Co-funded by the Eco-innovation Initiative of the European Union

Grant Agreement: ECO/12/332862

SI2.657673

**CLEANLEACH**

Treatment of nursery leachates by combining slow sand filtration and horizontal subsurface flow constructed wetlands

CIP-EIP-Eco-Innovation-2012

Project Coordinator: Institut de Recerca i Tecnologia Agroalimentàries (IRTA)

# **D3.5.** Manual of the system

# Lead beneficiary: Naturalea

Due date of deliverable: 29th April 2016 (Month 31)

Submission date: 3rd May 2016 (Month 31)

Version final

Start date of project: 10th October 2013 Duration: 30 months

| Project co-funded by the Eco-innovation Initiative of the European Union | | |
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| **Dissemination Level D3.5** | | |
| PU | Public | X |
| CO | Confidential, only for members of the consortium (including the Commission Services) | ☐ |

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## 1. Introduction

The plants used in gardening, landscaping and reforestation are grown in nurseries. In Europe, more than 127,000 hectares are dedicated to this activity. The production of plants in container facilitates the agronomic management, transport and transplantation at the final location. These are hydroponics crops, which generates some leachate. The current law states that these leachates cannot be discharged into the environment because they may contain nitrates and phosphates that are potentially polluting for the surface and subsurface waters.

In most of the EU countries, such as Spain, there are no manuals of good agricultural practices related to the use of water and fertilizers in nurseries contrary to what happens in the US (Bilderbarck, 2002 Garber et al., 2002). Several scientific studies conducted in nursery areas in the EU have detected leachate discharges to the environment of up to 30 $g/m^2$ nitrate, phosphorus and 9 $g/m^2$ in soluble forms (Marfà & Cáceres 1998), being both of these elements potentially polluting of the inland subsurface waters (Guerin et al., 2001). It also often happens that large areas of nurseries are installed in vulnerable areas regarding nitrate pollution, for example, in Catalonia (Marfà et al., 2006). However, in many areas there are not runoff collection and leachate recirculation systems in the nurseries. Moreover, it is much more difficult to find nurseries with in situ treatment systems of its leachates. For example, a recent study showed that only a 19% of the surface of the nurseries of the demarcations of Barcelona and Girona, in Catalonia, has a system of collection and recovery of leachates, and there aren’t any system for the treatment of them, filtration and purification of these contaminant ions (Marfà et al., 2011).

## 2. We must take action on the nurseries leachates management

According to the warnings given by the FAO and the World Water Council (WWC) in a report published on 14th April 2015, by 2050 there will be enough water to produce the food needed for a world population that will exceed 9,000 million people. However, the excessive consumption, degradation of resources and the impact of climate change will reduce water supply in many regions, especially in developing countries.

The document "*Towards a water and food secure future*" makes a call for governmental policies and investments from the public and private sectors to ensure that the agricultural production, livestock and fisheries production is carried out in a sustainable way and with a control on the water resources.

The reality is that water management is one of the most important problems that we must face in this century, considering both, the quality and the quantity of this natural resource.

It is necessary to focus the problem with celerity to introduce, as soon as possible, improved water management systems in the nursery management.

Cleanleach is a very useful tool for this purpose.

*Figure 1. Natural wastewater system.*

### 2.1 Water Cycle

Cleanleach is a system to improve the quality of leachates produced on the nursery activity with the aim of enable their reuse or assure the discharge of them without polluting the environment. Cleanleach manages these leachates with simple systems that doesn't require energy supply or that can work with renewable energy (solar or wind). The leachates treatment is based in natural procedures and requires low maintenance.

This system permits the recuperation of the maximum amount of water that receives de surface. Moreover, part of this water can be reused, producing a reduction of the external water supply necessities.

### 2.2 Management of leachates

Leachate management in nurseries is an important issue to take in consideration due to the important effects of them on what is defined as diffuse pollution. Millions of euros are allocated each year to improve the water quality because even groundwater are highly contaminated.

## 3. Natural water treatment systems

### 3.1. Introduction

Natural water treatment systems are based on the study of the functionality of natural systems in the reduction of pollutant parameters and their potential to recreate wetland habitats by building ponds and gravel beds with vegetation of native species. This kind of treatment are based on the activity of the ecosystem born from riparian species plantations, specifically helophytes, in saturated water areas.

These natural ecosystems have associated the bacteria responsible of the decomposition of organic matter which are used in the biological part of the traditional wastewater treatment systems.

In addition, these systems can promote the removal of some nitrogen contamination forms present in the water thanks to the bacterial activity. If a proper sizing of these systems has been made, the effluent water of the process will verify with the pouring contamination limits established by the legislation. Then, the water will be able to be poured into the river or reused as irrigation water or sanitary water.

These systems, while achieving adequate depuration of wastewater, also provide a benefit from the point of view of environment and landscape, promoting the integration into the environment and naturalization of the area.

The feasibility and simplicity of these systems rely on some project details such as the availability and characteristics of the physical space as well as the quantity and quality of the tributary. The design can be adapted to the reality of each case: the presence of a dead well or raft, existing topography, reuse needs, etc.

The vegetation used in this kind of systems is the same that can be found on the bank of a river, in a raft or in a lake. The species are selected taking into account the climatic factors of the area and its treatment capacity; the most common vegetal species are the common reed (*Phragmites australis*), cattail (*Typha sp*.) and yellow iris (*Iris pseudacorus*).

*Figure 2: Natural wastewater system.*

Performance or efficiency of wetlands is very high in reducing BOD (Biological Oxygen Demand), SS (Suspended Solids) and nitrogen (reduction greater than 80%) as well as significant levels in fungi, drugs, pesticide residues, metals and pathogens. This high levels on the reduction of the different contaminant forms on the water allows its reuse.

### 3.2. Nitrogen management

The ammonium is a nitrogen form that can be converted into nitrates and nitrites through the nitrification process. This process needs an aerobic media and the presence of nitrifying bacteria.

Nitrates and nitrites can be assimilated by the plants but may also return to the atmosphere as nitrogen gas through the denitrification process that occurs in anaerobic environments (without oxygen) and presence of denitrifying bacteria.

The Cleanleach system is an integrated system which collects all the leachates, filter and clean them. With these three functions, part of the water can be recovered for irrigation uses of the same crop, reducing the water global necessities. Moreover, a part of the leachates are directed to a wetland in order to remove nitrates, nitrites, phosphates and pesticide residues.

*Figure 3. Horizontal subsuperficial flow system.*

*Figure 4: Superficial flow water treatment system.*

### 3.3. Phosphates management

Phosphates removal is a complex process because, although the plants assimilate part of them, the main processes for phosphate removal are precipitation and accumulation in sediments by basic pH. The use of recycled gravel from construction creates a substrate that due his basic pH creates and excellent condition for the precipitation of phosphate. So, probably this is the substrate that we will use in future wetland Cleanleach construction.

## 4. Cleanleach System

The Cleanleach system makes possible to recirculate leachates to the irrigation system, and thus to take profit of the nitrate and phosphate content as fertilizers, or treat them by natural processes.

The Cleanleach project has been launched to improve technically and environmentally the system developed by the IRTA, and to adapt this system to other applications. With this aim, three SMEs have joined the project to provide complementary specialty and experience, and to develop innovative applications for the treatment of leachates generated on green architecture or urban gardens.

The Cleanleach project is being co-funded by the program of the European Union 'Eco-innovation (ECO / 12/332862)', a program that promotes eco-innovative actions to prevent and reduce the environmental impact of production activities and contribute to the optimal use of resources.

To sum up, the whole system works as it has been described in figure 5.

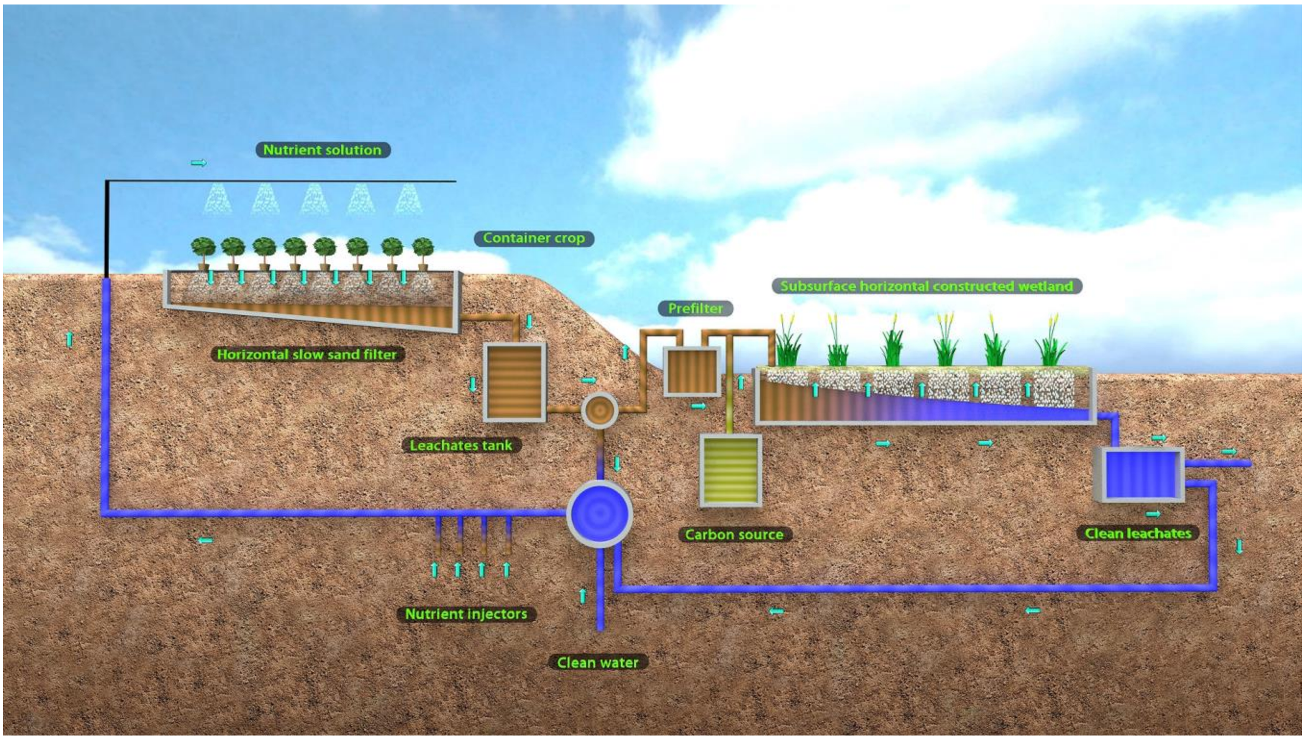



*Figure 5. Scheme of the Cleanleach system.*

The technology package of Cleancleach project is divided into two parts:

1. The collection, filtering and recovery of leachate through a system consisting of a horizontal bed which acts as a slow sand filter, arranged under growing areas. The horizontal slow sand filter has been tested at a pilot scale and full scale in nurseries and other applications developed with satisfactory results in terms of filtration efficiency and retention capacity of the propagules of plant pathogens. Furthermore, the maintenance in this system is not necessary and accumulates an operating experience without any clogging of at least 15 years (Marfà et al., 2006).
2. The treatment of leachates that must be externalized of the recirculating system is performed through a horizontal subsurface flow wetland (HSSF). Wetland treatment system consist of shallow ponds or channels with wetland vegetation. In these systems take place the decontamination processes through interactions between water, soil, plants and microorganisms. Through the development of the CLEANLEACH project, it has been demonstrated a reduction of the nitrate content below 50 mg/L and also 80% reduction of the soluble forms of phosphorus.

## 4.1. Planning

The implementation of the Cleanleach system at a given nursery should start with a comprehensive analysis of the situation (see section 5 Implementation of Cleanleach system); and starts with an overall management planning leachate generated in the nursery. For nurseries of new implementation this can be the basis of the executive project.

*Figure 6. Instalation process of a part of the Cleanleach system*

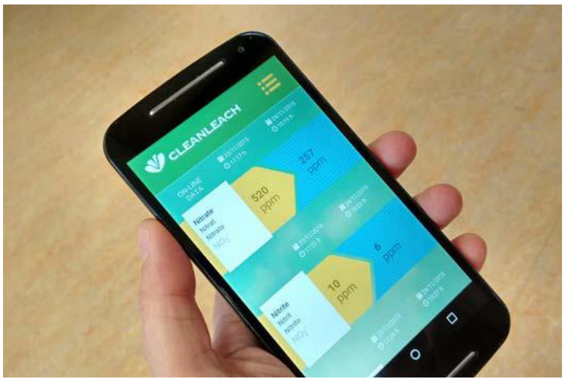



*Figure 7. Mobile application to manage the Cleanleah system*

## 4.2. Horizontal sand filter

All production areas must be prepared for a leachate collection filter bed. This system also makes the soil impermeable nursery, serves as a primary treatment. The system will consist of a 0.1m layer of sand that will be 0.05 to 0.17 meters in the deeper part. The deeper part has got a perforated pipe protected by gravel that also helps in water collection. All these

elements are confined by a waterproofing system consisting of a blanket and geotextile. The leachates will lead to a drain pipe of 63 mm diameter to the storage tank (Figure 8, 9, 10).

The system serves as a primary treatment and, thanks to the development of the CLEANLEACH project, it has been demonstrated its total effectiveness in removing fungi propagules from the collected water. This aspect is important dealing with the leachate recirculation.

*Figure 8, 9: Construction process horizontal sand filter.*

*Figure 10: Nursery with the Cleanleach system.*

### 4.3. Artificial wetland

One of the objectives of the project is the reduction of nitrate and phosphorus in leachates. In this regard, anoxic conditions in constructed wetlands is needed. As stated above, horizontal subsurface flow constructed wetlands are the kind of such natural systems ideal to create anaerobic conditions in which denitrification process takes place.

In the horizontal subsurface flow wetland (FSSH) flow runs horizontally thanks to the slope.

*Figure 11: Horizontal subsuperficial flow artificial wetland system.*

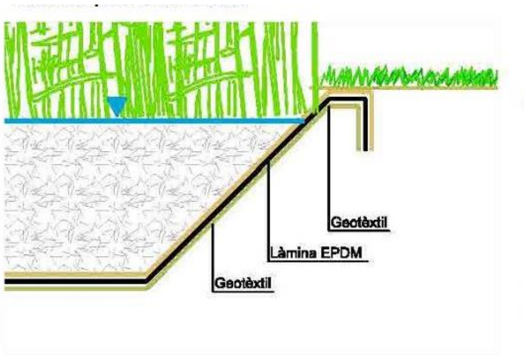
Entry is through a pipe that will lead directly to the start of the treatment plant. The collection pipe is drainage pipe that will lead the water to the tank end collection with a flexible pipe that poured over the river. The beginning and end of the wetland have a stretch of gravel with larger diameters (15-25mm). As a main substrate are used gravel between 5 and 8 mm across the surface. The output is performed with a geotextile drain tube that connects to a PVC 125mm fan, which come together in the final output with pumping back - the system.

The water level of the constructed wetland should have a minimum of 0.4 m depth to create the anaerobic condition needed.

It is essential to have a carbon source to allow the denitrification process. There is a clear correlation between carbon availability and the denitrification proces to reduce leachate nitrate concentration in less than 50 mg/L.

Artificial wetland characteristics:

**Waterproofing detail**




**Draining tube detail**

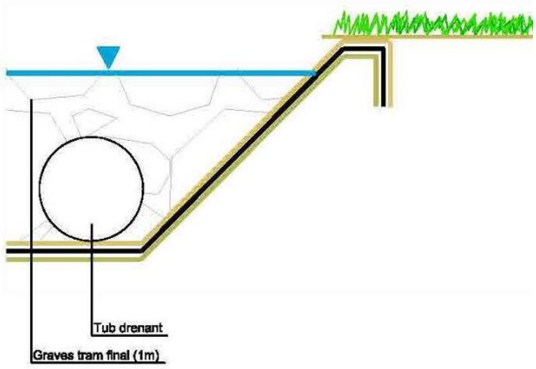



*Figure 12: Artificial wetland construction characteristics.*

### 4.4. Complementary elements

The irrigation of plant production usually could be done in different days and timings. However, for the treatment, we need a constant flux so we need to storage leachates and create a constant flux to the wetland system at the same time that we introduce the carbon source. The management of the leachates is performed using a tank or a pond with pump; this pumping system will be in connection with an automatic system managing the carbon source dosage. According to results obtained through the CLEANLEACH project, good results have been obtained using an effluent from breweries. The exact design of this equipment, always located between the filter bed and the wetland, will be designed especially in each project. The main objective will be managing the dosage of the carbon source.

Also the water needs of the plant nursery will have their own variation so we need to create ponds to storage leachates. Usually most of the plant nurseries have already water storage ponds; therefore these existing ponds could be used for the implementation of the project.

The final characteristics of these systems and their complexity should be addressed in the previous study.

## 5. Cleanleach application system

A good reason to implement Cleanleach may be the lack of water, improvement of irrigation system and fertilizacion and control of fungal diseases among others.

The phases of implementing a project Cleanleach and management needs detailed.

### 5.1. Writing Project: water management plan

The customer must decide the size of the project, but the best choice is the integrated water management.

a) Collection and processing of production areas (basic).

b) Internal runoff.

The project should take into account the terrain and provide the minimum pumps and recycles water. You have to anticipate the current and future scenario of the project; finally fit stages of implementation in the best way possible. For example build a wetland in different areas as it adapts to the nursery characteristics.

Wetlands can be adapted much to the characteristics of the nursery and be part of divisions, the nursery limits of landscape crieteria. For example can coat the outer enclosure.

#### 5.1.1. Characterisation

The first stage to do in any wastewater treatment system like Cleanleach is to make the characterization of the leachates in order to make a good design of the system. The characterization process consist on defining de pollutant concentrations and its temporality.

### 5.2 Maintenance

As in any technological system, Cleanleach needs some maintenance actions to be done to the system. We have divided this actions into two work lines: those actions which are compulsory and those which are only recommended.

#### 5.2.1 General actions

As any irrigation system, Cleanleach may require annual review of the circuits to ensure that the water flow is correct. The most important action is to manage the carbon source.

For his role in landscape, the basic maintenance gardening actions should be performed on the constructed wetland.

#### 5.2.2 Recommended actions

According to customer needs it is recommended periodic analysis to ensure system performance.

Moreover periodicals for direct reuse of leachate irrigation system and analytical fertilization may be necessary.