Fact Sheet #3
Disinfection technologies in water reuse

Introduction

The growing pressure on water sources and the perspective of diminishing availability are pushing the agenda for the quest of alternatives. New technological advances and legal instruments are improving the availability of treated urban wastewater for crop irrigation. Reclamo project aims to investigate how to optimize the process of water reuse for irrigation to achieve an efficient and sustainable management of wáter resources. This factsheet is part of 3 factsheets that describe the current state of water reuse in Spain.

Pathogens of concern

The main focus of water treatment to reach reuse quality standards is the removal of pathogen microorganisms. These can be classified as (order of magnitude of size between brackets):

- **Virus** (<0.1 µm): without an independent metabolism, virus need a host organism to reproduce. Different types are Rotavirus, Hepatitis A and E, Polio and Coliphages. It should be noted that no cases of waterborne transmission of SARS-CoV-2 have been identified.
- **Bacteria** (1 µm): Prokaryotic unicellular organisms (without a differentiated nucleus) that are found in all kinds of natural environments. Among the differtent types, Escherichia coli, Shigella, Salmonella, Campylobacter, Vibrio Cholera and Legionella are most usually found in contaminated water. There are several types of Escherichia coli, most of which are harmless; its presence in fecal matter makes it a good indicator of contamination in water. Some types of E. coli, however, are pathogenic as is the case with enterotoxigenic E. coli.
- **Protozoa** (10 µm): eukaryotic unicellular organisms (with a differentiated nucleus), which can form egg-like schists to survive in unfavorable circumstances. Some examples are malaria, giardia, cryptosporidium and entamoeba.
- **Helminths** (1000 µm): general term for parasitic worms such as nematodes.

All of these microorganisms are transmitted by digestion and cause gastrointestinal problems, except for Legionella pneumophila bacteria, which is transmitted by inhalation of water in aerosol form and causes respiratory infections. Some pathogens such as Legionella or Vibrio Cholerae can reproduce in water, while others such as Norovirus or Cryptosporidium do not grow but can persist outside host organisms.

Treatment technology (I)

Water reuse legislation prescribe that reuse plants treat the effluent of wastewater treatment plants to produce safe water for irrigation. Wastewater treatment legislation (stemming from European Directive 91/271/EEC) sets limits for the Total Suspended Solids, Biological and Chemical Oxygen Demand and (in particular cases) to the concentration of nitrogen and phosphorus, but no explicit limits are set to the presence of microorganisms. Therefore, the main priority of reuse legislation is to ensure the removal of potentialy harmful biota in the water. Both the Spanish RD 1620/2007 and the European Regulation 741/2020 on water reuse set very strict limits on the presence of pathogens in reused waters.

Treatment technology (II)

The most common available techniques to achieve these limits are:

- **Physico-Chemical treatment:** Based on floculation, coagulation and decantation (often in lamellar modules). While this treatment does not have a direct impact in the reduction of microorganism concentration, it may further reduce the presence of organic matter, suspended solids and reduce the turbidity, so that further treatments are more efficient.
- **Open and closed sand filtration:** Can be used to further reduce turbidity and remove larger microorganisms.
- **Membrane filtration:** water is passed through membranes where microorganisms larger than the pore size may be trapped. Depending on the pore size there exists Microfiltration, Ultrafiltration, Nanofiltration and Reverse Osmosis. The smaller the membrane pore size, the better the filtration but the higher the backpressure needed and the operational costs.
- **Chlorine oxidation:** Different Chlorine compounds (Chlorine gas, Sodium Hypochlorite, Chlorine Dioxide, etc) are used to oxidize organic matter. Effectiveness and cost grow with chlorine concentration and contact time.
- **Ozone oxidation:** Ozone has a higher oxidizing potential than Chlorine compounds, although it is typically more expensive to produce.
- **Ultraviolet radiation** at a wave length of 254 nm is able to inactivate microorganisms through photooxidation of their genetic material. The cost depends on the radiation dose required.

Virus are not very sensitive to Chlorine oxidation, often requiring Ultraviolet treatments. Bacteria are very sensitive to inactivation through Chlorine oxidation, and to Ultraviolet radiation. Protozoa are mostly insensitive to Chlorine and even Ozone oxidation, but may be inactivated through Ultraviolet radiation. Due to their relatively bigger size, filtration treatment is feasible.

Due to the technical difficulties and high costs required to reduce the indicators or pathogen concentrations with only one technology, current implementation schemes rely on the combination of two or more techniques: Ozone oxidation followed by Ultraviolet or Membrane Filtration followed by Ultraviolet radiation. In any case, even after the treated water has reached the requested level of disinfection, it is recommended to apply a residual Chlorine dose as an additional protection in the case that the recycled water would be contaminated during distribution.

Water distribution

To preserve the high quality standards of recycled water it is recommended to use the same materials for distribution pipes as drinking water: Ductile iron, Oriented PVC, Plastic Reinforced Glass Fibre and Polyethylene.

Recycled water distribution infrastructure is usually identified with a purple colour (**RAL 4001 or 4005, PANTONE 2577 U**) in order to avoid mixing with drinking water.

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