Composting of separately collected biowaste in Vienna - an example of BAT

The paper describes composting facility for separately collected biowaste of the city of Vienna.

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Abstract

In Vienna, the Municipal Department (MA) 48 (Waste Management) is responsible for collection, treatment and disposal of solid waste. Separate collection of biowaste was introduced in 1986. This is a precondition to product high-quality compost with low concentrations of contaminants. The paper described the composting plant Vienna Lobau that is designed for producing 40‘000 tons high-quality compost each year. The compost is used in municipality-owned farms and gardens, is given away for private use for free, and is sold to farmers in the neighbouring districts.

History of organic waste management in Vienna

Organic waste has accompanied humans from time immemorial. In the course of evolution, a natural eco-system developed which ensured environmentally compatible deposit, degradation and recycling of all ancillary and final products of biological-chemical activities. This eco-system guaranteed smooth preparation of general metabolic products, a process which initially encompassed humans as well. It was only humankind‘s cultural and economic development which made people aware of the production of undesirable substances.

Right into the 1960s, the household waste of a city included more than 60% of organic substances (today about 30%). At that time, many communities introduced composting as a technical method of waste disposal. Vienna similarly had a composting facility, which operated up to 1981. Over time, the (residual waste) compost produced by it, however, deteriorated in its quality until it became totally useless.

A new sorting plant completed in 1981 and run by the company Rinter AG was intended, i.a., to improve the quality of the organic waste fraction, but even complex technical measures employed by it could not adequately separate mixed waste.

The time was ripe to take another step forward: in 1986, a trial was launched for the separate collection of organic waste.

From its very start till today (2016), separate collection of such substances was considered as a part of organic waste recycling management. The idea of recycling was not new in itself. What was new was the realisation that each station of such a recycling process needs to be taken into account equally, from purchasing to separate collection, composting, applications in farming up to food production and marketing.

Public awareness of the effects of consumption

For the Municipality of Vienna, the chief task is to create public awareness for the effects of the generation of great amounts of waste on our society. To show that the throw-away society is damaging to the environment and thus has no future is done, by public awareness-raising campaigns.

Key messages:

The composting plant Vienna Lobau

- is operated by the City of Vienna‘s Municipal Department MA48 (Waste Management),
- is designed to treat more than 150‘000 tons separately collected biowaste per year, and
- produces 40‘000 tons high-quality compost per year.

Separate waste collection

A first bio container („Biotonne“) trial was started in 1986 based on the necessity of a separate organic waste collection to produce high-quality compost. Initially introduced on a test basis, the collection system was systematically developed. The experiences obtained in the process provided the main framework and targets of today‘s concept, which includes (a.o.):

- Only green-waste (from garden and household incl. kitchen) is being collected separately
- The quality of the material collected in the suburban areas is incomparably better than that obtained in central districts.
- The system best suited for the City of Vienna is a mixture of delivery and pick-up systems. The next “Biotonne” site should be located either within the property or in the immediate vicinity, if possible at a distance of not more than 50 metres.
- Containers are emptied at least once a week, even though tests are carried out to extend the intervals during the winter months. These tests have so far been generally successful.
- The separate collection of bio waste is free of charge; a system of fees based on „causation“ cannot be justified in a large city.
- The scheme must be accompanied by public relation activities, ensuring that the image of organic waste remains positive, e.g. by granting equal standing to separate organic waste collection and the compost heaps in private gardens.
- The guidelines for separate organic waste collection need to be precise and consistent; recommendations on substances to be collected must be restrictive. Meat, bones, cooked or liquid food, and remains of dairy products must be excluded from collection.
- In Vienna, private composting is not an equal and reliable alternative to the “Biotonne”, but is nevertheless to be promoted in private (common) gardens, provided that the initiative comes from the citizens.

Figure 1. Closed Loop of Bio waste Management in the City of Vienna.

Waste composition

In Vienna, organic waste is either collected in the “Biotonne” system or the waste depots or supplied by private companies. There is none collection of kitchen waste from private households in Vienna.

The composition of waste has changed in recent years. In terms of its constitution, waste from waste depots and private deliveries has more structural material; some 40-50 % of the “Biotonne” waste consists of partly structure-building components. The waste is always exclusively vegetable in origin. Other organic waste, such as meat waste, bones, liquid or cooked food scraps must not be put into a “Biotonne”. Microbiologically degradable sources of carbon and nitrogen are available at a balanced ratio. A C/N ratio of (20) 25 - 35 (40) / 1 can be assumed as a target ratio for the feedstock mixture.

Microorganisms are able to take up nutrients as well as oxygen in soluble form only. A sufficient degree of humidity, particularly during the initial and intensive/active rotting stage, is thus indispensable. The optimum degree of humidity decreases in the course of the decomposition process. Before processing, the materials have to be adequately mixed and blended. The water contents of the waste mixture for windrow formation do not exceed 65 – 70 %. The minimum water content is no less as 45%.

Current collection system, statistics on quantities

Vienna currently offers 80‘000 containers for the separate collection of organic waste („Biotonne“), located at more than 31‘000 sites. Some 3‘400 of the “Biotonne” containers are placed in the context of collection banks, the remaining are on separate sites of their own.

For each square kilometre of built-up area (126 km²) Vienna has 199 Biotonne sites. Each site (mathematically) covers 65 inhabitants or 30 households. The theoretical distance to the next Biotonne site thus is about 35 to 40 metres. Naturally, in the suburban districts, this distance is frequently less than 20 metres. About 29% of the tanks are located on private land.

In less densely populated areas bio beans are located inside of the property, in densely populated areas the beans can be found on collection banks. There are no “Biotonne” containers in the historical city center.

Figure 2. Open Composting Plant Vienna Lobau

Fees

In general, separate collection of garbage is not charged directly, but is covered by the garbage collection fee, together with all other waste collection and treatment costs (with the exception of packaging material).

Composting plant Vienna Lobau

In investigating a proper composting method, the City of Vienna started out from the premise that a process should be found which minimises handling of the rotting material even under conditions prevailing in a big city.

The following criteria were developed for a future facility:

- must allow prompt implementation;
- for future expansion the existing parts of the facility must be used again.
- no investment in facilities for which functionality cannot be guaranteed;
- optimum incorporation of existing facilities;
- no rapid rotting, but a method that takes into account future use of the compost (mainly farms); the high quality of compost depends on high content of humus, humus can be generated only during a slow rotting system
- easy to handle, low trouble-shooting requirements, which eliminates complex rotting systems;
- intelligent choice of location and rotting management, to reduce obnoxious smells.

System description

The composting plant Vienna Lobau is a completely outdoor (open) facility. The total capacity of the facility exceeds 150,000 metric tons per year.

The organic waste generated within the Municipality of Vienna is collected separately in compliance with strict guidelines with regard to composition, pollution and quality, and first given an initial treatment (crushing, screening, conditioning, mixing, etc.) at the compost preparation area of the composting plant Lobau.

During intensive rotting (pre-rotting and main rotting or unit rotting), the material is turned by a purpose-designed machine to ensure oxygen supply which is necessary to achieve a low-smell aerobic process. This stage, which takes about four weeks, is followed by post-rotting (rest phase). During this phase, the material is again turned by other purpose-designed machines (this to avoid a recontamination with pathogen bacteria). The

ripe compost is then screened and used for a range of applications. The rotting material is repeatedly checked for quality in the course of the composting process.

Quality control

The collection, treatment and composting methods for organic waste were chosen specifically to ensure quality control of the compost. Quality control itself is performed in three stages.

Stage 1: Examination of the collected waste
Samples are taken in regular intervals from the collected and treated biogenic material and examined particularly for heavy metals in an in-house lab.

Stage 2: Examination of the rotting material
All windrows at the Lobau compost yard are regularly monitored: in intervals of three to four weeks, they are tested for, loss of weight on ignition, nitrate, nitrite, total nitrogen, pH and heavy metals. Water content is being measured weekly, temperature daily. When high heavy metal content is found, the lab management first instructs to have the affected composting material treated separately. If the rate continues to rise, it may be necessary to eliminate the rick from the composting process and use it for, e.g. dump greening or filters. The disadvantage of this method is that substantial batches may be lost for composting. On the other hand it is known that heavy metals are dissolved only during composting when acted on by a number of acids, and are thus spread evenly through the batch so as to allow an analysis. In addition, the use of top-turn systems allows reducing the volume of composting windrows which thus become easier to manage.

Stage 3: Examination of the matured compost
For compost windrows where an in-house lab check finds sufficient maturation and acceptable expected heavy metal content, an external test is made at an outside lab in accordance with the regulations of the Austrian compost ordinance and Austrian Standard S 2203. Some 15 tests of this type are made annually.

Each compost batch in excess of 6,000 m³ (raw material) is given a unique designation. A special computer programme files all data on the rotting process, such as the date of stacking, number and date of turnings, results of accompanying tests, special events, etc., which can be retrieved at any time.

Bio waste preparation

The bio waste preparation plant is organised as a central handling point for all biogenic waste separately collected by the Municipal Department 48 and located within the composting plant Lobau.

All organic waste collection vehicles and other organic waste transports are directed to the preparation plant.

The preparation plant consists of the following sections:

- delivery,
- processing,
- homogenisation,

Delivery
The system distinguishes between „Biotonne“ (i.e. separately collected biogenic kitchen, garden and market waste) and „structural material“ (mostly waste from waste depots, private deliveries, screen overflow from fine compost treatment). The two groups are buffer-stored separately and treated differently. A buffer store holds at most a daily batch, i.e. about 360 tons.

The main difference between these two groups is that the “Biotonne” material is obtained by anonymous collection and must thus be carefully sorted, whereas structural material is checked upon acceptance at the waste depot, so that post-sorting is not necessary.

Accurate knowledge of the collection area (collection routes) also makes it possible to sort „clean“ and potentially „polluted“ “Biotonne” fractions already upon delivery and to feed them to different preparation steps.

All organic waste collecting vehicles and all other vehicles that deliver biogenic waste are routed across a weighbridge located at the Lobau compost yard and which exactly registers the input weight.

It has a capacity of about 150,000 tons per year at one-shift operation. The preparation facility is collected by video surveillance to a central control room and operated from there. The central control room also checks the proportion of structural material to „Biotonne“ material (C/N ratio) which is important for rotting.

Processing
As a first step, the “Biotonne” material is shredded by mobile choppers and screened. The fraction of less than 80 mm is routed to an iron separator; the next step is removing of other foreign materials such as plastics and other non-biogenic waste. It should be noted that the collected waste contains 1-5% in non-compostable substances, which can be concentrated in 20 percent of the mass by preliminary screening and then virtually eliminated by post-sorting. The material (>80 mm) is being incinerated.

Homogenisation
The two material flows are homogenised in a mixing station, which contents of two conveyor belts meeting each other before loading for transport to the composting area. During the mixing phase water can be added.

The homogenisation stage allows also adding a number of other additives such as rock dust or earth.

Immediately downstream of the mixing stage, provision can be made to fit an automatic sampling device for quality control checks of the raw composting material.

Loading for transport

The processed raw material is then loaded onto transporters (skips) of 50 m³ capacity. Currently, the department operates three vehicles of this type, but when required, other transporters can naturally be used as well. Loading is automated and takes 15 to 20 minutes per vehicle.

The raw material is taken to the composting area in a distance of several hundred meters only.

Composting area

Description

The compost yard is located at the edge of the Lobau wetlands to the south-east of Vienna. It consists of two consolidated rick ranges of about 26,000 m² each (together 52,000 m²), subterranean collection tanks for precipitation and seepage water of a total volume of 1,300 m³, and a sealed open water basin. The seepage water is discharged into the public sewage system. Rain water can be stored in the two collection tanks and, if necessary, in the similarly water-proofed open retention basin.

In an emergency the entire rick range is available as a retention basin. This ensures that all polluted water is collected and does not pollute the groundwater.

The yard also features an operations building and laboratory, a garage and workshop and a petrol station.

In addition it has a truck weighbridge, a weather station and a well to draw industrial water.

Also provided are access roads and parking lots. The yard is completely fenced in and is locked after working hours. Provision has been made for a direct railway siding.

The Lobau yard is staffed with nine employees: one manager, one electrician, one laboratory assistant, two engine operators and four truck drivers. Operations are handled by the highly qualified staff using a modem computer system.

Among the machines owned by the yard are:

- 3 wheel-loaders,
- 2 turners,
- 1 tractor,
- 1 irrigation vehicle
- workshop equipment,
- small machines,
- miscellaneous.

Operation

The Lobau yard can treat about 150,000 tons annually in input.

The course of volumes delivered over the year varies little from year to year, so that it is possible to define three phases:

- Phase 1: <6,000 m³/month January, February, December
- Phase 2 : 6,000-10,000 m³/month March, April, July-September, November
- Phase 3: > 10,000 m³/month May, June, October

At about 12,000 m³, the greatest volume is supplied in May, while the smallest quantities (4,000 m³ per Month) are recorded in January and December.

The windrows are placed in lines directly by the skips are turned over at least once a week in the first phase when degradation is most intense (four weeks). For this, a turner is used which is provided with a device for shifting windrows to allow optimum utilisation of the space. The rotting loss considerably reduces the volume of compost, so that the turner can combine several windrows in the course of rotting.

After primary rotting, the material undergoes secondary rotting for one to two months.

The material is irrigated as required.

Once the compost has achieved a suitable degree of ripeness, it is finally screened by mobile drum screens of a mesh size of 10 mm.

The following process parameters are being measured at the windrow core and documented for each windrow each working day during the first 4 weeks of the intensive/ active rotting stage:

- Temperature
- Oxygen (O_2) concentration
- Carbon dioxide (CO_2) concentration
- Methane (CH_4) concentration

Measurement points are set for each 300 m³. The triangular windrows have a height of 2.5 m, a windrow base width of 5 m and windrow length of 120 m, i.e. three measurement points per windrow are required.

At the open composting plant Lobau, monitoring of gaseous emissions is not possible. Measuring gas concentrations and temperatures at the windrow core serves the purpose of documenting a technically correct composting process in a traceable manner.

Neighbours

The compost yard is situated inside a dedicated industrial zone. It is enclosed by forests and fields of the Lobau in the north-west to north-east, and by the OMV and Shell plants on the other sides. The yard is not open to the public. The next publicly accessible facilities (e.g. inns along the New Danube) are at a distance of more than 1000 m. The next housing complexes are more than 2 km away.

Emissions to air

- Odour management: In order to prevent or reduce odour emissions from composting systems to air, the techniques given below are used:
  - Adequate aeration and moisture adjustment during the initial active composting phase. It is vital that aeration via natural convection is realised to ensure sufficient air is supplied to the composting material and ensure the process is maintained under aerobic conditions. During the most active composting stage at higher temperatures, moisture must be monitored and recorded. Water addition shall be recorded on batch records to ensure optimal conditions are maintained.
  - The operator has to mix input materials in order to achieve a consistent and balanced C:N ratio in the batch. Any moist or wet loads accepted are routinely blended with other woody or dry inputs or compost oversize material (compost screenings) upon discharge to reduce the possibility of anaerobic conditions developing and so increasing the potential odour release.
  - When possible, peak impacts can be avoided by timing operations at the site. Weather conditions and wind direction (towards sensitive receptors) have to be taken into account for formation or turning of windrows during when odour emissions are likely to occur. However this should be decided on a site by site basis, as lack of turning may sometimes exacerbate emissions if weather conditions persist. There is a wind sock to monitor wind direction. The weather monitoring data are being used to help determine site activities.
- Dust and Bioaerosols
  - Effective management of moisture, temperature and air supply of all material reduces a risk of generating dust and bioaerosols.
  - The adequate moisture content throughout the composting process is maintained to avoid the composting materials and finished compost drying out and potentially generating dusts when handled. Batch irrigation is being undertaken when the parameters for moisture content fall below the critical limits, but this needs balancing with optimising moisture conditions to enhance screening performance. For this reason moisture adjustments are to be decided on a site by site basis, following an appropriate assessment of the likely impact dust will have on the surrounding environment and moisture levels will have on the performance of screening.

Emissions to water

- All operation areas (waste storage, waste preparation, composting, compost storage) are impermeable.
- Polluted water and leachate are being passed into to the communal sewer system and further to the to the communal water treatment plant.
- Stromwater is originating from roofs or from areas of the site that are not being used in connection with storing and treating waste is being discharged directly to groundwater by seepage through the soil via a soakaway.

Utilisation/application

At the Vienna Lobau site 40‘000 t/a of compost with highest quality can be produced. With its soil/plant subsystem, nature points the way to an almost perfect recycling model. Any interference with the eco-system, such as imbalanced soil tillage, monoculture or removal of organic harvest waste, affects the turnover balance. Around Vienna, humus already disappears at a rate of 2-4 tons per hectare and year. Compost from organic waste is a major supplier of humus, soil improver and nutrient carrier. It thus acts as a fertiliser, even though its dynamic effect differs from that of mineral fertiliser.

Compost from the “Biotonne” in Vienna is used in a number of applications:

- City-owned farming operations,
- City gardens,
- Potting soil production
- Given away to the population (waste depots) and allotment gardens,
- Sale

The matured compost, which is rich in nutrients and humus, is spread on the fields of farmers in Vienna. To this end, the Municipal Departments MA48 (v) and MA49 (Forestry Office and Urban Agriculture) are working closely together to ensure organic waste management in the City of Vienna in the long run, and to persuade Viennese farming operations to change over to organic farming which, considered future-proof, should help to counteract the typical economic problems faced by agriculture.

The use of compost in organic as well as conventional farming is continuously monitored by the Bioforschung Austria (former: Ludwig Boltzmann Institute of Organic

Farming and Applied Ecology). The scientific monitoring programme encompasses the following subjects:

- fertilising effect of organic waste compost on a variety of crops, under a wide range of conditions for cultivation;
- effect of long-term compost application on the nitrogen household of the soil and groundwater;
- examination of the harvest quality (feeding tests, yield assessment).

In parallel, the institute carries out tests and investigations into issues cropping up from current practice, such as dioxin analysis, enhancement of the phytotoxic resistance effect of compost, testing of new composting methods, effects of trace elements on plants and soil.

Continuing this collaboration is seen as a major prerequisite to ensure that organic waste recycling functions smoothly. The project was in operation between 1988 and 2009. The current BIORES-project is a continuation of it. Results obtained so far are highly promising. Even though the changeover to organic farming usually entails a loss of revenues (compared to conventional farming), it can already be confirmed that compost from separate organic waste collection is suitable for use in farming.

The nutrients contained in the compost are organically bonded and thus not available immediately. This must be taken into account in determining the annual application rate. Whereas for the first years, a higher compost application rate (about 40 tons per hectare and year) is possible and even necessary to provide the soil with proper fertilisation, the rate must then be reduced to some 10 tons per hectare and year, to counteract the risk of increasing nitrate leaching into the groundwater.

In the long-term, the Municipal Department MA49 is nevertheless expected to consume 15‘000-20‘000 tons of compost from organic waste recycling per year.

Compost is also given away free of charge in small quantities to all interested private gardeners and allotment gardens, as well as sold. It is expected that future compost production will reach 50‘000 tons per year. Assuming that the free distribution to private individuals will be a maximum of 15‘000 tons pear year, new constomers will have to be found for 10‘000-15‘000 tons per year in the long term. Potential users of compost are companies working for the City of Vienna (reclamation, road construction, residential building) and private farmers in Vienna and Lower Austria.

Summary

The organic waste recycling system in Vienna is based on the principle of straightforward solutions that are safe and have established their value in practical applications.

Separate organic waste collection enables all people in Vienna to contribute to the system, without any disproportionate rise in costs from an excessive container coverage density. Great emphasis is given to ensuring that only clean substances of a suitable type are collected. The „Biotonne“ concept is to be closely linked to „compost“ -not everything that is biologically degradable can be composted under Vienna‘s organic waste recycling concept and should thus not be collected.

The choice and introduction of systems was guided by the principle of operational safety and cost-efficiency. As a result, expensive mechanical systems of the closed type were rejected and open composting was chosen.

Quality assurance has top priority in all sectors of organic waste management. For composting, the main emphasis is on a safe, long-term solution. The composting plant Vienna Lobau is an open composting facility operating according to all BAT-conclusions being in preparation by JRC in Seville.

Selling compost on the free market is naturally desirable, but does not secure the disposal autonomy which is required for a city like Vienna. The consequence was to opt for close co-operation with urban agriculture (Municipal Department MA49).

The system is based on the principle of a locally closed circle. This saves costs, is environmentally friendly and makes it possible for people of Vienna to make a personal contribution to turning their city into an environmental model town.

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