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Design and Application of an Innovative Composting Unit for the Effective Treatment of Sludge and other Biodegradable Organic Waste in Morocco

MOROCOMP (*LIFE TCY05/MA000141*)

Deliverable 4:

Review of best practices and success stories of composting of sludge and other BOW in the EU and internationally

composting
MOROCOMP

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1. Introduction

The aim of this report is to present the most successful composting schemes and practices which are currently operating in the European Union (EU) and worldwide. These composting schemes are drawn from several EU Member States, from the US, Canada and other technologically leading countries and consist of different technologies, including in-vessel reactors, windrows and aerated static piles. The report focuses on centralized, full-scale composting facilities that treat sewage sludge and other biodegradable organic waste including green and yard waste and Biodegradable Municipal Solid Waste. The case studies considered are from the countries of Spain, Ireland, UK, Germany, Netherlands, Finland, Denmark, Greece, USA, Canada and New Zealand. Table 1 provides the list with the success stories that are reviewed in this report. The Table provides information concerning the plant name and location, its design capacity, the types of waste being treated and the technology that is employed for the main stage of composting.

Table 1: List of the Composting Success Stories that are Reviewed

a/n	Plant Name	Location	Treated Waste	Capacity	Composting Technology
1	Ano-Liosia	Athens Greece	BSW[1] Greens sludge	1,100 tn/day	Tunnels
2	Edmonton	Edmonton Canada	BSW[1] Sludge	300,000 tn/year	Tunnels
3	Lichtenau-Scherzheim	Lichtenau Germany	Sludge Yard waste	9,600 tn/year	Aerated Static Piles
4	Bühl-Vimbuch	Germany	Sludge green waste, paper mill sludge, hemp residuals, grass	30,000 tn/year	Aerated Static Piles
5	Little Marlow	Maidenhead, UK	Sludge	27 tn/day	Windrows
6	St. Oedenrode	Netherlands	BSW[1], green	35,000 tn/year	Tunnels
7	Ipswich	England, UK	Sludge	10,000 tn/year	Tunnels
8	Zutphen	Zutphen Netherlands	Sludge	130,000 tn/year	Tunnels
9	Tiel	Tiel Netherlands	Sludge	75,000 tn/year	Tunnels
10	Deerdykes	Cumbernauld Scotland UK	Sludge	50 tn/day	Tunnels
11	Zeeasterweg Lelystad	Netherlands	Industrial sludge, green waste, organic residuals	75,000 tn/year	Tunnels
12	Wellington	New Zealand	Sludge	364 tn/day	Tunnels
13	West Palm Beech	Florida USA	Sludge Yard Waste	540 $yards^3$/day	Tunnels
14	Rapid City	South Dakota USA	Sludge BMW[2]	355 $yards^3$/day	Tunnels
15	Goldsboro	North Carolina USA	Sludge Yard waste	250 $yards^3$/day	Tunnels
16	Rockland City	New York USA	Sludge	110 tn/day	Tunnels
17	State College Pennsylvania	Pennsylvania USA	Sludge	75 tn/day	Tunnels

a/n	Plant Name	Location	Treated Waste	Capacity	Composting Technology
18	Rancho Las Virgenes	California USA	Sludge	120 $yards^3$/day	Tunnels
19	Burlington County	New Jersey USA	Sludge, Yard Waste, BMW[2]	200 tn/day	Tunnels
20	Philadelphia	Pennsylvania USA	Sludge	200,000 $yards^3$/year	Aerated Static Piles
21	Georgetown County	South Carolina USA	Sludge, yard waste	54 tn/day	Aerated Static Piles
22	Santa Rosa Laguna	California USA	Sludge, yard waste	50.5 tn/day	Aerated Static Piles
23	McGill-Leprechaun	North Carolina USA	All biodegradable	200,000 tn/year	Aerated Static Piles
24	Cappoquin	Ireland	Industrial sludge	12,000 tn/year	Aerated Static Piles
25	Odense	Denmark	Sludge	70,000 tn/year	Windrows
26	Kujala	Finland	Sludge	36,000 tn/year	Tunnels
27	Botarell	Tarragona Spain	Kitchen & garden waste	35,000 tn/year	Aerated Static Piles
28	Castelldefels	Barcelona Spain	BMW[2],sludge, wood waste	10,700	Tunnels
29	Barcelona	Spain	Sludge	25,000	Tunnels
30	Western Isles	UK	Sludge, organics	4,000	In-vessel reactor
31	Bromley	New Zealand	sewage grit & screenings	4,350 tn/year	In-vessel reactor
32	Army Bay	New Zealand	sewage grit & screenings	550 tn/year	In-vessel reactor
33	Palmerston North	New Zealand	sewage grit & screenings	550 tn/year	In-vessel reactor
34	Glasgow Wholesale Markets	Glasgow UK	Organic waste	5.4 tn/day	In-vessel reactor
35	Christchurch	New Zealand	Kitchen and green waste, manure	No Data	In-vessel reactor
36	Okotoks	Alberta Canada	Sludge wood waste	3,500 tn/year	In-vessel reactor
37	Big Sky	Montana USA	Sludge	130 tn/year	In-vessel reactor

a/n	Plant Name	Location	Treated Waste	Capacity	Composting Technology
38	Town of Gypsum	USA	Sludge	No data	In-vessel reactor
39	Ocean Shores	Washington USA	Sludge	360 tn/year	In-vessel reactor
40	Omak	Washington USA	Sludge, wood waste	3,100 tn/year	In-vessel reactor

[1] BSW = Biodegradable Solid Waste
[2] BMW = Biodegradable Municipal Waste

2. Ano-Liosia Composting Plant

Country: Greece

Facility: Ano-Liosia Integrated Waste Management Scheme

The Ano-Liosia Integrated Waste Management Scheme comprises of a landfill, an industrial unit of incineration of hospital waste and a mechanical recycling scheme for waste. The latter includes a large composting facility. The plant is situated in the Western suburbs of Athens in Greece. The factory of mechanical recycling of waste was designed and constructed after an international tender, which was procured by the Association of Communities and Municipalities of the Attica Region (ACMAR). The Scheme is one of the two largest waste treatment facilities in Greece. The other facility is the wastewater treatment plant in Psyttaleia which serves a population of 3,000,000. Furthermore, the Factory for mechanical recycling of waste is the largest one in Europe and one of the largest ones in the world. It receives waste from the Attica region. Currently, the population of Attica exceeds 4.5 million people. ACMAR is the Public Authority responsible for the management (treatment, recycling and disposal) of Solid Waste of about 95% of the population of the Attica Region. The construction of the factory of Mechanical Recycling was funded by the European Union and by the Greek government (http://www.esdkna.gr/pages/erga.htm).

Its capacity is the following:

- 1,200 tonnes/day of refuse
- 300 tonnes/day of sewage sludge generated from the Wastewater Treatment Plant of the Attica Prefecture
- 130 tonnes/day of green waste (leaves) and tree braches

Figure 1: Panoramic View of the Ano-Liosia Integrated Waste Management Scheme

The useful material that is produced in this factory is compost, refuse derived fuel (RDF), ferrous metals and aluminium. The by-products of the whole process are directed to the Ano-Liosia landfill which is located nearby. The Factory of Mechanical Recycling of Waste Consists of the following components:

A. **Entrance Facilities – Weighting of waste**
B. **Unit for the Reception of Waste**

This unit (Figure 2) consists of the following:

- Three (3) waste reception facilities (i.e. lowered reservoirs). In each reservoir eight (8) garbage trucks can unload waste simultaneously. Therefore, in total there are 24 positions from where waste can be unloaded simultaneously. Each waste reception facility comprises the following:
    i. One crane and one electrical hook which feeds with waste the waste collection hopper (Figure 3)
    ii. Three (3) hoppers for receiving waste. Each hopper corresponds to a conveyor, upstream of which there is a device that rips the bags that contain waste
    iii. The three (3) aforementioned devices that rip the waste bags

iv. One receptor of grass, greens and tree cuttings into which the trucks unload their content. A mechanically operating loader feeds the shredder with leaves and tree cuttings

v. Three (3) receptors of sludge (i.e. elevated reservoirs) into which the trucks unload sludge

Figure 2: Waste Reception Facility

Figure 3: Waste Reception Trench

C. Unit of Mechanical Separation

This unit (Figure 4) comprises the following components:

- Three lines of mechanical separation; each line is fed with waste from its respective receptor. Each line of mechanical separation consists of:
  i. Primary rotating screener
  ii. Secondary screener
  iii. Electrical magnets
  iv. Bioreactor in the last compartment of which there is a tertiary screener.
  v. Conveyor belts
- Line for the dry fraction of waste consisting of:
  i. Four (4) ballistic separators (Figure 5) in order to sort out the light weight fraction which is then shredded, the biodegradable fraction which is fed to the mixer and the remaining residues

ii. Four (4) shredders of the light weight fraction of waste; each shredder is fed by a conveyor belt
iii. Electrical magnet ballistic separators
iv. Conveyor belts

- One Refuse Derived Fuel (RDF) line which is composed of the following components:
  i. One compressor which is fed by the shredded light weight waste through conveyor belts. The light weight fraction is compressed and packaged
  ii. Conveyor Belts
- One Residuals Line which has:
  i. One silo for storing the ferrous metals with are then fed to the compressor of ferrous metals
  ii. One compressor for compressing the ferrous metals into cubes
  iii. Conveyor belts
- One Aluminium Line which consists of:
  i. Layout for aluminium recycling which employs eddy currents in order to recover aluminium material from the rest
  ii. One silo where the recovered aluminium is stored. Then it is fed to a compressor
  iii. Aluminium compressor where the recovered aluminium is formed into cubes
  iv. Conveyor belts

- One homogenization line with:
  i. Three (3) homogenization layouts; each one corresponds to one mechanical layout and to one sludge reception system. Each layout is fed with waste through the exit of the corresponding bioreactor (after the tertiary screening, with the screener which is incorporated in the bioreactor). Furthermore, it is fed with sludge

from the respective sludge receptor and with shredded tree cuttings and leaves.

ii. Conveyor belts (Figure 6)

Furthermore, the Factory of Mechanical Recycling of Waste has equipment which assures the protection of the environment and of the personnel. This equipment includes cyclones, air ducts and air ventilators for the suction of air etc.

Figure 4: Unit of Mechanical Separation

Figure 5: View of Ballistic Separators

Figure 6: Elevated Conveyor Belt

D. The Composting Unit

The composting unit (Figure 7) of Ano-Liosia employs the technology of tunnel composting to treat the organics of Municipal Solid Waste sorted out through the Mechanical Separation System, sludge and green waste. More specifically, the plant comprises of the following:

a. Three (3) feeding lines: each line feeds 16 composting tunnels with biodegradable material. The total number of composting tunnels is 48. The transportation of the biodegradable material is conducted via conveyor belts. The tunnels are fed with the following material:
    i. The mixture exiting the homogenization unit
    ii. The biodegradable fraction that is recovered from the ballistic separator
    iii. The recycled material from the screening process
b. The recycled compost material. As it will be described later, the end compost is screened. The reject stream is then recycled through an elevated conveyor back to the composting unit, as a product that has not been fully composted. It is split into three streams in order to be fed to the 3 lines of the composting unit
c. 48 parallel and horizontal composting tunnels (Figure 8) made of concrete. The compost mix is placed inside the tunnels up to a height of 2.1 m.
d. Six (6) electrical agitation devices. Each couple (2) of agitation devices is used to mix 16 composting tunnels, corresponding to one feeding line. Each day the agitator agitates 4 tunnels. Overall, 24 composting tunnels are agitated each day. As the agitators proceed inside the composting tunnel they displace the compost mix forward towards the exit of the composting tunnel. Therefore, every 2 days, the agitator completes one displacement of the compost mix towards the exit of the compost tunnel. This way the compost mix is gradually 'pushed' towards the exit of the composting tunnel. The residence time of the compost mix inside the tunnel is 46 days.

Each agitation device is equipped with sprinklers for providing water to the compost mix. This is important in order to ensure that the compost mix will not dry out from the high temperatures that develop inside the compost heap. This way the moisture level of the mix is controlled and maintained at desirable levels.

e. Thirty six (36) blowers provide the required air for the composting process to take place. This corresponds to 12 blowers for each feeding line of the composting unit. Aeration is achieved (apart from agitation) with air suction from the floor of the compost tunnels. The tunnel floor has a grid; air is sucked through aeration pipes placed beneath the grid and ends up in a main pipe. In total there are six (6) main pipes; the air that is sucked is fed to each central pipe through eight (8) tunnels. Therefore, 2 main pipes correspond to each feeding line of the composting unit. At the floor of each tunnel there is a collection pipe in order to collect the produced leachate. The top part of the collection pipe is perforated so that leachate can enter inside it. All the collection pipes converge to a centralized pipe which ends up at the wastewater treatment unit of the facility. At the end of each composting tunnel there is a conveyor belt which has been installed vertically to the composting tunnels. This conveyor belt transports the end compost to the screening unit.

f. Shredder for shedding the green waste (Figure 9)

Figure 7: View of the Building with the Composting Tunnels

Figure 8: View of Composting Tunnel

Figure 9: Shredder Employed for Shredding Green Waste

E. The refinery unit

The compost from the tunnels is fed to the refinery unit (Figure 10) through the conveyor belt of the composting tunnels. The compost is received at the reception unit. In the reception unit the compost is agitated and grinded. Agitated screws with blades speed up the simultaneous feeding, distribution and dosing of the material. Two rotating drum screens are utilized that produce three different streams of output material. The finest material is directed through a conveyor belt to the waste residuals. The coarser material, which is mainly comprised of material that has not been fully composted is directed to a densimetric table. The middle sized stream is directed to another densimetric table. The screening unit has in total three (3) densimetric tables. In two of these tables, the separation of the middle sized stream takes place. The separation is achieved through air and through ballistic separation. Each one of the two densimetric tables produces 3 different streams. The lightest and heaviest streams are directed through conveyor belts to the residual waste stream that is disposed. The third stream is directed to two flat, vibrating screens for further refinement. As mentioned earlier, the third densimetric table receives the coarse material from the rotating drum screens for further refinement. This third densimetric table also produces three new streams: the lighter and heavier streams go to the waste residuals in order to be disposed off; the remaining stream is directed through an elevated conveyor back to the composting tunnels in order to be composted again (Figure 11). Finally, the screening unit has a vibrating screen that produces two streams; the coarse stream is directed to the waste residuals while the finer one goes for curing after it passes the stage of magnetic separation. 85% by weight of this stream is directed to an open-air curing place and the other 15% to a curing warehouse.

Figure 10: Refinery Unit

Figure 11: Recycling of Coarse Material from the Refinery Unit to the Composting Unit

F. Curing Unit

The curing unit consists of the open-air curing system and the warehouse where curing takes place:

a. In the open-air curing place, the screened compost is placed into windrows with the use of loaders. The maximum height of the windrows is 3.5 m. The residence time of the compost in the windrows is 1 month. Curing is essential in order to fully stabilize the end compost. 85% of the compost is cured in this facility (Figure 12)

b. Inside the warehouse where the compost is cured, the material is placed in windrows. The warehouse protects the compost from the outside environmental conditions. The windrows have a maximum height of 3.5 m. The residence time is 1 month. 15% of the compost is cured in this installation (Figure 13).

Following the curing stage, the loaders feed the packaging unit, in order to package the end compost.

Figure 12: Open-air Windrows where 85% of the Compost is Cured

Figure 13: Warehouse where Curing of 15% of the Compost Takes Place

G. Packaging Unit

The packaging unit consists of the following:

a. Smoothening sub-unit for ameliorating the texture of the end product
b. Sub-unit for placing the end compost inside bags and for sealing these bags
c. Sub-unit of palletizing the packaged end compost

H. Wastewater Treatment Unit

The wastewater that is treated in this unit is generated from:

a. The reception unit for the trucks
b. The unit of mechanical separation
c. The composting unit (leachate collected from the floor of the composting tunnel)
d. Wastewater from all the sanitation areas of the factory

A two-stage aerobic biological process takes place for the treatment of wastewater (Figure 14). The final effluent is used for irrigating the grass facilities of the installation.

Figure 14: Wastewater Treatment Unit

I. Unit for Treatment of Air Emissions from the Mechanical Separation Unit

This unit treats the air emissions resulting for the Unit of Mechanical Separation. The treatment unit consists of three (3) biofilters for treating air exhausts from the unit of mechanical separation. Each biofilter corresponds to one reservoir of the unit of waste reception and to one line of mechanical separation. Biofilters are made up of end compost.

J. Unit for Treatment of Air Emissions from the Composting Unit

The unit consists of six (6) sub-units for the treatment of air emissions resulting from the composting process. The treatment is performed by employing chemical means; more specifically chemical scrubbing is performed (Figure 15). Each sub-unit is fed by one of the 6 main pipes that collect the air exhaust from the composting unit. Two sub-units correspond to one line from the composting unit. Each sub-unit consists of:

i. One (1) tower for the removal of NH_3 with the addition of H_2SO_4.
ii. One (1) neutralization tower where NaOH is added
iii. One (1) tower for controlling the pH value and the Red/ox potential through the addition of hypochloric acid
iv. Six (6) chimneys

Figure 15: Scrubbers Employed for Air Treatment

Furthermore, the Ano-Liosia plant has supplementary facilities (e.g. fire fighting facilities, water and acid reservoirs etc), green installations, road facilities (e.g.

roundabouts) and control buildings for most units. Each building is controlled through its Local Control Building. However, the whole operation of the facility is controlled from the Main Administration Building (Figure 16).

Figure 16: Administration Building

Note: Unless otherwise stated, the above information (including the photos) concerning the Ano-Liosia plant has been written by Dr Evangelos Kapetanios for the purposes of this report. Dr Kapetanios is the Director of the Development Department of ACMAR

3. Edmonton Composting Facility

Country: Canada

Facility: Edmonton Composting Facility

The composting facility has been constructed by the German company COMP-ANY. The operator of the composting plant is Earth Tech Canada Inc. The facility is one of the largest composting plants in the world and the largest co-composting facility in North America. It composts both residential waste and sewage sludge which is received from the Wastewater Treatment Plant of Edmonton and occupies a total area of 38,690 m^2 (Figure 17). It can process 200,000 tonnes of residential waste and 25,000 dry tonnes of biosolids each year (100,000 tonnes of wet sludge). The construction of the plant was 65 Million Euro, while the total plant area is 38,690 m^2

(http://www.edmonton.ca/portal/server.pt/gateway/PTARGS_0_2_1652658_0_0_18/Edmonton+Composting+Facility.htm).

Figure 17: Panoramic View of the Edmonton Composting Facility

The processes that take place in the plant are shown diagrammatically in Figure 18. Sewage sludge is pumped to the facility through a pipeline and is put into centrifuges where a spinning action like a washing machine on spin cycle, “dewaters” sludge (Figure

19). The biosolids are stored in a large hopper (Figure 20) and are then injected into the mixing drums together with the residential solid waste.

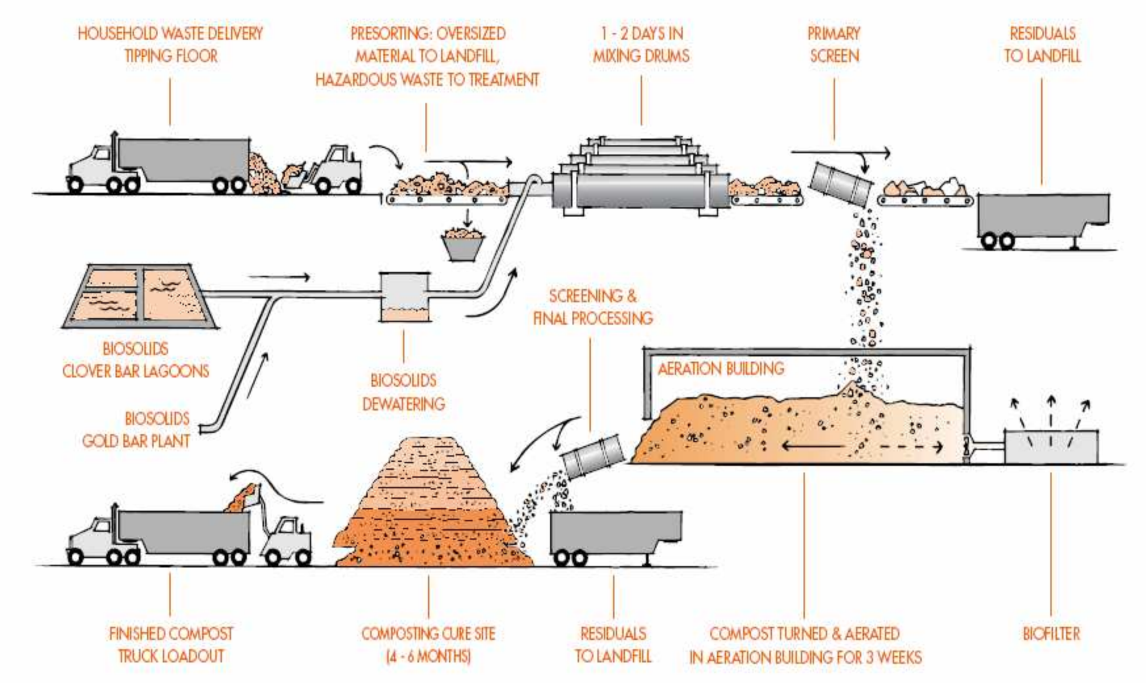

Figure 18: Flow Diagram of Edmonton Waste Processing Plant

Figure 19: Centrifugal Pumps Utilized for Dewatering Sewage Sludge

Figure 20: Storage Hopper

Solid waste is received in the facility by garbage trucks which unload the waste materials onto a large indoor concrete pad (Figure 21). This floor is known as the tipping floor; it occupies a total area of 4,000 m^2 (Figure 22) and it is where the separation process of the solid waste takes place. In particular, the oversized items such as furniture and the household hazardous waste such as propane tanks are manually removed (Figure 23). Tires and propane tanks are recycled. Most of the other oversized material is landfilled. Then the front end loaders push the remaining waste into concrete hoppers below the tipping floor. From there waste is pushed into large hollow cylinders known as the mixing drums (Figure 24).


Figure 21: Unloading of Solid Waste

Figure 22: View of the Tipping Floor where Solid Waste is Collected

Figure 23: Manual Selection of Oversized Waste

Figure 24: Placement of Remaining Waste Inside the Mixing Drums

Hydraulic rams push the waste inside one of five parallel rotating mixing drums (Figures 25- 27). Each drum is 74 m long and has a diameter of 4.9 m. Biosolids are injected into the drums together with the solid waste. Composting begins as the materials tumble together while traveling for 1-2 days from one end of the drum to the other.

Figure 25: Location of the Mixing Drums

Figure 26: View of one of the Mixing Drums

Figure 27: Inside View of the Mixing Drums

Then from the mixing drums the material is conveyed using conveyor belts (Figure 28) into two rotating trommel screens (Figure 29) which remove larger materials. This material consists mainly of plastics and textiles and is diverted to landfills. Then the ferrous material is removed with magnets which are placed above the conveyor belts. The ferrous material that is removed is recycled. The biodegradable material is then conveyed through conveyor belts to the aeration building in order for the composting process to take place.

Figure 29: Conveyor Belts

Figure 28: Trommel Screen

The aeration building is the largest stainless steel building in North America (Figure 30). Inside the building the high rate aeration is performed in suitable bays where the compost mix is placed. In total there are 18 bays having the following dimensions: 50 m long, 8 m wide and 3m high. The residence time of the compost mix varies between 14-21 days. The material is agitated through mobile augers which pass through the compost mix (Figure 31). The augers also gradually displace the material through the compost bay. Agitation allows the required oxygen to be transferred to the whole of the compost mix. Moreover, the auger has a sprinkling system in order to supply the required oxygen so that the compost mix is not left to dry. The temperature inside the compost mix exceeds 55ºC, thus destroying the potentially harmful bacteria. The Edmonton composting facility provides an affordable long-term solution for two of Edmonton's waste streams - municipal solid waste and biosolids. With its combined recycling and composting programs, Edmonton diverts about 60 percent of its residential waste away from landfills. The facility receives thousands of visitors from around the world, creating economic spin-offs for local business.

(http://www.edmonton.ca/portal/server.pt/gateway/PTARGS_0_2_1652658_0_0_18/Edmonton+Composting+Facility.htm)

Figure 30: Aeration Building

Figure 31: Mobile Compost Augers

The air inside the composting facility is hot, humid and odourized. Odourized air is produced during the composting process inside the aeration building and is exhausted through biofilters located outside the aeration building (Figure 32). The biofilters consist of one-meter layers of mature compost, woodchips and bark and effectively remove the unpleasant odours created from the composting process (www.comp-any.com)

The compost exiting the high-rate stage is conveyed from the aeration building to the screening unit in order to refine the compost from the larger particles (Figure 33).

Figure 32: Biofilters

Figure 33: Compost Refining System

Finally, the maturation phase takes places. The compost is placed in windrows and is left to mature for a period of 4-6 months (Figure 34). It is then used by farmers, landscapers, nurseries and oilfield reclamation companies.

Figure 34: Maturation of Compost Mix in Windrows

Note: The above information, unless otherwise stated, has been based on material provided by the company COMP-ANY which was responsible for the design and construction of the Edmonton composting plant.

4. Lichtenau-Scherzheim Composting Facility

Country: Germany

Facility: Lichtenau-Scherzheim Composting Facility

The Litchenau-Scherzheim (Figure 35) composting facility has been constructed by the German company COMP-ANY and is operated by WEWA GmbH. It treats raw and digested sewage sludge having a solids content of 22% (78% of moisture). The raw and digested sewage sludge are mixed with shredded yard waste (Figure 36) in a volume analogy of 1:1 (Figure 37). The facility treats annually 9,600 tonnes. Each year, approximately 7000 tonnes of biosolids are mixed with approximately 2,600 tonnes of yard waste (www.comp-any.com).

Figure 35: View of the high rate and the maturation phase of the Lichtenau - Scherzheim Composting Plant

Figure 36: Yard Waste Employed as Amendment

Figure 37: View of the Mixing Process in the Lichtenau –Scherzheim Composting Plant

The technology that is employed is that of aerated static piles. The plant consists of 4 heaps having dimensions 25 long, 8 m wide and 3 m high. The high rate stage is completed in 28 days. Then the maturation stage proceeds in open windrows. The maturation period lasts for 6 weeks. The high rate stage is completely controlled (Figure 38); in particular, the required oxygen is provided to the compost pile and adequate temperature and moisture levels are maintained. Forced air ventilation is applied. The system has a high degree of reliability and a low operating and maintenance cost. It is important to mention that this composting facility is only 200 m away from residents and there have been no complaints for odours (www.comp-any.com).

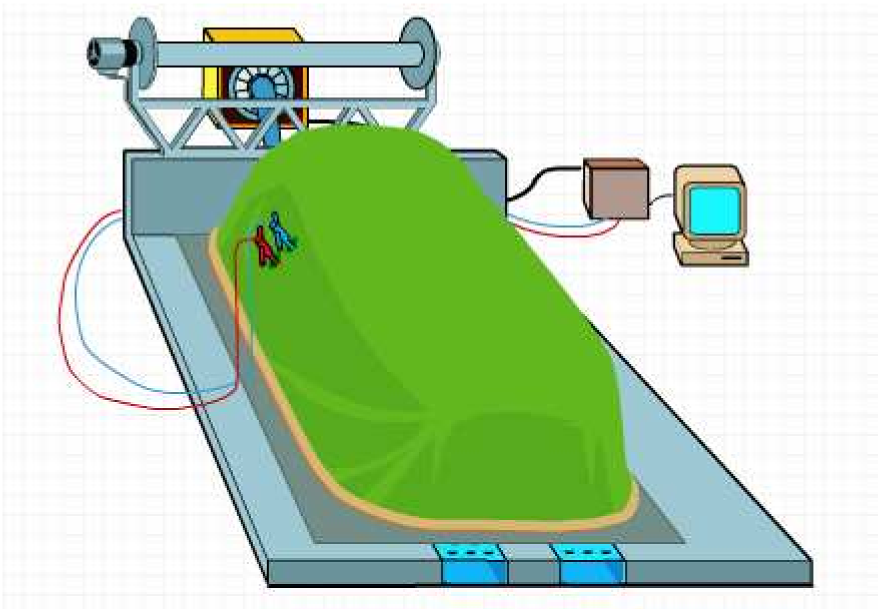

Figure 38: Completely Controlled Aerated Static Pile

Note: The above information, unless otherwise stated has been based on material provided by the company COMP-ANY which was responsible for the design and construction of the plant.

5. Bühl-Vimbuch Composting Facility

Country: Germany

Facility: Bühl-Vimbuch Composting Plant

The Bühl-Vimbuch composting facility has been constructed by the German company COMP-ANY**.** It employs the technology of aerated static piles (Figure 39 & 41) to compost a variety of waste, including green waste, paper mill sludge, hemp residuals, silica gel, grass clippings, tree branches (Figure 40) and long grass from conservation areas. It treats 30,000 tonnes of waste each year. The aerated static pile method is employed. The static pile dimensions are 40 long, 8 m wide and 3 m high. The residence time of the compost mix in the static piles is 28 days, while maturation is performed in windrows for 4-6 weeks. Ideal conditions are maintained within the static piles as the temperature and the moisture level are controlled through a forced aeration system that blows air inside the compost heap (Figure 42) (www.kompostanlagen.de).

Figure 39: Aerated Static Piles of the Bühl-Vimbuch Composting Plant

Figure 40: Shredding of Tree Branches and Leaves

Figure 41: View of Aerated Static Piles and Maturation Windrows

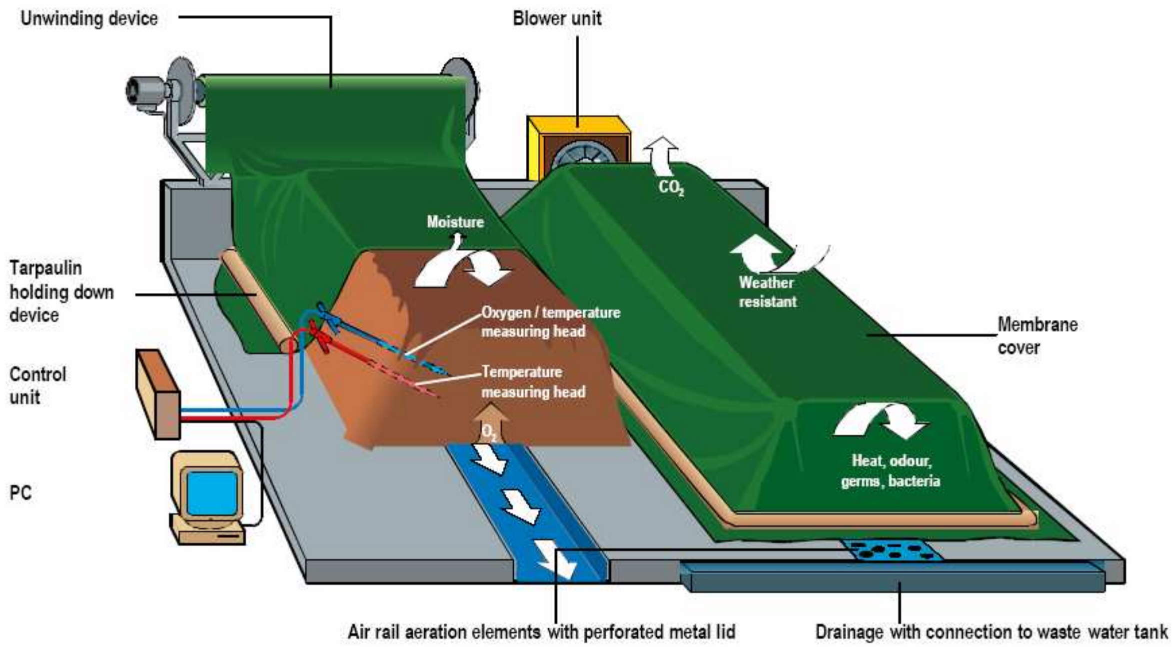

Figure 42: Completely Controlled Aerated Static Pile

Note: The above information, unless otherwise stated has been based on information provided by the company COMP-ANY which was responsible for the design and construction of the plant.

6. Little Marlow Composting Facility

Country: UK

Facility: Little Marlow Composting Plant

Marlow is a town situated South of High Wycombe and close to Maidenhead. Little Marlow composting plant is located a few km away from the town and is operated by Thames Water Utilities Ltd. It is a medium size sludge composting plant dealing with annual quantities of wet sludge of approximately 10,000 tonnes/year (27 tonnes per day). Composting is done through windrowing, both for the high-rate and the curing stage.

The site has a wastewater treatment facility, which consists of primary sedimentation tanks and dewatering of sludge. Wastewater flows in the sedimentation tanks and sludge settles at the bottom. Primary sludge is then pumped into the dewatering device that consists of filter presses. Dewatering of sludge increases the solids concentration to 24%-25%. Then the sludge is mixed with straw and windrows are formed. Currently, the personnel is testing the use of woodchips with sludge that have the advantage of being re-usable.

The windrows have a base that is 4m wide and are 1.0m-1.5m high (Figures 43 & 44). Agitation is provided by excavators and is done 3 times per week. Forced aeration is not supplied and thus windrows are only naturally ventilated. The C/N ratio in this plant is low (12:1-15:1) and agitation is not as frequent as it should be, mainly due to cost restraints. As a result, odour problems have been a serious concern and several complaints have been made by nearby residents. To deal with this problem a new building is being constructed to house the windrows (Malamis, 2000).

Figure 43: Windrows for the High-rate Stage of Composting

Figure 44: Windrows for the High-rate Stage of Composting

The mixture stays in windrows for 4 weeks; then compost is inserted into pads, known as maturation storage pads, which are turned once every 1-2 weeks (Figure 45). The personnel employed forced aeration using pipes (Figure 46) to provide air into the piles, but the process was not as effective as it was originally expected so they abandoned it. The curing stage lasts for 6–10 weeks and is done to achieve further pathogen inactivation and waste stabilization (Malamis, 2000).

Figure 45: Curing process in Operation

The refining system consists of a screening device (Figure 47) into which the mature compost is inserted and the result is a good-quality, fine end product. This is then packed into plastic bags and deposited into piles until the compost packs are distributed. It is estimated that 1kg of wet sludge (75% moisture) produces approximately 0.5 kg of compost. The price of good quality compost is £5 for each 60litre package. The best quality compost is sold to garden centres, while average quality compost is deposited to agricultural land. Low quality compost is given for land reclamation. Overall, the plant does not make a profit, but it efficiently treats sludge so that it can be used beneficially.

Figure 46: Pipes Used to Provide Natural Aeration During Curing

Figure 47: Screening Device

7. St. Oedenrode Composting Facility

Country: Netherlands

Facility: St. Oedenrode

The St Oedenrode composting system has been designed by the Dutch company GICOM. The plant operation is performed by Van Kaathoden B.V. The composting plant was built in 1991 and has undergone 3 extensions in 1992, 1995 and 2002. It treats both Municipal Solid Waste (MSW) and green waste. With the extensions that have been made, the plant has an annual treatment capacity of 35,000 tons/year. The construction period was 6 months and the extension works lasted for 4 months. The technology that was employed for the high rate stage of composting is that of compost tunneling. Currently, there are 14 composting tunnels having dimensions: 30×5×5 and 30×4×5 (length × width × height). The tunnels are housed inside the building. The outgoing process air is purified from ammonia and odours through a scrubber and a biofilter.

After the tunnel has been filled with compost feedstock the door is closed and the tunnel climate control program is initialized. The composting tunnels are managed with respect to temperature, oxygen and moisture levels to optimize the process, attain pathogen reduction requirements and meet process objectives. Once the tunnels are filled with compost, the variable speed blower connected with the tunnel starts operating and air is pushed into the aeration floor system of the tunnel. The recirculation route for the air is as follows: air is blown into the concrete plenum located behind each tunnel, then into the floor piping system and into the compost mix. From the head-space it goes into an external recirculation loop ductwork through the open recirculation damper and back through the blower and then into the plenum. As the air enters the circulation route, several parameters are measured at several positions including air temperature, air humidity, oxygen and carbon dioxide concentration and pressure.

The maturation phase also takes place in composting tunnels. The total composting period of the high rate and the maturation stages is 3 to 5 weeks, with the high rate composting lasting for 5-7 days.

Note: The information is based on material provided by Mr. Luc Klunder of the Dutch Company GICOM

Figure 48: View of the St. Oedenrode Composting Plant

8. Ipswich Composting Facility

Country: UK

Facility: Ipswich Sludge Composting

The Ipswich composting plant is located in Cliff Quay and is operated by the Anglian Water Services. The Dutch company GICOM was the main contractor. It treats both raw and stabilized sewage sludge which is mixed with green waste. The plant has an annual capacity of 10,000 tonnes. It was constructed in 1995/1996 and the construction period was 4 months. It consists of 3 sludge composting tunnels, each the following dimensions: 30 m long, 5 m wide and 5 m high. The composting process takes 2 weeks. The composting tunnels are completely housed inside the building shown in Figure 49.

Figure 49: Building of the Composting Tunnels of the Ipswich Composting Plant

It is proposed that the existing waste handling building be extended southwards over a concrete area used for shredding and storage. The extended building would be some 15 metres x 28 metres x 6 metres

<u>Note: The information is based on material provided by Mr Luc Klunder of the Dutch Company GICOM</u>

9. Zutphen Composting Facility

Country: Netherlands

Facility: Zutphen Composting

The Zutphen composting plant (Figure 50) is one of the largest sludge composting facilities in the world. It is located in Zutphen, a small city that is 80 km away from Amsterdam. It is operated by GMB and has been designed and constructed by the Dutch company GICOM. The first part of the plant was constructed in 1991 and the plant was extended in 1993 and in 1994. The construction of the plant took 3 months, while the extension was carried out in 6 months.

The composting plant receives dewatered sewage sludge from several wastewater treatment plants, including the nearby wastewater treatment plant. The mean solids concentration of the input sludge is 24% and the annually treated sludge is approximately 32,000 tonnes of dry solids which corresponds to approximately 130,000 tonnes/year of wet sludge. The technology of tunnel composting is employed. In particular, 13 parallel tunnels are in operation, each one having dimensions 40 m long, 8 m wide and 6 m high. This provides a total volume of 24.960 m^3 for the compost mix.

Figure 50: Panoramic View of the Zutphen Composting Facility

Figure 51 presents a flow diagram of the processes taking place in the plant. Initially, the trucks unload the sewage sludge in a hopper, as shown in Figure 52. Sludge is then transferred through conveyor belts to the mixing stage of sludge with wood chips. Then the compost mix is placed into the composting tunnels with the use of appropriate loading trucks (Figure 53). The residence time of the compost mix inside the tunnels is 14 days. The whole process has a high degree of automation as the parameters of temperature, oxygen and moisture are completely controlled in order to optimize the process, attain pathogen reduction requirements and meet process objectives. Then the material is screened. The fines (size < 3 mm) is the end compost which is marketed, while the reject stream (size > 3 mm) which consists mainly of additives are recycled back into the mixing stage of the process [(http://www.gicom.nl/)](http://www.gicom.nl/)

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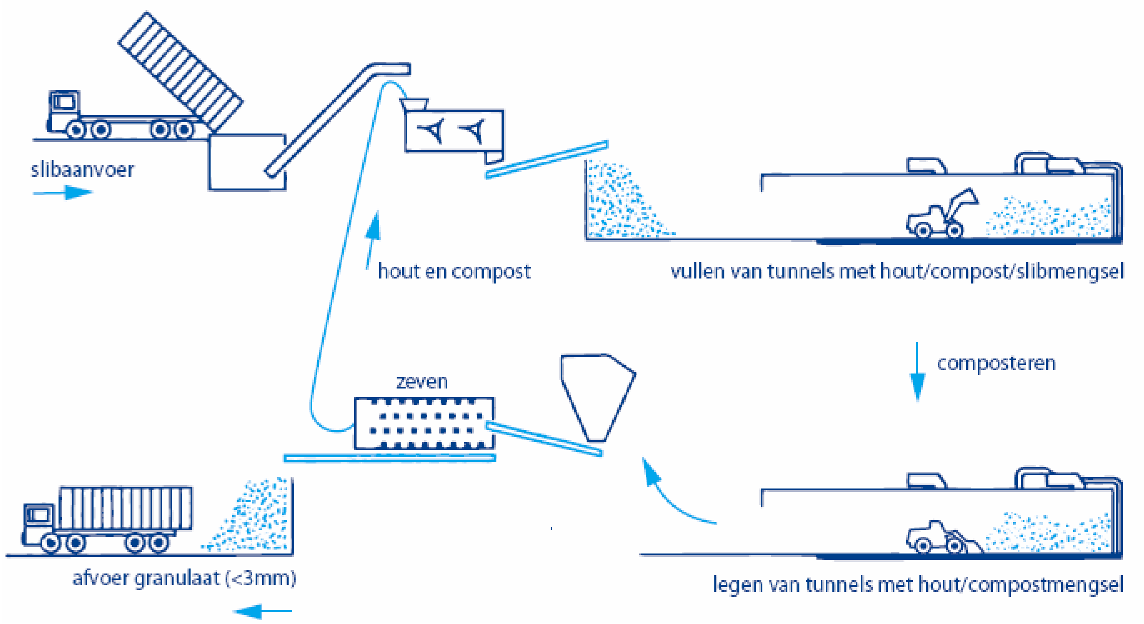

Figure 51: Flow-diagram of the Composting Process in the Zutphen Composting Plant

Figure 52: Unloading of Sewage Sludge

Figure 53: The Compost Mix Placed Inside the Composting Tunnels

Note: Unless otherwise stated, the information is based on material provided by Mr. Luc Klunder of the Dutch Company GICOM

10. Tiel Composting Plant

Country: Netherlands

Facility: Tiel Composting Plant

Tiel Composting Plant

The Tiel composting plant (Figure 54) is located in Netherlands, is operated by GMB and has been designed and partly constructed by GICOM. The technology of tunnel composting is employed. It was constructed in 1993, for a design capacity of 10,000 tonnes/per year and was extended to reach 25,000 tonnes/year. In 1999 it was further extended to reach its current capacity of 75,000 tonnes/year. The compost plant treats sewage sludge. The system is identical to that of Zutphen. It consists of 12 composting tunnels which are housed inside a building. Each tunnel has dimensions 40 m long, 8 m wide and 6 m high. The residence time inside the compost tunnels is 14 days. The treated sludge is generated from several different wastewater treatment plants and has an average solids' concentration of approximately 25%. The outgoing air from the building where the composting process takes place is purified from ammonia and odour by means of a scrubber and a biofilter. The whole process has a high degree of automation as the parameters of temperature, oxygen and moisture are completely controlled in order to optimize the process, attain pathogen reduction requirements, and meet process objectives. Then the material is screened; the fines that pass through the screener are marketed as final compost, while the reject stream is recycled back into the mixing stage of the process.

Figure 54: View of the Tiel Sludge Composting Plant

Note: The information is based on material provided by Mr. Luc Klunder of the Dutch Company GICOM

11. Deerdykes Composting Facility

Country: UK

Facility: Deerdykes Composting Plant, Scotland

In this case study a 30-year old abandoned Wastewater Treatment Plant was converted into a contemporary composting facility. This project took place in Cumbernauld of Scotland. This project was designed and constructed by the environmental company Enviros. The development of the composting plant was decided in order to achieve the EU Landfill Directive Targets for the diversion of organic waste away from landfill in Scotland (Last et al., 2005).

For the high rate composting stage the technology of compost tunneling has been employed (Figure 55). In particular, 4 compost tunnels are employed as seen in Figure 40. The plant treats industrial sludge, green waste and liquid wastes. The liquid wastes are stored on site and are discharged to the sewer. Sludge is dewatered through the use of filter presses and the cake is composted together with green waste in composting tunnels. Some green waste is composted separately in open windrows. The tunnels and the process control system have been designed and constructed so that the plant can also accept animal waste. The aeration system employed is that of forced aeration. The residence time in the composting tunnels is 14 days. The composting process provides an initial sanitization and stabilization process. Air is supplied using blowers through a network of pipes cast into the concrete base slab. Control over the air-flow rate is achieved through frequency inverters linked to the tunnel blower/fan, with the primary movement being re-circulation of air through the composting mass (Last et al., 2005). A series of probes set within the composting mass are used to monitor the temperature. The aeration process is automatically controlled to maintain minimum oxygen, whilst controlling a target temperature, set by the operator. Exhaust air from the tunnel is extracted by another smaller centrifugal fan and is passed through a wet scrubber and a biofilter in order to remove odours before discharging the air into atmosphere. The exhaust air fan is controlled using a pressure sensor located in the head space of the compost tunnel. The tunnel is operated under a slight negative pressure in order to prevent odours escaping to the atmosphere (Last et al., 2005).

The tunneling system is fully automated, being controlled by a software package developed specifically for this kind of process. The composting mass inside the tunnel is aerated using a high air volume/pressure centrifugal fan. Air is re-circulated through the floor of the tunnel, through the composting mass and via an outlet in the tunnel roof leading into duct work back into the fan. Fresh air is drawn into the fan to ensure an operator settable minimum oxygen content in the re-circulating stream. A series of probes set within the composting mass are used to monitor the temperature. The aeration process is automatically controlled to maintain minimum oxygen, whilst controlling on a target temperature, again set by the operator. Air exhausted from the composting tunnel is passed through a scrubber and a biofilter. The wet scrubber comprises a packed bed up flow reaction column and uses water as the scrubbing liquid. The biofilter medium consists of selected wood chips. Treated air, free from adverse odours, is then discharged to the atmosphere (Olufsen et al., 2006).

The processes that take place are shown in the flow chart of Figure 56. The waste material to be treated (i.e. industrial sludge, green waste) is received at the waste reception unit. The green waste is then shredded and blended with sludge in order to produce an appropriate mixture. The shredded material to be composted is loaded into the tunnel using a wheeled loading shovel. Each tunnel has dimensions: 25m long, 5.3m wide and 5 m high and can be filled up to a maximum height of 4 m. When a tunnel has been filled, the lightweight insulated tunnel door is closed and sealed by hand using special manual door handling equipment (Figure 57) (Olufsen et al., 2006).

Figure 55: View of Composting Tunnels Employed in Deerdykes Composting Plant

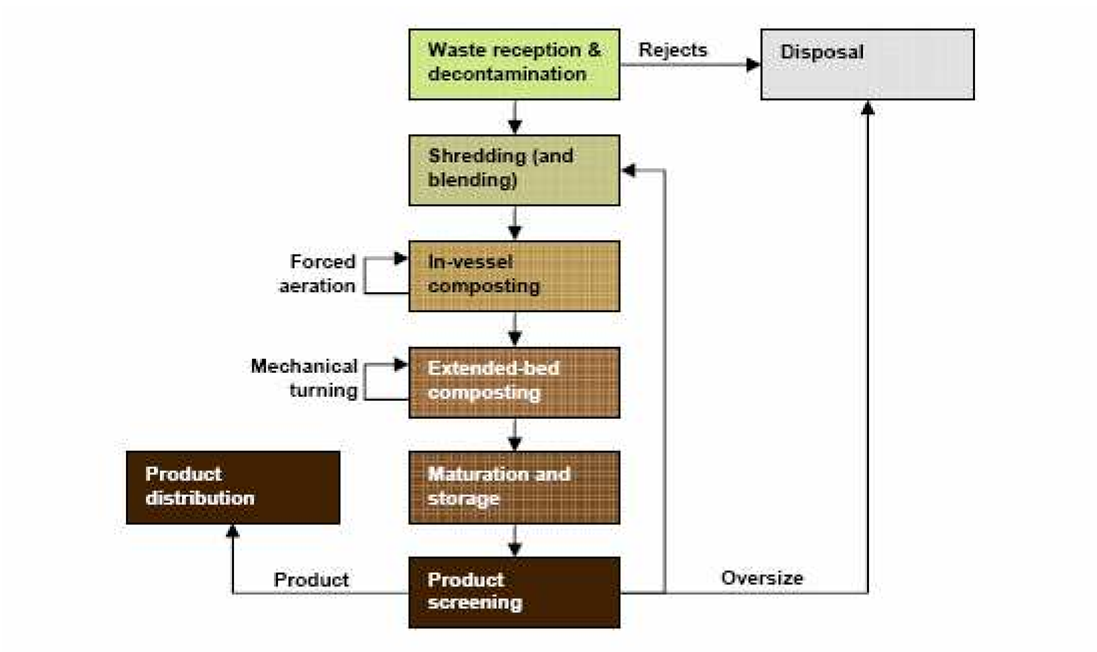

Figure 56: Flow Chart of the Processes Taking Place at the Deerdykes Composting Plant

Figure 57: View of the Insulated Tunnel

The composted material is removed from the tunnels using a wheeled loading shovel and is placed in windrows where it is cured (Figure 58). The windrows are turned approximately once per week in order to allow for agitation (Figure 59). The residence time in the windrows is 12 weeks. The end compost is then refined with the utilization of a trommel screen. The reject stream of the screening process (i.e. coarse material) is either recycled back into the composting process (particularly if incoming the waste is lacking in structure or sent to landfill (Olufsen et al., 2006).

Figure 58: Open Air Windrows for Curing

Figure 59: Agitation of the Curing Windrows through an Extended Bed Turner

12. Zeeasterweg Lelystad Composting Facility

Country: Netherlands

Facility: Zeeasterweg Lelystad Composting Plant

The Zeeasterweg plant at Lelystad of Netherlands is an aerobic tunnel composting plant and is the most up-to-date of its kind. The plant has been designed and constructed by the Dutch company Orgaworld. It processes a variety of waste including industrial waste, green waste, residual waste and sludge from the food-processing industry and has an annual capacity of 75,000 tonnes. It receives organic waste from the Municipality of Lelystad which has around 70,000 inhabitants. In Figure 60 the flow diagram of the processes is shown. Waste is received and is placed inside the parallel compost tunnels where the composting process takes place. The input waste does not receive any pre-treatment. The compost mix remains inside the composting tunnels for 10 days. The aeration system is that of forced aeration; via thousands of under-floor nozzles pressurized air is passed through the material to be processed, thus initiating the composting process. During this process part of the organic matter is degraded and water vaporizes, resulting in stable compost as the end product. The tunneling system does not have any leachate collection system or water provision system. The material is then screened. The reject stream (i.e. course material) is mixed together with the new input material and is thus composted again. The material that passes the screen (i.e. fine material) is the final compost that is packaged accordingly. The energy required for the whole process is low (approximately 15 kWh/ton of incoming waste). This facility is a simple low cost facility.

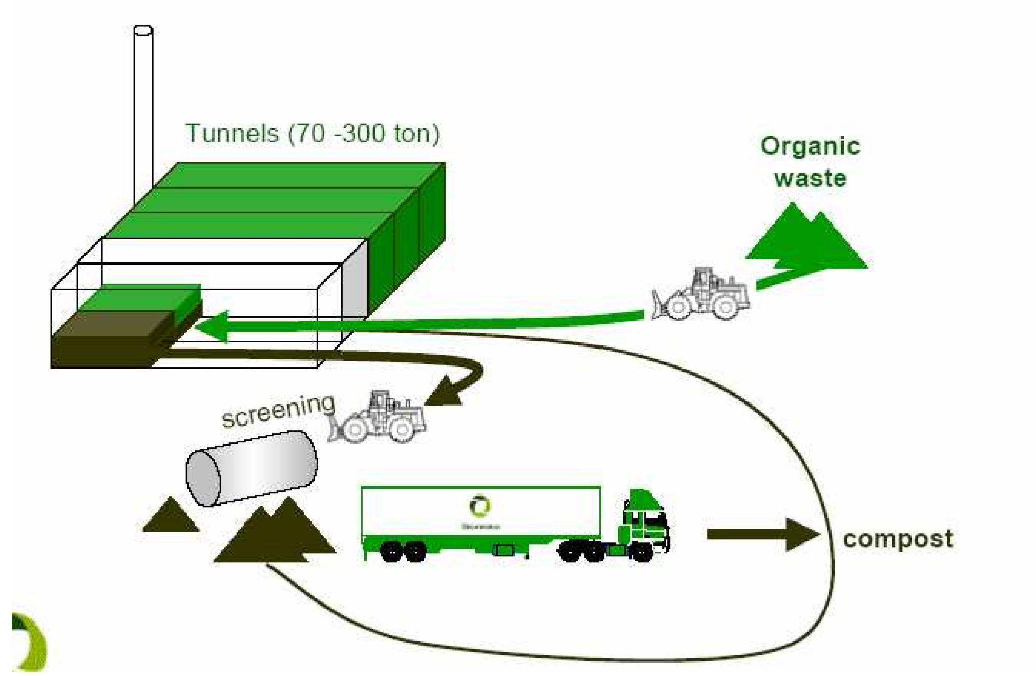

Figure 60: Flow Diagram of the Composting Process in Lelystad Plant

<u>Note: The information is based on material provided by the Dutch company Orgaworld which was responsible for the design and the construction of the plant</u>

13. Wellington Composting Facility

Country: New Zealand

Facility: Wellington

As an island country, New Zealand constantly weighs the delicate balance between developing its economy and preserving its environment. The City of Wellington helps to maintain this balance through its recycling and composting schemes. In 1998, the City selected the IPS Composting System for processing biosolids with green waste and contracted with Living Earth Waste Management (LEWM) (owner of the facility) to design, construct and operate the facility. Centrally located, Wellington serves as the nation's capital, the third largest municipality and a major seaport. Its population of 160,000 people generates an abundance of solid waste; however, disposal options are very limited. Wellington is surrounded on one side by the Cook Strait and on the other by a hilly, mountainous terrain. Consequently, an excavated ridge is the site of the City's state-of-the-art landfill and co-composting facility. Processing organic residuals in the IPS Composting System allows the City to extend the life of its landfill and produce a high quality marketable end product.

Figure 61: General View of Wellington Composting Facility

The facility (Figure 61) started to operate at August 1999. It has a capacity of handling 134 tonnes/day of biosolids and 230 tonnes/day of green waste (240 m^3/ day) which are composted at 10 tunnels, each 81m long x 3m wide x 2m high, in a 4,753 m^2 enclosed composting building (2000 m^2 compost curing and storage). For odour control a 3220 m^2 biofilter is installed. LEWM blends the finished compost with various materials, such as lava pumice, composted yard waste and vermiculite. Some compost is fortified with organic fertilizer. Multiple end products reach broader market segments.

14. West Palm Beach Composting Facility

Country: USA, Florida

Facility: West Palm Beach

Florida State legislation mandated a 30% waste recycling rate by 1994. To reach this target the West Balm Beach composting facility was constructed. This plan employs the tunnel composting technique to compost sewage sludge and yard waste. The compost mix is placed inside parallel, long, concrete channels where the composting process takes place. After conducting a demonstration project using four tunnels, which started at October 1991, the Solid Waste Authority of Palm Beach County (owner of the facility) expanded the facility to 36 tunnels. The expanded facility started its operation at August 1994. The 36 tunnels have dimensions (252’ x 6,5’) and have the capacity of processing 540 cubic yards per day of sewage sludge with yard waste (Figures 62 & 63). The tunnels are enclosed inside two composting buildings which have a combined area of 121,280 square feet. For controlling odours three biofilters having a total area of 39,530 square feet are installed at the facility.

Figure 62: West Palm Beach 4-Tunnel Pilot Demonstration Before Expansion

Figure 63: West Palm Beach 36-Tunnel Facility Expansion

15. Rapid City Composting facility

Country: USA

Facility: Rapid City, South Dakota

The Rapid City composting plant (Figure 64) in South Dakota was built in three stages. It is a facility that treats both Municipal Solid Waste (MSW) and sewage sludge. Partnering enabled Rapid City to complete the third and final phase of its biosolids and municipal solid waste (MSW) co-composting facility on time and within budget. The first phases of the solid waste program which consisted of the Material Recovery Facility and the two rotating bioreactors was completed in 1997. Economic concerns prompted the City to put the final phase composting project on hold. Interest was renewed in 1999 when Rapid City decided to upgrade its Water Reclamation Facility and discovered that biosolids land application would require purchasing an additional 1,100 acres of land. Co-composting biosolids with MSW would achieve greater economic benefits, meet the recycling goals and preserve landfill space. However, problems surfaced again in 2002 when the first round of bids for the co-composting facility exceeded the project budget. US Filter presented an approach that the City accepted. The technical team conducted an intense design workshop to achieve the project and budget objectives. Within six months the design was completed, the project was successfully rebid and construction was underway. Finally, the facility started to operate at May 2003. It has the capacity of processing 355 cubic yards per day of municipal solid waste with biosolids at 9 tunnels, each 10 feet wide x 8 feet high x 280 feet long. The solids retention time is 29 days, while the area of the composting building is 47,000 square feet. The facility consists of the active composting facility, aerated curing (20,000 square feet compost aerated curing shelter with a retention time of 30 days) and a refining building with a screener and destoner. The product is stored at a 3 acre area. The compost product is used in land reclamation and landscaping projects.

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Figure 64: Transportation of Municipal Solid Waste and the Final Product after co-composting of Solid Wastes with Biosolid

16. Goldsboro Composting Facility

Country: USA

Facility: Goldsboro, North Carolina

Economics and the Neuse River nutrient sensitivity resulted in the City of Goldsboro selecting the tunnel composting system as their best biosolids management alternative (Figure 65). The land application alternative was problematic due to inaccessibility to fields during extensively rainy periods and also due to the potential of environmental liability. Another way to reduce nutrient discharge into Neuse River was to create a 40-acre wetlands area for “polishing” nutrients from advanced treated wastewater prior to river discharge. An additional nutrient reduction project was the construction of a reclaimed water (treated wastewater) irrigation system for use on the municipal golf course and some farmlands. ARCADIS G&M, Inc. consulting engineers assisted Goldsboro in the biosolids study. US Filter’s IPS Composting System was selected because it met the City’s goals and united two municipal programs. Composting combined woodchips from the yard waste collection program with biosolids from the Water Reclamation Facility. The 35-acre composting facility started to operate at December 2002. It has the capacity of processing 250 cubic yards per day of biosolids with yard waste at 8 tunnels, each being 10 feet wide x 7 feet high x 235 feet long. The facility comprises of a 40,000 square feet enclosed composting building, a 5,000 square feet amendment shelter providing 15 days storage, a 12,000 square feet compost curing shelter having a residence time of 30 days and a 46,800 square feet paved area where product is stored. For controlling odours a 15,000 square feet biofilter was installed.

Figure 65: Tunnel Composting Facility and the Control System

Figure 66 shows the areas where the several processes take place. The woodchips that are used as additives to the process are initially grinded to sizes that promote the composting process and are then stored in the amendment shelter. Then the woodchips are mixed with sewage sludge and the compost mix is placed inside the compost tunnels of the main composting building. Curing of the compost mix is performed inside an adjacent building. The end product is screened using a trommel screen.

As a Class A, Exceptional Quality (EQ) end product, compost could be distributed year-round without restriction. Compost characteristics help to control erosion, establish and maintain turf and improve soil chemistry and structure. Goldsboro markets the compost to landscapers and nurseries and to the City's golf course and its parks. The Goldsboro Biosolids Composting Facility project team included ARCADIS G&M, Inc., who handled engineering and project management for both the wastewater treatment and biosolids composting projects, and Engineered Construction Company, general contractor, who constructed the facility.

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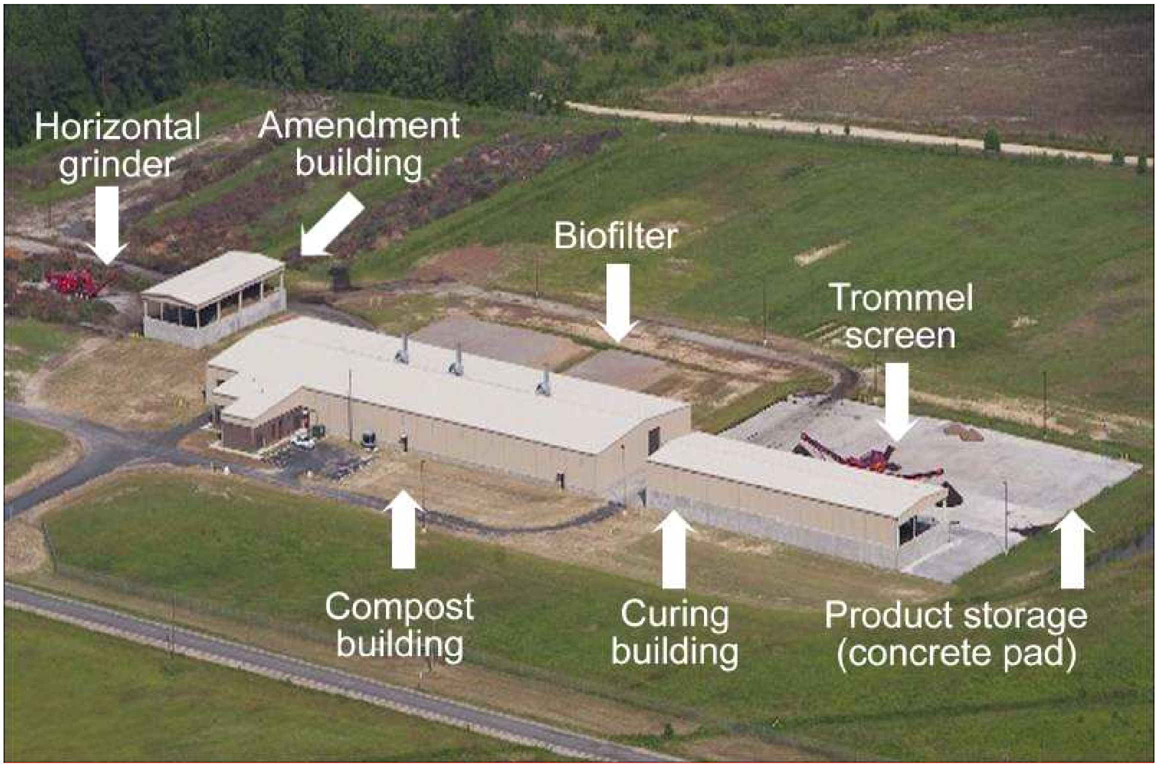

Figure 66: Overview of Goldsboro's Composting Facility

17. Rockland City Composting Facility

Country: USA

Facility: Rockland City, New York

The Rockland City composting facility employs the tunnel composting technique to process sludge, yard waste and wood waste (Figure 67). Rockland County Recycling and Composting Centre serves as a model for other communities in the state of New York. At the beginning of 1991, the Authority found a 34-acre Facility in Hillburn, New York to fulfil its solid waste and biosolids management goals. Rather than depend on short-term out-of-state solutions, the Authority opted for self-sufficiency and provided a long-term management alternative. The plan involved four county-owned facilities, including a transfer station, a recyclable pre-processing facility, a materials recovery facility (MRF) and a composting plant. Designed by the Maguire Group and Wright Pierce, Inc. and constructed by the Waste Management of New York (WMNY), the nine-tunnel composting facility utilizes the US Filter IPS tunnel Composting System to process biosolids, yard waste and clean wood waste. The facility, which started operating at February 1999, has the capacity of processing each day 110 wet tonnes of biosolids mixed with clean wood at 9 composting tunnels. Each tunnel has the following dimensions: 215 feet long x 10 feet wide x 7 feet high. Agitation is achieved through mechanical agitators that are fit inside the tunnels and agitate the compost mix through the tines located at the surface of a rotating cylindrical apparatus. The composting and curing building occupies an area of 50,465 square feet, the amendment building an area of 3,000 square feet and the compost storage warehouse an area of 27,000 square feet. For odour control, chemical scrubbers are employed as well as an enclosed inoculate, bark-type biofilter.

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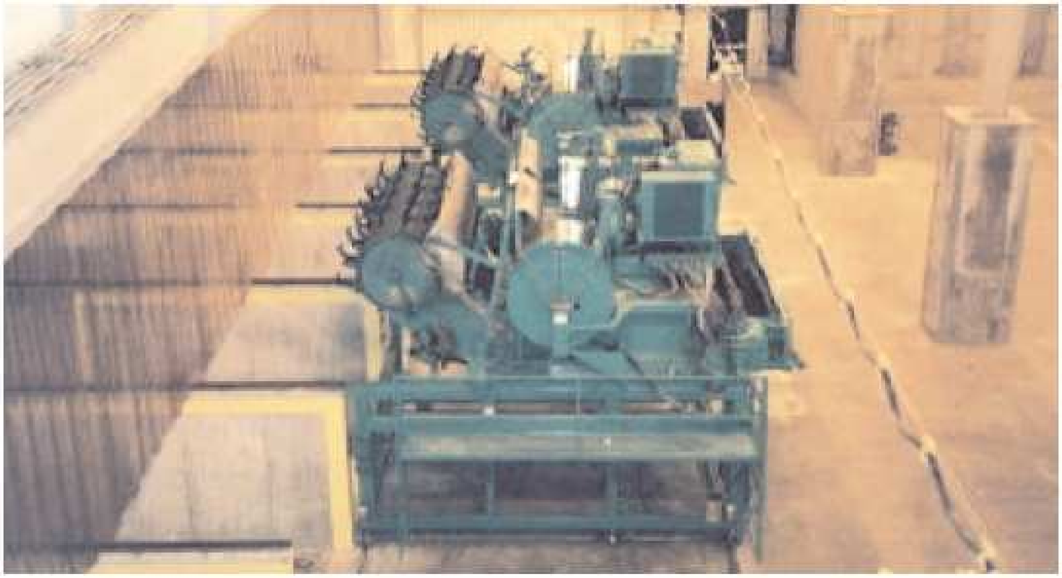

Figure 67: Tunnel Composting Facility of Rockland City (inside and outside overview)

The County owns the four facilities and contracts operations to private companies. The contracted services of the facility include shredding wood waste on-site, compost operations, hauling biosolids to the facility from the wastewater treatment plants and marketing the finished compost. Biosolids and other waste material are mixed inside the totally enclosed composting plant and are loaded into the tunnels. There the compost mix is processed for 21 days; then the compost is transferred to an aerated curing area in the same building. After a 39-day curing period, the finished compost is transferred to a covered screening, storage and distribution area.

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18. State College Pennsylvania Composting Facility

Country: USA

Facility: State College, Pennsylvania

The State College composting site in Pennsylvania employs the compost tunnelling technique (Figure 68). University Area Joint Authority (UAJA) employed a beneficial reuse project to resolve rapid community growth and environmental mandates. Using the US Filter's advanced wastewater treatment technologies and the IPS Composting System helped to achieve the desired results. UAJA's Spring Creek Pollution Control Facility serves several towns and a portion of the Borough of State College, home of the Pennsylvania State University (PSU). In 1992, UAJA, as part of the 6 MGD plant upgrade, built its original 12-tunnel IPS Composting System. At that time, secondary treated wastewater was discharged into Spring Creek, a brown trout fishery. The 2002 plant upgrade required advanced treatment and diversion of as much as 4 Million Gallons per day from Spring Creek to reduce the thermal load that could adversely impact the reproductive cycle of trout. Instead, the treated water would be used to recharge the aquifer, create artificial wetlands, and assist agriculture and commercial operations. The expanded facility started to operate at June 2004. It has the capacity of processing 75 wet tons per day of raw and activated sludge with sawdust as amendment at its 18 tunnels. Each tunnel is 216 ft. long x 6.5 ft. wide x 6 ft. high. It comprises of a 3,000 square feet amendment area and an 18,000 square feet curing/storage building. Agitation is achieved mechanically through the apparatus illustrated in Figure 6. For odour control a 27,000 square feet biofilter is installed.

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Figure 68: Tunnel Composting Facility at State College of Pennsylvania

UAJA compost has been used in high profile projects including the Pittsburgh Steelers athletic field and the Little League World Series Field in Williamsport, Pennsylvania. PSU has conducted collaborative research with the compost. In addition to receiving the 1996 Governor's Award, UAJA received the U.S. Environmental Protection Agency 1997 national first place award for outstanding Beneficial Use of Biosolids.

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19. Rancho Las Virgenes Composting Facility

Country: USA

Facility: Rancho Las Virgenes, California

Rancho Las Virgenes Composting Facility (Figure 69) is part of nine building complexes where wastewater sludge holding, anaerobic digestion, centrifuge dewatering, methane gas production, energy recovery and water reclamation take place. Tapia Water Reclamation Facility pumps wastewater sludge to the biosolids complex of processing and ultimate distribution to commercial markets.

For thirty years biosolids were transported and land applied as beneficial soil conditioner on Racho Las Virgenes, a 91 acre farm. Land application restrictions and a planned expansion of the wastewater facility forced the joint municipal owners (Las Virgenes Municipal Water District and Triunfo Sanitation District) to seek a more viable biosolids treatment and disposal alternative. The District conducted an extensive systems evaluation and selected the IPS tunnel composting technology as the core for their biosolids management system.

This fully automated compost facility started to operate on February 1994. It has the capacity to process 120 cubic yards of biosolids per day. A programmed material handling system transports dewatered biosolids, finely shredded wood and recycled compost to a mixer. The mixture is conveyed to an overhead distributor and is evenly loaded into eight composting tunnels (220' x 6,5' each). Shaftless screw conveyors return the composted material back to the mixer or to 25,000 square feet enclosed building for curing and long-term storage. For controlling odour a 17,000 square feet biofilter is installed.

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Figure 69: Rancho Las Virgenes Composting Facility

20. Burlington County Composting Facility

Country: USA

Facility: Burlington County, New Jersey

Figure 70: Burlington County's composting facility

The Burlington Country (Figure 70) composting plant in New Jersey employs the tunnel composting technology to compost sewage sludge, wood waste, yard waste and organic waste. In May 1998, the Burlington County Board of Chosen Freeholders opened its 25-wide tunnel (each tunnel 205 feet long and 10 feet wide) co-composting facility. This regional facility is designed to process every day 200 tons of biosolids from the county's wastewater treatment plants with shredded wood waste, yard waste and other organic materials. Located at the 522-acre Burlington County Resource Recovery Complex, the co-composting facility is one of numerous environmental enterprises. The complex features a landfill, hydroponic greenhouse, aquaponics, wood recycling facility, research and education eco-complex and methane to-electricity microturbines. The County owns all the facilities but out-sourced the composting design, building, operation and end-product marketing. The facility is comprised of: 1) a 160,000 square feet enclosed receiving, composting and curing building; 2) a visitor observation room; 3) finished compost storage (1.5 acre asphalt storage pad) and 4) a 3500 square feet administration and maintenance building.

Inside the process building, two reel auger blenders mix the materials that will be composted. The blended mixture is placed inside tunnels where a machine mixes, agitates, and moves the material every day. The system is computer-controlled so that the process is easily optimized in order to produce high quality compost. All the air from the process building is treated through two biofilters (43,000 square feet each). The composting facility assures the community long-term self sufficiency by recycling materials into a valuable resource. It extends the county landfill life and eliminates dependence on uncertain out-of-county disposal alternatives.

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21. Philadelphia Composting Facility

Country:USA

Facility: Philadelphia, Pennsylvania

The Biosolids Recycling Centre (BRC) is located in South West Philadelphia (Figure 71).

Figure 71: Panoramic View of the Philadelphia Composting Facility

BRC is 72 acres in size and is close to the airport and adjacent to the Southwest Water Pollution Control Plant. The BRC processes all the biosolids produced by Philadelphia's 3 wastewater treatment plants. The plant receives a dilute suspension of biosolids which is then dewatered using centrifuges. The resulting sludge "cake" has a solids concentration of 30% solids. Figure 72 shows the dewatering centrifuges that produce the semisolid material used for composting. Operation of the centrifuges is around-the-clock, and is largely automated, producing about 900 tons daily. The whole process is controlled through a suitable PLC (Figure 73) (Philadelphia Water Department Biosolids Management Unit, 2003)

Figure 72: Centrifugal Pumps Used for Sewage Sludge Dewatering

Figure 73: Automation System Employed for Dewatering Sewage Sludge

Excess water is collected and returned to the Southwest wastewater treatment plant. Dewatered samples are collected 3 times per day to document equipment performance (Figures 74 & 75).

Figure 74: Collection of Excess Water 'Squeezed out' from Sewage Sludge

Figure 75: Collection of Dewatered Sludge Samples

The dewatered sludge cake is then mixed with woodchips in order to further reduce the moisture level, increase the C/N ratio and provide suitable voids that will ensure aerobic conditions inside the compost mix during composting process. The dewatered cake collected beneath the centrifuges is carried through conveyors (Figure 76) into the mixing building, where the woodchips are blended in to produce a compost mix. In Figure 77 a loader adds woodchips to the dewatered sewage sludge (Philadelphia Water Department Biosolids Management Unit, 2003).

Figure 76: Transferring of Dewatered Cake through Conveyors to the Mixing Building

Figure 77: Mixing Process of Sewage Sludge with Woodchips

The high rate composting process that is employed is that of aerated static piles. The compost mix is formulated into compost pads. The BRC plan has a fleet of heavy equipment -loaders and trucks- that build the piles and move compost through the process (Figure 78). In Figure 79 a specially designed truck receives the biosolids compost mix from the mixing building (Philadelphia Water Department Biosolids Management Unit, 2003).

Figure 78: Equipment Utilized for the Formulation of Static Piles

Figure 79: Truck Receiving Biosolids Compost Mix from the Mixing Building.

The static piles of the high rate stage occupy an area of 12 acres (Figure 80). Aeration is provided by means of 27 75-horsepower blowers which draw air through perforated pipes underlying each row of composting biosolids. The forced aeration system is employed, in which air from the outside environment is drawn inside the compost mix (Figures 81 & 82). The air is vented through a specially-built biofilter made of compost to control odours. The residence time of the compost mix in the static piles is 30 days. The Philadelphia composting plant treats over 200,000 cubic yards / per year of input mix by employing the technology of aerated static piles. The high temperatures of composting cause water vaporization, eliminate pathogens and decompose organic matter, yielding 60,000 cubic yards of compost per year (Philadelphia Water Department Biosolids Management Unit, 2003).

Figure 80: High-rate Static Piles at the Composting Site of Philadelphia

Figure 81: Close-up of the Aeration System, Showing the Ports Through which Air is Sucked.

Figure 82: Perforated Pipe Underneath the Composting Mix.

Figure 83: Curing Stage with Windrows

After the aeration stage, the compost mix is “cured” in windrows, providing time for additional decomposition and stabilization (Figure 83). Then, the end product is dried to complete the maturation stage (Figure 84). Finally, the end product is screened in order to refine it (Figure 85). Four pair rotary screens separate out the woodchips used in static pile composting from the stabilized compost. The woodchips are reused and the final compost product is put into storage. The end compost is placed in piles which are protected during the winter months by applying a suitable cover over the compost (Figure 86). Part of the final compost is sold at garden centres in Philadelphia. The compost is traded as EarthMate. Most of the EarthMate is sold in truck load quantities to large users or to stocking dealers, who re-sell it to homeowners and landscapers. Philadelphians can visit the BRC and pick it up at the “Give-Away Bin” at no charge for their home use. (Philadelphia Water Department Biosolids Management Unit, 2003) http://www.mabiosolids.org/docs/26542.PDF).

Finally, Figure 87 shows a panoramic view of the plant during winter time.

Figure 84: Drying of End Compost Prior to Screening.

Figure 85: Screening Apparatus for the Final Compost

Figure 86: Applying Suitable Cover to the Stored End Product

Figure 87: Panoramic View of the Philadelphia Composting Plant
(http://www.mabiosolids.org/docs/26542.PDF**)**

22. Georgetown County

Country: USA
Facility: Georgetown County, South Carolina

The Georgetown County Composting Facility (Figure 88) has been established in South Carolina. It has the capacity of processing 54 wet tons per day of biosolids and yard waste. The biosolids are generated by Georgetown County Water and Sewer Facilities and yard waste is collected from the county landfill and convenience centres. The yard waste is ground to suitable size and is mixed with sludge; the mixture is left to compost at aerated static piles (Figure 89). The equipment of the facility comprises a horizontal grinder with 3-inch minus screen, a front end loader with a 3.5 cubic yard bucket and a 3/8-inch trommel screen. The composting technology employed is that of aerated static piles (http://www.carolinacompost.com/CCC/VTdepot_files/vtdepot.htm).

Figure 88: Georgetown County Composting Facility

Figure 89: Aerated Static Piles and Windrows

23. Santa Rosa Laguna Composting Facility

Country: USA

Facility: Santa Rosa Laguna, Sonoma County, California

The 1995/96 Waste Characterization Study conducted for Sonoma County does not identify biosolids as a significant waste stream that is disposed at the County's landfill sites. Landfilling of biosolids is allowed, provided the solids concentration is greater than 80%. Nevertheless, it was decided to build up a composting plant for the treatment of sewage sludge. The City of Santa Rosa Laguna Plant (Figure 90) uses a forced air, agitated bed system comprising of twelve, 6 feet by 10 feet by 210 feet, composting tunnels for the composting operation. The facility has a capacity of 50.5 wet tons per day, which varies seasonally because additional moisture in winter months requires additional bulking materials. Laguna has been using approximately 35 tons/month of yard debris collected from residential curbside programs as a bulking material. About one part biosolids is blended with four parts of green waste. The high rate composting process lasts for 14 days and then the product is cured for at least another 30 days. The Laguna Composting Facility produces 20,000 cubic yards of compost each year, most of which is sold on the bulk market (www.recyclenow.org/CoIWMP/Ch4_SRRE_Composting.pdf;

http://ci.santa-rosa.ca.us/default.aspx?PageId=2133)

Figure 90: Santa Rosa Laguna Composting Facility

24. McGill-Leprechaun Composting Facility

Country: USA

Facility: McGill-Leprechaun, North Carolina

There are two composting units in North Carolina, at Harrells and New Hill. Each facility has the capacity to process 100,000 tons/yr. It accepts all non-hazardous biodegradable materials. The composting process takes place indoors in aerated static piles. The equipment of the facility comprises of a blending unit, front end loaders and a screening unit for the refining of the end product (Figure 91).

http://www.carolinacompost.com/CCC/VTdepot_files/vtdepot.htm

Figure 91: McGill-Leprechaun Composting Site

25. Cappoquin Composting Facility

Country: Ireland

Facility: Cappoquin, Waterford County

The Cappoquin composting facility (Figure 92) operates under the name of Molaisín Compost limited and has been operational since January 2004. It was officially opened by Martin Cullen, Minister for the Environment, on 14th May 2004. The facility has the capacity to compost 12,000 tonnes of material (non-hazardous industrial sludge) per year. The technology that is employed is that of in-vessel composting.
http://www.mcgillireland.com/Facilities.htm
.www.epa.ie/OurEnvironment/Waste/NationalWasteReport/PDFsforNWR/FileUpload,10210,en.pdf

Figure 92: Cappoquin Facility in South East Ireland

26. Odense Composting Facility

Country: Denmark
Facility: Odense

Composting of sewage sludge together with straw and cuttings from parks and gardens was initiated when in the mid-nineties the spreading of sewage sludge directly on farmland gave rise to some concerns for farmers and their organisations. Studies and experiments started in a fruitful cooperation between Odense Waste Management Company Ltd., Odense Water Company Ltd. and leading consultants in order to determine the effect of compost application to land. The results of the experiments were positive as they showed that substances harmful to the environment were decomposed during the composting process. Moreover, no pathogens, parasites or any significant quantities of heavy metals were found in the finished compost.

Figure 93: Odense Composting Facility

In 1999 a plant for composting of sewage sludge was established at Odense Environmental Centre (Figure 93). The sludge is received from the three wastewater treatment plants of the municipality of Odense. Today the total area occupied by the composting plant is about 62,000 square metres, including the storage site covers. Approximately 30,000 are used for the composting process which takes place at aerated windrows. The annual production is about 35,000 tonnes of final compost, most of which is today used as fertilizer for farmland crops, such as grain (www.odensewaste.com).

27. Kujala Composting Facility

Country: Finland

Facility: Kujala

Figure 94: Kujala Composting Plant

The Kujala composting plant (Figure 94) has been part of Finland's strategy to increase recycling of all biodegradable waste. Serving several large municipalities in southern Finland, the Kujala composting plant is setting the trend for large-scale closed biowaste management in Finland. It employs the technique of tunnel composting. More specifically, it comprises of 20 closed tunnels covering an area of 8,302 m^2 and 92,000 m^3 of space. The plant has an annual treatment capacity of 36,000 tonnes/year. Though advanced process control the plant is able to convert biodegradable waste and sludge into high-quality compost products with minimum impact to the local environment. It was planned and built in co-operation with best Finnish, Austrian, German and Dutch experts. The owners are Kujala Compost Ltd, PHJ and LV Lahti Water Ltd and municipalities. The investment cost was 12 million euro (vat 0%). The treatment process is effective, since the final compost product meets key environmental standards and is practically odour-free. The plant also has a large odour control unit that minimizes compost gas emissions.

http://www.phj.fi/downloadable_material/waste_management_PHJ.pdf#search=%22KUJALA%20COMPOSTING%20PLANT%2C%20FINLAND%20%22
www.investin**finland**.fi/.../en_GB/topical_issues/_files/11233219940002258/default/Update_ETS_0405.pdf

28. Botarell Composting Facility

Country: Spain

Facility: Botarell Composting Scheme

The Botarell composting system is located in the Baix Camp area of the province of Tarragona, in the north-east of Spain. The Baix Camp area is part of a Catalonian administrative division and provides centralized services to the nearby Municipalities. The composting system receives household biodegradable waste from 50,000 households (145,000 inhabitants) as well as biodegradable waste from hotels, schools, markets and industries. The biodegradable fraction of waste is collected through a house-to-house kerbside separate collection and is transported by lorry to the composting plant, which is located near the Botarell village. The Botarell composting site (Figure 85) started its operation in June 1997. During the first 2.5 years of operation approximately 7,000 tonnes of kitchen and 3,000 tonnes of garden waste were composted, producing 900 tonnes of compost. However, the quantities of biodegradable waste received at the plant have been increasing with time, as more municipalities have undertaken separate collection (EC, 2000).

The technology that is employed is that of aerated static piles. The annual design capacity of the plant is 30,000 tonnes of biodegradable kitchen waste and 5,000 tonnes of garden waste. These two fractions of organics are mixed and composted in the static piles for a period of 2-3 weeks. Then the mixture is screened through an 80 mm diameter trommel screen. The rejected stream is sent to landfill and the screened fraction is placed in aerated static piles where it is left to mature for a period of 12-14 weeks. Aeration is provided through a mechanical mixer. The produced compost is screened through a 25 mm trommel screen and a densimetric table. The end compost is separated by the trommel screen into different fractions depending on demand. The aerated static piles are housed in buildings. Air treatment is provided in these buildings through biofilters

(Figure 96). There are no specific standards concerning the quality of the compost, other than the legal definition of compost for agricultural purposes and the size requested by different clients. The current market for the compost is private gardens and individual farmers, mainly for fruit and olive orchards. It has also been sold for public works, like landfill closure and road revegetation. The current price of the compost that is sold is approximately 12 € per tonne. The compost is seen as too expensive for farmers (there is excess of manure available in the area) and fairly cheap for private gardeners. Therefore efforts are made to market the product amongst retailers. Table 2 summarizes the total cost of the source separation, collection and composting of organics, while Table 3 summarizes the capital and running cost (EC, 2000).

The running costs are covered from the flat rate which each municipality charges the households (20 €) for the treatment of the compostable biodegradable fraction and from the charges wastes coming from municipalities outside the Baix Camp area. The revenue obtained from compost sales is increasing as the quantities of biodegradable waste that is treated increases. During the first 2.5 years of operation, a total of 10,850 € were earned through compost selling. The price of the compost is low as there is great competition from manure which is abundant in the area (EC, 2000).

The Botarell Composting Scheme (Figure 95) is considered one of the most successful composting sites in Spain. Apart from the technical excellence, one of the main reasons of success was the participation of a high number of individuals in the separation of the biodegradable fraction of waste. This was achieved through appropriate Catalonian legislation which imposes separate collection for Municipalities greater than 5,000 inhabitants and through an intense publicity campaign which included door-to-door distribution of leaflets and brochures, the organization of a bus road show and of radio and press campaigns.

Table 2: Cost of the Baix Camp Separation, Collection and Composting Scheme for the Year 1998 (EC, 2000)

Type of Cost	**Amount (€)**
Setting-up	6,000,000
Operating cost	45 per tonne
Publicity Cost	228,000
Disposal Cost	7.2 per tonne
Avoided disposal cost & revenue	1.1 per tonne

Table 3: Capital and Running Cost of the Botarell Composting Scheme (EC, 2000)

Type of Cost	**Number (€)**
Total Capital Cost	5,420,000
▪ Construction	3,600,000
▪ Machinery	1,400,000
▪ Land Purchase	420,000
Annual Running Cost	180,000
▪ *Operational*	90,000
▪ *Staff*	54,000
▪ *Assorted (insurance & treatment of rejects)*	36,000

The scheme undertakes similar continuous publicity efforts in areas to which separate collection will be extended, together with other initiatives such as taking schools to the plant, training volunteers, and setting up a school centre. Furthermore, there has been political will on the part of the Baix Camp Area Council to implement the scheme and coordinate with the municipalities. Initially, the scheme had some difficulties including technical constraints in the management of putrescible wastes, but this was solved by adding garden waste, thus reducing moisture, and by fermenting waste in the first stage of the pre-treatment. Other constraints, such as the lack of critical mass of biodegradable fraction for the efficient running of the plant, have been overcome by taking waste from areas outside the Baix Camp area and from the industry (EC, 2000).

Figure 95: Botarell Composting System

Figure 96: Biofilter in the Composting Plant of Botarell

Note: The pictures have been taken by the NTUA team during the site visit that took place in Botarell in the Framework of the Life-Environment Project COMWASTE

29. Barcelona Integrated Composting Scheme

Country: Spain

Facility: Castelldefels Composting Scheme in Barcelona[1]

The composting plant is operating since 1992 and treats sewage sludge, garden and wood waste. It is located at the Castelldefels town and services the Southern part of the Metropolitan Area of Barcelona. The whole of the Barcelona Metropolitan Area includes 33 Municipalities with approximately 3 million inhabitants and covers an area of 585 km^2. The central composting system receives organic waste from the Municipalities of Castelldefels, Viladecans, Gavá and Begues, which have a total of 137,000 inhabitants and cover an area of approximately 113 km^2. The plant is under the responsibility of the Barcelona Metropolitan Area Environmental Authority, which is a supra-municipal administration created by law. The socioeconomic structure of the area is diverse, depending on the municipality. Castelldefels is a coastal service municipality, with a fair amount of holiday and weekend households. Gavá and Viladecans have a mix of industry, service industry and tourism and Begues is mainly a rural municipality. The population of the area consists of a mix of rural residents and urban population (EC, 2000).

The organic fraction of waste is collected through kerbside collection; the organics consist of garden waste and biodegradable wastes from large producers (particularly food markets). The collected biodegradable waste is transported by lorries to the composting site in Castelldefels. From 1992-1996 the composting plant treated only sewage sludge from the nearby wastewater treatment plants (WWTP). Other biodegradable organics (garden and kitchen waste) are composted since 1997 when the separation and collection

[1] The data provided for the composting plant are for the year 2000, when the plant was operating with 3 tunnels, not including the planned extension with the construction of 3 extra compost tunnels.

of organic waste started. In 1998, the composting plant was expanded in order to increase its capacity (EC, 2000).

The reasons for the successful operation of the system are the enthusiasm amongst the metropolitan area staff and the experience of the operating company in composting. Furthermore, the Catalonian regulations impose separate collection of organics for Municipalities having more than 5,000 inhabitants, thus ensuring the transfer of sufficient amounts of organics to the composting site.

The quantities of biodegradable waste received at the plant are increasing, as more municipalities undertake separate collection schemes. On the other hand the quantities of sewage sludge that are composted decrease. At the year 2000, the plant treated 3,500 tonnes of biodegradable waste, 2,400 tonnes of sewage sludge and 4,800 tonnes of wood waste. Therefore, the compost plant treated a total of 10,700 tonnes of waste at the year 2000. It is expected that the plant will reach an annual treating capacity of 16,000. The technology that is used is that of compost tunneling. The mixture to be composted is placed in long, horizontal, parallel compost channels. The biodegradable fraction (mainly food waste) is mixed with yard waste with the aid of an agricultural mixer. In a parallel line, sewage sludge is mixed with wood waste. Both mixes are then introduced in the composting tunnels. There are three tunnels in the plant having a total volume of 280 m^3 and a usable volume of 210 m^3. The tunnels are filled with waste mixture in 2-3 days. The residence time of the mix inside the tunnels is 10-14 days. The whole process is centrally controlled through probes which are inserted in the compost mix, through air blowers and ventilators. The parameters that are controlled are air flow rate, temperature, oxygen, carbon dioxide and potentially other parameters. The air inside the buildings is treated with biofilters made of compost or of vegetal re-circulated material. A leachate collection system has been placed beneath the compost mixture; the collected leachate is re-circulated to the composting tunnels. The compost mix is then left to mature in piles in the open air. The piles are turned once every week for a period of two months. Finally, the end compost is screened using a vibratory table into two different sizes (5mm and 15mm). In the year 2000, approximately 1,990 tonnes of compost were produced. There are no specific standards for the quality of the compost, other than the legal definition of compost for agricultural purposes. In order to ensure compliance with the requirements of the clients, the quality of the end compost is tested with the use of appropriate laboratory experiments. The end product is used in private gardens and in plant nurseries and is sold at the price of 24-36 € per tonne depending on the quality and on the quantity ordered. The demand for the produced end compost is relatively high and no difficulties have been encountered in finding suitable markets (EC, 2000).

The sales from the compost are part of the plant company's revenue. Currently, there are no problems in selling the product. The scheme is rapidly expanding, in terms of population covered by separate collection and the area of scheme coverage. It is planned to increase the capacity of the composting plant to 16,000 tonnes of biodegradable waste per year, which is possible by building three new composting tunnels. This planned expansion will ensure that the plant can cope with the increasing participation rate from those municipalities already included in the scheme and the inclusion of other municipalities. This will bring the total population covered by the scheme to approximately 220 000 inhabitants.

Table 4: Cost of the Barcelona Separation, Collection and Composting Scheme for the Year 2000 (EC, 2000)

Type of Cost	**Amount (€)**
Setting-up	5,400,000
Operating cost	108 per tonne
Publicity Cost	361,000
Disposal Cost	7.2 per tonne
Avoided disposal cost & Revenue	5.2 per tonne

Table 5: Capital and Running Cost of Composting Scheme in Barcelona (EC, 2000)

Type of Cost	**Number (€)**
Total Capital Cost	5,2000,000
▪ Construction	1,600,000
▪ Machinery	1,600,000
▪ Expansion	2,200,000
Operational	180,000
▪ *Staff*	90,000
▪ *Assorted (insurance & treatment of rejects)*	54,000 36,000

30. Barcelona Sewage Sludge Composting

Country: Spain

Facility: Barcelona Sewage Sludge Composting

The GTR/BFI et Generalitat Catalunya composting system treats exclusively sewage sludge and an annual capacity of 25,000 tons. Although it is located in Tarragona, it is known as the Barcelona sewage sludge composting system. It was constructed in 1994 and the construction period was 5 months. The plant has been designed and constructed in collaboration with the Dutch company Gicom, which is a pioneer in composting technology.

The sludge to be treated is mixed with woodchips, straw and with fresh compost in order to reduce the moisture level and increase the C/N ratio to satisfactory ranges and in order to improve the pile structure. The well-known technology of tunnel composting is employed. The tunnels are housed in a building. In total there are 6 parallel sludge composting tunnels. Each tunnel is 35m long, 6m wide and has a height of 6m. Once each tunnel is filled with the feed mix the door is sealed. The aeration piping system is located at the bottom of each channel. Air is blown through adequate blowers inside the concrete plenum located behind each tunnel and then into the piping system and finally into the compost mix. The air is then re-circulated back into the compost mix through an external recirculation loop ductwork and through the open recirculation dumper.

The entire process is automatically controlled by process computer equipped software which allows dynamic control and pre-programming of key process set-points within each composting activity unit. The temperature, oxygen and the moisture level in the compost heap is automatically controlled through the aeration system and through the system that provides water to the compost heap. All monitored results are recorded and displayed by the computer on a continuous basis. As results are recorded, they are simultaneously compared with set-point data. Based on this comparison and the range tolerance specified for process variables, the computer adjusts air and water flows and conditions effecting respectively the composting cycle in the tunnels, set values for the building area, operation parameters for the water-scrubber and bio-filter.

Figure 97: View of the Barcelona Sewage Sludge Composting Facility

Note: The information is based on material provided by the Dutch Company GICOM

31. HotRot Composting Systems

The HotRot system (Figure 98) is a horizontal in-vessel system used for composting a wide variety of organic wastes, including sewage sludge, grit and other screening materials from wastewater treatment plants, garden and kitchen waste and other municipal solid waste. HotRot is an enclosed U-shaped vessel with a central axial shaft. The tine bearing shaft is periodically rotated to maintain porosity, achieve appropriate agitation and aerate the material. The shaft movement as well as the waste feed rate are automatically controlled. This way the retention time of the material inside the reactor is adjusted. Shaft rotation and aeration are under continuous control. The units contain temperature and other sensors, and feedback from these enables the on-board computer to optimize processing. All HotRot units are equipped with Internet connections to enable smooth software upgrades, remote monitoring and control and facilitate troubleshooting.
http://www.hotrotsystems.com/Main/how/

The capacity of the HotRot system is dictated by the residence time of the material to be composted in the HotRot unit. With HotRot's ability to manipulate residence time via shaft rotation and increasing input quantities, plant capacity can be manipulated to compensate for short-term or systematic fluctuations, as for instance caused by 5 or 6-day working weeks or the receipt of specific wastes at specific times.

The HotRot system utilizes a modular horizontal composting chamber; each chamber is individually controlled and monitored to ensure a consistent and predictable compost product. The material to be composted enters in one end of the HotRot unit where a central shaft mixes the waste and distributes moisture evenly. The central, tine-bearing, shaft is turned intermittently under programmable logic control (PLC) to provide both aeration and assist waste transport (Figure 99). Rotating the shaft both forward and reverse allows for independent process control of residence time and aeration.

http://www.hotrotsystems.com/Main/how/

Figure 98: The HotRot In-vessel Composting System

Figure 99: The Programmable Logic Control (PLC)

The central shaft moves the material through the unit and folds air in to the mix from the overhead airspace. Regular but periodic movement prevents compaction of wastes and maintains oxygen levels while minimising operating costs. Supplementary low-volume air injection also ensures that the material is maintained in an aerobic state and the compost process proceeds at an optimum rate. Similarly, supplementary heat can be applied to minimise the effects of colder environments or achieve excessive temperatures required by some international legislation. The PLC system coupled to the central shaft is the key difference between HotRot and other in-vessel systems. Physical turning of the composting mix by the tines and a control system are advantageous because:

- The tines reduce the importance of inherent porosity and allow composting of smaller particles with a beneficial increase in efficiency over static methods such as containerized forced air systems.
- Mechanical aeration is more energy efficient than forced air systems.
- Thorough mixing in a horizontal system removes any chance of material bypassing treatment temperatures, ensuring the elimination of pathogens
- The control of shaft rotation and air exhaust reduces the production of odours through maintenance of a uniform aerobic state.
- Tine mixing does not cause balling of sticky wastes in the way that rotating drums can.
- Air draw is manipulated in order to regulate moisture levels within the material being composted, leading to more efficient processing.

The HotRot Composting System is fully modular, allowing plant capacity to be easily expanded as community organic waste separation and collection programs increase in efficiency. Modularity can also allow an organic waste treatment facility to be configured to produce niche products from specific feedstocks. Although the residence time in the system is variable depending on the waste feed rate and on the shaft rotation speed, it is usually adjusted to 15-18 days. Nevertheless, lower residence time can be implemented.

The HotRot units are fully enclosed and do not need to be housed in a building. This minimizes capital and maintenance costs. A significant problem with in-building composting systems is the build-up of moisture and corrosive gases, causing corrosion of structures and electronic components. This is completely avoided with the HotRot Composting System.

Figure 100: Installation of HotRot at Sewage Treatment Works in New Zealand.

Each unit incorporates a relatively small free airspace. This ensures that the amount of air that is passed through the process is minimized, reducing the size of biofilters and the cost of moving air. There are no fugitive emissions from the HotRot Composting System as the entire system is under negative pressure. More importantly, plant operators are not exposed to the composting atmosphere, eliminating the risk of respiratory illness, and providing a more comfortable work environment. Each HotRot module is equipped with monitoring equipment that provides on-line diagnostics and an auditable data record demonstrating compliance with USEPA 503, AS/NZS4454, UK and EU Animal By-Product Regulations 2003 and equivalent standards. Each unit is fully insulated, protecting the process from the influence of fluctuating ambient environmental conditions, including solar heat gain and moisture loss.

The HotRot system is employed for composting various types of waste, including municipal waste, food waste and sewage sludge. HotRot systems have been installed in several locations around the world, particularly in New Zealand and the UK. Below certain successful composting installations which employ the HotRot system are described:

Country: UK

Facility: Western Isles

The Western Isles composting plant (Figure 101) is located in Scotland and is operated by the Highlands and Islands Council. It employs the HotRot in-vessel technology to treat organic waste and sewage sludge from anaerobic digestion. The plant is a small to medium scale plant, having an annual capacity of 4,000 tonnes. The in-vessel composting system consists of four (4) HotRot models 1811 (Figure 101). Each HotRot reactor has the following dimensions: Length = 12.8 m, Width = 2.17 m and Height = 2.33 m. The capacity of each reactor is 2.2-2.7 tonnes per day. The plant started its operation in June 2006.

Figure 101: HotRot Composting Plant at Western Isles

Country: New Zealand

Facility: Bromley Plant

The Bromley plant at New Zealand (Figure 102) employs the horizontal in-vessel system of HotRot for the treatment of sewage grit and screenings. The plant is under the operation of Christchurch City Council (CCC) and is operating since April 2003. It has installed the largest HotRot module (model 3518), which has a capacity of 10-12.5 tonnes per day. The annual capacity of Bromley plant is 4,350 tonnes. This in-vessel system has been constructed from more than 150 tonne of pre-cast concrete hull-sections and has undergone continual development since its installation (Figure 100).

Figure 102: HotRot System Installed at Bromley Plant

Country: **New Zealand**

Facility: **Army Bay, Aukland**

The Army Bay composting plant is located in Aukland (Figure 103) of New Zealand and is currently operated by the Rodney District Council. It is a small size plant that utilizes the horizontal in-vessel technology of HotRot. The system has a capacity of 550 tonnes per year and treats sewage grit and screenings generated from the nearby wastewater treatment plant. The Army Bay plant started in October 2003. The intention is to demonstrate the feasibility of the in-vessel sludge composting with the intention of implementing it in a larger scale. The in-vessel composting system of Army Bay is shown in Figure 101.

Figure 103: Auckland Composting Plant

Country: **New Zealand**
Facility: **Palmerston North**

The Palmestron North (Figure 104) composting plant is a small-sized plant of New Zealand and is operated by the Palmerston North City Council. It treats grit and screenings from nearby wastewater treatment plants and has an annual capacity of 550 tonnes. It is operating since February 2001. The technology employed is the horizontal in-vessel system HotRot. In particular, the model 1509 is utilized which has a daily capacity of 1.3-1.5 tonnes per day and the following dimensions: Length = 10.6 m, Width = 1.9 m, Height = 2.1 m.

Figure 104: Palmerston North Composting Site

Country:UK

Facility: Glasgow Wholesale Markets

The Glasgow Wholesale Markets (Figure 105) is located in Glasgow, Scotland and is under the operation of the Glasgow City Council. It also employs the HotRot in-vessel composting technology. This HotRot composting facility has been established to process organic waste (particularly damaged fruits and vegetables) and produce quality compost. A pre-sorting line was installed prior to waste shredding to allow inorganics to be handpicked from the waste to be composted. Then waste is shredded and enters one of the in-vessel modules. The plant consists of two HotRot 1811 modules, each one having Length = 12.8 m, Width = 2.17 m and Height = 2.33 m. The maximum daily capacity of the plant is 5.4 tonnes. The plant initiated its operation in March 2005.

Figure 105: Glasgow Composting Plant

<u>Note: Unless otherwise stated, the above information on the HotRot system is based on material provided by Dr Peter Robinson who is Marketing Manager of HotRot Ltd</u>

32. ROTOCOM Composting System

The Rotocom in-vessel system (Figure 106) is a horizontal in-vessel composting reactor with has proven to be very effective in composting various types of organic waste, including sewage sludge, yard waste, kitchen waste and grit a. The system design ensures all waste materials meet time and temperature requirements for pathogen and seed destruction. The Rotocom system is ideal for industry, large companies, local councils and small communities.

http://www.allertex.co.uk/rotocomintro.htm

Figure 106: Rotocom In-vessel Composting System

Waste is delivered to the processing facility where it is first sorted out then shredded and mixed with additives. It is then fed inside a rotary drum, horizontal flow reactor (Rotocom), which is essentially a slowly rotating cylinder with a counter-current airflow The in-vessel reactor has carefully designed internal features in order to manage the even flow of biomass through the system. Rotocom does not require fuel; it works by concentrating the natural decomposition processes, promoting the growth of microbes offering an accelerated composting process. The majority of organic material is decomposed to form stable compost. Vapours are processed through either a biofilter or scrubber to remove any offensive odours. The compost that exits the reactor is then conveyed to storage or maturation areas prior to end use. The Rotocom unit was built by ANDAR Holdings Ltd and has been operating almost continuously at a range of sites including slaughterhouse and woolscour factories. Below a successful composting installation which employs the HotRot system is described:

http://www.allertex.co.uk/rotocomintro.htm

Country: New Zealand
Facility: Christchurch

Several Councils in New Zealand are currently evaluating alternative options for the collection and processing of kitchen waste. ANDAR Holdings Ltd made available its containerized Rotocom plant to the Christchurch City Council for the purpose of determining optimum composting parameters such as input mixtures and residence times. The ANDAR Rotocom is used to compost green waste, kitchen organics and animal by-products. It consists of a horizontal in-vessel rotary composting system that continually mixes the organics as they move through the vessel at a residence time controlled by the operator (Figure 107). The plant consists of the composting bioreactor, in- and out-feed mechanisms and a control system. To provide data on the performance of the unit, temperature probes in the vessel continuously monitor temperatures, while a number of portable loggers added with the raw materials log the temperature every 15 minutes.

Putrescible waste is received daily from cafes, a supermarket, a fellmongery and Council offices. The putrescible waste is mixed with shredded green waste (particle size less than 150 mm) at a ratio of approximately 1:1 on a weight basis and is then fed to the reactor. Temperatures increase from ambient to 50ºC in as little as four hours after the mix is added to the Rotocom, and temperatures above 70ºC are logged consistently during the process. High temperatures can be sustained for 10 days. Contamination in the kitchen waste (about 5% by volume), which consisted mainly of plastic packaging, posed no problems to the operation of the Rotocom.

http://www.andar.co.nz/Products/Environmental/Rotocom/default.asp

Figure 107: The ANDAR Rotocom Unit at Christchurch

Immature compost is produced at a residence time of 10 days. No seagulls or flies are attracted to the compost, which contains a small amount of identifiable components such as corn cobs and bones. The compost is then cured in order to fully stabilize it.

In summary, the ANDAR Rotocom unit proved to be mechanically reliable, simple to operate, and was not prone to waste compaction or balling. A 1:1 mix of putrescible waste and shredded green waste was well composted after a 10-day in-vessel composting phase.

http://www.andar.co.nz/Products/Environmental/Rotocom/default.asp

33. Engineered Compost Systems

Engineered Compost Systems (ECS) designs and manufactures equipment and provides technical support for a wide range of composting operations. ECS systems have designed composting systems for composting organic feedstocks such as biosolids, food waste, manure, yard waste and MSW.

Composting system

The CV Composter (Containerized Vessel) (Figure 108) is a sophisticated, in-vessel composting system that can treat a wide range of organic feedstocks for volumes ranging from 1 to 50 tonnes per day. This system excels at meeting pathogen and vector attraction reduction regulations, controlling odours and providing reliable composting in a broad range of climates. The mobile and modular nature of the CV Composter minimizes infrastructure investments and easily provides for future expansion to accommodate growth.

http://www.compostsystems.com/

Figure 108: The stainless Steel Containerized Vessel employed for Composting

The CV Composter employs a sophisticated aeration system and insulated stainless steel vessels designed for a 20-year life time. A roll-off truck (usually available from local haulers) is used to move and unload the vessels (Figure 109). The system also includes heavy-duty feedstock mixers, vessel-loading conveyors and product refinement screening equipment, all integrated with the CV Composter.
http://www.compostsystems.com/

Figure 109: The roll-off truck is used to move and unload the vessels.

The system features include (http://www.compostsystems.com/):

- Automated aeration control and monitoring
- Reversing and recirculating process aeration
- Plug-resistant aeration floor
- Leachate and condensate collection
- Biofiltration of all exhaust air.

The CV composter has been installed in the following facilities:

Country: Canada

Facility: Okotoks Alberta Facility

The City of Okotoks decided that producing a Class A Compost would be the best way of managing their biosolids. Their challenges included:

- Very cold winter weather
- The ability to easily accommodate future growth and a possible change in location
- Neighbors who had already voiced odour complaints concerning an adjacent composting operation
- A very tight space for mixing and vessel loading.

ECS was awarded the contract to supply Okotoks with a turn-key CV Composter in- vessel system. Working with a local contractor, ECS installed a nine (9) in-vessel CV Composters (Figure 110) at the town's treatment plant to compost about 3,500 tons of dewatered biosolids (mixed with ground wood waste) per year. The aeration and control systems (Figure 111) are designed to allow for future expansion to 16 vessels. The system is integrated with the treatment facility's existing equipment for efficient operation and in order to minimize worker exposure to potentially pathogenic materials. The plant was installed in 2003.

http://www.compostsystems.com/

Figure 110: The nine Bioreactors at Okotoks

Figure 111: The Aeration System of the CV Composter at Okotoks

Country: USA

Facility: Big Sky Biosolids Composting Facility, Montana

In June 2005 Engineered Compost Systems (ECS) installed a five (5) in-vessel CV Composter (Figure 112) for the ski resort town of Big Sky Montana. The five in-vessel bioreactors have a capacity of 130 tons per year and the system includes provisions to add seven more vessels for a total of twelve as the needs for capacity increase.

Figure 112: The five Bioreactors at Big Sky, Montana

The bioreactors are made of stainless steel interiors, exteriors and specialized aeration floor. The vessels are built on roll-off skids compatible with locally available refuse container hauling trucks. The ECS CompTroller provides automated process control and monitoring within the vessels. It modulates the amount and direction of air flowing through each the vessel based on temperature measurements and user selected set-points.

The facility has an enclosed mixing building for controlling odours when blending biosolids and amendments at their odour-sensitive site (Figure 113). The aeration system uses the exhaust air generated inside the mixing building for the compost system's process air, eventually sending it for treatment through site-built biofilters.

http://www.compostsystems.com/

Figure 113: The enclosed Mixing Building at Big Sky, Montana

The CV Composter aeration system is installed partially below ground to accommodate the facility’s small footprint, abundant accumulation of snowfall and cold weather conditions. The vessels are equipped with a “cold weather package” that doubles the typical amount of vessel insulation found in most applications.

Country: USA

Facility: Town of Gypsum Biosolids Composting Facility

The Town of Gypsum has implemented the in-vessel composting system of CV Composter to process its biosolids (Figure 114). Initially three (3) reactors were installed, with a pre-planned expansion for five more. Pathogen reduction and primary stabilization occurs during a 16-day in-vessel retention time. The compost is then transferred to turned-windrows for curing and stabilization.

Figure 114: Three in-vessel Composters at the Town of Gypsum

The compost site is sensitive to odours. Residential housing is within several hundred feet of the composting site. The ECS in-vessel system does not allow fugitive air emissions. The aeration design "recycles" as much as 80% of the in-vessel process air. Process air that is exhausted from the system is sent to a site built biofilter for treatment. Compost Class A is produced

http://www.compostsystems.com/

Figure 115: The Reclaiming System for Bulking Amendment

The facility reclaims as much as 50% of their bulking amendment using an ECS supplied live-bottom loading hopper, trommel screen and radial stacking conveyors (Figure 115).

Country: USA

Facility: Ocean Shores, Washington

The problem

The City of Ocean Shores faced limited options for land application of biosolids due to an annual average rainfall of over 80 inches. Rainfall also limited composting options to covered facilities and nearby neighbours made controlling odours a priority. Additional concerns included:

- Limited number of operational staff
- Very corrosive area (site located near the beach)
- Rapidly growing population

The solution

The City of Ocean Shores chose a CV Composter with three composting vessels, configured for future expansion to eight vessels (Figure 116). The system produces Class A biosolids compost from 90 tons of dry sludge per year (i.e. 360 tonnes/year of wet sludge). Because of the facility's remote location and limited access to roll-off trucks, ECS supplied a mobile heavy-duty four-auger mixer along with the system.

Figure 116: Composting In-Vessel System with Three Reactors at Ocean Shores

The mobile mixer (Figure 117) collects biosolids directly from the dewatering press. The mixer automatically shuts off the belt press when the proper weight of biosolids is received. A tractor pulls the mixer to a composting vessel that is empty and already connected to the aeration vessels.

The mixer blends the biosolids and bulking agents together and they are loaded into the vessels using an ECS mobile vessel-loading conveyor. Using a mobile mixer in the facility reduces the number of roll-off truck trips necessary to load and unload the vessels. (http://www.compostsystems.com/).

Figure 117: The mobile mixer that collects biosolids

Country: USA
Facility: Omak, Washington

Omak's engineers concluded that the CV Composter would be more economical to install and operate than building large digesters. The ECS' system resolved operational issues concerning odours, material drying and freezing. Labour requirements are minimal due to the system's integrated equipment for one-step vessel loading, no-turning requirements, automated monitoring and compliance report generation. The plant started its operation in 2001 (Figure 118).

Figure 118: Bioreactor Composting Plant at Omak

ECS installed six reactors (i.e. CV Composters) at the Town's existing wastewater treatment plant to compost about 3,100 tonnes of dewatered biosolids (mixed with ground wood waste) per year. The aeration and control systems are designed to allow for future expansion to eight reactors. The system is integrated with the facility's existing equipment for efficient operation and for minimizing worker exposure to potentially pathogenic materials. The Omak WWTF is producing EPA Class A compost that is suitable for unrestricted use. The compost is in demand by local gardeners and orchardists who are working with the area's sandy and organic-poor soils (http://www.compostsystems.com/).

34. Conclusion

The above report reviewed 40 composting case studies from all over the world. Case studies from the EU Member States, from the USA and from other countries (e.g. New Zealand, Canada) were reviewed. From this review the following can be concluded:

- The composting technologies that are employed in most success stories are aerated static piles and tunnel composting. It seems that these technologies are the most efficient, producing a high quality end compost with minimal environmental impacts at a relatively low-medium cost.
- Very few cases of windrow composting are considered successful. In this review two such case studies is included. Although windrow composting was employed in the past, it seems that the environmental problems associated with this method (mainly the diffusion of odours), has limited its application.
- In tunnel composting the tunnels are enclosed in a building, thus making it easier to collect and treat the air exhausts. In the aerated static piles the covering of the piles minimizes odour problems. In both technologies the process is fully controlled in terms of the compost mix temperature, the aeration rate and the moisture level.
- Composting plants that employ a bioreactor are usually employed in small to medium scale composting plants to treat biodegradable organics at a local level. It seems that the cost of bioreactor technology makes them more efficient for small to medium scale operations

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