COMPOSTING AND DIGESTION – A COMPARISON BETWEEN EUROPE AND ASIA

I. KÖRNER[*], and C. VISVANATHAN [**]

** Institute of Waste Resource Management, Hamburg University of Technology, Harburger Schloßstr. 36, 21079 Hamburg, Germany.*
*** Environmental Engineering and Management Programme, Asian Institute of Technology, P.O. Box 4, Klong Luang, Pathumthani 12120, Thailand.*

SUMMARY: The situation regarding biological treatment is significantly different between Europe and Asia regarding goals, substrates and technologies. Factors which have an impact on the establishment of a biological treatment technology were compiled and compared for European and Asian situations. Beside driving forces and the availability of suitable substrates, further impacts on the selection of a treatment system become discussed. They include treatment capacity, location and climate. Furthermore following case studies become presented: Decentralized composting in boxes in Cloppenburg-Stapelfeld, Germany; Decentralized composting in Dhaka, Bangladesh; Commercial large scale composting in India; Case study of vermicomposting in Thailand; Co-digestion facility, Gröden, Germany; Rayong waste to energy and fertilizer project, Rayong, Thailand.

1. INTRODUCTION

Biological treatment of organic waste comprises two types: aerobic composting and anaerobic digestion, depending on the type of microorganism that converts the organic mass. Worldwide, composting is more frequently applied than digestion. Both processes replicate the natural degradation of biodegradable materials. The situation regarding biological treatment is significantly different between Europe and Asia in terms of substrates and technologies. The terms used for describing the biological treatment options are not always consistent between European and Asian professionals either. The terms used in this paper and possible sysnonyms are explained in the following to avoid confusion:

- Composting refers to biological degradation processes which take place with the consumption of oxygen. It is considered as a predominantly aerobic process, but does not exclude certain anaerobic processes which should not dominate. Commonly-used synonyms for composting include aerobic degradation or rotting. The term fermentation or aerobic digestion should be avoided to prevent misunderstanding.
- In contrast, digestion refers to biological processes which occur under an oxygen-free atmosphere, and is therefore anaerobic. If oxygen penetrates the system, the digestion process can be disrupted or failed. Synonyms for digestion include anaerobic fermentation, anaerobic

Proceedings Sardinia 2007, Eleventh International Waste Management and Landfill Symposium
S. Margherita di Pula, Cagliari, Italy; 1 - 5 October 2007

digestion, anaerobic degradation or biogas generation. Synonyms such as anaerobic composting or fermentation should be avoided.

Composting and anaerobic digestion serve to stabilise, hygienise and reduce the mass of organic waste. Furthermore, organic compounds and nutrients can be recycled to land. Anaerobic digestion also aims to produce energy in the form of biogas. Composting and digestion are not opponents; depending on the situation and the kind of waste material, one or the other may have priority. Aerobic and anaerobic steps may also be combined in one treatment facility (Körner and Visvanathan, 2006).

2. OBJECTIVES AND METHODOLOGY

To enable a successful technology transfer, it is important to note that this cannot be carried out on a 1:1 basis. To avoid economic and technical failures, the differences in the situations between the concerned parties must be determined. As a result, factors which have an impact on the establishment of a biological treatment technology were compiled and compared for European and Asian situations. To aid understanding, some case studies are presented as well. In the following, the state-of-the-art of the main impact factors and technologies is shortly summarized:

- **Driving Forces**: In Europe, the main driving forces to enhance biological treatment are given by policy with the intention to improve environmental quality. Furthermore, the installation of biological treatment systems has also an economical background. Though, policy intervention in terms of biological treatment system in Asia has not been established, an increased environmental awareness and economic influence had stimulated the stakeholders or NGOs to create a number of small and medium scale biological treatment facilities.
- **Substrates:** For composting, biodegradable materials with different origins may be used. Sources from communities include wastes from kitchens, yards, gardens, parks, trade and light industry, and biological sludge from wastewater treatment plants. Sludges are less suitable for composting due to their high water content and poor structure, but could be used if mixed with structure-rich substances. In some countries, compost is produced from mixed municipal solid waste (MSW). However, when using MSW compost, one should be aware of an eventuall pollution potential. Furthermore, a broad field of substrate for digestion applications includes industrial waste (food and paper industry), urban waste (sewage sludge and organic fraction of MSW) and agriculture waste (manures) and energy crops.
- **Composting Systems:** The applied composting system may vary strongly with respect to pre- and post-treatment techniques, rotting systems, regulation measures as well as emissions treatment. Pre-treatment includes measures such as sieving and sorting to remove impurities. Mixing can be applied to unify different waste streams or to add structural material. Post-treatment measures focus on the removal of impurities, non degraded, structure-rich organics and the size fractionation of the compost. Rotting systems may be divided into open or enclosed systems, and differ with respect to their size. Rotting systems can be further distinguished into windrow, container, tunnel, hall, box, tower and drum composting systems, depending on the shape of the reactor or the pile-up of waste. During the rotting process, emissions such as highly polluted percolate water, condensed water and odorous exhaust gas may be generated. In some facilities, these emissions are not treated. In principal, process water should be treated in waste water treatment plants while odorous exhaust gas by biofilters. Partly these emissions becomes also recycled within the rotting process. During rotting, environmental conditions are regulated to obtain adequate biodegradation over the whole process period. The most commonly applied measures include turning, aeration and moistening.

- **Digestion Systems:** There are various known technologies for anaerobic digestion. Anaerobic digestion is a complex process involving several bacterial groups living in syntrophic association to carry out hydrolysis, acidification and methanization phase. Pretreatment step is crucial to allow a stable digestion performance which primarily involves removal of impurities and particle size reduction. Mono-digestion technologies treat only one specific substrate. Co-digestion technologies using substrate-mixes and have established several benefits by increasing gas production and improving process stability. Furthermore, anaerobic digestion systems can be classified into wet and dry fermentation depending on the water content, which is adjusted in the fermenter. They can be further classified according to the number of process stages (one-/two-/multi-stage) and the process temperature (mesophilic: 35-37 °C, thermophilic: 50-55 °C). It is important to mention that in most cases an aerobic system as post treatment is needed, in order to enhance the quality of solid digestates.

The comparison between the European and Asian situation includes not only economical and technical factors, but also general aspects. Beside driving forces and the availability of suitable substrtates, further impacts on the selection of a treatment system become discussed. They include treatment capacity, location and climate.

3. COMPARISON OF SOME MAJOR FACTORS

3.1. Driving Forces

In Europe, increased political awareness on environmental issues has led to the formulation of laws and regulations which influenced the creation of biological waste treatment facilities drastically. For instance, some EU-laws restrict disposal practices (1999/31/EG; 2003/33/EG). These encourage indirectly the establishment of biological treatment systems. Aside from EU-laws, different national regulations exist such as those demanding the compliance of the waste hierarchy (1^{st} priority: avoidance, 2^{nd}: recycling, 3^{rd}: disposal). Further national regulations give strategies and limiting values for a successful, secure and environmental-friendly operation of biowaste treatment facilities (e.g. Germany: BioAbfVO, 1998). Since the European nations have partly different specific strategies, this has led to an inhomogeneous but rising trend in the application of biological waste treatment across Europe.

Often biological treatment systems become prefered over the modern incinerator technologies or sanitary landfills due to economic factor. The economics is strongly dependent on the region and the available alternatives. The biological treatment costs in Europe can range from approximately 30-130 €/Mg waste.

Since composts and digestates can only be sold for low prices of about 0-40 €/Mg compost, the biological waste treatment is commonly financed over the “polluter pays” principle including the waste fees charged to the local community and the sale of collection bags and charges through taxes. Measures to enhance positive behaviour (e.g. to intensify source segregation; to apply home composting) include fee reductions or tax returns (Allen, 2002). For digestion, additionally governmental subsidies are an important instrument to enhance the establishment of facilities (see 3.4.2.).

In many Asian countries, waste related issues such as limited disposal areas and escalating waste generation triggered by urbanization and economic growth has led the countries to suffer detrimental environmental pollution. Because of this, action against environmental degradation is augmenting which lead to increase in political awareness. Also, the importance of biological waste treatment options has been recognized in Asia. Currently, measures to introduce biological treatment options are often carried out on a project basis, established by private companies, and supported by personal activities of decision-makers or NGOs.

Only in certain situations has the compost price been reported to be higher than the production costs. Under these circumstances, economic reasons can lead to the introduction of biological treatment. However, this is only possible in exceptional cases. With the increasing supply of composts and digestates, this will probably not be possible in the future (Körner and Visvanathan, 2006).

3.2. Availability of Suitable Substrates

The main origins of organic waste, both in Europe and Asia, are from households, commerce, landscaping and agriculture. Waste composition and generated quantity is dependent on local conditions and is influenced by product consumption or lifestyle, climatic condition and degree of industrialisation. These factors varies enourmously between Europe and Asia. Organic waste which is suitable for biological treatment may also contain impurities or contaminants that would impaire the compost or digestate quality. In some European countries, the types of waste suitable for biological treatment are exactly defined by law (e.g. Germany: BioAbfVO, 1998), whereas no such activities are currently known in Asia.

Waste composition: In Asia, around 40-80% of MSW is comprised of organic waste (Visvanathan et al., 2004), while in Europe an average of 30-40% of MSW consists of food and garden waste (EEA, 1999). This clearly shows that Asian countries generate higher organic content of MSW than European countries. However, it is expected in the future that the waste composition will be likely similar due to the strong Asian economic development.

MSW-organics can be separated for biological treatment in two ways: separation from other waste in households at the source, or collection of mixed waste for later separation before or after composting. Most European countries use source separation. Since in Asia biological treatment is mainly implemented on a project basis, all forms of organic/non-organic separation can be found, but mixed collection with a later separation is the most common. Source separation is tested in some Asian projects; a special method is the wet-dry separation at the source, where the wet fraction is mainly represented by organics.

Waste quantities: Compared to the actual streams, only a minimal part of the putrescible fraction is biologically treated in Asia. In Europe, it is estimated that 17 million Mg/annum of putrescibles are collected after source-separation which makes up 35% of the actual organic waste production in municipalities (Barth, 2005). Certain organic fractions from households are additionally treated via home composting. In Europe, this is partly through tradition and partly through support by communities and governments to avoid transport and treatment costs. In Asia, home composting is practied more on an informal manner. Here, household organics are often used as animal feed.

In the near future, it can be expected that the use of putrescibles for biological treatment will increase drastically in Asia. However, using mixed MSW as a substrate should be avoided, since the composts and digestates will be of low quality for agricultural application. The risk is high that product marketing fails and facilities have to be closed again or re-designed. Since only a few projects for the organic separation or wet-dry separation in households exist, a small fraction of MSW organics will be available for biological treatment in the near future. It will take some time to build area-wide collection systems on the basis of source-separation. In Germany for example, the first projects were realized in the 80s. In the early 90s, approximately 5 % of the inhabitants were connected. The degree of connection increased to 60-75 % in 2000. In certain Asian regions it may not be possible to install such systems for source separation of organics in the households at all due to limitations regarding the consumption of pork meat by the Islamic population. This applies especially to regions where Islamic and non-Islamic people live close to each other (e.g. in Malaysia). The compost or digestate produced from pork-containing organics could never be used on agricultural soils, if the product is to be sold to the Islamic population.

Apart from the increasing number of projects for the separation of organics from MSW, a focus should be made on the types of waste which are generated without impurities. For instance, market or restaurant waste could be used to introduce biological treatment systems step by step. An advantage for Asia is that such waste fractions could be available in certain regions in large amounts due to the very high population density. Therefore enough substrates for starting biological treatment operations could be available without the introduction of systems with source-separation (Körner and Visvanathan, 2006).

3.3. Further impacts on treatment systems

The operation of biological treatment facilities is state-of-the-art in many, but not all European countries. In Asia, biological treatment is at the beginning of the road, but has huge potential. Numerous planning tasks will be realized in the near future. To avoid failures and to speed up the process, experiences from Europe can be used. It must be kept in mind that the frame of conditions in Asia differs from those in Europe so that a 1:1 technology-transfer can often leads to failures.

Regarding the *treatment capacities* of facilities, the demographic structure must be considered. The average population density and the migration of the population from rural areas to the cities are much higher in Asia than in Europe. The only city in Europe with over 10 million inhabitants is Paris. Tokyo is the largest Asian city with 27 million inhabitants. Many Asian cities have a population size over 10 million (e.g. Shanghai, Kolkata, Seoul, Peking, Delhi, Osaka, Karatchi), and are still growing fast. The high concentration of people in Asian megacities leads to alternative planning approaches. Since much more waste is generated at one place, the throughput capacities of the facilities would be much bigger on average.

One of the biggest European biowaste treatment plants is located near Padua in Italy (SESA). The facility works with an combined anaerobic and aerobic process. Further two big European composting plants are in the Netherlands and process together approximately 470,000 Mg of organics per year. They use source separated bio and green waste as a substrate. Also high treatment capacities has a composting facility in Belgiumm which treats 60,000 Mg/annum. But commonly European treatment capacities ranging more from 5,000-20,000 Mg/annum. Very small plants also exist such as those in Austria, where facilities with capacities of less than 500 Mg/annum are common (Barth, 2005). In contrast, some of the existing Asian composting facilities have a capacity of 10,000-180,000 Mg/annum, such as those in India (Box 3-2).

The *location* of a biological treatment facility is important as well. In decentralized systems, the waste has to be transported only a short distance, whereas in centralized systems, the waste produced in a large area is commonly collected and treated at the outskirt of the city. The selection depends on the available space, the centralization of the population and the available infrastructure. In Europe, both centralized and decentralized systems exist. In Asian megacites, decentralized treatment facilities may have priority, since huge amount of waste accumulate, and efforts to transport it through crowded streets may become difficult. Space availability inside a city must also be considered. Composting facilities need to be further away from populated areas due to odour emissions compared to digestion plants. In this respect, enclosed facilities have an advantage compared to open facilities. The latter should be avoided within the city, with the exception of home composting or very small facilities for green waste composting. Anaerobic systems are operated airtight, and therefore more suitable for such locations.

Another consideration is the availability of a market for the products in the nearby surroundings. In cities, garden and park areas could be used for application of composts and digestates, whereas larger quantities will have to be transported to agricultural areas outside the cities. In Asian cities of comparable size to European cities, the partly underdeveloped infrastructure should be considered, which also favours decentralized systems. However, open and enclosed composting systems could have priority due to easier technical and economical realization. Decentralized plants in Asia may reach the same size as centralized plants in Europe.

Climate has to be especially considered when an open composting facility is planned. Rainfall and prevalent temperatures may affect the biological processes significantly. In cases of frequent heavy rain, covering or roofing composting piles is suggested, and in cases of strong heat, frequent irrigation may be necessary. Furthermore, climatic conditions can be important for operation of digestion systems. Most digestion processes run with mesophilic temperatures. The sourrounding temperatures in tropical countries are suitable to operate the digestion without an additional heating system.

3.4. Case Studies

3.4.1 Composting

Currently in Europe, a great number of composting facilities exist and a variety of different composting systems is applied. They mainly differ from each other to the effect that in some of them high-rate degradation takes place outside (open systems), in an enclosed building (enclosed-reactor systems) while in others it takes place in an in-vessel reactor. But even when the same system is used, the results - regarding emissions, duration of the process and compost quality for instance - can differ a lot since feedstock and regulation methods are variable. In Europe, the open windrow systems are still the most popular (Barth, 2005). However, newly-built facilities are often enclosed. Tunnel systems are quite common, but others such as containers, boxes and hall composting are applied as well. Overall, there is a tendency to establish larger plants. One process example for a box system is presented in Box 3.0. Further cases studies are described for example from the German Compost quality ensurance organisation (BGK, 2007). In principal, European composting facilities run successfully. But although long term experience is available, an optimisation potential still exists. Technical problems often occur in European countries where biological treatment is still in the start-up phase.

Box 3. 0: Decentralized composting in boxes in Cloppenburg-Stapelfeld, Germany

The biowaste composting facility in Cloppenburg-Stapelfeld, Germany, processes source-separated biowaste from households, yard waste from residential, institutional and commercial sources and potato processing waste. It is in operation since July 1994, has a current capacity of 17000 Mg/a (13400 Mg/a biowaste, 3400 Mg/a yard waste, 200 Mg/a potato processing waste) and employes 3.5-4 people. Composting is carried out in 12 boxes, each with a volume of 50 m^3. Further equipment includes 2 front-end loaders, 1 trommel screen, 1 self-built air classifier, 1 hammermill, 1 overhead magnet, 1 handsorting room, 2 biofilter boxes (50 m^3 each), various belt conveyors. Temperatures in the off-gases are initially controlled at 45°C for optimum degradation and then at 60°C for 3 days for pathogen control. A composting box is divided into six different aeration segments and has 1 blower for fresh air and 1 blower for the off-gas and air recirculation. Leachate is recirculated to keep the moisture content of the biowaste at 50% by weight and to avoid discharging highly contaminated water into the sewer at high costs. The retention time in composting boxes are 6-7 days plus 2 weeks in windrows (end-product is fresh compost) or 10-12 weeks in windrows (end product is a mature compost) (Krogmann, Körner, Diaz; 2007).

Box 3. 1: Decentralized composting in Dhaka, Bangladesh

This case study highlights the experiences of *Waste Concern*. This research-based NGO implemented a community-based decentralized composting project in Dhaka, Bangladesh. The NGO began its composting activities in 1995 with the aim of developing a low-cost technique for composting of MSW suitable for the city's waste stream, to develop public-private partnership in the MSW management and to create job opportunities for the urban poor. The composting facility uses a labour-intensive *Indonesian Windrow Technique* and is operated at its full capacity of 3 Mg/day of waste serving 1,430 households. The composting process was carried out over a period of 53 days. The compost piles are turned manually and as the compost becomes mature (dark-brown in colour) it is then manually screened and packed. The marketing of compost is facilitated by NGO through direct marketing to end users and through a bulk supplier or retailer which is carried out through MAP Agro Industries, a fertilizer company in Dhaka. The project's financial analysis revealed a revenue from compost sales covered 91% of the operation costs and 76% of the total annual costs of the plant with an annual profit of US $3,745. The analysis did not include the land acquisition cost as it was freely given to *Waste Concern* by the government. This case of *Waste Concern* in Dhaka is one example of a viable decentralized composting plant, which saves the municipality an estimated amount of US $18,518/year for transportation and landfill services. Based on its success in Dhaka, *Waste Concern* designed another composting plant at Khulna city and also initiated a composting project at Chittagong city.

In Asia, only a few composting facilities are in operation. Windrow technologies seem to be the mostly applied option. More frequently, the small and medium-sized facilities run more successfully compared to the larger facilities, which have a record of operational failures. Despite of several constraints and failures there are cases of successful composting operations. Although there is a need for larger dimensions, the small and medium scale facilities have been the more successful so far. Large-scale technologies have not yet had as much success in terms of technical realization and operation. Enclosed systems can are also be prone to technical failures due to higher automisation. Nevertheless, in the growing economies of Asia, often highly technical systems are prioritised, and complex composting facilities constructed. The more technology is involved, the more sources for failures exist which could lead to the failure of a whole process. Up-scaling of facilities also has its problems, especially regarding odours and dust control (Körner and Visvanathan, 2006). The case studies presented (box 3.1-3.3) highlight the present trend towards sustainability in resource recovery from organic waste in Asia. The waste is utilized instead of being dumped into landfills which definitely reduced the volume of MSW for disposal.

Box 3. 2: Commercial large scale composting in India

The company M/s Excel Industries Ltd produce compost which is sold as a "bio-organics soil enricher". Their centralized composting plants with capacities of 35-500 Mg/day were set-up at Kolkata, Bangalore, and a few other places in India. Most of these plants run on a "build-own-operate" basis or as joint ventures with local or state agencies have been successful in marketing their compost and able to sustain their production. M/s Excel Industries has a nationwide distribution and sales network for its agro-chemicals, which confers a distinct advantage in marketing *Celrich* compost. According to M/s Excel Industries, farmers buy about 95% of *Celrich* for growing sugarcane, grapes and bananas, and have cut down on their chemical fertilizer consumption by more than 25%. According to the company's own estimates, a 500 Mg/day plant will require a capital investment of about US $1.7 million, exclusive of the land cost. The overall production cost is estimated to be in the range of US $25–30 per Mg of compost. The direct operating costs are estimated as US $10.4–12.5 per Mg of compost. Depending upon the transportation distance and other local overheads, the selling price varies between US $33.5–42 per Mg of compost (Visvanathan et al., 2004).

Box 3. 3: Case study of vermicomposting in Thailand

Twenty one communities, who form the residents of Barommatrilokanat, make compost using tiger worms to reduce the volume of household waste. Making the compost begins with the separation of household waste into three categories: organic matter, recyclables and general rubbish. Organic waste is collected in plastic bins and brought to the community composting centres where it is dumped in circular cement and brick enclosures used to house the worms. It takes 3 to 4 months to turn a batch of waste into compost. This compost is rich in humus that helps improve the structure and quality of the soil. It makes clay soil more porous and fertile, and helps it better retain water. This compost, which costs about THB 5/kg, has become a source of extra income to the 21 communities in Barommatrilokanat (Visvanathan et al., 2004).

In figure 1, two actual examples for typical composting set-ups in Europe and Asia are shown.

Figure 1: European and Asian composting systems. Left: Aerated pile composting in a rotting hall in Germany. Right: Windrow composting in Sri Lanka.

3.4.2 Anaerobic digestion

In some European countries the capacity for anaerobic digestion increased drastically in the last years. Main reason is the economical support by the respective governments. For instance Germany guaranteed a subsidy by means of revenues for electricity and heat produced from renewable resources (EEG, 2004). In 2005 the installed electrical power was 650 MW, cumulative for the existing 2700 anaerobic digestion facilities (Anonymus, 2007). Small European anaerobic digestion plants commonly use only one specific substrate type. This is typical for farms, which treat manure from their animal breeding activities. Most agricultural digestion facilities are operated in Germany. Larger production facilities co-digest substrates like manure together with organic household or commercial wastes, such as food wastes and organic wastes from production processes. An overview on the capacities of the most important European producers is presented in table 1. These results were summarized in 1997. In the meantime the capacities increased further. Co-digestion can be found in facilities with both low and high throughput capacities. In Germany, about 80% of all digestion plants run as wet fermentation. Approximately 90% of all full-scale anaerobic digestion plants for municipal solid waste and source separated organic household waste in Europe rely on one-stage mesophilic systems. One-stage systems are also commonly applied to agricultural wastes and sewage sludge due to the more simple process technology (Kranert and Hillebrecht, 2000; Körner und Visvanathan, 2006). More and more, energy crops such as corn are used for digestion as well. However, the ethical aspects should be more discussed.

Table 1: Co-Digestion and biowastedigestion facilities (>2500 Mg/a) in Europe (Anonym, 1997)

Country	Number of facilities	Treated Waste (Mg/a)
Denmark	22	1 396 000
Germany	39	1 081 700
Italy	6	772 000
Sweden	9	341 000
Austria	10	90 000
France	1	85 000

An example case study for a co-digestion process is shown in Box 3.4.

Box 3.4: Co-digestion facility, Gröden, Germany

In 1995, this digestion facility went in operation and employs 30 workers. The digestion substrates consist of pig and cattle manure (80 000 Mg/a) as well as of biowaste (30 000 Mg/a). The biowaste becomes treated with 70°C before digestion to allow hygienization. The digestion takes place in 2 parallel running reactors (one stage process) with a volume of 3000 m³ for 21 days. Each reactor contains a stirring system and works with mesophilic temperatures (37 °C). The biogas production rate is 17 000 ³/d. For biogas storage a 1000 m³ vessel is available. The biogas becomes used to produce electrical and thermal energy (35 000 kWh/d). The block heat and power plant operates with 3 modules (maximal engine power: 403 KW electric, 403 kW thermal, 469 KW electric). The liquid digestion residue can get stored in a 12 000 m³ reactor before it becomes used in agriculture as a fertilizer (Schradenbiogas, 2007).

In Asia, anaerobic digestion of MSW can be considered as a feasible biological treatment technology due to its highly biodegradable waste fraction with high moisture content of 50-70%. However, though the technology is attractive it is not widely implemented across the region due to known limitations including financial constraint and poor policy intervention, which is also true in terms of composting. For this reason, as similar with composting, the digestion plants are often operated in project-term basis and supported by decision makers or NGOs. An example case study from Thailand is shown in Box 3.5.

Box 3.5: Rayong waste to energy and fertilizer project, Rayong, Thailand

In 2002, the Rayong Municipality, Thailand established the pilot MSW treatment plant using anaerobic digestion. The project objective is the production of electricity while the by-product (digestate) is to be used as soil conditioner or fertilizer. The plant has a capacity to treat 25,500 tons of biowaste annually and may produce 5,800 tons of digestate and 3,826 MWh surplus of electricity from 21,900 tons of biowaste. The process is wet single-stage continuous using a slurry substrate of 5% TS. Basically, with this project the increasing problem in solid waste in Rayong has ended to a successful project. Among the contributing factors for this achievement is the community willingness to solve the problem along with the support and cooperation from NGOs and government agencies (NESDB, 2003).

Figure 2 shows two actual examples of typical digestion facility in Europe and Asia.

Figure 2: European and Asian digestion systems. Left: Digestion facility for Chicken manure, Wewelsburg (Germany), Right: Waste to energy and fertilizer project, Rayong (Thailand).

5. SUMMARY AND FUTURE PROSPECTS

Biological waste treatment can be successfully integrated into the waste management strategy in Asian countries with the enforcement of legislative measures, and technical and managerial support. This would undoubtedly reduce the landfill space requirement, enhance resource recovery and restore the fertility of scarce agricultural lands. Profits from selling of compost or digestates should not be highly expected. However, in the long term, the biogas from digestion may significantly contribute to cover the treatment costs, depending on the development of energy prices. Furthermore, the indirect economic benefits of biological waste treatment such cleaner environment and cost-saving in energy and fertilizer use may become more attractive.

The application of biological treatment options could be developed by establishing successful demonstration projects to show the feasibility of the method and the advantages of cleaner and healthier environment. Due to high generation of organic waste in Asia, biological treatment facilities will be most probably designed with higher capacities than those in Europe. Furthermore, certain process steps may be better carried out manually instead of mechanically after considering carefully the limitations. For instance, the separation of impurities, and the irrigation or moistening the substrate during the process could easily be done manually. However, since certain manual working steps incur a high hygienic risk, the safety of workers must be ensured e.g. by providing masks and gloves, as well as by giving health and safety instructions.

The problem of contaminating the soil with heavy metals and non-biodegradables present in the compost cannot be ruled out if using mixed MSW for biological treatment. Only in certain cases are segregated waste streams readily available, e.g. from agricultural wastes, market wastes or restaurant wastes. In the near future, making compost from mixed waste will probably be unavoidable due to the nature of the waste management systems that are practiced in Asia. However, this scenario can be improved in the long term through environmental education and creation of environmental awareness with the aim of source segregation. In each case, public participation and understanding is necessary for the success of biological waste treatment.

ACKNOWLEDGEMENTS

The Authors wish to thank the European Union for their support in the TETRAWAMA project. This project enabled the cooperation between AIT and TUHH. The authors would like to extend their appreciation for the Sustainable Solid Waste Landfill Management in Asia project under the Asian Regional Research Program on Environmental Technology (ARRPET).

REFERENCES

Allen, C. (2002): Financing and incentive schemes for municipal waste management – case studies. European Commission, Environment DG, Brussels, 2002, English, 132 pp, Contact: christopher.allen@cec.eu.int

Anonymus, 1997: Systems and markets overview of anaerobic digestion. IEA Bioenergy Anaerobic Digestion Activity Brochüre 1997. Lusk. P., Resource Dev. Assoc. (Ed.) 240 Ninth Street, NE, Washington D.C. 20002-6110, USA

Anonymus, 2007: Biogas in Deutschland. Fachverband Biogas e.V., Freising, Germany, http://www.biogas.org/datenbank/file/notmember/presse/Pressegespr_Hintergrunddaten1.pdf

Barth, J. (2005). Biological waste treatment in Europe. http://www.compostnetwork.info/

BGK, 2007: Produktionsanlagen. In: Bundesgütegemeinschaft Kompost e.V., http://www.bgkev.de/infodienste/uebersicht.htm?kat=prodanlagen

BioAbfVO (1998). Verordnung über die Verwertung von Bioabfällen auf landwirtschaftlich, forstwirtschaftlich und gärtnerisch genutzten Böden BioAbfV – Bioabfallverordnung. Vom 21. September 1998, (BGBl. I 1998 S. 2955; 2001 S. 3379; 25.4.2002 S. 1488; 26.11.2003 S. 2373 [03]) BioAbfVO, 1998

EEA (1999). (European Environment Agency (EEA). Environment in the European Union at the turn of the century. Environmental assessment report No. 2. 1999). (Last updated 12.9.2002), EEA. Waste generation from daily household and commercial activities Source: EEA http://europa.eu.int/comm/environment/waste/compost/index.htm

EEG (2004). Gesetz für den Vorrang Erneuerbarer Energien- EEG - Erneuerbare-Energien-Gesetz ; Vom 21. Juli 2004; (BGBl. I Nr. 40 vom 31.7.2004 S. 1918)

Körner, I.; Visvanathan, C. (2006): ***Biological Treatment.*** In: Solid waste management in Asia. Körner, I.; Stegmann, R.; Visvanathan, C.; Tränkler, J.; Cossu, R.; Hassan, M.N. (Eds.) - Modul 1 of the TETRAWAMA-Teaching and training modules in the waste management sector, Körner, I.; Stegmann, R.; Visvanathan, C.; Tränkler, J.; Cossu, R.; Hassan, M.N. (Eds.), on-line: http://www.tu-harburg.de/aws/asia-link/TETRAWAMABOOK06112006S.pdf and DVD, self published, Hamburg University of Technology, Hamburg, Germany; Chapter 4, pp. 87-114.

Kranert and Hillebrecht, 2000: Anaerobic Digestion of Organic Wastes – Process Parameters and Balances in Practice. Institute of Waste Management and Environmental Monitoring, University of Applied Sciences, Braunschweig/Wolfenbüttel, Germany

Krogmann, U. Körner, I., Diaz; L. (2007). Composting:Technology In: Solid waste technology and management, Christensen, T. (Ed.). Chapter 9.2., in print

NESDB (2003). The National Economic and Social Development Board (NESDB), Rayong Municipality Bangkok, Thailand.

Schradenbiogas, 2007: Wir machen aus Abfall Energie.Abfallverwertung - Das Verfahren http://www.schradenbiogas.de/

Visvanathan, C., Tränkler, J., Joseph, K., Basnayake, B.F.A., Chiemchaisri, and Gongming, Z. (2004). Municipal solid waste management in Asia. Asian Regional Research Program on Environmental Technology (ARRPET). Published by Asian Institute of Technology, ISBN: 974-417-258-1.

Sardinia 2007

01.- 05.10.2007 / Italy

COMPOSTING AND DIGESTION – A COMPARISON BETWEEN EUROPE AND ASIA

Ina Körner / Hamburg University of Technology / Hamburg / Germany

C. Visvanathan / Asian Institute of Technology / Bangkok / Thailand /

Co-operation
AIT-TUHH

AIT
Asian Institute of Technology

Environmental Engineering and Management Programme

TUHH
Hamburg University of Technology

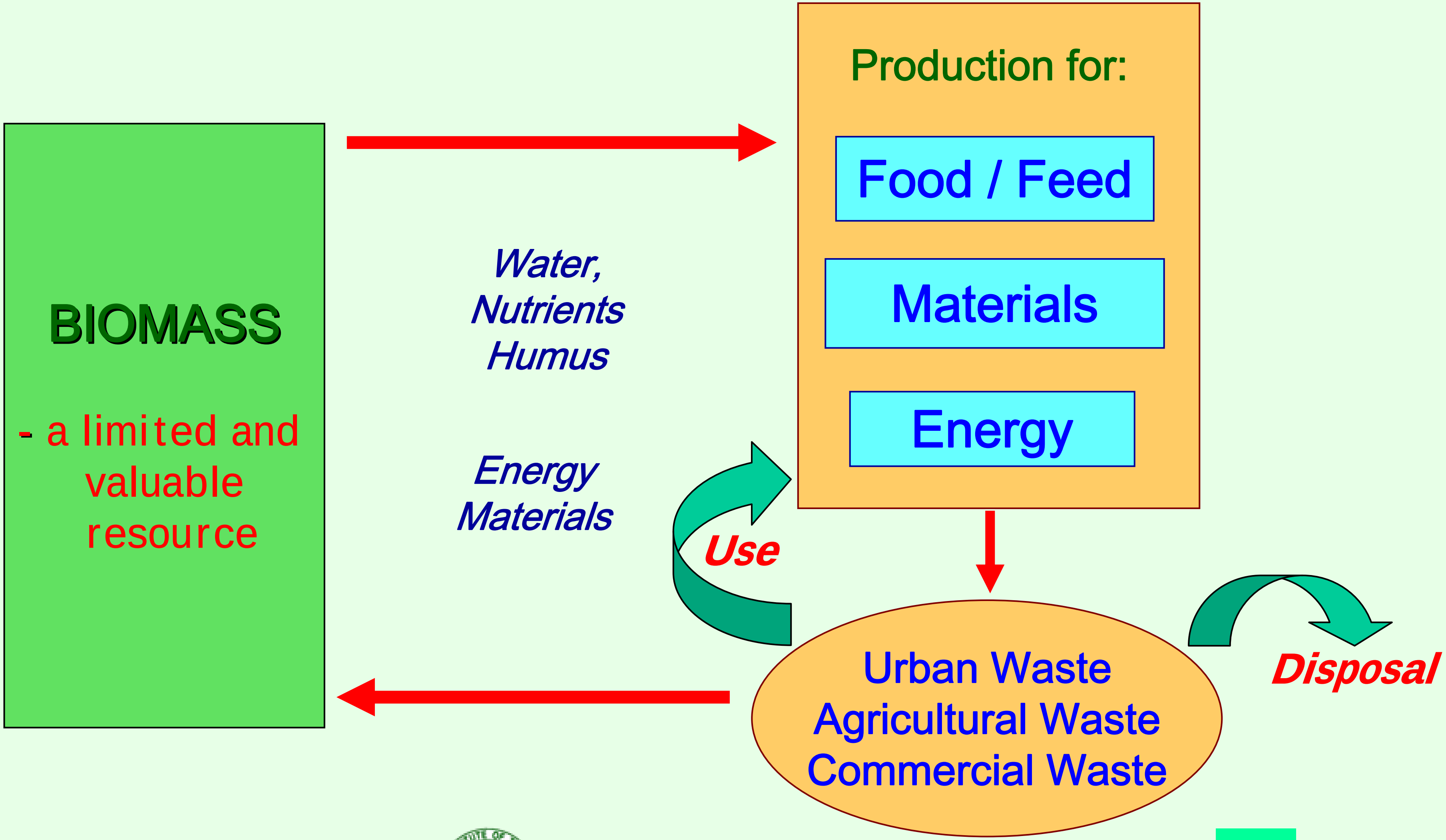
Institute of Waste Resource Management

Structure

- Introduction
- State-of-the-Art and Comparison
  - ➢ Driving Forces
  - ➢ Substrates
  - ➢ Treatment systems
- Case Studies
  - ➢ Composting
    - ✓ Europe
    - ✓ Asia
  - ➢ Digestion
    - ✓ Europe
    - ✓ Asia
- Summary and future prospects

Some photos from Europe?

Overview


BIOMASS
- a limited and valuable resource
Water,
Nutrients
Humus
Energy
Materials
Production for:
Food / Feed
Materials
Energy
Use
Urban Waste
Agricultural Waste
Commercial Waste
Disposal

Introduction
-Biological treatment-

Terms commonly used:

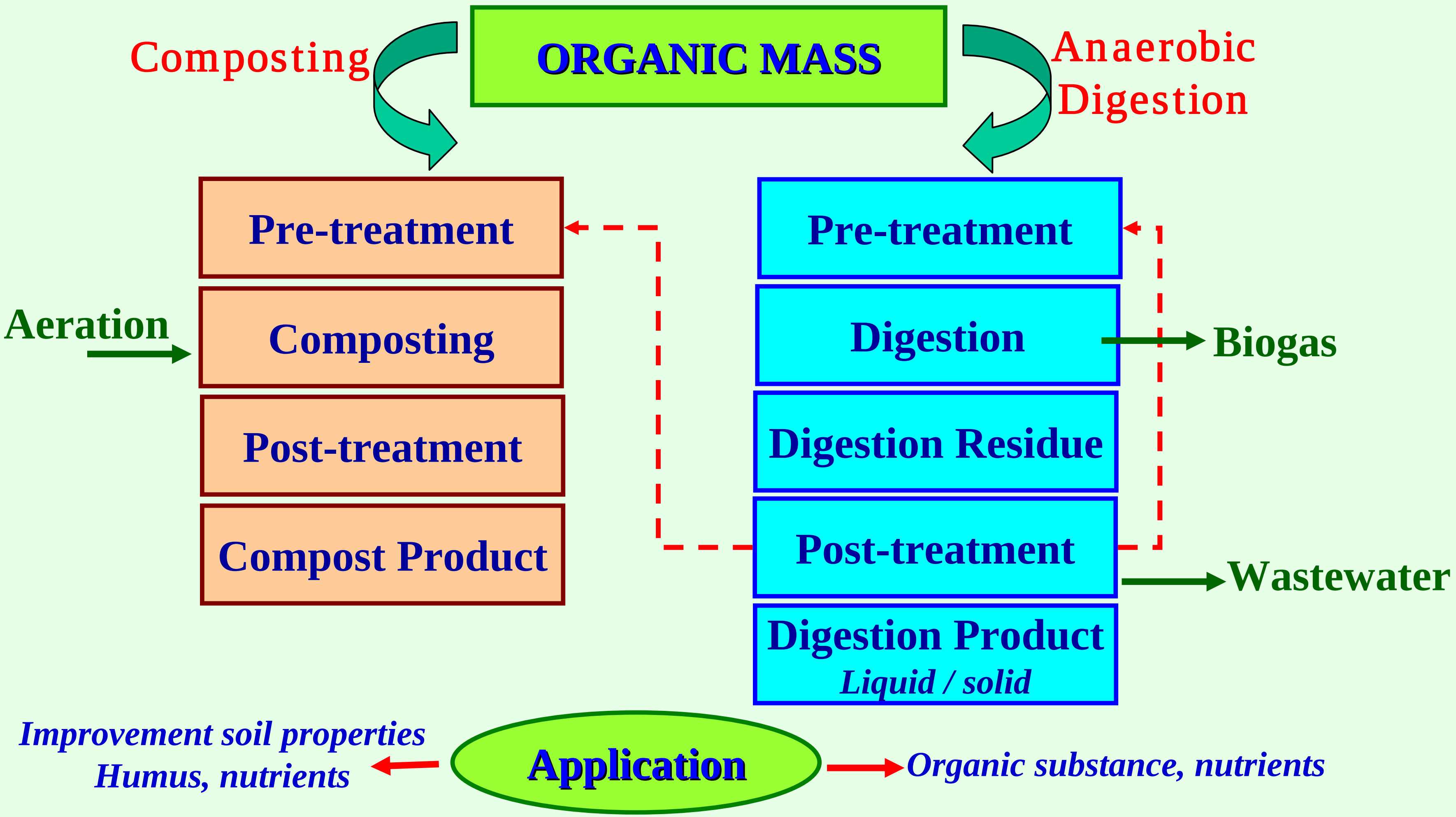
	Composting	Digestion
Europe	?	?
Asia	Rotting, aerobic decomposition	Biomethanization, biogasification, anaerobic fermentation

- Commonly-used synonyms for **composting** include aerobic degradation or rotting. The term fermentation or aerobic digestion should be avoided to prevent misunderstanding.

- Synonyms for **digestion** include anaerobic fermentation, anaerobic digestion, anaerobic degradation or biogas generation. Synonyms such as anaerobic composting or fermentation should be avoided.

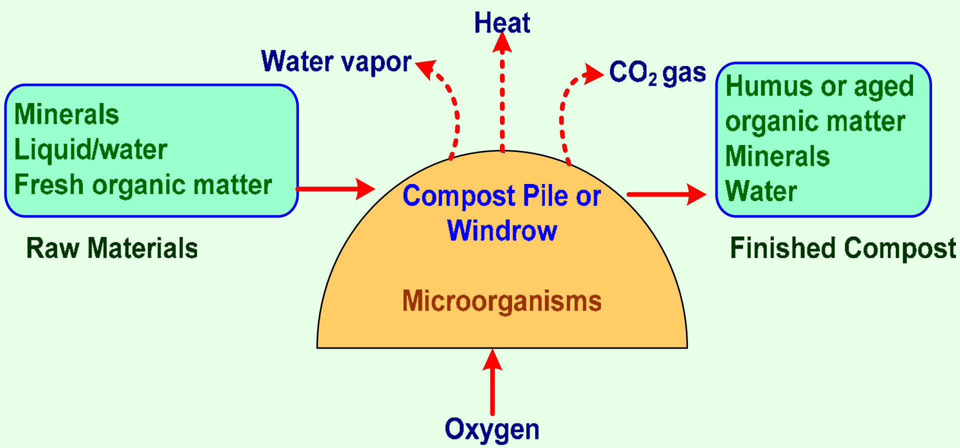
Introduction

-Biological treatment-

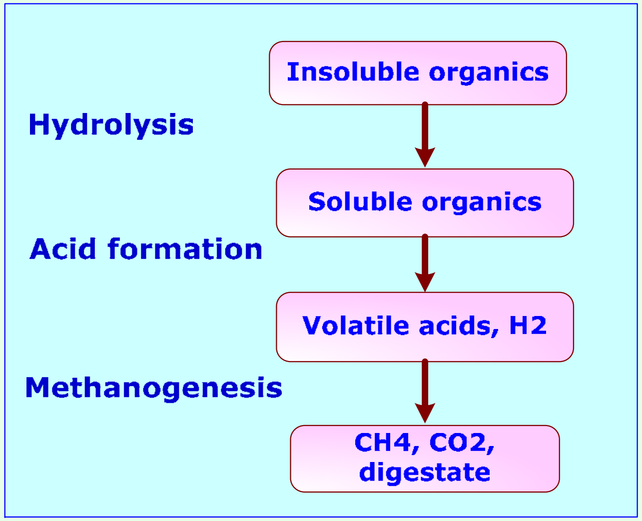


Introduction
-Biological treatment-

COMPOSTING



ANAEROBIC DIGESTION



Eventually the flow sheet from before, but additionally some additions to show difference Europe / Asia

Organic Mass Examples Europe, pictures, data

Grain: 280 Mio. Mg (EU-25, 2007)*
Wheat, maize, barley, oat, rye

Animal consumption: 20 kg/ capita Beef,
Pork 40 kg/capita, poultry 19 kg/capita**

Energy Crops for biogas generation,
Maize and Cereals 400.000 ha, Germany 2007***

*Eurostat, 2007: http://www.eds-destatis.de/de/downloads/sif/sf_07_086.pdf
**h ulture/publi/pa
***

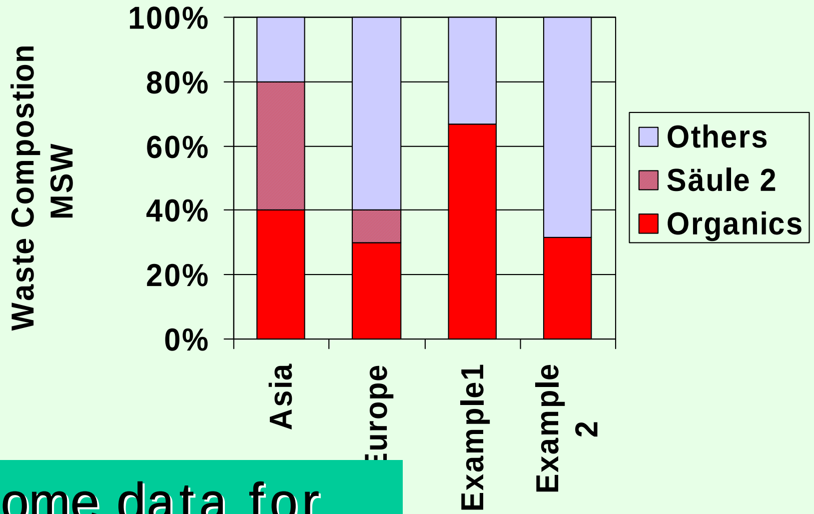
Department of Waste Management
www.tu-harburg.de/aws/

Biological Treatment
-Substrates-

Sources

- Communities:
  -organic wastes from kitchen, yards, gardens, parks, trade, light industry, sludge from waste water treatment plants
  -mixed municipal solid waste (MSW)

- Industry (e.g. food and feed, paper industry)
- Agriculture: manure, cultivation residues, energy crops



Collection systems:
-no collection (home composting, feed, pollutant)
-source separation
-mixed collection, no separation
-mixed collection, later separation
-wet-dry-separation

Pictures / Methodes Europe/ Asia

Some data for wast compostion in different cities...

Biological Treatment
-Driving Forces-

Problems

- Large waste amounts
- Scarce disposal areas
- Odour annoyance
- Diseases
- Water pollution
- Shortage of energy
- Shortage of resources
- Climate relevant emissions

Environmental Awarness
Economic Influences
Legislative Influences

Voluntary

Necessity

Biological Treatment
-Driving Forces-

Economics strongly depends on regional situation
Costs for biological treatment: 30-130 €/Mg waste
Cost-covering waste fees
Compost prices: 0-40 €/Mg compost

Subsidies for energy generation
from renewable resources:
Germany EEG

Problems

- Large waste amounts
- Scarce disposal areas
- Odour annoyance
- Diseases
- Water pollution
- Shortage of energy
- Shortage of resources
- Climate relevant emissions

Environmental Awarness
Economic Influences
Legislative Influences

Voluntary

Necessity

EU: Restriction of Disposal practices
1999/31/EG; 2003/33/EG

National Laws:
Waste hierarchy: avoidance, recycling, disposal
Strategies and limits for biological treatment
Germany BioAbfVO, 1998

Comparison of Major Factors: Driving Forces

In Europe:

1. Increased environmental awareness

2. Increased political awareness on environmental issues

EU: Restriction of Disposal practices
1999/31/EG; 2003/33/EG

Formulation of laws and regulations

Subsidies for energy generation from renewable resources:
Germany EEG

Creation of biological waste treatment facilities

Different national regulations

National Laws:
Waste hierarchy: avoidance, recycling, disposal
Strategies and limits for biological treatment
Germany BioAbfVO, 1998

Inhomogeneous but rising trend in the application of biological waste treatment

3. Economic factor

Biological treatment cost: 30-130 €/Mg;

Selling price of compost: 0-40 €/Mg

Commonly financed by: ”Polluter Pays” principle (waste fees, sale of collection bags, and taxes)

Comparison of Major Factors: Driving Forces

In Asia

1. Increased environmental degradation and awareness

2. Increased political awareness

Recognition of the importance of biological waste treatment systems

Establishment of biological treatment system is based on: Project basis, private companies, decision makers or NGOs

3. Economic factor

Lead to the introduction of biological treatment: in certain situations, compost price can compensate the production cost

Comparison of Major Factors: Substrates

Origin of organic waste in Europe and Asia: households, commerce, landscaping and agriculture

Waste composition and generation is dependent on local conditions, product consumption, climatic condition and degre of industrialization

Waste Composition

In Asia: 40-80% of MSW is organic waste

In Europe: 30-40% of MSW is organic waste

Waste Quantity Treated

In Asia: minimal part of the putrescible fraction is biologically treated. Home composting is practice in informal manner. Household organics often used as animal feed.

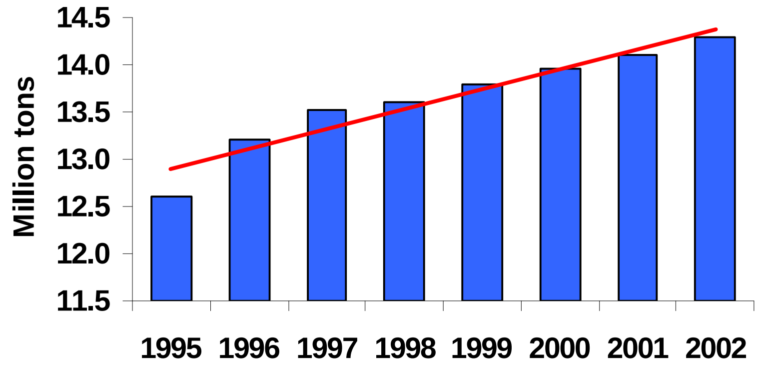
In Europe: it is estimated that 17 million Mg/year of putrescibles are collected which is 35% of actual organic waste production in municipalities.

Comparison of Major Factors: Substrates

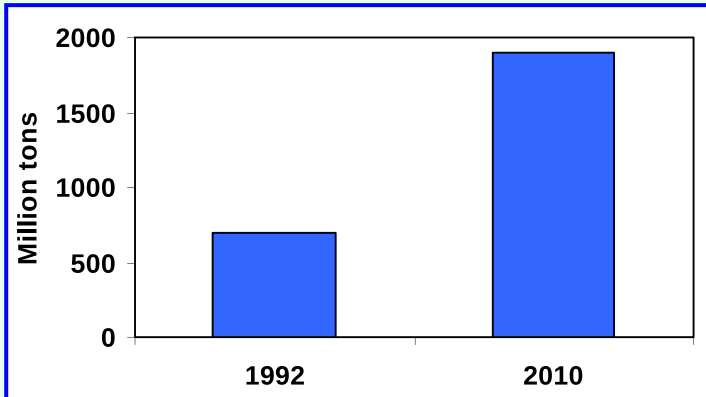
MSW Generation

In Europe

In Asia



MSW generation in Thailand



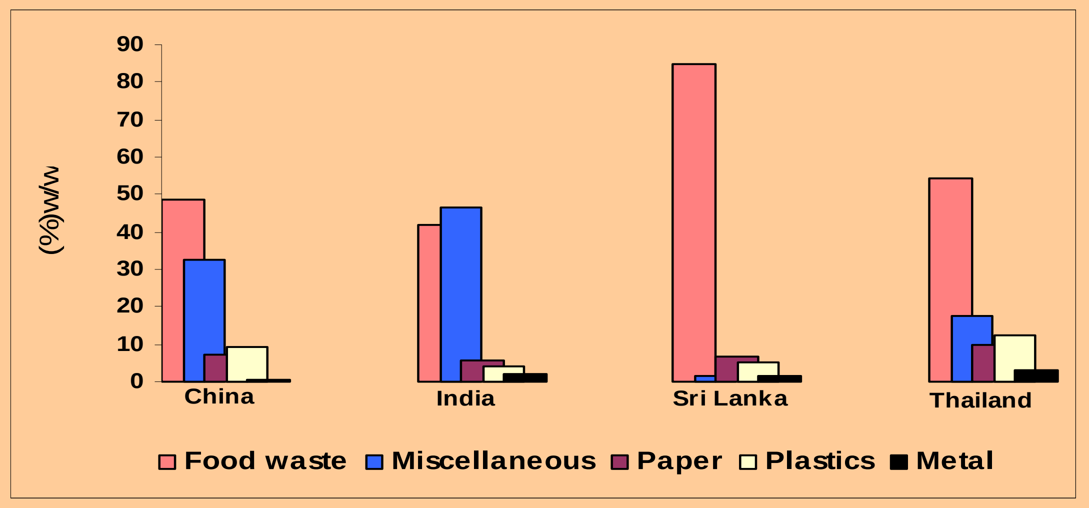
Municipal solid waste in Asia (ESCAP 1995)

Comparison of Major Factors: Substrates

MSW Composition

In Europe

In Asia, dominated by organic fraction (<50%)



Comparison of Major Factors: Treatment Systems

Europe and Asia conditions differs significantly, the 1:1 technology transfer often leads to failures

Demographic structure:

Population density and migration in Asia is higher than in Europe

Treatment capacities:

In Europe: Treatment capacities range from 5,000-20,000 Mg/year; small plants of less than 500 Mg/year also exist

In Asia: Treatment capacities range from 10,000-180,000 Mg/year (in India)

Comparison of Major Factors: Treatment Systems

Location of treatment systems:

In Europe: Centralized and decentralized systems both exist

In Asia (mega cities): decentralized systems is prioritized due to large amount of waste generated and to avoid problems on waste transport

Decentralized plants in Asia may reach the same size as centralized plants in Europe

Climate:

For composting: open composting should be planned and managed well during rainy reason and dry season

For digestion: most digestion process runs in mesophilic. In tropical countries like Asia, digestion can be operated without additional heating.

Case Studies
-Composting-

Decentralized composting in Bangladesh



Agency: Waste Concern (NGO)

Aim: to develop a low-cost technique for composting, to develop public-private partnership in the MSW management, and to create job opportunities to the urban poor.

Vermicomposting in Thailand

Barommatrilokanat 21 community in Thailand is consist of 120 households with 425 populations. This community has established a committee to solve the solid waste management since 1997.


Case Studies
-Composting-

In Europe?

Case Studies
-Digestion-

Waste to Energy and Fertilizer Project (Rayong, Thailand)

Plant capacity: 25,500 tons of biowaste annually and may produce 5,800 tons of soil conditioner and 3,826 MWh surplus of electricity.

Front-end treatment area

Anaerobic digester

Case Studies
-Digestion-

In Europe?

Summary / Future Outlook

- Biological waste treatment can be successfully integrated into the waste management strategy with enforcement of legislative measures with technical and managerial support
- Profits from selling of compost or digestates should not be highly expected
- Indirect benefits of biological waste treatment such as cleaner environment and cost-saving in energy and fertilizer use may become more attractive
- Application of biological treatment options could be developed by establishing successful demonstration projects
- Biological treatment facilities in Asia will be probably designed with higher capacities than in Europe due to its high generation of organic wastes
- Biological treatment of source separated waste offer benefits over the mixed MSW
- Public participation and understanding is necessary for the success of biological waste treatment