European Commission

Science for Environment Policy

30 September 2016
Issue 472
Subscribe to free weekly News Alert

Applying sewage sludge to soil may spread antibiotic resistance

Sewage sludge and manure are sometimes added to soil to improve crop production. However, these 'natural fertilisers' may contain not only nutrients and organic matter but also antibacterial agents. This study investigated their impact on the microbes in soil, revealing an increase in antibiotic resistance genes. The researchers recommend greater efforts to remove antibiotic residues from wastewater and manure.

Antibiotics can enter the natural environment through multiple routes, including urban wastewater. Although wastewater goes through numerous treatment and cleaning processes, some antibiotic residues cannot be removed by these methods[1].

Genes that allow bacteria to survive against antibiotics (antibiotic resistance genes) have been detected at all stages of the municipal wastewater treatment process. As a result, they can be found in sewage sludge, the residual material left after wastewater treatment. Sewage sludge is also rich in nutrients and organic matter and therefore spread on land as a fertiliser. This is also a cost-effective method of disposal for wastewater treatment plants.

Similarly, animal manure is often applied to land as a cheap and effective method of fertilisation. Due to the use of antibiotics in the livestock industry, animal manure is likely to contain antibiotic residues, and several studies have shown that manure stimulates the spread of antibiotic resistance among microbes in soil. This is a particular problem in China, which used around 15 000 tonnes of antibiotics for its livestock in 2010 (and is predicted to double its use by 2030)[2].

Soil amendments can represent a major route for antibiotic resistant bacteria to develop in farmland soils, which can lead (indirectly) to untreatable infectious diseases in humans and animals. However, their precise effects on arable land remain poorly understood, and most studies have been purely laboratory based.

In order to obtain findings that are relevant to real world conditions, this study was conducted in the field, by researchers from three Chinese research institutes. The researchers applied various amounts and combinations of sewage sludge (from 4.5 to 36 tonnes per hectare), chicken manure (10 tonnes per hectare) and chemical fertiliser (urea, potassium sulphate and superphosphate, which should contain no antibiotics or related residues) to garden soil in China. There were a total of eight different treatments. After 10 months, they collected 24 samples of surface soil.

Using a method of DNA quantification, they evaluated the effects of the various treatments on the soil. They found that sewage sludge and chicken manure both increased the number of antibiotic resistance genes in the soil. Compared to the control soil (which contained around 40 antibiotic resistance genes), and to the soil fertilised only with chemical fertiliser (which contained a similar number), treatment with chicken manure (10 tonnes per hectare — t/ha) and sewage sludge (36 t/ha) more than doubled the number of antibiotic resistance genes (to around 100).

They also found that the effects increased with the amount of treatment that was applied, leading them to suggest that 4.5 tonnes of sludge per hectare (t/ha) may be a safe limit (as this level did not cause a significant increase in the abundance of antibiotic resistance genes). Confirmation would require further investigations considering environmental and health parameters.

Continued on next page.

Source: Chen, Q., An, X., Li, H., Su, J., Ma, Y. & Zhu, Y. (2016). Long-term field application of sewage sludge increases the abundance of antibiotic resistance genes in soil. *Environment International*, 92–93: 1–10. DOI: 10.1016/j.envint.2016.03.026. This study is freely available at: http://www.sciencedirect.com/science/article/pii/S0160412016301064.

Contact: ygzhu@iue.ac.cn

Read more about:
Agriculture, Chemicals, Environment and health, Soil, Waste

1. The main aim of these treatments and processes is to minimise the organic pollution, nutrients and pathogens contained in the untreated wastewater generated by human settlements, that otherwise would enormously affect the nearby water bodies, soils and the environment in general. It is not the primary objective of the treatment plants to remove all the polluting substances that can be found in urban wastewater, such as the antibiotic residues mentioned in this article.

2. http://rendezvous.blogs.nytimes.com/2013/02/18/global-health-threat-seen-in-overuse-of-antibiotics-on-chinese-pig-farms/?_r=0

European Commission

Science for Environment Policy

30 September 2016
Issue 472

Subscribe to free weekly News Alert

Source: Chen, Q., An, X., Li, H., Su, J., Ma, Y. & Zhu, Y. (2016). Long-term field application of sewage sludge increases the abundance of antibiotic resistance genes in soil. *Environment International*, 92–93: 1–10. DOI: 10.1016/j.envint.2016.03.026. This study is freely available at: http://www.sciencedirect.com/science/article/pii/S0160412016301064.

Contact: ygzhu@iue.ac.cn

Read more about:
Agriculture, Chemicals, Environment and health, Soil, Waste

Applying sewage sludge to soil may spread antibiotic resistance *(continued)*

They detected a total of 130 unique antibiotic resistance genes, which conferred resistance to several antibiotic types, including beta-lactams and tetracyclines. Some genes conferred resistance to multiple different types of drugs. The highest number of antibiotic resistance genes were detected following sewage sludge treatment (36 t/ha).

The treatments also changed the composition of the bacterial community in soil, revealed by sequencing of microbial DNA. The researchers identified increases in five particular groups of bacteria that were associated with antibiotic resistance. For example, *Chloroflexi* and *Planctomycetes* were associated with chicken manure, while *Firmicutes* and *Gemmatimonadetes* were linked to (36 t/ha) sewage sludge treatment.

To assess if any of the bacteria could be dangerous, the researchers compared their findings to the Virulence Factors Database — a reference database for harmful bacteria, developed by the same researchers in 2005. They found 34 pathogenic bacterial species, which were detected in all samples. Of these, two were important human pathogens: the causative agent of tuberculosis (*Mycobacterium tuberculosis*) and a common cause of hospital-associated infections (*Pseudomonas aeruginosa*).

Finally, the researchers used network analysis to identify 'indicator genes' that could be used to quickly assess environmental samples. They identified three genes as indicators of antibiotic resistance, which they say provides a useful tool for quickly estimating the antibiotic resistance potential of environmental samples.

Overall, this study shows that the long-term (in this case, 10-month) application of sewage sludge and manure can change bacterial communities, causing an increase in antibiotic resistant forms. To reduce the risk, the researchers say greater efforts should be made to remove antibiotics before these soil amendments are applied to land. These findings could be relevant for land management techniques and legislation on sewage and biosolids in Europe and worldwide.

Although China — where this study was conducted — produces and consumes the most antibiotics globally[3], antibiotics have also been used for intensive farming in the EU, despite a ban on their non-medicinal use (e.g. as growth agents). In Germany for example, 1 734 tonnes of antimicrobial agents were used for animals in 2011 alone (more than twice the amount used in human medicine)[4]. This study re-affirms the importance of limiting antibiotic use in livestock and reveals the risks of using livestock manure as a fertiliser.

The findings are especially relevant for the treatment of sewage sludge, use of which in agriculture is regulated by European Directive 86/278/EEC. Directive 91/271/EEC on urban wastewater treatment supports the recycling of sludge but states that it should only be used 'whenever appropriate', and that it is necessary 'to ensure that the environment is protected from the adverse effects of the discharge of wastewaters'. Accordingly, at the current level of technology, the reuse of sludge is not explicitly encouraged; and if it is reused, the highest priority is to avoid any negative effect on the environment, including in agriculture.

3. Ibid.

4. http://www.spiegel.de/international/europe/danish-pig-farmers-reduce-antibiotics-to-prevent-drug-resistance-a-933344.html