How to plan a compost plant

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1. Introduction

Good planning of a compost plant is the indispensable basis for obtaining a facility that is adapted to the situation and the desired objectives. Each situation is different, and thus each compost plant has its own specificities. This is even though the general basis for planning is universal. The planning of a compost plant is not limited to the technical aspects but must also include the general concept of its management.

The various aspects to consider when planning a compost plant are as follows:

- Organic waste (material) to be treated
- Market opportunities for the compost produced
- Place at disposal
- Geographical location
- Possible resources (machinery, human resources, financial capacity)
- Legal regulations of the country

When planning a composting facility, compromises must often be made to best meet the various aspects. So, it makes sense to investigate and quantify several alternatives before making a decision. In addition, it is advisable to plan a compost-plant concept that can be optimized, expanded, or redesigned at a later stage, in order to adapt to changing circumstances.

2. Organic waste to be treated

The first essential point to be clarified are the organic remains (material) that are available or that can be organized and that one wishes to compost. The aim is to produce starting mixes optimally suitable for composting. This means a C:N ratio of between 30 and 40, and a mixture structure that allows air to circulate within it without being too loose. If the material available is too one-sided (e.g. one type of material makes approx. 90%), the organization of other inputs to balance the starting mixture may be necessary. The finally available starting mix will also influence the choice of composting system.

The planning of a composting facility should have a focus on a complete year. Indeed, the arrivals of the various inputs often vary in quantity during the year. Some, such as wood products, can be stored for long periods of time, while others, without structure (such as vegetable waste), need to be processed as quickly as possible. Thus, stockpiles of storable wastes must be created so that appropriate starter mixes can be made as soon as the unstructured materials arrive at the composting facility.

To plan and to make these mixtures it is necessary to know what material is available at what time during the year. For this, a table has to be generated with the various materials that may be available per quarter (Tab. 1: Input material).

Tab. 1. Quantification of biological waste materials available: List the different types of organic material that you would like to compost, indicate the time of availability during the year and the amount of material available at a certain period. This table is the basis to plan a specific mixture of material that is well suited to make good compost.

Material[1]	Origin	Moisture[2]	Structure[3]	Density [ton/m³]	Accuring quantity [tons fresh material]				Remarks
					Jan.-March	April-Juni	Juli-Sept.	Oct.-Dec.	

[1]examples: vegetable waste, rest of tomato crop, horticultural waste, cow manure, collected municipal organic waste, mushroom culture medium, etc.
[2]estimation of product moisture: dry, medium-moist, moist, wet, very wet, …
[3]estimation of material structure: poor (like vegetables waste, sawdust), good (like horticultural waste, manure with stroh), high (like wood braches)

3. Market opportunities for the produced compost

At the other end of the composting system, when you have the final product, it is important to define the intended uses for the compost produced. If the composts are not used by the company of the compost plant itself, the product can be sold. For best-selling, a rough study of the market potential for the composts (or the products derived from them) should be carried out.

Indeed, depending on the intended uses, the characteristics of the composts sought are not the same (degree of maturation, sieving granulometry, nutrient content, addition of other components, etc.). To achieve this, a further table is to be made for the output products of the composting plant (Tab. 2: Market areas for various output products).

Tab. 2. Market opportunities for the composts produced.

Market[1]	Request maturity[2]	Sieving mesh [mm]	Addition of other component[3]	Density [ton/m³]	Potential market opportunities [m³]				Remarks
					Jan.-March	April-Juni	Juli-Sept.	Oct.-Dec.	

[1]examples: field crops, vegetables in field, vegetables in grennhouse, private gardening, potting soil, etc.
[2]maturity stage of compost: fresh (just after hot phase), medium mature, mature
[3]example of other component: filed soil, coconut fiber, sand, perlite, clay, peat, …

4. Choice of composting system

The types of inputs available and the qualities of the composts produced certainly play an important role in the choice of the composting system. However, other factors will also play an important role: the total annual quantity of organic waste treated, the geographical location of the composting facility (e.g. proximity to houses), water resources, available financial and human resources, etc.

In general, between 0.8 and 1.5 m^2 per ton of organic waste treated per year should be expected. When the quantity of organic residues treated is low (1'000-2'000 tons per year), the space required per ton is more important (because of the surface area needed for machine traffic and for the operations to be carried out such as shredding and screening). Similarly, the more elaborate the products produced (like production of potting soil), the greater the demand for space.

Different types of composting systems with their advantages and disadvantages will be presented here.

4.1. Field edge composting

This system is good appropriate for rural areas, mainly for horticultural waste, manure.

<u>Advantages</u>

- Financially advantageous.
- Does not require the construction of a large composting area: one place to collect the organic waste and prepare the starting mix is sufficient.
- Both solid manure and green waste can be treated with this method.
- Shows good flexibility.

<u>Disadvantages</u>

- Needs enough appropriate field edges. Appropriate for 500 - 1’000 tons / year.
- No clear separation between environment and compost, it is difficult to assure weed free compost.
- Management of the composting process not always easy (moisture management).
- Relatively labor-intensive.

Fig. 1. Field edge composting.

4.2. Small windrows composting (up to 2 m high, 3-4 m wide)

This system is good appropriate for horticultural waste, manure, peelings, … The structure of starting mixture can be relatively fine. In general, the process is relatively intensive managed (curing time: 2-3 months).

<u>Advantages</u>

- Good appropriate also with starting mixture relatively poor in structure material.
- Method appropriate to treat solid manure and green waste up to 5-6,000 tons per year.
- Management of the process management can good be controlled.
- Clear separation between environment and compost.
- Each pile can be managed individually (starting mixture, maturation degree), so that it is possible to produce different composts for different applications.
- If enough surface available, important quantity of organic waste can be treated.

<u>Disadvantages</u>

- Medium investment costs (construction of the place, machine, ...).
- Needs a relatively high surface area.
- Relatively labor intensive.
- If process not good managed, odor problems can appear.

Fig. 2. Small windrows composting.

4.3. Large windrows composting (up to 3.5 m high, width not limited)

Method appropriate to treat large quantities of solid manure and green waste. Enough coarse structure material is needed to assure a good circulation of the air in the pile. In general, the process is relatively low intensive managed (curing time: 6-12 months).

<u>Advantages</u>

- Good appropriate with starting mixture rich structure material (with a lot of wood in the starting mixture).
- Good work efficiency.
- Can be implemented with forced aeration.
- Clear separation between environment and compost.
- Management of the process management can good be controlled, biology is stable.
- Appropriate to compost also important quantity of material (20-30’000 tons/year).
- Surface saving.

Disadvantages

- Needs relatively high investments costs (construction of the place, machine, ...).
- No clear separation between different compost batches.
- Need an important quantity of structure material (wood).
- If process not good managed, odor problems can appear.

Fig. 3. Large windrows composting.

4.4. Tunnel composting (approx. 2.5 m high, 5 m wide)

This system is good appropriate for horticultural waste, manure, peelings, … The structure of starting mixture can be relatively fine. In general, the process is relatively intensive managed (curing time: 2-3 months).

Advantages

- Method appropriate to treat large quantities of solid manure and green waste.
- Compost turning is regulated automatically.
- Can be implemented with forced aeration.
- Clear separation between environment and compost.
- Clear separation between different compost batches.
- Plant can be closed, and air treated to avoid odors emissions.
- Low labor intensity.

Disadvantages

- High investment costs.
- Process management limited: the frequency of turning for a compost batch is fixed (given by the system).
- A lot of technology is involved: relatively sensitive to trouble shooting.

Fig. 4. Channel composting.

4.5. Box composting system (approx. 3.5 m high, 6 m wide, 20 m long)

Method appropriate to treat large quantities of solid manure and green waste.

Advantages
- Compost turning, forced aeration and moisture control happen automatically.
- Clear separation between environment and compost.
- Clear separation between different compost batches.
- Plant can be closed and air treated to avoid odors emissions.
- Economic use of available surface area.
- Plant can be closed, and air treated to avoid odors emissions.
- Low labor intensity.

Disadvantages
- High investment costs.
- The distribution of the material over the box at the beginning of the process must be homogeneous; otherwise, the evolution of the composting process in a box will vary greatly from one part of the box to the other.
- A lot of technology is involved: relatively sensitive to trouble shooting.


Fig. 5. Box composting system

4.6. Vermicomposting

Method appropriate to treat solid manure, green waste poor in wood, vegetable waste, ...

Advantages
- Process can be performed with low technology system (low cost, but labor intensive) or with an automatic system (low labor intensity, but relatively high investment costs.
- Can treat an initial mixture with low structure (pomace, vegetable waste, manure, ...)
- Compost produced is rich an fertilizers (especially available nitrogen)
- Clear separation between different compost batches.

Disadvantages
- Only "healthy" material should be treated in this way (no heat phase, and so no guarantee of hygienization), or a short hot rotting should be used previously.
- A lot of technology is involved: relatively sensitive to trouble shooting.

Fig. 6. Vermicomposting

It is to mention that good compost can be produced with a lot of systems, but all systems can also produce bad compost! The process management is decisive to obtain quality compost.

5. Elaboration of the global concept of a compost plant

In many cases, a composting system with small compost windrows is well suited. It is a very flexible system that can be adapted, through appropriate process management, to various starting mixtures. Depending on the size of the system, input quantities from 2'000 to more than 30'000 tons / year can be processed. Depending on the development of the situation, such a plant can be expanded without too many problems.

Therefore, we will take this system as an example for the planning of a composting plant and consider an input material quantity of 5’000 tons/year.

For the treatment of about 5000 tons of organic waste per year (including storage space for the compost produced), a surface area of approximately 7500 m^2 is required. This surface should be hard to facilitate the composting work and to limit the risks for the environment.

A composting facility must have the following elements:

Space for the disposal of organic waste. This space must be divided for the separate handling of the various inputs. As a minimum, a clear separation between structuring materials (such as woody material), which can be stored for a long time, and non-structural waste that needs to be treated in the short term should be made.

Space for the realization of the starting mixes. This is the place where inputs with structure are shredded and mixed with materials without structure.

Space for windrows. This is where the actual composting takes place. This part of the square should have a slope of 2-3% parallel to the windrows so that rainwater can run off in case of heavy rainfall. If this is technically and financially feasible, covering the windrow area would be a great advantage for the management of the process and would also collect the rainwater that falls on the roof, which can be used to regulate the humidity of the windrows.

Covered space for the storage of the compost produced. These mature composts are very sensitive to the vagaries of the weather and must therefore be protected there to guarantee the quality of the composts until they are used. In between the place of the windrows and the compost storage area, a sufficient surface area must be provided for sieving the composts.

An office with room to set up a small laboratory is needed to manage the operations of the composting plant and to carry out the work necessary to ensure the quality of the products. Depending on the waste collection concept, a scale may also be required.

A schematic diagram of the composting site is shown in Fig. 7. Of course, an exact planning of the place can only be carried out once the exact situation is known and evaluated.

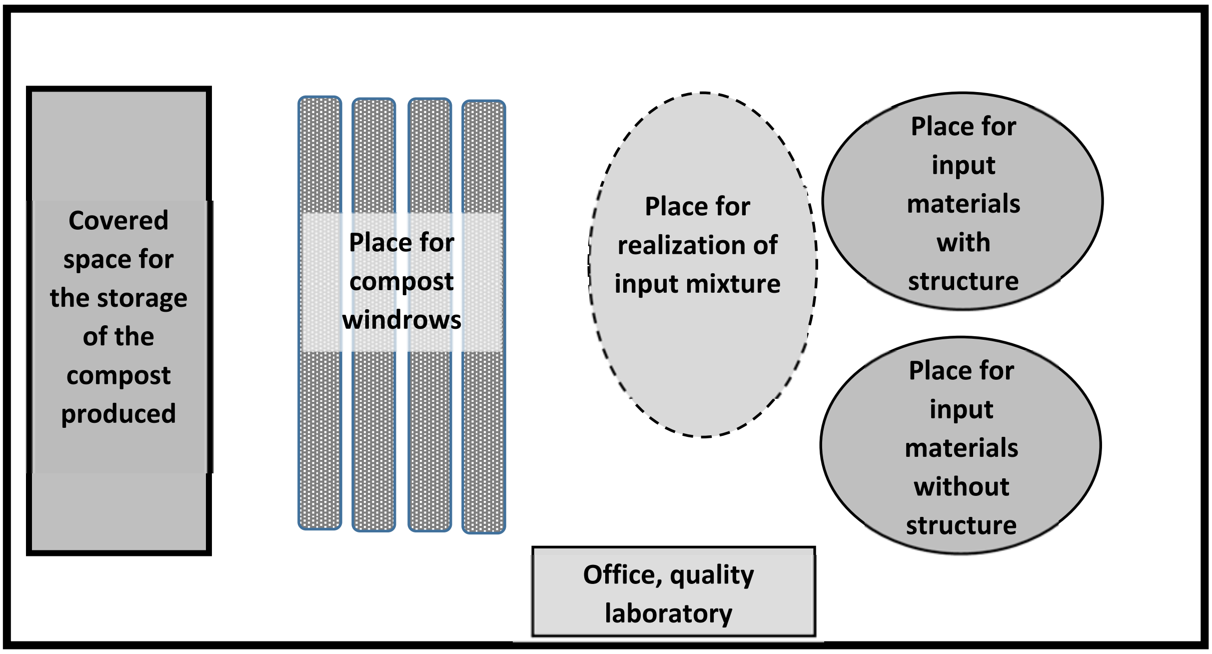

Fig. 7. Schematic diagram of the organization of the compost plant.

6. Necessary infrastructure for the realization of the compost plant

In addition to the construction of the compost place itself described in the previous chapter, various infrastructures are needed for composting. In this document, we will not detail the necessary "small equipment" such as thermometers or laboratory infrastructure. Only the larger cost machines are discussed here.

The three most important machines are a loader, a shredder and a turning machine. Second priority has a sieve machine, and last priority has a packaging machine.

6.1. Loader

A loader is required to handle treated materials. A front-end tractor is probably the most appropriate solution to start, as this tractor could also be used to brew compost heaps with a tractor-attached brewery. However, the tractor must have sufficient power to do this work.

Fig. 8. Example of tractor and loader.

6.2. Shredder

A shredder is needed to defibrate structuring materials such as branches of trees or shrubs. An important point is that this machine does not cut the products, but that they are shredded. Indeed, only well-defibrated woody products can be attacked during composting. Given the amount of material processed, a medium shredder could be appropriate.

Fig. 9. Example of shredders for the compost plant.

6.3. Turning machine

To produce quality compost is a turning machine an important investment. To start, a tractor-drawn turning machine is certainly an advantageous solution. You must choose a model that can turn windrows with a height of 2 meters. It is also important, when choosing this machine, to be well informed about its requirements in question tractor (these two machines must work together). It is also advantageous if this machine has a system to remove and deliver the geotextile used to cover the windrows of compost (if the composting space is not covered). The disadvantage of a pulled turning machine is that it requires a larger composting space, because each two windrows an empty slot must be left to allow the tractor to pass.

A self-tracked turner is of course also possible but is much more expensive. However, it saves place on the compost plant.

If the purchase of a compost turner is not possible at the beginning of the project, the compost can be turned with a loader, taking care to break up the compost clods during this operation. However, the quality of the work done with a loader never reaches the quality of the work done with a real turner, and moreover it requires more work.

Fig 10. Example of a pulled turning machine and of a self-tracked turning machine.

6.4. Sieve machine

An artisanal system is possible. However, there are middle-sized drum sieves that would be well adapted to the dimensions of the planned composting plant.

6.5. Closing remarks

Only a rough concept can be proposed at this stage, an on-site evaluation being necessary to make a final planning and then the implementation of a composting concept adapted to local conditions.

When it comes to the choice of machines, the following should be taken into account:

- Appropriate sizing of the machine for the amount of material treated
- Proven machine technology
- The quality and strength of the machine
- Opportunity for after-sales service (among other parts availability) in Liberia
- Machine price (including transport)

It is advisable, if possible, to test the machine before its purchase. This is particularly recommended for the shredder, to see the result obtained with its own way (quality of the defibering, possibility of adjustment of the machine (size of the grinder), time capacity of the machine, etc.).

Fig. 11. Example of an artisanal sieving system of two drum sieve and a star sieve.

7. Operating documents

The operating documents are especially important aids for a compost plant. They actively contribute to the production of products of consistent quality and to the optimization of plant processes. They provide proof of quality for both the plant manager and the compost purchaser.

The most important documents for the management of a composting plant are the register of delivered organic waste, the register of outgoing products, and especially the process control protocol. The latter is essential to optimize the management of the process itself.

The process control protocol describes the main activity of a composting facility. It is the basis for composting management and quality assurance. It must be completed for each batch. For this reason, the different batches must be clearly numbered and followed from the time they are set up until the compost produced is marketed.

The windrow monitoring protocol should contain the following information:

- Batch number and date of installation
- Components of the mixture (in m³ or % of the mixture)
- Possible addition of additives (soil, enzymes, microorganisms) with the quantity and date of addition
- Subsequent addition of raw material with quantity and date of addition
- Composting logbook (temperature, humidity, if possible O_2 content, operations done, such as turning, adding water, covering the windrow with compost fleece)
- Date of sampling, if any, for quality control purposes
- Further processing of the batch

The monitoring protocol must be always kept up to date and with care. Among other things, it serves as a basis for monitoring the natural hygienization of the compost produced at the facility.

An example of protocol is presented in the Tab. 3.

Tab. 3. Example of a protocol of composting process

Protocol of composting process								**Compost No.**
Total starting material [m^3]:								**Pile No.**
				Pile setting up				
Date	Gardening waste [m^3]	Vegetable waste [m^3]	Cow manure [m^3]	Chicken manure [m^3]	Rice straw [m^3]	Other (…………….)	Other (…………….)	Remarks
Compost seaving:					**Delivrery of compost:**			

														Process control							
Date	T1	T2	T3	Gas composition [%]									M1	M2	M3	Mixing	H_2O [m^3]		Taking sample for analyse	Remarks	Visum
				O_2 1	CO_2 1	CH_4 1	O_2 2	CO_2 2	CH_4 2	O_2 3	CO_2 3	CH_4 3	0: OK; -: dry; ---: very dra; +: wet; +++: very wet								
General remarks:																					

T1, T2, T3: pile temperature (three mesures); M1, M2, M3: compost moisture (three evaluations)
Mixing: pile mixing; H_20: water supply