Biological Waste Treatment

Unit 7

Comparison of composting and digestion processes

Editor
Prof. Dr.-Ing. habil. W. Bidlingmaier
Bauhaus Universität Weimar

Authors
Prof. Dr.-Ing. habil. W. Bidlingmaier

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7 Comparison of decomposition and digestion processes

Besides the question “what does it cost?” questions must be answered regarding

- the adaptability,
- the technical state and thus realisation,
- the utilisation of the products,
- the area demand,
- the incorporation of the site in the scenery of landscape or town,
- the operational safety and
- the potential of emissions

in order to assess the techniques.

7.1 View

7.1.1 Plant sizes - collecting areas/sizes

Three standard plant sizes exist in practical operation, which cover the arising sizes of the collecting areas. These are plants with a throughput of

- 5,000-6,000 Mg/a (“small” plants),
- 10,000-12,000 Mg/a (“medium sized” plants) and
- 20,000-25,000 Mg/a (“large” plants).

These plant sizes correspond to the collecting areas with reference to the number of inhabitants (population equivalent) shown in *Table 7.1*, with which the usual collecting areas for separate collection of biowastes are covered.

Tab. 7.1: Sizes of collecting areas (population equivalent) for plants for biological waste treatment

Specific amount of biowaste [kg/(cap·a)]		70	90	110
Small plants	[1000 inhabitants]	71-86	56-67	45-55
Medium-sized plants	[1000 inhabitants]	143-171	111-133	91-109
Large plants	[1000 inhabitants]	285-357	222-278	182-227

7.1.2 Technical classification of the process

The technical plants for biological treatment of biowastes (aerobe and anaerobe processes), can be divided into four constructional components, of which the following three are essentially identical:

- Storage and mechanical treatment,
- confectioning of the solid residues and
- exhaust air treatment.

The two discussed techniques differ from each other only in the biological part. *Table 7.2* shows an overview, the individual differing characteristics are discussed in *Chapter 7.3 Differences in process technology*. An assistance for decisions offers *Figure 7.1*.

Tab. 7.2: Comparing overview aerobe/anaerobe techniques

Characteristic	Unit	Aerobe	Anaerobe
Suitability (see also *Table 7.3*)	[-]	Wastes rich in structure with water contents under 70 %, but also mixtures	Wastes weak in structure with high water content, not for ligneous material (lignin, cellulose)
Area demand			
Small plants	$[m^2/Mg]$	0.6 - 1.9	0.7 - 1.6
Medium-sized plants	$[m^2/Mg]$	0.4 - 1.2	0.4 - 0.9
Large plants	$[m^2/Mg]$	0.4 - 1.0	0.3 - 0.6
Waste water			
Quantity	[l/Mg]	100 - 400	300 - 570[1]
BSB_5	[g/l]	2 - 50	2 - 5
Solid residues (basic input)	[%]	Approx. 7	4 - 7
Odour[2]			
Small plants	[OU/s]	2,500 - 4,500	1,000 - 1,500
Medium-sized plants	[OU/s]	2,000 - 5,000	1,800 - 3,000
Large plants	[OU/s]	4,500 - 6,000	2,500 - 4,000
Energy demand			
Small plants	[MWh/Mg]	0.03 - 0.10	0.1 - 0.2[1] (all plant sizes)
Medium-sized plants	[MWh/Mg]	0.04 - 0.08	
Large plants	[MWh/Mg]	0.02 - 0.06	
Energy yield			
- Biogas 0.3 - 0.7	[MWh/Mg]	-	
- Heat	[-]	Heat recovery only possible from exhaust air	Power-heat coupling in blocktype thermal power station
Final product			
- Compost (basic input)	[%]	Approx. 30 % marketable, requirements according to sales area	Approx. 25 - 45 %, subsequent decomposition required, salt content more favourable, heavy metal contents partly slightly increased
- Biogas (basic input)	[%]	-	10 - 16
Costs[3]			
Small plants	[€/Mg]	85 - 140	180 - 285[4]
Medium-sized plants	[€/Mg]	120 - 240	150 - 205[4]
Large plants	[€/Mg]	90 - 175	125 - 190[4]

1) Without subsequent decomposition area

2) Total emissions including eventually purification measures

3) Price status 1993 (converted from Deutschmark)

4) Without profit inclusive subsequent decomposition

7.2 Suitability and realisation

Both systems are applicable for biological treatment and other organic wastes.

Considering the unproblematic realisation compost plants offer the advantages that

- experiences referring to pricing from numerous approval procedures and constructional measures are available,
- limitations of the process are well-known, as many plants are already working and
- the manufacturers having had sufficient optimising phases in order to guarantee an operation without problems.

Anaerobe systems, in waste treatment the younger conceptions, in the meantime are also operated in a large industrial scale and are a further treatment option. The decision on one of the two systems or a combination of both will depend on

- the waste materials to be processed,
- the specific location,
- the product consumers around the plant and
- the cost development.

The suitability of different wastes to be composted and/or digested is broadly described in *Chapter 2 Input material for aerobic and anaerobic waste treatment* and *Chapter 4 The anaerobic process (digestion)*. Protruding criteria are the water content and the structure stability, whereby wastes with a high portion of structure material and a water content of less than 70% are more suitable to be composted and wastes with little structure material and a high water content are more suitable to be digested. Excepted are wastes with lignin and cellulose portions which cannot be easily degraded anaerobically or not at all.

7.3 Differences in process technology

7.3.1 Preparation of the input materials

The preparation of the supplied wastes is nearly identical for composting and the anaerobic dry fermentation. The individual steps for the input materials are:

- coarse comminution,
- impurity selection,
- magnetic separation,
- screening and
- homogenisation

One single possible difference is a fine comminution applied before the digestion process which causes an improved material break-up and more favourable transport conditions at the following fermentation.

In addition to the mentioned steps the production of a digestion suspension is necessary for an anaerobic **wet fermentation.** This occurs e.g. in a pulper or in a mashing reactor with a portion of a recycled process water. Proper pulpers have the advantage that a manual selection can be omitted by the float/sink separation of light and heavy impurities. A following dewatering process of those separated impurities will become necessary (*Chapter 6.5 Fermenter for Fermentation Plants*).

7.3.2 Biological treatment

The fundamental difference of the two systems performed here, is based in this process step. While in order to sustain a proper composting process the presence of oxygen is compellingly necessary (aeration of the decomposition material), the anaerobic fermentation must be processed under cut-off of oxygen (see *Chapter 1.5.3.2 Anaerobic respiration*).

This involves the technologies respectively frame conditions differing from each other, listed in *Table 7.3*.

7.3.3 Product handling

Compost arises with both treatment processes which must be treated and stored. The aggregates used for confectioning like screens, hard material separator, air classifier are the same.

Another product of digestion is the so-called biogas which is a compound of fundamentally methane (CH_4, approx. 55-60 % v/v) and carbon dioxide (CO_2, approx. 40-45 % v/v) and some other trace gases (e.g. hydrogen sulphide (H_2S)). The biogas treatment and utilisation implies the following steps:

- Gas storage,
- gas purification and
- gas utilisation.

Furthermore, measures against explosions and for waste gas purification when used in a block-type thermal power station and an emergency blow-off (flare) must be provided.

Tab. 7.3: Differences in the process course between aerobic and anaerobic biological treatment of biowastes

	Composting	Digestion
Delivery	Scales Registration	See composting
Bunker	Flat bunker Deep bunker	See composting
Coarse preparation	Screening Comminution Impurity selection Magnetic separator Homogenisation	See composting Micro-comminution (e.g. pulper) Dewatering of the residues (only wet processes) At float/sink process, manual separation not necessary

Biological treatment	Decomposition area/container Aeration of the decomposition material Restacking of the decomposition material Watering of the decomposition material Presence of oxygen	Digestion reactor Stirring of the digestion material Gas collection Dewatering of the digestion residues Exclusion of oxygen Subsequent aerobic decomposition, see composting
Fine preparation	Screening Impurity selection	See composting
Storage	Buffer for 6 months' production (at direct sale correspondingly smaller)	See composting
Biogas	Inapplicable	Purification Storage Utilisation Emergency flare
Exhaust air	Biofilter Biowasher Large air amounts	See composting Smaller air amounts
Waste water	Re-circulation Purification Smaller quantities	See composting Larger quantities

7.4 Area and space demand

On the first sight digestion seems to be the better choice for the demand of area and space.

The area demand of pure digestion plants is about half of the demand for composting plants with a comparable size. As, however, for a safe sale of the end product (hygiene, acceptance) a subsequent decomposition of the digestion residue has to be carried out, this advantage is partly or totally used up depending on the plant conception.

The advantage of the digestion process concerning the area demand is reflected by a compact construction of the pure digestion part. This can lead to relatively high buildings, depending on the plant manufacturer, what has to be considered when the plant is integrated in the landscape.

Advantageous is a combined composting of digestion residues and green cuttings regarding the minimisation of the area and space demand (volume of the decomposition mix only slightly higher than with pure composting of green cuttings). On account of the abbreviated decomposition times (approx. 6 weeks) in separate plants for digestion residues the area and space demand of such combined plant types does not exceed - or just insignificantly - the one of pure decomposition plants with the same throughput.

7.5 Emission potential

Concerning odours (odour emissions) the anaerobic processes have significant advantages as the most odour intensive process step happens in an enclosed reactor without air supply, sites with bordering buildings can be used.

In cases where a subsequent decomposition is attached to the anaerobic technology, it can be assumed that with an enclosed construction and corresponding exhaust air collection in total 40-70 % of the odour freights will be emitted which are reached at composting plants with comparable throughputs when fresh green cuttings are processed. A subsequent decomposition of the digestion residue alone might cause an odour freight of just 30-50 % for the value quoted for the composting plant according to the available scarce measuring data. With “medium-sized” and “large” plants and in enclosed composting plants the released air amount at the filter is relevant.

Whereas pure composting plants should always have a save distance to the next residential buildings (at least 500 m), unless the emission situation will be improved by costly measures (in-vessel filter, exhaust air chimney) and an all round enclosed technology and thus can be accepted.

Dust will not be expected from plants with encapsulated construction and a proper management. At windrow operation or not enclosed compost storage dust emissions will arise during a part of the operation time (e.g. loading of compost) which on account of the low portion of airborne dust particulates will not fly very far. In most of the cases a dense planting at the border of the site will be sufficient to avoid noteworthy dust emissions in the neighbourhood.

Waste water arises at both plant systems. The quantity in biogas plants is higher (up to factor 5), on account of the lower charges in the total freight (BSB_5), it is likely to be assessed, however, more favourable depending on the plant specification. If a decomposition step follows digestion portions of waste water can be taken to water the compost materials. The condensates coming from the exhaust air treatment of decomposition plants are situated at the lower end of the range stated in *Table 7.2* considering their load, leachates from the first decomposition weeks and from the bunker area are situated in the upper third.

Fresh water is usually not used when biowastes are digested (exception: Two-step BTA process, see *Chapter 10.1.3 Data sheet two-step BTA process*), in composting, however, the water discharge, caused by aeration, must be compensated. With a satisfying water management (re-circulation of leachates and condensates) it can be kept at minimum.

Noise emissions do only arise by delivery and at open plants by the operation of equipment in open air or in open halls.

Waste gases arise only in digestion plants with integrated gas utilisation (e.g. blocktype thermal power station). The legal emission regulations can be adhered to without problems with a preceding gas purification. Some manufacturers use waste gas converters.

The emission potential of both systems is close together. Anaerobic plants in densely populated areas have light advantages, insofar as odour emissions are eliminated successfully.

7.6 Energy

Composting is an exothermal process, where heat only arises at a low temperature level. Utilisation is widely impossible as only heat recovery from warm exhaust air streams via heat exchangers is possible to maintain temperature of additional air streams in the winter season or for the heating of water.

Anaerobic processes produce chemically bound **energy** in form of biogas, that is combusted and used for electricity and heat. Approximately 70-80 % of the produced energy can be utilised if a power-heat-coupling is used. An energy surplus is generated with most of the digestion processes, which after deduction of own needs (including subsequent decomposition and fuel) sums up to approx. 30-45 % of the totally produced energy.

7.7 End products

According to the guidelines of the **Federal Compost Quality Assurance Organisation of Germany (BGK e.V.)** the solid end products of both processes (compost) can be used when the waste has been collected in clean shape (content of impurities and harmful matter).

Both processes achieve the hygienic harmlessness, the anaerobic technology after the aerobic subsequent treatment. Thermophile digestion systems can produce a hygienised digestion residue, whereas mesophile systems need an additional treatment in any case.

The chances to sell the produced composts are satisfactorily given only, if a product with a high quality standard is produced, that, after proper treatment, is acceptable for all market areas and fulfils the quality criteria of the Federal Compost Quality Assurance Organisation of Germany (BGK e.V.).

The momentarily most effective sales markets are **horticulture** and **landscaping**, another focus is **hobby gardening** and the production of substrates. The compost quantities to be expected need a massive involvement of agriculture as there is the potential for big areas.

Unlike to composts from purely aerobic processes, such from digestion plants with subsequent decomposition part have lower salt contents. This can be explained by the wash-out of the salts at dewatering of the digestion residues. On the other hand heavy metal contents are increased in the follow of the upgrading during the process. Float/sink processes have a positive influence on the impurity contents in the compost product (above all glass and plastics) at the treatment of biowastes for wet fermentation techniques.

The differences between the one-step and two-step digestion techniques considering the **biogas** yield, are insignificant; according to the plant size it is 10 - 16 % of the input. About 20 % of the generated gas are used for the own energy demand. If the gas shall be fed into the gas distribution system purification is indispensable. The most favourable type of utilisation is the block-type thermal power station with power-heat-coupling.

7.8 Costs

The costs for composting and digestion processes collected in *Table 7.2* are treatment costs per Mg input without costs for real estate and development costs and costs for the equipment of the constructional site. Too large a dependency from the individual demands for the location and conditions exists to compare these costs among each other.

The necessary investments for these technologies are dependent on the plant throughput, considering composting also distinctly on the required measures for protection from emissions, above all in the range of odours. The improved rates of utilisation of the machinery at higher amounts of throughput, positively influences the costs for biological waste treatment.

A striking cost advantage for the aerobic process in “smaller” plants can be seen, contrary to digestion where higher costs for the equipment are the multiplying factor. Pure digestion processes for “medium-sized” and “large” plants are more favourable, however, if subsequent decomposition is added, the same or possibly higher prices have to be calculated for both plant sizes. The latter applies above all for “large” plants.

It must be pointed out that this cost comparison can only be preliminary and a matter of the momentary situation on account of the higher knowledge in composting technologies and on account of the high number of digestion processes which did not yet stand the test in composting plants. The very close market for digestion plants and the still increasing technical development will strongly influence the prices during the next years, higher prices may be the result.

The costs, shown so far, do not include the expenditures for a professional marketing of composts, as in the past these costs were looked upon as being secondary compared with the existing problems at the instalment of a compost plant.

A likewise fixedly size within a calculation for the construction of a site for biological waste treatment are the expenditures for planning. This expenditure must be calculated with about 10 - 20 % of the total investment, including the necessary expert opinion.

7.9 Requirements for planning

The most different possibilities for the use of aerobic and anaerobic processes and the special features for the individual location makes it necessary to consider the following measures.

A solution that keeps in mind the conditions at the location must be worked out. These are:

- Data about the collection area with the expected waste streams (consistence, quantity, suitability for the individual processes, etc.),
- data about the location (distance to buildings, residential areas, infrastructure, etc.) and
- examinations about possible sales markets for compost, gas and heat or their use for own purposes, respectively.

The treatment process must be chosen by means of an independent preliminary planning. Hereby must be checked:

- The practicability of the processes in question (e.g. operational experiences, manufacturers' liabilities, etc.),
- quantity and energy balances,
- requirements for area and room,
- possibilities for the combination of processes (e.g. 1^{st} step digestion 2^{nd} step composting),
- suitability of universal processes (e.g. partly enclosed/fully enclosed composting, etc.),
- situation of emissions and immissions,
- integration into the surrounding area (e.g. natural scenery) and
- costs.

In cases were these frame conditions are kept it will certainly be possible to find a suitable solution according to the state of the art for the application procedure and the realisation. Both composting and digestion have their optimal utilisation areas, the possible combination without problems makes biological waste treatment more flexible and safer.

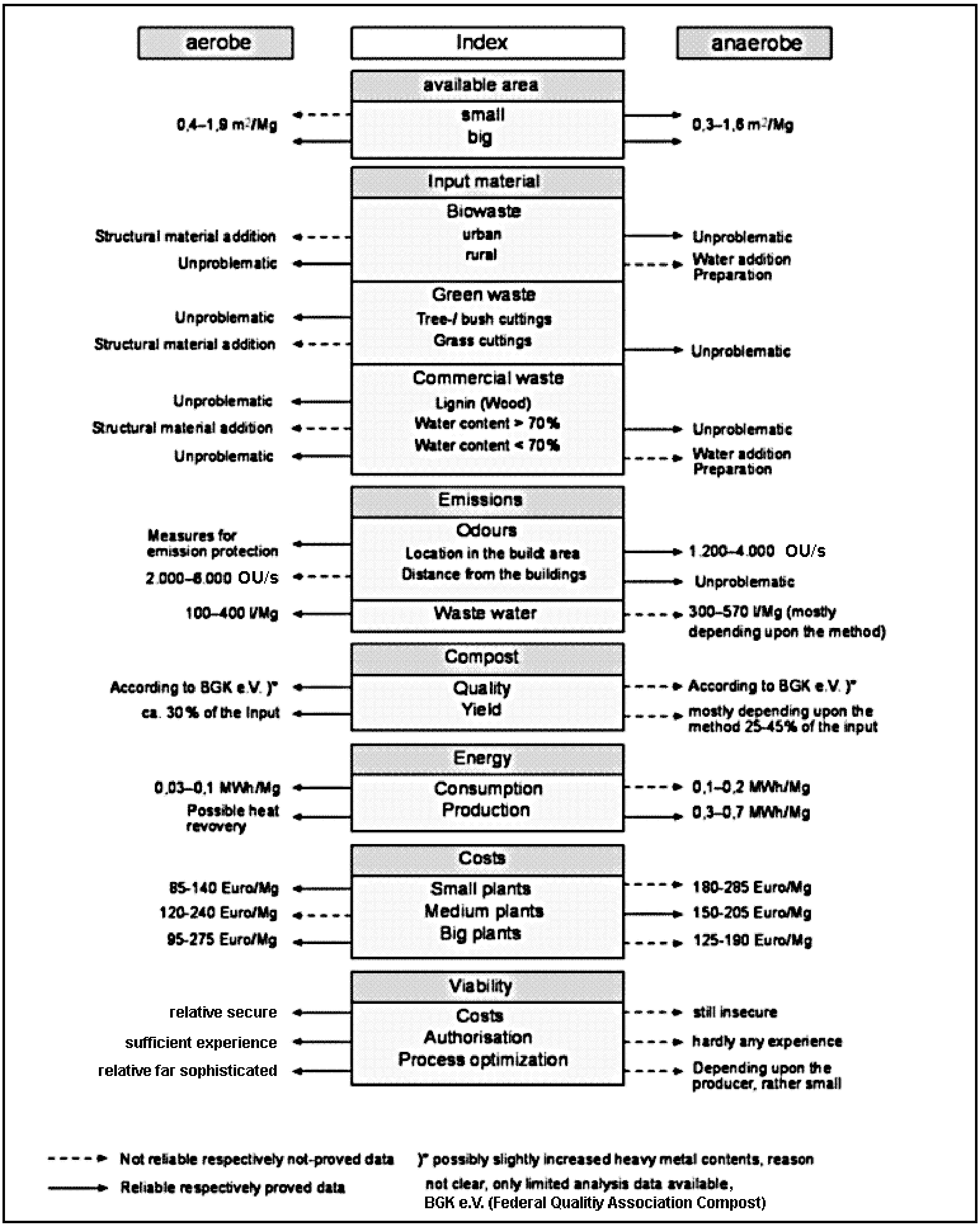

Fig. 7.1: Comparison of aerobic and anaerobic waste treatment processes

7.10 Literature

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