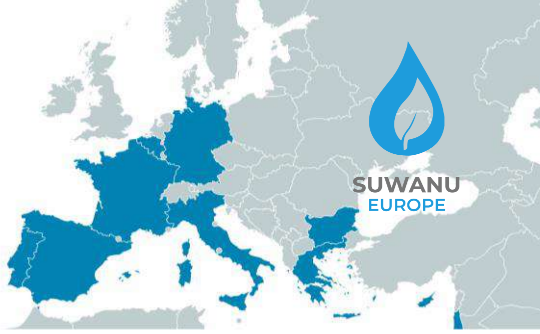
Sustainable **Water treatment** and
Agricultural reuse options in Europe



Info-package 4
Water Engineering Companies

Fact Sheet 4.3 – **Light-driven technologies for producing reclaimed water**

Filtration membranes and new filter materials → Sensors and other innovative tools for monitoring reclaimed water quality → **Light-driven technologies for producing reclaimed water** → Nature based options for water reclamation processes → Other technologies for water reclamation

SUWANU EUROPE is a H2020 project aiming to promote the effective exchange of knowledge, experience and skills among practitioners and relevant actors on the use of reclaimed water in agriculture. This factsheet is part of a total of 5 factsheets in Info-package 4 aimed at water engineering companies, that describe different reclamation technologies able to provide a treated effluent that complies with the standards for irrigation in agriculture.

1. Introduction

Ultraviolet (UV) light is a form of electromagnetic radiation invisible to the human eye. UV electromagnetic spectrum is between X-rays and visible light. Within the range of wavelengths between 200 and 300 nanometers, UV light has germicidal properties, meaning it is capable of inactivating microorganisms, such as bacteria, viruses and protozoa.

UV disinfection systems are one of the most common and most effective technologies for water and wastewater disinfection. A significant body of scientific research has proven UV light's ability to inactivate an extensive list of pathogenic bacteria, viruses and protozoa. Moreover, water can be disinfected and treated with UV light without the addition of supplemental chemicals. And the special advantage: pathogens cannot build to resistance to UV light.

UV disinfection is based on a physical process that instantly neutralizes microorganisms as they pass by ultraviolet lamps submerged in the effluent (liquid). UV light inactivates cells by damaging their nucleic acid (DNA and RNA), thus preventing the replication of microorganisms. When UV radiation penetrates the cell wall of an organism, it destroys the cell's ability to reproduce. The process adds no chemicals to the water and therefore, has no impact on the chemical composition or the dissolved oxygen content of the water.

However, the damage of nucleic acid does not prevent the cell from experiencing metabolism and other cell functions. Some of the damages of the UV light may be repaired by enzyme mechanisms within the cell; therefore, microorganisms can repair themselves and become infectious again after the UV light treatment. Consequently, the UV treatment has to provide enough dosage of UV light to ensure that nucleic acid is damaged beyond the stage where it can be repaired.

The effectiveness of a UV disinfection system depends on the characteristics of the wastewater, the intensity of the UV radiation, the amount of time the microorganisms are exposed to the radiation and the reactor configuration. Disinfection success is also directly related to the concentration of colloidal and particulate constituents in the wastewater. Colloids and other molecules may absorb part of the UV light reducing the exposure of microorganisms to germicidal UV light. Therefore, water quality entering the UV system plays a significant role in the disinfection performance.

The adoption of ultraviolet light for wastewater disinfection has grown significantly over the past few decades. Thousands of municipalities have converted from chemical-based disinfection, such as chlorine gas, to UV due to the significant safety advantages for their communities, plant employees and local water bodies.

2. Technical specifications

The main components of a UV disinfection system are a reactor, mercury arc lamps and a control box. The optimum wavelength to effectively inactive microorganisms is within the range of 250 to 270 nm (UV-C). The intensity of the radiation emitted by the lamp dissipates with the distance to the lamp.

The source of UV radiation is either a low pressure (LP) or medium pressure (MP) mercury arc lamp with low or high intensities. LP lamps work with approximately 0.01 mbar (1 Pa) and MP lamps with higher than 1 bar (100 kPa). MP UV lamps are generally used for large facilities. They have approximately 15 to 20 times the germicidal UV intensity of low pressure lamps. The MP UV lamp disinfects faster and has greater penetration capability due to its high intensity. However, these lamps operate at higher temperatures with higher energy consumption than LP UV lamps.

3. UV lamps maintenance

Since UV radiation must reach the bacteria to inactivate them, the housing for the light source must be kept clean. Commercial products are available for rinsing the unit to remove any film on the light source. An overnight cleaning with a solution of 0.15 percent sodium hydrosulfite or citric acid effectively removes such films. Some units have wipers to aid the cleaning process.

4. Ultra Violet Light Emitting Diodes (UV-LEDs)

Light-emitting diodes (LEDs) differ from conventional lamps because they are built with semiconductor materials such as silicon or sapphire. Latest improvements in semiconductor technology have made ultraviolet UV-LEDs a viable alternative to conventional UV systems. UV-LEDs have longer life, are less fragile, and are free of toxic components such as mercury. One of their advantages is the ability to generate UV radiation at specific wavelengths which could be exploited to improve treatment efficiency by designing treatment systems for specific applications. Moreover, high-power-density UV LEDs and advanced controls allow for a much smaller footprint compared to traditional UV systems. However, UV LEDs present higher initial cost compared to mercury vapour lamps and relatively costly materials, including nanoceramics and aluminium nitride which must be used on the circuit board to provide the necessary thermal conductivity

References/further readings

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