

cost of investment seem to be ozone treatment, activated carbon filtration, and membrane separation (Dodd et al. 2010; Dodd 2012; Riquelme Breazeal et al. 2013; Björlenius 2018). Ozone treatment is an effective method for disinfecting the effluent water and at the same time removing many harmful chemicals. However, it also creates new substances from the reaction products, some of which may be toxic or otherwise harmful. It is also a fairly energy-demanding technique and requires substantial expansions of current sewage treatment plants to be employed at full scale. Filtration with activated carbon essentially binds bacteria and chemicals to porous carbon and effectively removes those. However, it requires to be either replaced or cleaned regularly to be kept functional, and supplementing the entire sewage treatment infrastructure with this type of treatment would create a need to cheaply produce activated carbon at a very large scale. The carbon also has to be properly taken care of post-use to avoid spreading resistant bacteria from the carbon filters. Membrane separation solutions, which essentially keep bacteria within the sewage treatment plants using size filtration, have similar issues with replacement cycles and end-of-life disposal of the membranes. While all of these techniques are quite efficient in bringing the number of released bacteria down, the gains from this reduction relative to other possible interventions need to be carefully evaluated. One important consideration in this respect is whether other improvements to the general treatment process can be made. There are, for example, indications that thermophilic anaerobic sludge digestion could be better at removing resistance genes than mesophilic digestion (Diehl and LaPara 2010; Ma et al. 2011). Another consideration should be if other gains, besides antibiotic resistance reductions, are achieved with ozonation. If ozone treatment is to be used to reduce the concentrations of other harmful compounds in the effluent water, the reduction of (resistant) bacteria may come as an added benefit, essentially without increasing the costs.

There could also potentially be benefits in installing different types of highly efficient treatments at particularly relevant sources, such as hospitals. Such technologies include those mentioned above, as well as membrane bioreactors (Kovalova et al. 2012). These could remove not only resistant bacteria but also antibiotics and other drugs, which are known to be present in higher quantities in hospital wastewater (Verlicchi et al. 2012), and often are mixed with public sewage systems and treated in the same treatment plants. Targeting hospital wastewater would make sense because it is likely to eliminate higher numbers of the most relevant human pathogens before they have a chance to reach the sewage treatment plants and potentially interact with bacteria of other origins, reducing the possibility for resistance genes to be shared between bacteria. This is a fairly cost-effective approach and for which there seems to be reasonably easy to harness political support (Lienert et al. 2011).

In parts of the world, sludge from the sewage treatment process is used as fertilizer on fields, which is an appealing solution as it allows the disposal of a