LIFE16 CCM/GR/000044

Deliverable Name: Manual for GFF production

Action C.1: Installation of GFFs in all areas

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Introduction

Since the very beginning of the project, the Biomass C+ consortium has been trying different designs and materials in order to achieve the most efficient and cost effective Green Floating Filters (GFF). After validating and adjusting the rectangular tray design, several materials were tested, among them: Expanded Polystyrene, Expanded Polyethylene, Polypropylene and Mycelium composite. In order to make the GFFs easily replicated, this manual will depict all the necessary specifications to allow anyone to produce an efficient GFF and start to produce biomass in a sustainable way and with an added value.

1. Design

1.1 Floating trays

The dimensions of the trays should be around 1200mm x 600mm x 20mm (0,72m^2). These dimensions are not fixed and should be adapted to achieve the most convenient and cost effective option. Therefore, they can be adjusted according to following variables:

- **Length and width** should be adjusted according to the pond dimensions in order to fit as many trays as possible and adjusted according to the manufacturer requirements, trying to make both sizes a multiple of the raw piece dimensions. Additionally, very large lengths and widths should be avoided, as too long trays can be very complex to handle, transport and become too flexible which can be an issue on open waters.
- **Thickness** should be adjusted according to the manufacturer requirements, trying to make it a multiple of the raw piece thickness. Big thicknesses are not desirable as can prevent the sapling from having contact with the water. Too little thicknesses can decrease the tray's stiffness and not guarantee enough floatability. Therefore, thicknesses should be between 20 and 25mm.

Regarding the holes, their diameter should have 40mm, in order to allow a tight adjustment between the tray and the saplings. Bigger diameters are not advisable as will cause the sapling to fall off. Only if the saplings' size is bigger than normal, the holes can be wider. Furthermore, the holes should be equally distributed in intercalated rows as seen in the picture below. This distribution has the objective of avoiding any weight concentration on the tray. Additionally, the different holes will allow the *Typha* plants to spread through the tray. The distance between them should not be less than 35mm otherwise the tray will become too week and not support saplings' weight. As tray dimensions might change, the suggested "hole density" is 100 holes/m^2.

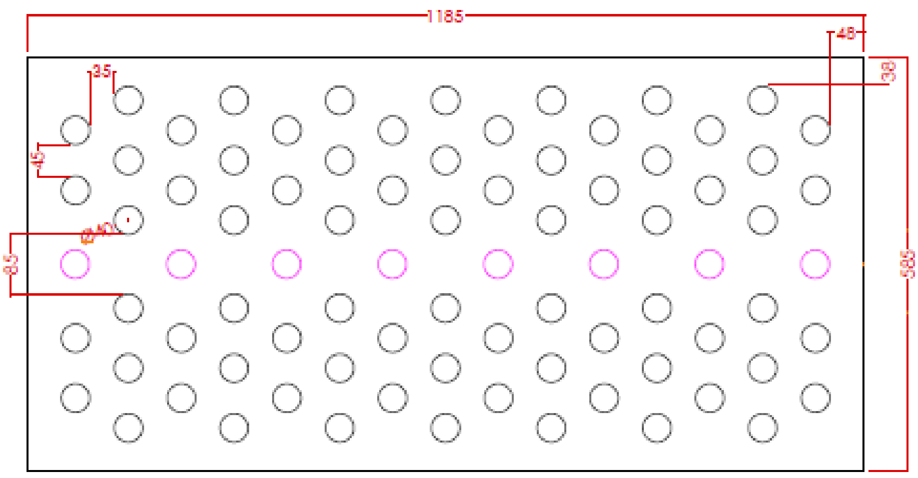


Figure 1 - Floating tray design

The holes should be manufactured by drilling, milling or die cutting in order to make a clean hole without additional damage to the overall tray strength. Processes like hot wire, which demands cutting other parts of the tray in order to make the holes will significantly reduce the tray's strength and should not be used.

1.2. Planting bags

In order to make planting easier, avoid soil loss and give more stability to the seedlings during the first months, planting bags made out of biodegradable cotton can be used. Bags should have a minimal size of 8cm length and width, otherwise the sapling placement start to be too difficult, making the planting process very inefficient. Using smaller bags can significantly increase the planting time process and only making it more difficult the GFF establishment. The height are not that critical but should be around 10-12cm.

2. Material

Initially (2018 plantation), the floating trays were designed to be made out of fiberglass. However, it turned out to be very expensive and very complex to manufacture, especially for production of small amounts.

For this reason, many other materials were trialed and investigated in order to find a suitable substitute. After visiting manufacturers and carrying out small scale trials with many types of plastics, foams and wood composites, the consortium used three materials in its plantations; Expanded Polystyrene, Expanded Polyethylene and Mycelium composite. Now VOLTERRA is trying a new solution with Coconut mesh.

2.1. Expanded Polystyrene (EPS)

For the 1st plantation, in 2018, trays made out of expanded polystyrene (EPS) were designed, together with UPM, and produced in order to kick off the first trials in Spain and Greece. Usually EPS is a very cheap material; however, the floating trays require several holes to be made with a milling machine, which greatly increases their manufacturing price. During the first trials some advantages and disadvantages were concluded.

- **Advantages**: Cost effective material, easy to find suppliers, easy to handle, good floatability and it does not affect the sapling growth.
- **Disadvantages**: It releases tiny parts when cut and tensioned that can go into waterways, very rigid and therefore easily breakable, low recyclability, it does not degrade with time and it has an expensive hole manufacturing.

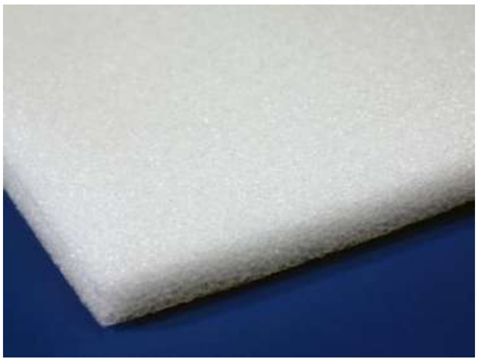
Despite the fact this material was used during the 2018 plantations, VOLTERRA does not recommend it as the disadvantages are higher than the advantages. Nevertheless, if used we advise an EPS density of at least 30 kg/m^3. Less than that the material will be too weak and will break with a minimal effort. Higher the density higher is its durability, reducing the release of tiny parts (its most critical disadvantage). Additionally, higher the density more expensive the material.

Figure 2 - EPS trays in 2018 trials in Spain

Figure 3 - EPS trays in 2018 trials in Greece

2.2. Expanded Polyethylene (EPE)

For the 2nd plantation in 2019, trays made out of Expanded Polyethylene (EPE) was trialed. Their design follow the same specifications that in the previous year (rectangular with evenly spread holes). The consortium concluded that EPE had a better performance when compared with the EPS, especially because the fact that this material do not release tiny parts in the water and it is less rigid, resulting in an easier handling. The advantages and disadvantages of EPE are as follows:



- **Advantages**: Continuous material, which does not release small parts when tensioned, cost effective, easy manufacturing, 100% recyclable and new parts can contain up to 80% of recycled material. EPE is flexible and cope well with small waves, additionally has low densities and offers good floatability.
- **Disadvantages**: It is a plastic, which takes long periods to completely degrade.

EPE usually has densities between 15 kg/m3 to 120 kg/m3. Nevertheless, VOLTERRA recommends using densities between 25 kg/m3 and 35 kg/m3, as lower densities would result in a very flexible and week material and higher densities would result in a rigid and more expensive material.

Figure 4 - EPE trays in 2019 trials in Spain

Figure 5 - EPE trays in 2019 trials in Greece

2.3. MycoComposite

During the research for an alternative material to EPS, VOLTERRA made contact with some very interesting solutions. The most promising contact was with a North American company called Ecovactive Design, which produce a Mycelium based composite mixed with wood chips. This material is now used for packaging, however the company was very interested in trial new applications for their innovation. In a cooperation between Ecovactive and VOLTERRA, some samples of Mycomposite was sent to Spain and placed at replication sites to test their performance.

Trials are still underway, however preliminary results show a good performance. As a biodegradable material, the biggest limiting factor will be how long the trays will take to degrade. The trays should last at least 6 months (1 year would be ideal), as this is the minimal time the *Typha plants* need to grow enough in order to guarantee their own floatability. Therefore, if the tray degrades before that period, the saplings will sink and not fulfill their objective. As could be checked during the first monitoring visits, after 1,5 months in the water, the trays already started to degrade, but they are still maintaining a good floatability.

The downside of this material is definitely its price, which it is still far more expensive than EPS and EPE. At the current scale, Ecovactive would be able to offer a material 10 times more expensive than the plastics ones. Furthermore, as they are already in motion to construct a bigger factory, with enough buying scale they expect to be able to reduce this cost by half in the next years, however this would still mean a material 5 times more expensive.

Because of confidentiality reasons, not much specifications about the material could be given, but according to them it is made out of wood chips (from agricultural waste) bonded by a Mycelium substrate in mold.

Figure 6 - MycoComposite tray preparation

Figure 7 - MycoComposite tray after 2 weeks.

2.4. Coconut mesh

During the research for an alternative material to EPS, VOLTERRA is now testing a new method to grow the *Typhas*. The idea is to use a Coconut mesh, which is biodegradable, as a "carrier" to the plants, where they would germinate and grow at the same location. This would save space and logistics from germinating them in a nursery, on the other hand the survival rate will decrease.

Once the *Typhas* are more developed, the location where they are growing will be flooded with contaminated water and the Coconut mesh will help the saplings float and achieve the same application as in the aforementioned materials.

So far, trials are just starting at VOLTERRA's office and we are still waiting the seeds to germinate. However, if until 2020 plantations this material is proven to be successful at this small scale, they will be trialed in larger scale in 2020. VOLTERRA is trying too types of meshes; one with high and other with low density in order to check which one is more effective. The final conclusions for this trial will be better explained in the final report

This method has the potential to be more cost-effective than the others (coconut meshes are considerably cheaper than the Tray materials), biodegradable and simpler to scale (as it would not need a nursery). Nevertheless, the main disadvantage of this method will be the longer time needed to stablish the GFFs.

Figure 8 - Low density with coconut mesh

Figure 9 - High density with coconut mesh

Conclusion

After many trials with different materials VOLTERRA can conclude that the EPE trays are cost effective and, so far, the most suitable solution to the GFFs. Despite the fact that this material is highly recyclable, the consortium understand that a 100% sustainable solution should be developed. Therefore, the Mycomposite material is the one with the highest potential to become more cost effective and consequently the best solution for GFFs. Below there is a table summarizing the advantages and disadvantages of all materials trialed so far.

Material	**Advantages**	**Disadvantages**
EPS	Price, floatability, stable	Not biodegradable, low recyclability, easily breakable, release of tiny parts
EPE	Floatability, stable, 100% recyclable	Not biodegradable
MycoComposite	100% biodegradable, floatability	Price, still not available worldwide
Coconut Mesh	100% biodegradable, price	More time to stablish

VOLTERRA will continue its collaboration with Ecovactive in order to follow closely this technology development. VOLTERRA will provide some feedback from the Biomass C+ trials in order help them improve their material and call their attention to this market.

Regarding the Coconut mesh trial, updates will be posted on project’s website and social media, and if feasible applied in the next project’s plantations.