city's water supply, as is done already in Orange County, California, Singapore and Perth.

Faster, lower-cost wastewater treatment

"Implementing this water treatment in municipal wastewater treatment plants should be relatively quick and simple," says Prof Gupta.

Titanium dioxide nanofibers remove Diazepam and related drugs in a targeted way during the photocatalytic decomposition process. The fibers can be used as filters in municipal or industrial treatment plants, he says.

"The filter and screen will be made up of hybrid nanomaterials which are highly efficient in the removal of noxious pharmaceutical and other inorganic and organic impurities from municipal and industrial wastewater," says co-author Dr. Ali Fakhri from the Department of Chemistry at Islamic Azad University, Tehran, Iran. "We use a modified hydrothermal manufacturing method, which produces a dense chain network of hollow fibers. The fibers are cross-linked and stable, so there is low risk for fibers to be emitted in the purified wastewater."

The nanofibers can be used to remove industrial dyes and other organic pollutants, as well. However, they need to optimize some important parameters on the fibre structure first, he says.

Prof Gupa says, "The process to make the fibers is also simple and cost-effective. We are planning a pilot plant at the University of Johannesburg to manufacture these nanofibers. Every aspect of the pilot plant is planned to minimize nanofiber pollution to the environment.

"Later the pilot plant will be followed by a demonstration wastewater treatment plant, to show how nanotechnology can remove a range of pharmaceutical impurities efficiently, rapidly, and at low cost."

More information: Vinod Kumar Gupta et al, Preparation and characterization of TiO 2 nanofibers by hydrothermal method for removal of Benzodiazepines (Diazepam) from liquids as catalytic ozonation and adsorption processes, *Journal of Molecular Liquids* (2017). DOI: 10.1016/j.molliq.2017.11.144

Provided by University of Johannesburg

Citation: Removing globally-used anxiety drug from wastewater at low cost (2018, February 21) retrieved 25 April 2024 from https://phys.org/news/2018-02-globally-used-anxiety-drug-wastewater.html

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