European Commission

Science for Environment Policy

Constructed wetlands for removing human pathogens: factors affecting water safety

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Constructed wetlands can remove disease-causing bacteria from wastewater, but their performance is highly dependent on the systems they use, a new study shows. Researchers reviewed results from a wide range of studies on constructed wetlands and found that combining different approaches increased removal of bacteria. However, further research and improvement of wetland systems is required to produce water that is safe for reuse.

Source: Wu, S., Carvalho, P. N., Müller, J. a., Manoj, V. R. & Dong, R. (2016). Sanitation in constructed wetlands: A review on the removal of human pathogens and fecal indicators. *Science of The Total Environment*, *541*, 8–22. DOI:10.1016/j.scitotenv.2015.09.047

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Increasingly, studies on constructed wetlands focus on how well they remove certain human pathogens and faecal indicators. One of the main advantages of constructed wetlands over traditional water treatment systems is that they reduce the requirement for disinfectants such as chlorine. However, some pathogens in untreated wastewater are already removed using secondary or biological treatment (as is compulsory for wastewater generated by human settlements with populations above 2000). Furthermore, disinfection is required in some areas to fulfil certain Directives, such as the Habitats Directive (92/43/EEC) and Bathing Water Directive (2006/7/EC).

All constructed wetlands have different influencing factors, such as water composition, seasonal fluctuations and local vegetation. This means constructed wetlands cannot provide standardised performance, unlike treatment plants. The pathogen removal mechanisms are also complex — most frequently including natural die-off due to starvation or predation, sedimentation and filtration, and adsorption. It is therefore difficult to assess wetlands' performance on average. The researchers attempted to provide deeper insights into the workings of constructed wetlands by carrying out a review of findings on state-of-the-art technology in this field.

Many of the studies that the researchers considered assessed the performance of constructed wetlands based on the presence of *Escherichia coli* and *Staphylococcus* bacteria and coliforms (bacteria from the intestines of animals, whose presence in drinking water indicates that pathogens could be present). It was unclear from the existing literature to what extent such bacteria continue multiplying within the wetland environment, and whether waste from wild birds, livestock and other animals add significantly to the total from human waste. The researchers suggest these issues require further investigation. Such additional contamination is a disadvantage compared to conditions in a treatment plant, in which pathogens do not multiply but reduce in number (under proper wastewater management conditions).

The researchers mainly reviewed studies of free water surface systems, where the water surface of the wetland is exposed to the atmosphere, and horizontal subsurface systems, where the water flows horizontally through the ground. Studies investigated different mechanisms for removing bacteria as well as factors affecting the efficiency of those mechanisms.

Results from the studies suggested that sedimentation can successfully remove some bacteria but not others — particularly those that do not attach to larger particles. Filtration is effective at removing bacteria including *E. coli* and protozoa, with one study showing that smaller filter pores worked better. Some bacteria could also become stuck to plant roots, but the researchers suggest that, in the long-term, the number removed through this adsorption process might not be significant. In addition, many bacteria die, due to the presence of chemicals or being consumed by larger microbes.

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Factors influencing the rate at which pathogens were removed included water composition; the presence of vegetation and filter media such as sand; oxygen, sunlight and pH levels; and seasonal temperature changes. Patterns of water flow and retention were also key. For example, several studies demonstrated that when the same water is retained in the treatment system for longer, more bacteria are removed due to increased exposure to removal processes. Removal rates peak somewhere between three and seven days, according to available evidence.

Overall, horizontal subsurface flow systems were better at removing *E. coli*, faecal coliforms and staphylococci, but not total coliforms. Combining different kinds of wetland systems did help to remove more pathogens from wastewater but still not to a degree that would make the water safe for reuse in farming, according to World Health Organization guidelines. The researchers suggest that aerated treatment beds could increase pathogen removal, as several studies indicated that higher oxygen levels increased bacterial die-off. Vegetation also promoted bacteria removal. More intense studies of removal rates in some of the newer, more innovative wetlands systems could also help to guide progress. The researchers propose some specific areas for future investigations, and suggest that the results obtained thus far show remarkable bacteria removal efficiencies.

In sensitive areas where disinfection is continuously required, it is advisable to treat wastewaters with treatment plants equipped with disinfection systems, until it is proved by means of regular monitoring that constructed wetlands can provide a similar level of protection.