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Processes of treatment of wineries effluents adapted to the organic wine sector: current situation and prospects.

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Summary. In addition to the wine and oenological routes, organic viticulture must also address the different aspects of sustainable viticulture, in particular the treatment of cellar effluent, with an ecological approach. In addition to wastewater treatment performance, effluent treatment must integrate different ecological orientations: low energy consumption and limiting waste (sludge) that is increasingly difficult to manage by agronomic means. In addition, in conjunction with the concept of eco-enotourism, a harmonious integration of the system can be envisaged, which combines a limitation of olfactory and noise pollution, a landscape and biodiversity enhancement as well as possibly a reuse of treated water for irrigation. Constructed wetlands or bed techniques have proven their effectiveness in the treatment of domestic effluents. Their application to cellar effluents, which has been the subject of various research projects for several years, makes it possible to enhance the aesthetic and ecological environment of the cellar. The objective of the communication is to present the principle of purification by a bed planted with reeds with the different possible implementations in the cellars.

1 Introduction

Born from an ideological movement born at the beginning of the 20th century, organic agriculture and viticulture are based on a close link between agriculture and nature, favouring biological balances between the cultivated plant and its environment, respect for natural rhythms and excluding synthetic products. In addition to the wine and oenological routes, organic viticulture must also address the different aspects of sustainable viticulture, in particular the treatment of cellar effluent, with an ecological approach.

Discharges from presses and cellars are likely to disturb the biological balance of the rivers, particularly during the harvest period. Indeed, the organic elements resulting from wine-making activities generate, in an aquatic environment, the development of micro-organisms that extract dissolved oxygen to the detriment of fish fauna.

The cellar effluents (0.5 to 5 litres/litre of wine) are organic in nature (COD of 5 to 30 g/litre) and are mainly discharged during the harvest period (2 to 8 weeks). The treatment generally aims, according to local regulations, to reduce pollution to a level of 125 to 300 mg of COD per litre.

The fight against pollution in the wine sector is based on two complementary approaches. Upstream, an adaptation of the development process must be implemented to reduce the pollutant load and ensure optimal water management. Downstream, the treatment of cellar effluents, carried out individually or collectively, can be considered with several techniques: evaporation, spreading, biological devices[1][2].

Until now, the most commonly used treatment processes have been based on technological developments in aerobic and, to a lesser extent, anaerobic processes. The objective of current research is to integrate sustainable - development guidelines into the operation of the treatment system. Effluent treatment must integrate different orientations: low energy consumption and limitation of waste (sludge) that is increasingly difficult to manage by agronomic means. In addition, in connection with the concept of eco-oenotourism, a harmonious integration of the system can be envisaged, which combines a limitation of olfactory and noise pollution, a landscape enhancement and possibly biodiversity. Of course, optimal upstream water management is necessary in order to facilitate treatment and with a view to scarcity of the resource in many regions in connection with climate change.

Soil treatment is a mechanism that has been used for a long time, particularly the technique of spreading effluents. The spreading of cellar effluent is often used on agricultural land or more intensively in areas planted with species with high vegetative development potential (willow, bamboo, eucalyptus).

Another approach is to use the principle of natural wetland purification linked to plants with high root potential, adapted to alternating dry and wet conditions[3].

Some of these plants (reeds/Phragmita *Australis*) also transfer oxygen to the soil via the stem (Figure 1).

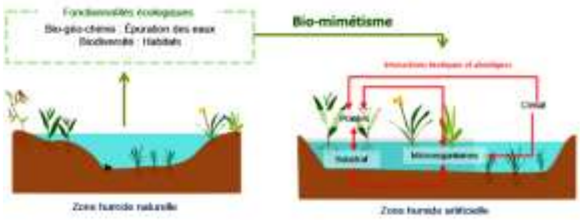


Figure 1: Comparison of a natural wetland with an artificial device. *Source Blueset*.

Filters planted with reeds (or "constructed wetlands") are classified among the biological treatment processes based on the principle of infiltration - percolation. This process reproduces the self-regulatory dynamics of a real ecosystem: it includes the living interactions between different species of bacteria, macrophyte roots, substrate, air, sun, water (Figure 2).

Planted bed or bed techniques have proven their effectiveness in the treatment of domestic effluents. Their application to cellar effluents has been the subject of various research projects for several years.

Figure 2: Purifying role of wetlands**.** Source: Wetlands: A heritage to be preserved RMC/Rhône-Alpes Region water agency.

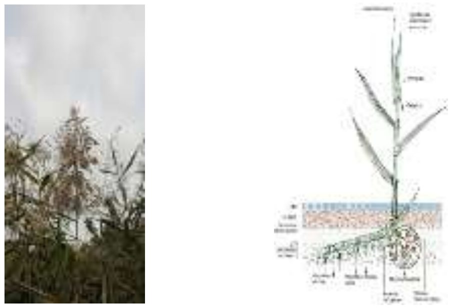
2 PRINCIPLE OF THE DEVICE PER BED REED PLANT

The process reproduces in a way the natural water purification process in marshes where wastewater is naturally pre-filtered and free of solid particles, then undergoes natural physical, chemical and especially biological treatments promoted by aquatic plants, ultimately degrading organic matter, transferring metal compounds to the leaves, filtering and significantly reducing pathogenic germs in wastewater.

The presence of plants indirectly induces a number of mechanisms that promote purification: maintenance of the structure of the massif, oxygen supply to the filtering medium and development of bacterial flora.

The gravel pack is installed in a basin generally between 50 and 70 centimetres deep, usually sealed by a geo-membrane to prevent untreated water from seeping into the groundwater table.

For domestic wastewater treatment, the standard dimensioning is 1.5 m2 per inhabitant or about 60 g COD/m2.d. For wine effluents, given the high variability of the characteristics of the effluents according to the cellars, the surface calculation must be established on a case-by-case basis depending on the type of implementation of this process.



Figures 3: Inflorescence and cross-section of a reed (*Phragmita Australis*)

Aquatic plants, and particularly reeds (Figures 3) have a particular tissue that allows oxygen to be transferred from the aerial parts (stems and leaves) to the underground parts: it is released at the young roots in the aqueous film surrounding the "root hair" (Figure 4). The purifying bacteria present near these roots are thus supplied with oxygen.

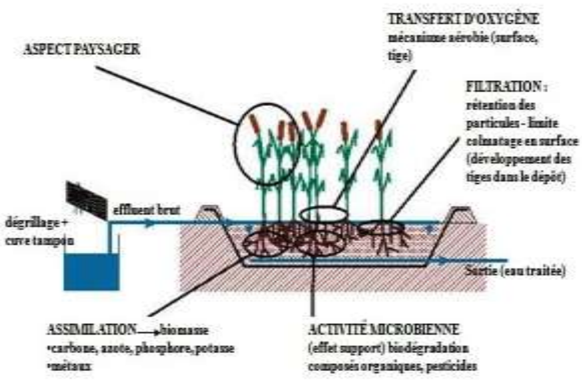


Figure 4. Principle of a bed planted vertically according to J. Rochard

The use of the purification capacities of the planted filter beds can be implemented in two ways:

- Either by **infiltration of water vertically** into soils planted with macrophytes and generally drained (vertical flow filter or vertical filter).

The vertical flow bed (Figures 4 and 5) is an artificial soil composed of several layers of granular materials superimposed on each other in which the rhizomes develop. To promote oxygenation of the filter, the water to be treated is injected sequentially into a spreading network placed on the surface of the massif. As the supply network is loaded at each tarpaulin, the effluent is distributed evenly, thus avoiding the formation of saturation zones.

The effluents percolate by gravity to drains at the bottom of the basin and are thus discharged into the lower part of the system. The rods, by their oscillations, under the effect of the wind, maintain at their base a free ring which facilitates hydraulic circulation in the massif and reduces clogging, especially when the effluents are very loaded with suspended matter.

The relatively short residence time and the sequential feeding prevent saturation, allow the aeration of the massif and promote aerobic degradation phenomena.

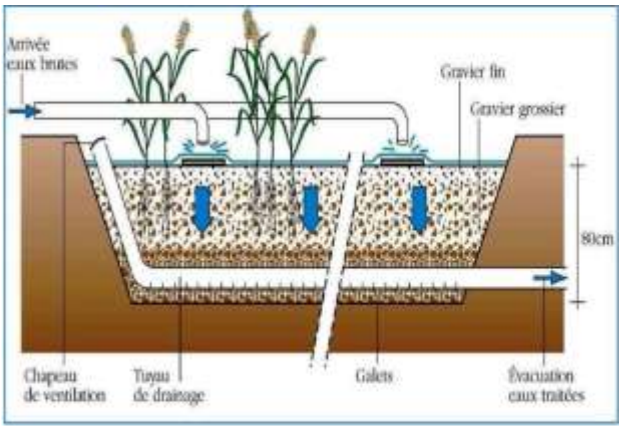


Figure 5. Principle of the vertically planted bed

- Either by **circulation of water** in the macrophyte rhizosphere by horizontal flow below the soil surface (horizontal filter).

The horizontal flow bed (Figure 6) is an artificial soil whose granulometries are staggered into filter barriers according to a horizontal vector. The water to be treated, injected at one end of the filter bed, enters the structure horizontally and is then drained away at the other end.

The feeding is generally carried out continuously, so as to permanently saturate the materials.

Only a low surface aeration, supplemented by oxygen transfer through the reed stems, occurs. This device requires treating effluents with a low content of suspended matter. The risk of clogging requires very fine screening.

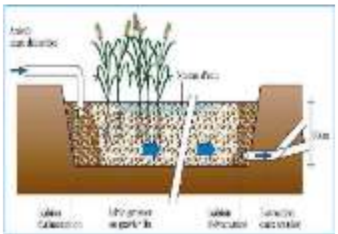


Figure 6. Principle of the horizontal planted bed

In addition to their purifying function, the establishment of a bed planted with reeds can be integrated into a landscape and biodiversity approach in the cellar's environment and serve as a support for an eco-enotourism approach (Figure 7)

Figure 7. An example of ecological valorization (biodiversity, landscapes) of the treatment of cellar effluents by reed beds (Blueset system being installed at the Buzet cooperative in southwest France).

3 APPLICATION TO THE WINE SECTOR

3.1 Treatment of biological process sludge from biological treatment devices

The sludge can be treated by means of a specific bed. Compared to drying on a sand bed, plants allow sludge degradation and stabilization, which reduces the final volume of the product and its odor nuisance. This phenomenon is probably accentuated by the presence of vegetation cover that limits air movement and odour dispersion.

The sludge is removed from the storage tank after treatment and emptying of the treated water, and deposited in successive layers on the surface of the beds, according to the feeding and resting cycles.

In the end, they are extracted by cleaning and recovered by spreading them on agricultural land or composting (Figure 8)

Figure 8. Example of sludge treatment by a planted bed system equipped with a natural ventilation system by the Sint system at Château Mont Redon in Châteauneuf-du-Pape.

3.2 Effluent treatment by recirculation

The limited biodegradation potential of a planted bed (about 1 gram of COD/litre) can be overcome by recirculation of the effluent from a closed storage buffer tank without aeration (Figure 8). Thus, the effluent is gradually purified during successive percolations on the device (32m3 of effluent for a surface area of 27 m² of bed planted with reeds).

Tests carried out in a small cellar in the Bordeaux region have shown the feasibility of this system.

Depending on the initial COD level, purification can be achieved within 4 to 6 weeks (Figures 9-10).

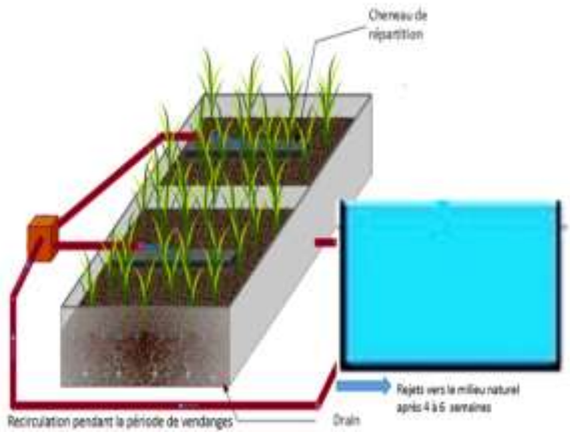


Figure 9: Effluent treatment system on a planted bed with recycling period during the harvest. Diagram adapted from www.plantepure.fr

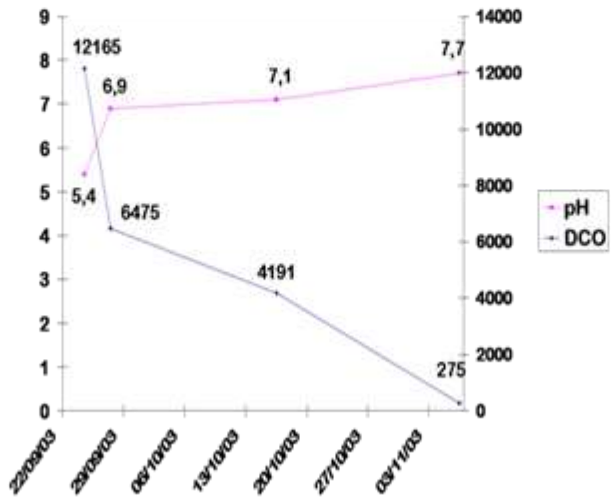


Figure 10: Purification kinetics of a bed device planted by recirculation (Source: S. KERNER and J. ROCHARD)

3.3 Finishing treatment

Most reed bed systems treat effluent with a COD content close to 1 gram per litre to meet discharge standards that vary from 125 to 300 milligrams per litre depending on the region[4]. The planted bed is generally placed downstream of an aerobic basin or possibly an anaerobic device, combining, depending on the case, a purification of 80 to 95% to reach a level close to 1 to 1.5 grams of COD per litre. In this case, in parallel with the finishing treatment, the planted bed can ensure a degradation of the sludge from the upstream biological device (Figures 11 and 12).

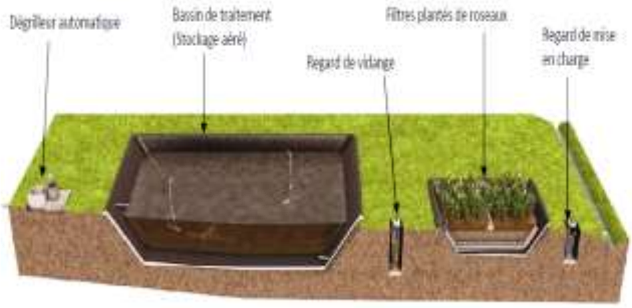


Figure 11. Schematic diagram of a treatment combining a first stage by aerated storage and a finish by filters planted with reeds. (*Source: Agri-environment/ Syntea*)

Figure 12. Example of finishing treatment by a bed planted with reeds after a first aerobic floor (Spier Cellar in South Africa)[5].

This traditional approach of treatment by planted bed in finishing requires maintaining an aeration basin upstream, energy consuming is a potential source of olfactory and visual nuisance, hence the search for processes likely to treat effluents directly by obviously combining measures upstream of the elaboration process to limit the pollutant load and concentration.

3.4 Bed planted on zeolite support

One way to optimize the process is to use a highly adsorbent material compared to the sand or gravel used in traditional filters (Figure 13). An experiment was carried out in a cellar in Barolo (Rochard et al.) in Italy with a filter composed of zeolite which has interesting adsorption and cation exchange properties[6].

Measurements carried out during a grape harvest and vinification campaign showed the possibility of treating effluents with an average content of 3 grams of COD with an average concentration of the treated effluent close to 100 mg/litre (Figure 14).

Following this experiment, many cellars, particularly in Italy, have equipped themselves with this device in direct treatment without an aeration tank with a preliminary screening / filtration system and, depending on the case, possibly neutralization (Figure 15).

Figure 13. A zeolite is a rock formed by a microporous skeleton of aluminosilicate, whose voids optimize the adsorption and biodegradation processes of the reed root system. (Source Zeofito ®).

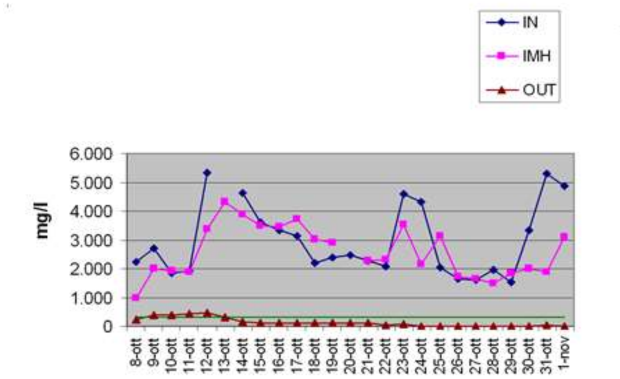


Figure 14. COD content of effluents entering after settling (IMH) and leaving the device with Zeofito zeolite massif (direct treatment), (Rochard et al.)

Figure 15. Effluent treatment by a bed planted with reeds on a zeolite support with the Zeofito ® device (Baroli cellar in Italian Piedmont)

3.5 Planted bed intensified by forced ventilation

Figure 16. Diagram of effluent treatment by forced aeration Rhizosph'air ®)

The Rhizosph'air ® process) is a vegetalized treatment planted (reeds, iris) and intensified by forced aeration. It aims to combine, by air blowing, the rusticity of a first filter stage supplied with raw water and integrated sludge management (Figure 16). At the same time, the oxygen supply allows the treatment to be adapted to variations in charges and different levels of discharges. Forced aeration operates at low pressure (low water level in the filter), which, according to the designer, leads to low energy consumption (less than 0.3 kWh/m3 of treated water), compared to intensive processes for which, for an equivalent level of treatment, the energy consumption related to aeration is higher (generally higher than 0.6 kWh/m3 of treated water).

4 Conclusion

The planted beds, which are inspired by wetland ecosystems, are integrated into the diversity of cellar effluent treatment and spraying systems.

Rustic design, simplicity of management, low energy consumption, landscape recovery are all arguments that interest professionals wishing to develop sustainable approaches to cellar effluents. Beyond the aesthetic dimension, it is possible to consider recreating artificial wetlands that enhance local biodiversity.

The finishing treatment or sludge management of devices resulting from the treatment of domestic effluents is widely developed. More innovative developments (recycling, direct treatment on zeolite, forced ventilation system) offer interesting prospects for the future.

As with any ecological system, the choice of this type of treatment requires optimal management of water and by-products (sludge, lees, descaling solution, filtration soils, etc.). At the same time, if the operation of these systems is simple and rustic, the production must be entrusted to specialists, with good experience in the wine sector if possible, to optimise the design and dimensioning (integrating in particular the peak of activity during the harvest).

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