Pharmaceutical residues in sewage sludge and cattle manure do not have the feared effect

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Pharmaceutical residues and chemicals from personal care products in sewage sludge and cattle manure do not have a detectable toxic effect on nematodes living in agricultural fields, according to 14-year-long experiments by the University of Copenhagen. At the same time, manure

and sewage sludge enhance soil quality more than conventional mineral fertilizers and can contribute to more sustainable, circular agriculture.

Organic fertilizers in the form of urban sewage sludge and cattle manure can contribute to more circular and sustainable agriculture and prevent the exhaustion of agricultural soils. However, a fear that pharmaceutical and personal care product residues in these types of fertilizers will pollute soil has caused several EU countries to ban or restrict the use of sludge in agriculture.

This fear explains the widespread skepticism among Danish organic farmers as well. In Denmark, it is legal to use treated sewage sludge—known as biofertilizers, which are controlled for excessive concentrations of heavy metals, among other things. However, pharmaceutical residues and most personal care product chemicals are not tested for in Denmark.

A new University of Copenhagen study demonstrates that pharmaceutical and household chemicals can be measured in sludge fertilized soil, but that the quantities were insignificant for the biological parameters measured. At the same time, sludge and manure provide significantly better soil quality than conventional mineral fertilizers.

"We expected to find a lot of pharmaceutical residues in the soil—which is why the use of sludge is prohibited in many countries. And we also hypothesized that these residues might stay in the soil and become problematic for soil organisms. The latter doesn't seem to be the case," says professor and lead author Nina Cedergreen from the Department of Plant and Environmental Sciences.

The researchers measured soil quality based on certain physical characteristics and on the abundance and reproductive capacity of nematodes in the soil, as they serve as recognized bioindicators of soil

health. Ph.D. fellow and first author Jeanne Vuaille elaborates:

"The small worms grow and reproduce significantly better in the soils that receive sludge and manure than in those where conventional fertilizers are applied. The soil has better structure, a higher carbon content and greater humidity. At the same time, we see no toxic effect on the worms from the pharmaceuticals and personal care chemicals that we were able to measure in the soil. This is most likely because their concentrations were incredibly small."

Fourteen years of experimentation

The research, which is a case study, is based on fourteen years of experiments. Throughout the years, University of Copenhagen researchers—led by Associate Professor Jakob Magid—fertilized the experimental fields in Taastrup with different types of organic matter and conventional NPK fertilizers. To calculate worst-case scenarios, sewage sludge and cattle manure were added in quantities approximately four times greater than what Danish law allows.

"It is unique for a research project to apply fertilizer to the same tract of soil for 14 years—and in extreme quantities for most years. So, if the chemicals were to have accumulated and have a toxic effect, one ought to have been able to see it after so many years. But there is nothing to note when we measure the well-being of the worms. The pharmaceutical residues are probably broken down in time, as there is so much biological activity in the soil," says Jeanne Vuaille.

The researchers identified twelve different substances derived from various pharmaceuticals and personal care products in the soil that had been fertilized with sewage sludge, which is in line with what previous studies have shown. The substances came from painkillers, antidepressants, heart medication and perfume residues. As expected,

none of these chemicals were present in the conventionally fertilized fields. Nevertheless, the nematodes thrived better in the organically fertilized soil.

"We need a new narrative"

The researchers emphasize that the results in themselves cannot guarantee that there are no environmental risks associated with using sewage sludge and cattle manure in agricultural fields. Therefore, the researchers hope that this study will allow for more research to support these findings. Among other things, there is currently a great deal of focus on fluorinated substances, which are also found in sewage sludge.

"A range of substances are present in organic fertilizers. Therefore, we need to look at all of the potential risks associated with using it and hopefully demonstrate that they are minimal when compared to the many benefits. Right now, sludge has been branded as a "bad" type of fertilizer by some. So, we need a new narrative about organic fertilizer from cities for it to gain social acceptance," says Nina Cedergreen, who continues:

"If we are to move society toward a circular economy and sustainability, we need to find a way to replace the soil nutrients that we remove when harvesting crops. And ideally, with a minimal use of conventional fertilizers, which are energy-intensive and expensive to produce. This is currently not the case. But it's where we ought to be headed. Otherwise, we will exhaust our soils, as has occurred many places on Earth."

Other studies are currently underway at the University of Copenhagen, based in the same experimental fields. Among other things, these focus on how organic fertilizer affects plant production, and to what extend chemicals measured in the soils can be taken up by the crops.

The study is published in the journal *Agronomy for Sustainable Development*.

More information: Jeanne Vuaille et al, Long-term fertilization with urban and animal wastes enhances soil quality but introduces pharmaceuticals and personal care products, *Agronomy for Sustainable Development* (2021). DOI: 10.1007/s13593-021-00726-8