Design of Solid Waste Treatment Plant Report

Group 2

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Chapter 1

Problem description

1.1 Given data

The data specifying the problem is listed below:

Table 1.1: Problem specification table

Disposal area	
Population	515000 inh
Area	641 m^2
Municipalities	44
Biowaste	70 $kg/inh.a$
Garden - Park waste	20 $kg/inh.a$
Structure	
Buildings total	106938
With 1 dwelling	59464
2 dwellings	25751
3 and more dwellings	21723
Households	239245
Person/Household	2.2
Single Households	35

For this area we have to select an appropriate composting technology and design a solid waste treatment plant using that technology.

1.2 Input capacity

With an input of 70 kg per inhabitant per annum, and a population of around 5 million, one can guess the required capacity of the plant by calculating yearly input of biomass:

$$
\begin{aligned}
Q_a &= Population \times Input\ capacity \\
&= 515000 inh \times 70 \frac{kg}{inha} \\
&= 36050 \frac{Mg}{a}
\end{aligned}
$$

Assuming 250 working days per year, with 8 hours per day, following table can be calculated:

Table 1.2: Input capacity calculation

Q_a	36050 Mg/a
Working days (per year)	250 d
Working days (per week)	5 d
Working hours (per day), t_{wh}	8 h
Availability, η	80%
Maximum factor	1.1
Yard waste	20 $kg/inh.a$
Density of biowaste, $\rho_{biomass}$	0.3 Mg/m^3
Density of yard waste, ρ_{yard}	0.15 Mg/m^3
Q_d	144.2 Mg/d

$Q_{d,max}$ is calculated from Q_d by multiplying it by maximum factor. For throughput calculation, we use following formula:

$$
\begin{aligned}
Q_h &= \frac{Q_{d,max}}{t_{wh} \times \eta} \\
&= \frac{158.62 Mg/d}{8h \times 80\%} \\
&= 24.78 Mg/h
\end{aligned}
$$

We store biomass for only 1 day. On the other hand, yard waste can be stored almost 2 months. From this data, we can calculate the area required for storage of biowaste and yard waste. Even though the biowaste already contains structured material, it is assumed that the amount of structured material is not enough for proper composting. Therefore, additional yard waste of 20 $kg/inh.a$ will be added in the biomass.

$$
\begin{aligned}
Area_{biomass} &= \frac{Q_{d,max} \times t_{biomass}}{\rho_{biomass} \times h} \\
Area_{yard} &= \frac{Q_{d,yard} \times t_{yard}}{\rho_{yard} \times h}
\end{aligned}
$$

The height is taken to be 2 m. Assuming the receiving area to be square, one can calculate the width.

The calculated values are listed in Table 2.3.

Chapter 2

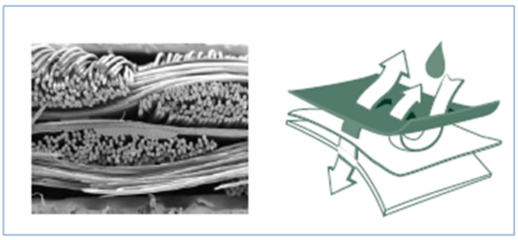
Description of the Plant

One can see that the given data describes an urban area. Since the prescribed location for composting is less than 1 kilometres away from residential area, the odour problem is crucial. Thus, a closed plant is preferred choice. However, we also want to minimize the building cost of the plant, closed plant was not an option, due to high building cost. Thus, *BIODEGMA In-Vessel Composting System* from BIODEGMA GmbH was considered to be the best choice. Decreased running cost was a plus.

2.1 BIODEGMA

Biodegma has been active in biological waste treatment since the early 1990's. Their composting system utilises semi-permeable membranes from GORE to cover the composting tunnels. Although such types of membranes have been used to directly cover compost heaps, the Biodegma application is unique.

The membrane can be covered or uncovered according to the need. Thus, Biodegma provides a very flexible system for composting large quantities of biowaste.



2.1.1 Technical data

The membranes are supplied by GORE. According to GORE, the membranes are better suited for composting since they allow selective aeration through the pores. The waste covers consist of a specially developed GORE-TEX membrane, laminated between two highly robust polyester layers. Due to the right pore structure, it is possible to selectively influence the treatment process. The membranes used in waste treatment protect the composting material from the penetration of rainwater and yet allow CO_2 produced during the composting process to escape.

Odours are extensively retained, since the cover acts as a physical barrier against gaseous substances escaping from the rotting material. In addition, a fine film of condensation develops on the inside of the tarpaulin covers during the composting procedure, suppressing odours and other gaseous substances. These gases are partly dissolved in the film of water and drop back into the composting material where they continue to be broken down by bacteria. The right choice of membrane influences the extraction of moisture during composting. It prevents the final product being too wet, yet at the same time ensures that there is sufficient moisture retained to allow the material to be decomposed.

Due to the micro-porous structure of the membrane, it is impossible for microbes to penetrate. Numerous microbiological tests have proved that microbes can be reduced by $> 99\%$. Thus the workers and nearby residents are protected and safe. The insulating effect of the cover and the pressurisation for "even temperature distribution", means that achieving the necessary temperature for sanitising the material across the entire cross-section of the heap can be guaranteed. Pathogenic micro-organisms are safely destroyed throughout the entire composting material.

2.2 Mass balance and flow diagram

2.2.1 Mass balance

The mass balance of our system is shown in the Fig 2.2.1. Around 1.5 % of the total input of biowaste will be screened out to the off-site treatment. 20 % of the structural material and 49 % of waster will be added for composting. AS a result, there will be 58.7 % compost. 20.6 % organic material, and 88.9 % water as the output.

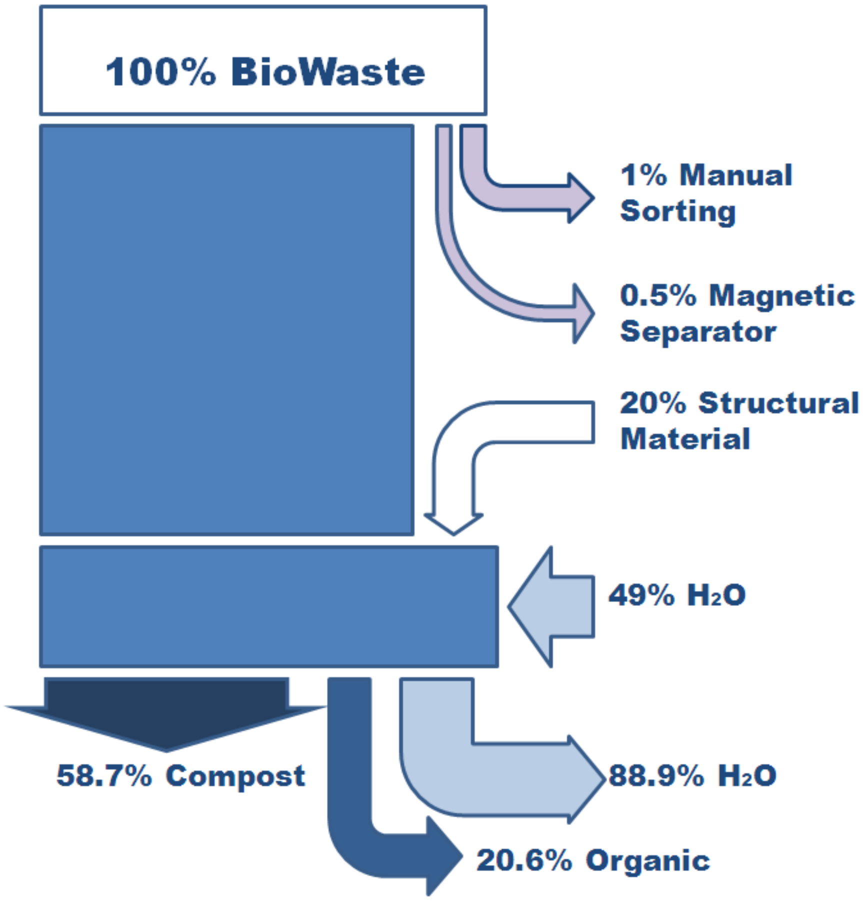


Figure 2.1: Mass balance

2.2.2 Flow diagram

The flow diagram is shown in Fig 2.2.2 for flow diagram. Detailed explanation for each process is as follows:

1. Water transport - waste is transported by trucks to the plant.
2. Receiving area - we have two receiving areas for collection of biowaste and structural material.
3. 1 Day storing - biowaste will be stored in the receiving area for maximum of 1 working day.
4. Visual screening - biowaste is manually sorted in the visual screening process. Impurities are sent to off-site.

5. Screening - biowaste is screened in the screening drum. Waste which has a size bigger than 80 mm is sent to the shredder. If it is smaller than 80 mm, then it is directly sent to the magnetic separator.
6. Shredding - biowaste which is bigger than 80 mm is shredded and is sent to magnetic separator.
7. Magnetic separator - magnetic separator sorts out the metals from the biowaste.
8. Mixer - biowaste is sent to mixer and mixed with waster and structural material shredded by shredder.
9. Temporary storing - After pre-treatment stage, biowaste will be stored temporarily at the temporary storing place just between the tunnel and the pretreatment building.
10. Composting tunnel - biowaste will be transported to the composting tunnel. In the composting tunnel, biowaste will be composted in two stages. Leachate is collected to the leachate tank and sent to the water treatment plant.
11. Drum screening - compost will be screened by drum. Compost bigger than 300 mm will be sent back to the tunnel for more composting.
12. Half year storing - compost will be further degraded in the open maturation hall for half year.
13. Marketing - final compost will be transported to the market.

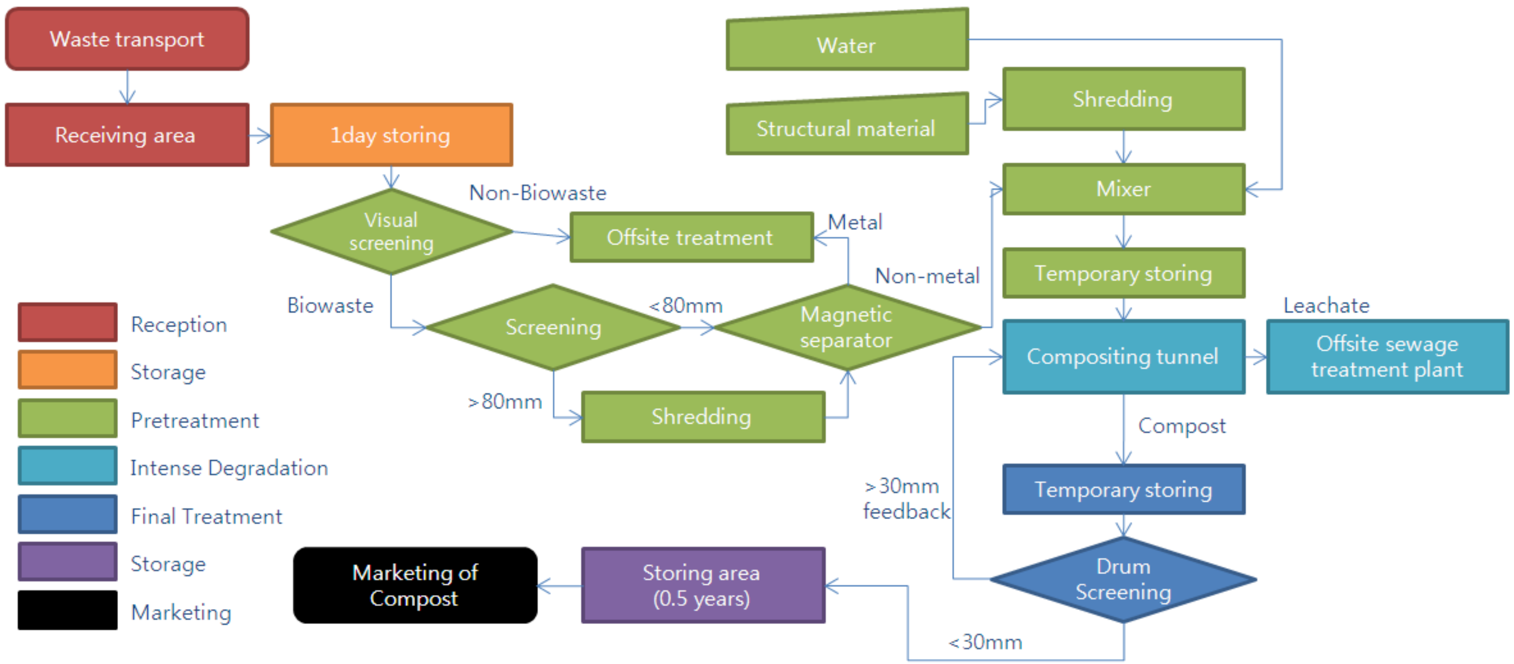


Figure 2.2: Flow diagram

2.3 Process diagram

Truck coming from residential area with either biowaste or yard waste will be first visually inspected and weighted at the entrance building.

Unloaded biowaste is stored in the capsulated storage building for biowaste. Maximal storage time is one day because of odour problem. On the other hand, yard waste, which causes no odor problem, can be stored up to 2 months in an open hall.

In the pretreatment building, biowaste will be manually sorted, screened and purified by magnetic separator to take out the ferrous fraction. After this, milled yard waste and biowaste will be mixed to reach optimal water content by adding water. The mixture is than ready to be brought to tunnels for 8-week-intensive composting.

After 8-week-composting, compost is taken out from tunnels and brought to maturation hall, where it can be stored up to 6 month. Compost here is ready to packed and sale.

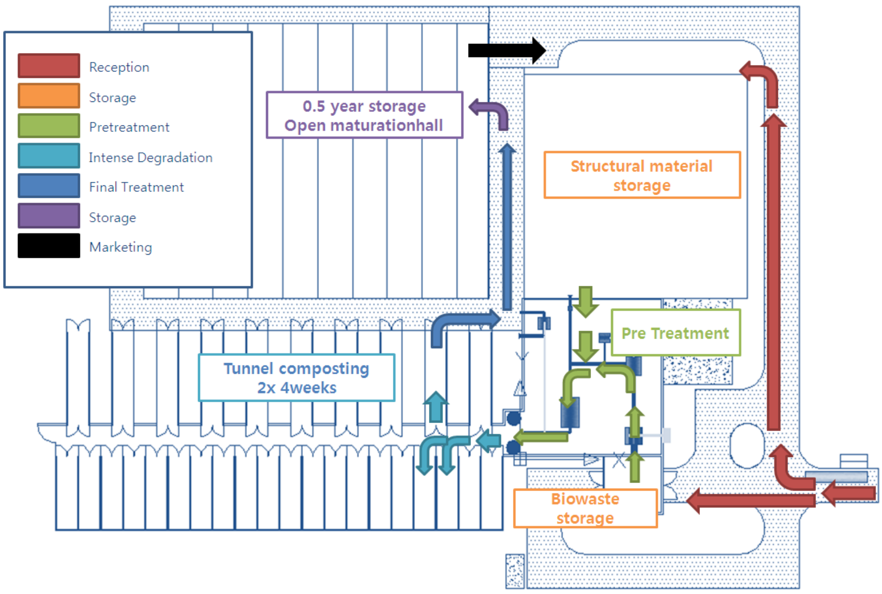


Figure 2.3: Process diagram - See Fig 6 for details.

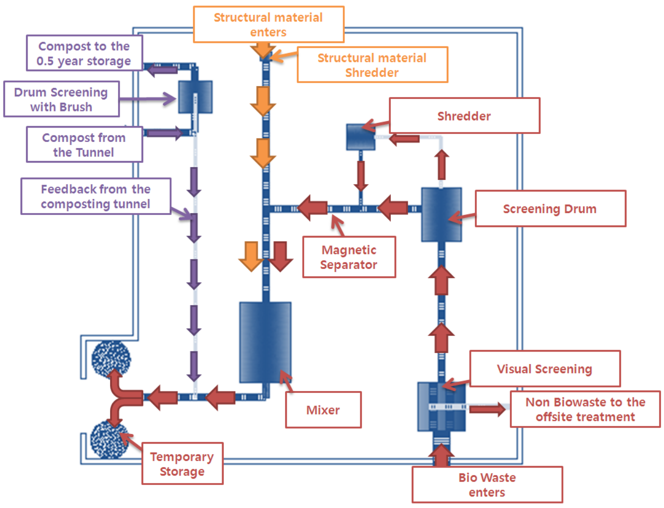


Figure 2.4: Process diagram for pretreatment area - See Fig 6.1 for details.

2.4 Buildings

Due to large amount of biowaste that is needed for composting, aeration is essential and crucial. Even though Biodegma membranes provide a convenient way of aeration, turning at regular intervals is necessary.

For our case, we have assumed that turning after every 4 days is enough.

Figure 2.5: Building overview *(3D)*

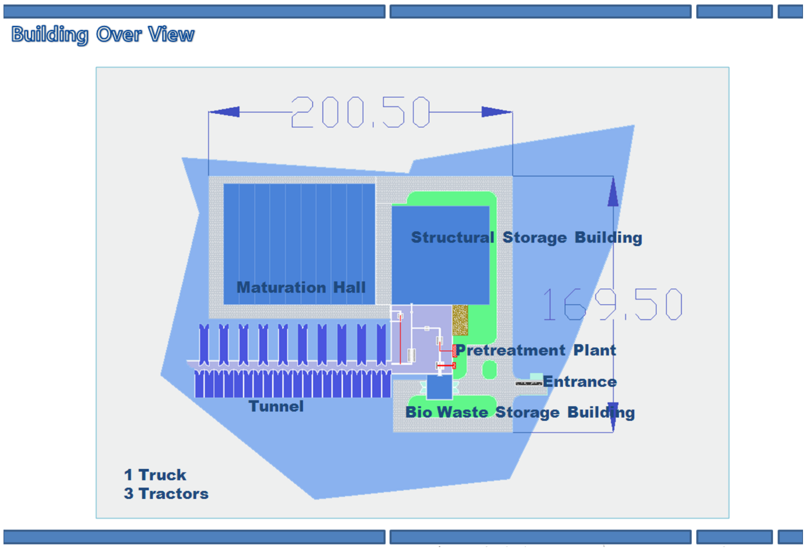


Figure 2.6: Description of the plant

2.4.1 Entrance building

Entrance building is designed for the guards, and workers. It is located in front of the gate entrance. Workshop and small toilet will also be placed inside.

Calculations

Table 2.1: Annex building

Length	7 m
Width	3 m
Height	3 m
Total volume	63 m^3

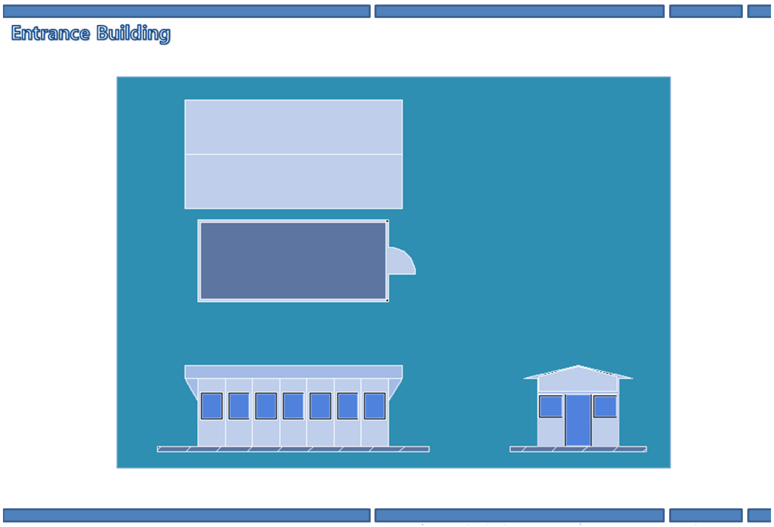


Figure 2.7: Entrance building

2.4.2 Storage building

The size of storage building depends on daily input of biowaste and structural material and storage time. Since biowaste is biologically unstable, the storage time is only 1 day, and the building is a closed hall. On the other hand, storage building for structural material is open hall, and will hold the material for almost 2 months. Thus is will be very large when compared to the that of biowaste.

The location of storage buildings is just after the entrance. A rotary connection for trucks is prescribed for easy transportation.

Calculations

Table 2.2: Storage buildings

Biowaste	
Height	$5\ m$
Volume	$1321.83\ m^3$
Structural material	
Height	$5\ m$
Volume of ventilations	$26252.03\ m^2$

Table 2.3: Calculated Input data

$Q_{d,max}$	$158.62\ Mg/d$
Q_h	$24.78\ Mg/h$
Area for receiving biomass, $A_{biomass}$	$264.37\ m^2$
Area for receiving yard waste, A_{yard}	$4120\ m^2$
Width for receiving biomass, $w_{biomass}$	$\sqrt{A_{biomass}} = 16.26\ m$
Width for receiving yard waste, w_{yard}	$\sqrt{A_{yard}} = 64.19\ m$

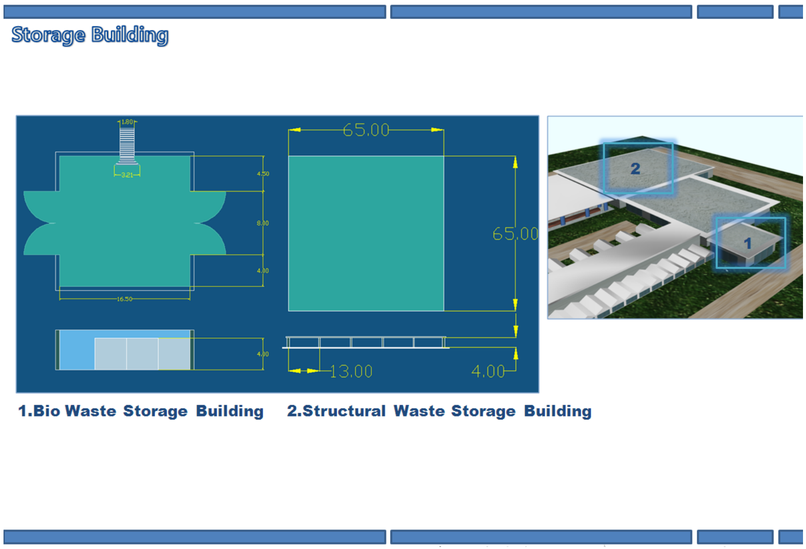


Figure 2.8: Storage building

2.4.3 Pretreatment building

Pretreatment building will be closed due to odour problems. Size of pretreatment building depends on the size and height of all the equipments. According to our calculation, the highest equipment is mixing drum. Also, for calculation of the length of the pretreatment building, the length of the conveyor belts should also be considered.

In our case, we have placed all the equipments for post-treatment also in the pretreatment building.

It is important to note that pretreated biowaste will not immediately be taken to the composting tunnels. Thus, there is a need for a temporary storage area, which can hold the raw material for 6 hours before tractors can move it to the composting tunnels.

Calculations

Table 2.4: Pretreatment building

Length	45 m
Width	40 m
Height	10 m
Storage area after mixing	43.02 m^2
Total volume	18430.2 m^3

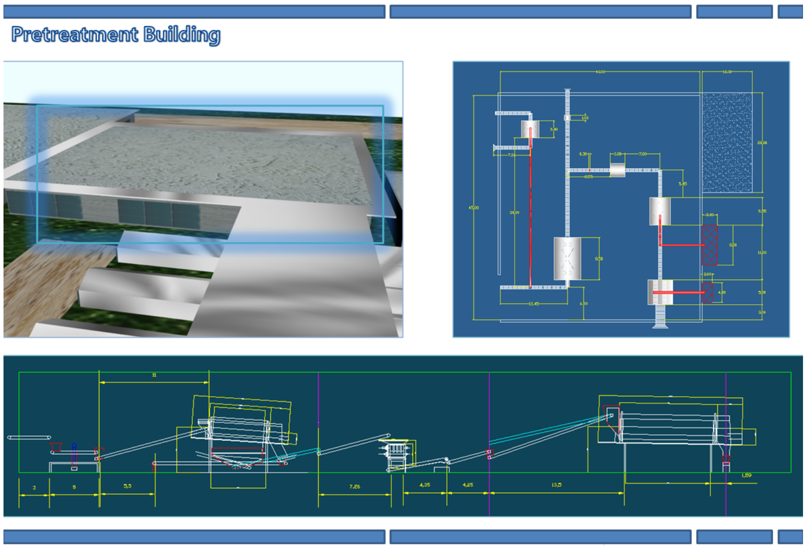


Figure 2.9: Pretreatment building

2.4.4 Composting tunnels

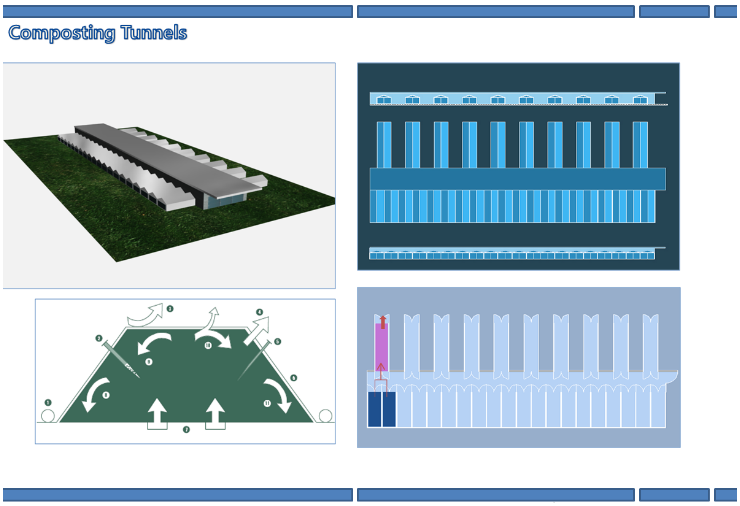


Figure 2.10: Composting tunnels

As stated earlier, we have chosen Biodegma tunnels for composting.

Due to the need for turning the compost after 4 weeks, we have designed our composting plant for composting tunnels of two different sizes. The smaller tunnels are 21 m long, and are 20 in number. It is assumed that after a time period of 4 weeks, a volume decrease of around 30 % will happen. After 4 weeks, premature compost from 2 such tunnels will be collected and put in a large tunnel of 27 m length. A total of 10 such tunnels have been planned.

In the due process, turning will automatically happen.

Calculations

Table 2.5: Composting area

Compost	
Quantity of biomass received	189.38 Mg/d
Quantity after back flow, $Q_d = M_{mb}$	200.76 Mg/d
Back flow	10%
DOS	50%
W_b	60%
W_e	40%
VS_b	70%
Amt. of compost as output,M_{me}	87 Mg/d
Loss by composting, R_v	56.67 %
R_r	$100 - R_v = 43.33\%$
ρ_r	0.7 Mg/m^3
V_r	8221.52 m^3
Tunnels	
Width	6.5 m
Height	2.5 m
Number of small tunnels	20
Length of small tunnels	20.59 $m \approx 21$ m
Area of small tunnels	2730 m^2
Number of large tunnels	10
Length of large tunnels	25.53 $m \approx 27$ m
Area of large tunnels	1755 m^2
Junction	
Length of junction	130 m
Width of junction	10 m
Height of junction	5 m
Volume of junction	6500 m
Total area	4485 m^2
Volume taken by compost	11212.5 m^3

2.4.5 Maturation hall

The premature compost is not suitable for immediate use in field. Thus, it is stored for some time before the microbial growth dies.

The finished compost after composting will be screened in a screening drum. It is assumed that 10 % of the compost will not be suitable for marketing due to its large size. This percentage will be taken to the pretreatment building and mixed with pretreated biowaste. The rest of the premature compost will be taken to the maturation hall for storage of about 6 months.

The compost does not have odour problems, and thus the maturation hall is proposed to be an open hall with cover for weather protection.

The premature compost will be put in a trapezoidal structure with $80m \times 8m \times 3.5m$ dimension.

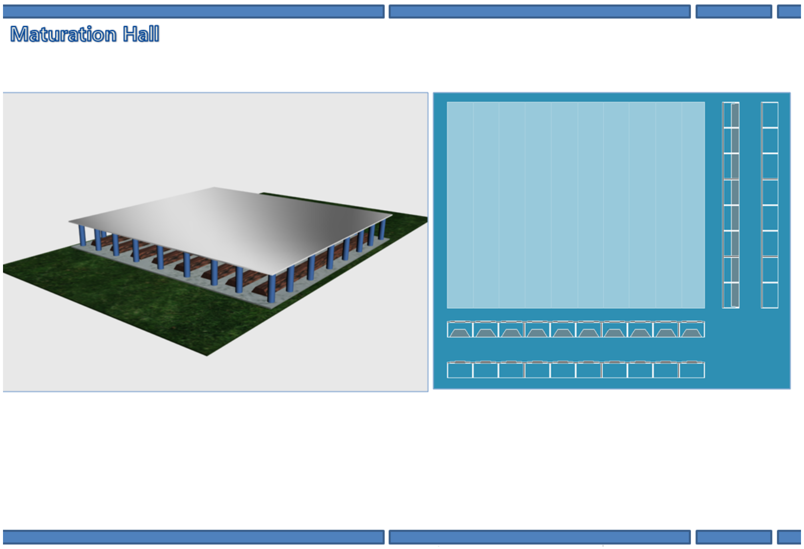


Figure 2.11: Maturation hall

Calculations

Table 2.6: Maturation area

Received quantity, Q_{dk}	87 Mg/d
Back flow	8.7 Mg/d (10%)
Maturation time, $t_{r,n}$	26 $weeks$
Volume, V_n	16156.25 m^3
Height	3.5 m
Top width of the windrow	4 m
Bottom width of the windrow	8 m
Length of the windrow	80 m
Number of windrows required	10
Gap between windrows	2 m
Total width required	98 m
Total area required	7840 m^2
Length of the hall	100 m
Width of the hall	80 m
Height of the hall	6 m
Total area of the hall	8000 m^2

2.5 Management

2.5.1 Leachate and water management

The plant has its leachate production only during the intensive tunnel degradation.

Leachate is collected from each tunnel into the drainage pipe and then sent to the leachate tank. After the collection, it will be sent to the water treatment plant with the help of trucks.

The tank is designed such that it can hold the continuous production of leachate for 3 days.

Recirculation of water is not done in our plant. Rain water is also not used. All the water comes from the nearest water supplier by pipeline.

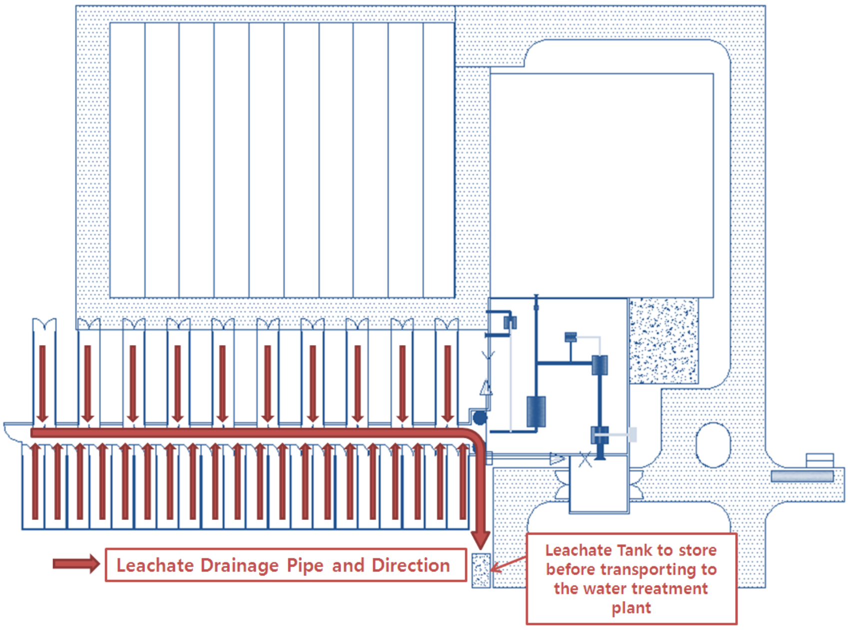


Figure 2.12: Leachate management

Table 2.7: Leachate management

	Specific volume (l/Mg)		**Volume flow** (Mg/d)	
	Min	Max	Min	Max
Leachate	0	20	0	1740
Condensation	30	100	2610	8700

2.5.2 Air management

Odour problem is crucial to composting plants. Thus, air purification is essential.

In our case, we are using negative pressure for sucking the impure air and sending it to a bio-filter for purification. The bio-filter is located near the pretreatment area, as can be seen in Fig 2.8.

Air from 3 buildings - storage area, pretreatment area and junction - are needed to be purified.

The exchange rate depends on both time and area, as well as needed working conditions. Thus, exchange rate is different for the three buildings, as well as daytime and night-time.

Air is supplied into the tunnels from below. For more details, please refer to the Fig 2.10.

Calculations

Table 2.8: Air purification

	Hall volume (m^3)	**Exchanging rate** (l/h)	**Volume of air** (m^3/hr)
Day			
Biowaste Storage Area	1321.83	1	1321.83
Pretreatment Area	18430.2	3	55290.59
Junction	6500	3	19500
Night			
Biowaste Storage Area	1321.8	1	1321.83
Pretreatment Area	18430.2	1	18430.2
Junction	6500	1	6500

Total ventilated volume is $26252.03m^3$. As can be seen from the Table 2.8, the required surface area for bio-filter is $475.7m^2$. A $1.6m$ heigh bio-filter with $\times 20m \times 25m = 500m^2$ of surface area will be sufficient to handle $100m^3/m^3.h$ of volume load.

2.5.3 Traffic

Three kinds of traffic should be considered to design composting plant:

1. The number of trucks for transporting bio waste
2. The number of trucks for transporting structure material
3. The number of trucks for transporting composting products

Table 2.9 shows the daily biowaste input, structural material input and daily compost output. The capacity of trucks is according to the normal waste transporting trucks. The daily compost output is assumed to be 15 % of the daily compost production. (The composting plant has plan to sell 15 % of daily output per day in order to save storage area.)

Table 2.10 shows the traffic condition of composting plant. The number of trucks are calculated by dividing the input or output of designated waste or compost with capacity of a single truck. The receiving area and inspection area are designed after taking in consideration of traffic conditions.

Calculations

Table 2.9: Basic traffic information

Daily biowaste input $Q_{d,max}$	158.62 Mg/d
Daily structured material input	41.20 Mg/d
Capacity of truck	10 $Mg/truck$
Daily compost output	9.61 Mg/d

Table 2.10: Traffic of compost plant

	No. of trucks	
	$(Trucks/d)$	$(Trucks/h)$
Transportation of biowaste	15.86	1.98
Transportation of structured material	4.12	0.52
Transportation of product every day	0.96	0.12

2.5.4 Roads

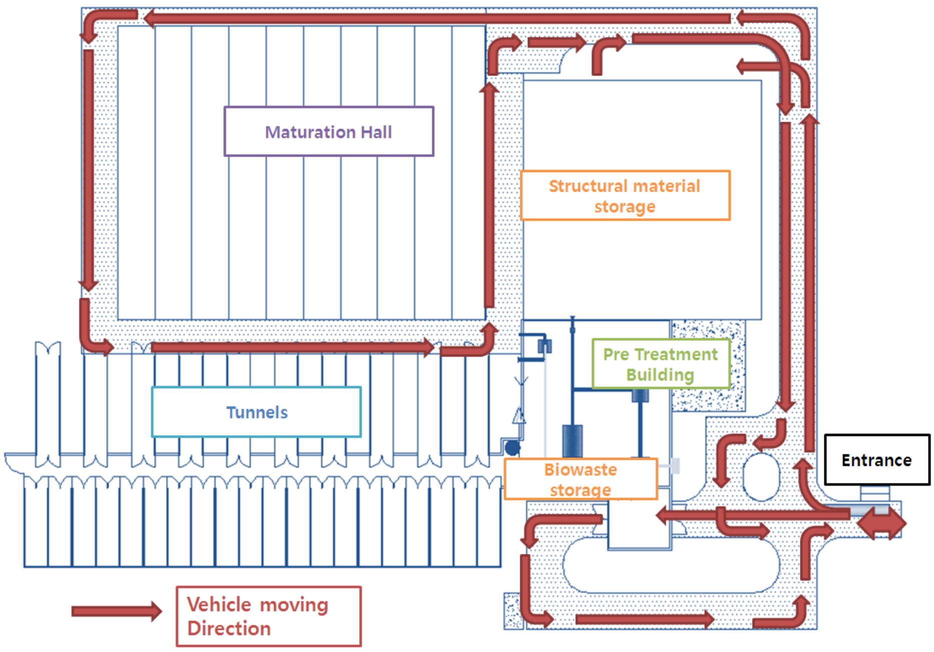


Figure 2.13: Layout of the roads

Design of road involves study of width required by trucks under predictable movements, e.g, at turns.

As specified earlier, there will be a circular junction just after the entrance so that incoming trucks and outgoing trucks can have independent motion.

The whole maturation hall will be surrounded with roads for easy loading of final compost on the trucks.

Storage buildings also need to be connected by roads.

2.6 Equipments

The equipments are placed inside the pretreatment building.

Two different screening drums are used for screening premature compost and pretreated biowaste. Since the amount of premature is very low, a small screening drum is used (**Lindemann 10**). **Lindemann 16** is used for biowaste.

For details, please refer to Table 2.11 and Table 2.13.

Lindemann 25 is used for mixing structural material and biowaste. Details are listed in Table 2.12.

For shredding, we have chosen a screw mill from **Buehler ZBG 800 X 1700**. Screw mill was chosen because it is good for shredding biowaste. The dimensions are $1.7m \times 1.7m$, which will process a 86.8 $m3/h$.

Hammer mill is good for structural material. We are using one hammer mill from **Buehler ZHR-620** with dimensions $1.02m \times 1.2m$.

A magnetic separator is needed for screening magnetic impurities. The size of magnetic separator depends on the size of conveyor belts.

We are using a magnetic separator from **Wagner Magnete Type 431-30/65**. It is situated at the end of conveyor belts, where the ferrous material is collected in a container ($1.5m \times 2m \times 0.5m$).

Table 2.11: Screening drum calculations - Lindemann 16

Residence time, t_{rs}	1 min
ρ_s	0.3 Mg/m^3
Load to screen/Area, q_f	0.06 m^3/m^2
Area, A_s	22.95 m^2
Diameter, d	1.56 m
Area required	$5 \times 10 = 50$ m^2
Volume flow rate, V_h	82.61 m^3/h

Table 2.12: Mixing drum calculations - Lindemann 25

Throughput for biomass, Q_h	26.04 Mg/h
Throughput with yard waste, $Q_{h,mix}$	31.19 Mg/h
Residence time, t_{rs}	25 min
Filling grade, F_g	50%
Density, ρ_t	0.06 mg/m^3
Volume, V_t	43.32 m^3
Density, d	2.4 m
Length, l	9.59 m

Table 2.13: Screening drum calculations - Lindemann 10

Residence time, t_{rs}	1 min
Throughput, Q_h	11.11 Mg/h
ρ_s	0.7 Mg/m^3
Load to screen/Area, q_f	0.06 m^3/m^2
Area, A_s	4.41 m^2
Diameter, d	0.68 m
Area required	$3.45 \times 7 = 24.15$ m^2
Volume flow rate, V_h	15.87 m^3/h

Table 2.14: Conveyor belts

From	**To**
Storage	Sorting
Belt size	800 mm
Velocity	0.2 m/s
Sorting	Offsize treatment
Belt size	300 mm
Velocity	0.5 m/s
Sorting	Screening
Belt size	650 mm
Velocity	1 m/s
Screening	Mixer
	Continued on next page

Table 2.14 – continued from previous page

Belt size	300 mm
Velocity	1 m/s
Screening	Magnetic seperator
Belt size	650 mm
Velocity	1 m/s
Magnetic seperator	Mixer
Belt size	650 mm
Velocity	1 m/s
Magnetic seperator	Offsize treatment
Belt size	300 mm
Velocity	0.2 m/s
Structural material	Mixer
Belt size	650 mm
Velocity	1 m/s
Mixer	Composting tunnel
Belt size	650 mm
Velocity	1 m/s
Composting tunnel	Screening drum
Belt size	650 mm
Velocity	1 m/s
Screening drum	Backflow
Belt size	300 mm
Velocity	0.2 m/s
Screening drum	Storaging area
Belt size	300 mm
Velocity	1 m/s

Chapter 3

Cost calculations

Interest rate is 5 %.

Table 3.1: Cost analysis

	Quantity	Price (€/*unit*)	Costs (€)
Building design costs			
Biowaste (Building)	1321 m^3	150	198275
Structural waste (Open hall)	4120 m^2	175	721000
Entrance building	63 m^3	150	9450
Pretreatment building	18430 m^3	150	2764529
Junction building	6500 m^3	150	975000
Biodegma tunnels	13455 m^3	50	672750
Maturation (Open hall)	7840 m^2	175	1372000
Leachate storage tank	50 m^2	100	5000
Extras			
Pavement	2600 m^2	100	260000
Free spaces	33245 m^2	30	997350
Fence	1000 m	70	70000
Aggregate costs			
Storage aggregate	1	125000	125000
Conveyor from storage	2	70000	140000
Pretreatment			
Sorting belt with cabin	2	225000	450000
Screening drum	1	200000	200000
Mixing drum	1	350000	350000
Magnetic Separator	1	40000	40000
Conveyor belt	200 m	2500	500000
Screw Mill	1	250000	250000
Hammer Mill	1	75000	75000
Intensive degradation			
Composting aeration	11212.5	2	56062.5
Maximal factor	2.5		
Final Treatment			

Continued on next page

Table 3.1 – continued from previous page

Screening drum	1	200000	200000
Ventilation System			
Ventilated Buildings	26252.03 m^3	7.5	196890.22
Bio-filter	500.0 m^2	250	125000
Transport			
Wheel charger	3	150000	450000
Trucks	1	70000	70000
Containers	6	4000	24000

$$\text{Building design} = 8045354.39 \text{ €}$$
$$\text{Aggregate} = 2707952.72 \text{ €}$$
$$\text{Transport} = 520000 \text{ €}$$
$$\text{Container} = 24000 \text{ €}$$
$$\text{Building additional costs} = 564865.36 \text{ €}$$

Total Investment Costs = 11862172.47 €

Table 3.2: Annuity

Building design	0.07
Aggregate	0.13
Transport	0.17
Container	0.17
Building additional costs	0.07

Table 3.3: Operating costs

Repair costs			
	Repair Factor(%)		Cost(€/a)
Building design	1.0		5648.65
Aggregate	3.5		94778.35
Transport	5.0		26000
Personal			
	Quantity	Price (€/a)	Cost (€/a)
Schift engineer	1	40000	40000
Skilled worker	4	35000	140000
Driver	1	27500	27500
Auxilliary/sorting Peopl	4	30000	120000
Service Costs			
	Amount per year	Price (€/$unit$)	Cost (€/a)
Diesel	112500 l/a	1.0	112500
Electric power	105000 kWh/a	0.12	12600
Water/waste water	1875 Mg/a	5.00	9375
Disposal of residues	1500 Mg/a	75.0	112500
Continued on next page			

Table 3.3 – continued from previous page

Others	36050 Mg/a	0.5	18025
Analysis	36050 Mg/a	1.0	36050
	Total operating cost		**754977 (€/a)**

Table 3.4: Annual costs

	Cost (€/a)
Building design	571220.16
Aggregate	352033.85
Transport	89960
Container	4152
Building additional cost	40105.44
Total annual cost	1057471.46

3.1 Specific production costs

$$\text{Total cost} = 1812448.45€/a$$

(Annual+Operational)

$$\text{Capacity} = 36050$$
$$\text{Production costs} = 50.28€/Mg$$

$$\text{Leachate and condensation storage} = 31.32m^3$$

The storage tank will have a cross section of $1m \times 5m \times 10m = 50m^3$

Chapter 4

Suggestions

Since the roads already present are not wide enough for the trucks, neither it is good for high traffic, it is advised that a wider road be formed, as shown in Fig 4.1.

A junction is also highly recommended at Bundesstrasse for easy and efficient traffic.

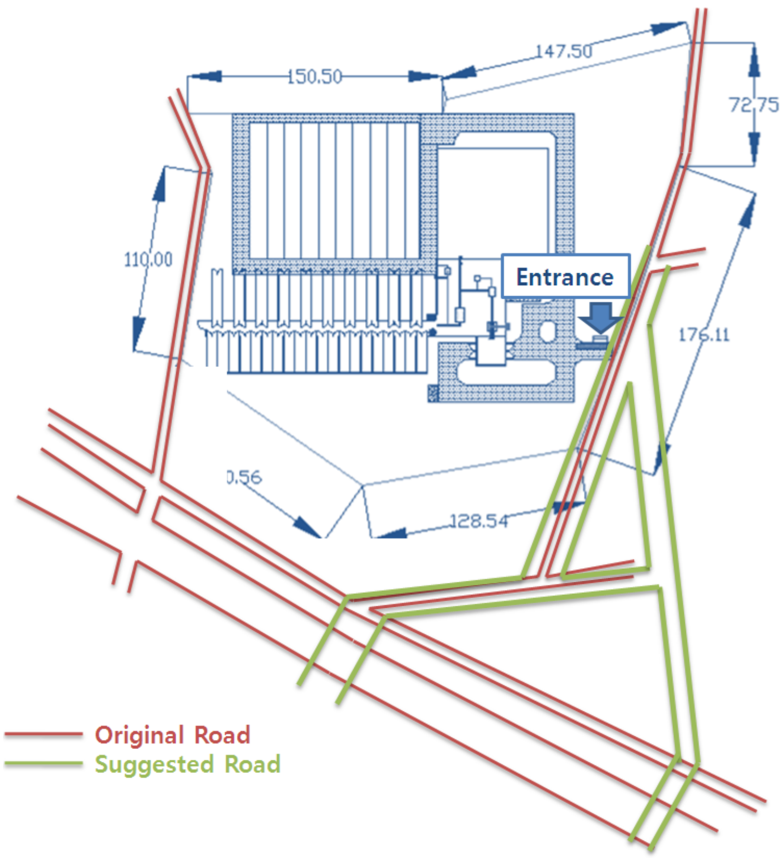


Figure 4.1: Suggestion for the entrance to the plant

Chapter 5

Conclusion

Composting of solid waste is a very old and proven method for maximizing the output of fuel. Since old times it has been used to enrich fields with nutrients for proper agriculture. Due to recent surge of interest in sustainable technologies, composting becomes an obvious choice for recycling of biowaste.

Biodegma is an upcoming technology by BIODEGMA™. Since its inception, it has been used at different places for preparation of compost. Such compost has been used at different places with successful results. Although long term problems are yet to be foreseen, we think Biodegma technology will be adequate for the proposed plant.

Use of Biodegma tunnels for composting greatly decreases the effort in constant turning, which is great boon since cost for equipments as well as manpower, which is generally very expensive, can be cut without decrease in quality of compost.

While designing this solid waste compost plant, we have learned a lot about solid waste and problems caused by it, as well as a number of technologies to avoid such problems. As a side effect, we have also learned how to work in a team, as well as different ways to be optimally productive.

Chapter 6

Appendix

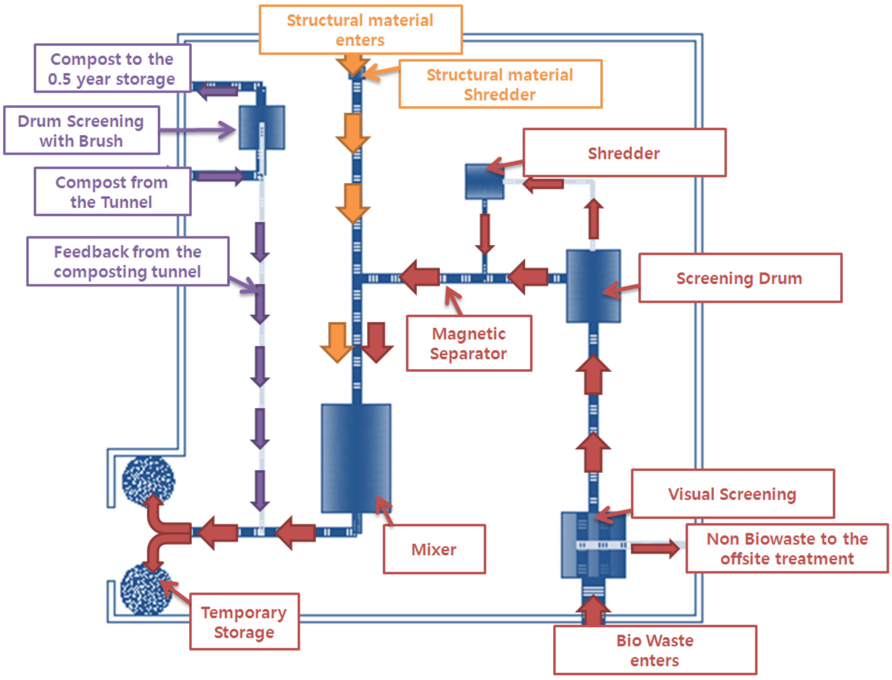


Figure 6.1: Process diagram for pretreatment area

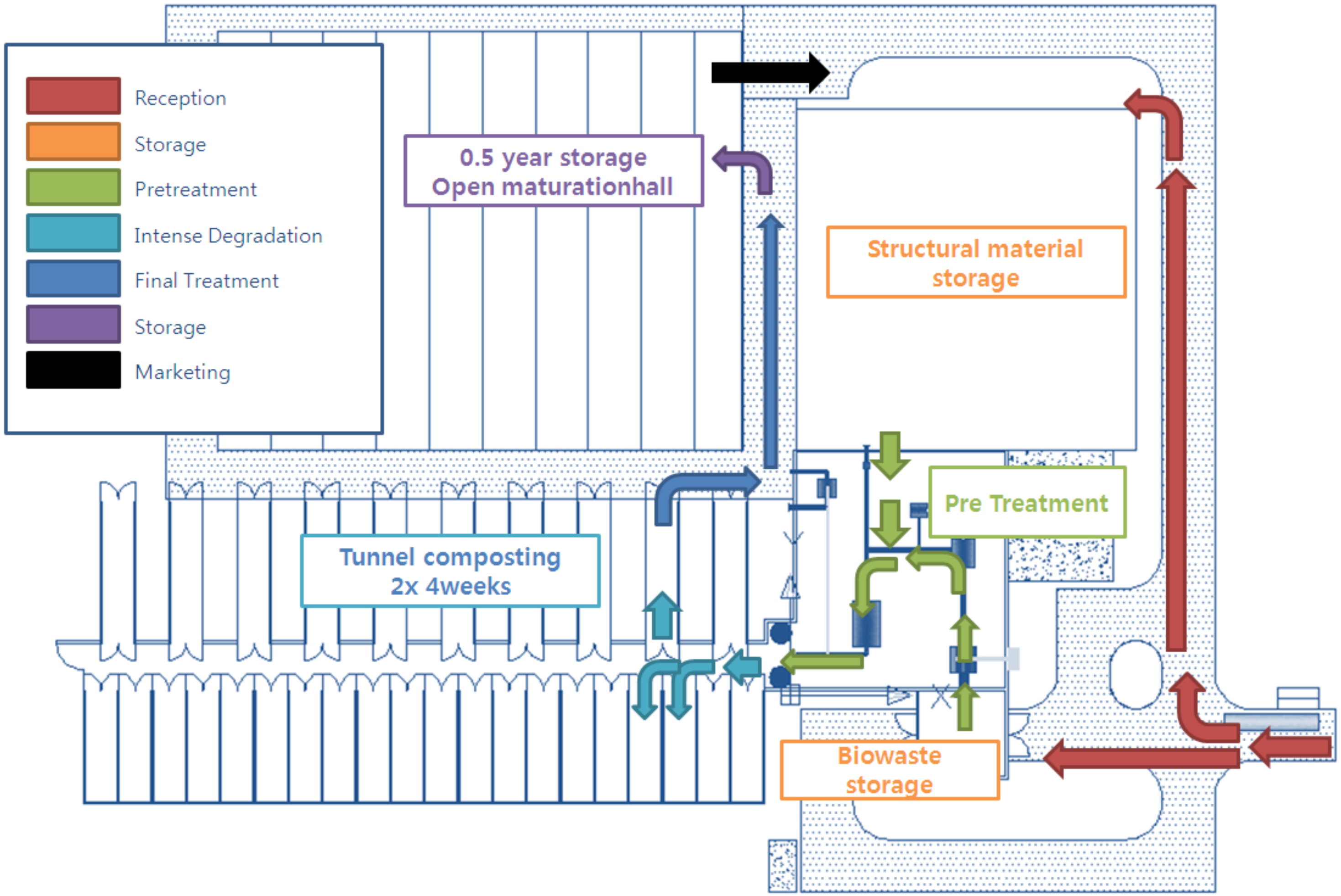


Figure 6.2: Process diagram

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