MECHANICAL BIOLOGICAL TREATMENT OF RESIDUAL WASTES, ADEQUATE LANDFILLING TECHNIQUES AND REHABILITATION OF OLD LANDFILL DEPOSITS

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PICTURE NOT AVAILABLE

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ABSTRACT

Research work of the last years has been committed to developing residual waste treatment technologies and the corresponding landfilling techniques. Among the research results the mechanical biological residual waste treatment in combination with its newly developed landfilling practice have proven to be cost-efficient and environmentally safe solutions.

Characteristics of the new technology are:

- reduction of waste volume to be deposited by means of decomposition of biologically degradable components;
- separation of valuables and recyclables out of the waste stream results in 30-50 % mass reduction;
- stabilization of the waste to be safely deposited, thus decrease of the landfill settling process and reduction of malodor emissions;
- reduction of the gas formation potential by 80 to 90 %;
- reduction of leachate volume and its contaminant loading through biodegradation of organic matter, contaminants are fixed and immobilized within the stabilized waste;
- options for highly compressed installation of stabilized waste into the landfill, installation densities increased from 0.7 t/m^3 to 1.4 t/m^3;
- reduction of hydraulic conductivity to < 10^{-7} to 10^{-8} m/s;
- landfill space required can be reduced by > 70 %.

KEYWORDS: Mechanical Biological Residual Waste Treatment, Waste Stabilization, Rehabilitation of Old Landfill Deposits, New Landfilling Technologies, Reduction of Methane Emissions.

INTRODUCTION

With progressing industrialization around the globe reasonable solutions in waste management gain importance. According to the hierarchy of waste - avoidance, re-utilization, safe disposal - new solutions for reuse and landfilling are sought. The emerging nations of Eastern Europe, Asia and Latin America have shown specific interest in raising their ecological standards to Western European or North American levels. At present, many of their landfills are operated on very low environmental standards. Distinctive feature of the waste of these countries is its high content of biologically degradable organic matter, thus resulting in a high organic contamination of landfill leachates and production of large amounts of landfill gas.

Research work of the last years has been committed to developing residual waste treatment technologies and the corresponding landfilling techniques. Among the research results the mechanical biological residual waste treatment in combination with its newly developed landfilling practice have proven to be cost-efficient and environmentally safe solutions.

The mechanical biological processing technique is particularly interesting for regions with low population density, few industrial estates and comparatively poor infrastructure, often characterized by an excessive availability of land, landfill volume or space to establish new landfills. These conditions guarantee long-term safe disposal sites for mechanically biologically treated wastes.

TEXT

The average composition of Brazilian waste is characterized by a high content of biologically degradable components in the range of 80 %. The corresponding high water content causes a low calorific value of the waste and results in an unsuitability for direct thermal treatment or energetic reuse. As a consequence of the low level of disposal costs in Brazil thermal treatment has to be considered as an economically inefficient solution.

A material specific concept, consisting of mechanical treatment (material stream separation and pre-treatment of the waste), biological treatment, reuse of partial fractions and landfilling of the biologically stabilized waste fractions is currently the best solution as far as economical and technological considerations are concerned. Energetic reuse of partial fractions characterized by high calorific value may be optionally considered at a later stage of planning.

Goal of the first step is to separate the recyclable materials and most of the materials of high calorific value, to recycle them and – in the second step – reuse them energetically. Using manual separation methods employment options for scavengers remain or may even be created in a socially acceptable manner. The residual waste to be treated mechanically biologically will then be separated from coarse non-degradable components before being delivered into the mechanical treatment facility. Coarse parts of the waste material, especially bulky refuse and commercial or industrial waste, will be crushed, magnetically separated and loaded into the screening unit. The separated coarse fraction, characterized by high calorific value, will be used for thermal processing or deposition. The waste that remains after sieving and magnetic separation will be composted. The biological treatment will be followed by a screening unit to extract different grain sizes. The various grain size fractions will be used for seal construction, especially for impermeable base and surface seals. The residual waste will be deposited in a landfill of specific design.

The processing technique can be combined either with the construction of a new landfill or with the rehabilitation of old landfills by using partial fractions of the mechanically biologically processed wastes. Considerable cost-savings can be achieved in the field of rehabilitation of old landfill deposits by using partial fractions of the mechanically biologically treated waste for methane filtering, surface sealing and recultivation. Transformation of old composting plants for unsorted wastes into mechanical biological waste treatment facilities is technically possible and economically favorable.

Various large scale scientific trials of the German Federal Ministry of Education, Science, Research and Technology have shown entirely new ways of landfill construction and operation. The possibility to combine mechanical-biological treatment of residual wastes and the re-development of old landfill deposits by using mechanically biologically treated fractions of residual waste creates an economically feasible option to reduce leachate and methane gas emissions.

Decisions on the right pre-treatment and composting technologies may be based on experiences made with composting in mechanical biological residual waste treatment facilities and in recycling facilities in Germany. Results of trials made to investigate biodegradation in landfills may also be considered. It is of special importance for a step-by-step implementation of a technical concept, that experiences with biological treatment processes have been collected during the last years on a highly advanced technical scale as well as on a low technical scale (extensive processes). Figure 1 shows an example of process technologies possibly to be applied at a site in Northeast Brazil.

In the field of pre-treatment technology it has been shown that an intensive crushing, a material specific separation and intensive homogenizing of the residual waste is essential to ensure a high efficiency of biological degradation. Since Brazilian waste is characterized by a content of water and biologically degradable organic substance waste crushing technology has to fulfill these specific demands. Pre-treatment technology has to meet different requirements than in Germany because the majority of Brazilian wastes is not collected in containers but in bags and cardboard boxes.

During approximately three months of decomposition time of the residual waste in Germany the native organic substance (OS-bio) has been degraded by 60 to 70 %. This reduced the content of organic substance (ignition loss) of the biologically degradable components – depending on the material – to values between 19 and 38 % of the dry matter (Figures 2 and 3).

By means of mechanical biological residual waste treatment the volume is being reduced – depending on the composition of the treated residual waste and the method of pre-treatment and separation of recyclable materials – by 50 to 70 %. The mechanical biological residual waste treatment lead to a significant increase of installation density of the treated residual waste at the landfill. Under consideration of the obtained reduction of volume and increase of installation density the use of landfill volume can be reduced – compared to untreated residual waste – by 60 to 80 vol%. This is especially significant for the Brazilian waste with its high content of water and biologically degradable organic substance.

By means of biological pre- treatment the production of landfill gas can be reduced by 90 %. Active gas collection of the remaining gas emissions will not be necessary (Figure 4).

Mechanically biologically treated residual waste can be used for methane oxidation filtering. With fairly low input methane emissions from old contaminated deposits can be effectively reduced. Within old landfills gas disposal systems followed by gas utilization or flaring installations are expensive and inefficient for reasons of remaining methane content. By means of conventional technical gas disposal systems only 40 to 60 % of the produced gas can be collected and reused or safely disposed. The methane filtering system provided by the mechanical biological processing package realizes a cheaper solution with higher efficiency. By reason of the warm and humid climate an even higher filtering efficiency can be expected. Material for reclamation (plant growing layer) can be obtained from mechanical biological residual waste treatment (Figure 5 and 6).

The results of research projects investigating exhaust air emissions from mechanical biological residual waste treatment that have been obtained so far, show that exhaust air emissions from the composting or maturation stage contain considerable amounts of organic and inorganic contaminants in the dirty gas. Enclosure of the site including exhaust air collection and filtering at the beginning of the composting stage is essential from what is known so far. For simple composting technologies such as the „Chimney process“ an exhaust air collection at the composting stage does not seem to be necessary.

Partial fractions of mechanically biologically treated residual waste, suitable for base sealing or for intermediate or surface sealing, may reach By means of the corresponding deposition techniques hydraulic conductivities of > 10^{-7} to 10^{-8} m/s (Table 1). By mixing in various fine-grained residuals, such as ashes, hydraulic conductivities of 10^{-9} m/s may be realized. This makes it possible to use those materials for base sealing or intermediate and surface sealing (Table 2).

Table 1: Dry and moist densities and hydraulic conductivity in relation to the vertical pressure.

Vertical Pressure (kPa)	Dry Density (Mg/m^3)	Moist Density (Mg/m^3)	Hydraulic Conductivity (m/s)
0 – 100	0,25 – 0,7	0,7 – 1,15	$5*10^{-3} – 10^{-5}$
100 – 200	0,35 – 0,8	0,8 – 1,25	$10^{-4} – 10^{-6}$
~ 320	0,5 – 0,9	0,9 – 1,3	$10^{-6} – 10^{-7}$
~ 600	0,6 – 90,95	1,2 – 1,4	$10^{-7} – 10^{-9}$

Table 2 : Installation parameters of compressed waste bodies of mechanically biologically treated waste.

Plant/Trial		Trial 1		Trial 2		Trial 3	Trial 4	Trial 5	Trial 6	Trial 7
		Number 1	Number 2	Number 1	Number 2					
Landfill Trial		Highly compressed waste body in a landfill reactor trial (V = 300 l)							Large lysimeter V = 60m³	Trial area V = 5.500m³
Source		Dach 1997, Dach et al. 1997							Bidlingmaier and Rieger 1996	Rettenberger 1997
Physical parameters of the treated waste										
Largest Grain Size d_{max}	(mm)	60		40		40	60	60	70	60
Grain density ρ_S	(kg/m³)	2007		1780		1872	2279	2022	2130[2]	2250[1]
Ignition loss GV_0	(%)	30,10%		46,60%		37,70%	21,20%	30,60%	25,80%	19,50%
Parameters of the compressed waste body (at start of trial)										
Water content (moist) w_f	(weight-%)	7,4%	34,0%	16,9%	30,1%	27,7%	27,8%	35,6%	34,0%	*24,2%*
Dry installation density ρ_t	(kg/m³)	956	914	883	852	835	1163	952	*1010*	1250[2]
Moist installation density ρ_f	(kg/m³)	1032	1385	1062	1218	1155	1610	1479	1530	1650[2]
Total pore volume ψ_{tot}	Vol.-%	52,4	54,5	50,4	52,1	55,4	49,0	52,9	52,6%	44,4%
Saturation S	Vol.-%	14,6	86,5	35,6	70,3	57,7	91,3	99,5	98,9%	90,0%
S at water retention capacity	**Vol.-%**	**ca. 85**	**87 - 92**	**ca. 82**	**ca. 80**	**90 - 95**	**91 - 96**	**97 - 99**	**n.a.**	**n.a.**
Theoretical water content at full saturation $w_{f,max}$	weight-%	35,4%	37,3%	36,4%	38,0%	39,9%	29,6%	35,7%	34,2%	26,2%
Saturated hydraulic conductivity										
Hydraulic conductivity k_f	m/s	$2,0*10^{-06}$	$7,2*10^{-09}$	$8,0*10^{-09}$	$4,9*10^{-10}$	$4,0*10^{-06}$	$4,5*10^{-08}$	$<1*10^{-10}$	n.a.	$5,8*10^{-10}$

[1] estimation based on ignition loss, [2]mean values of the given scattering

Mechanically biologically processed waste demands only very few post-closure monitoring activities since the technical requirements have been fulfilled in advance by biological treatment. By saving landfill space, ensuring maximum utilization of certain waste components and ecologically safe deposit of residual waste mechanical biological waste treatment may actively contribute to raise Brazilian ecological standards of landfilling.

FIGURES

Figure 1: Example of Process/Mass Flow Chart to be possibly applied at site in Northeast Brazil.

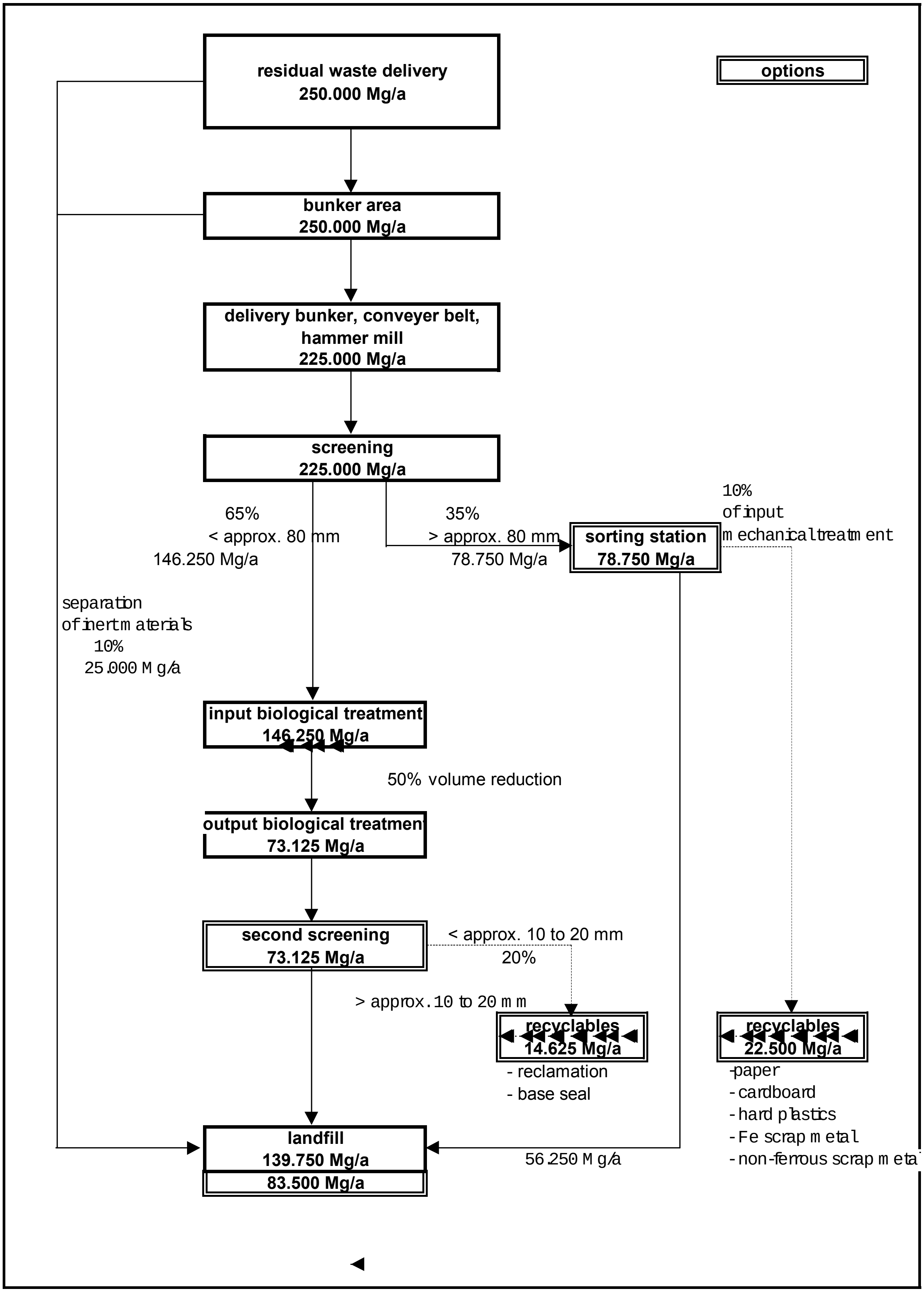


Figure 2: Degradation of Organic Substance in Relation to Low and High Composting Technology Options.

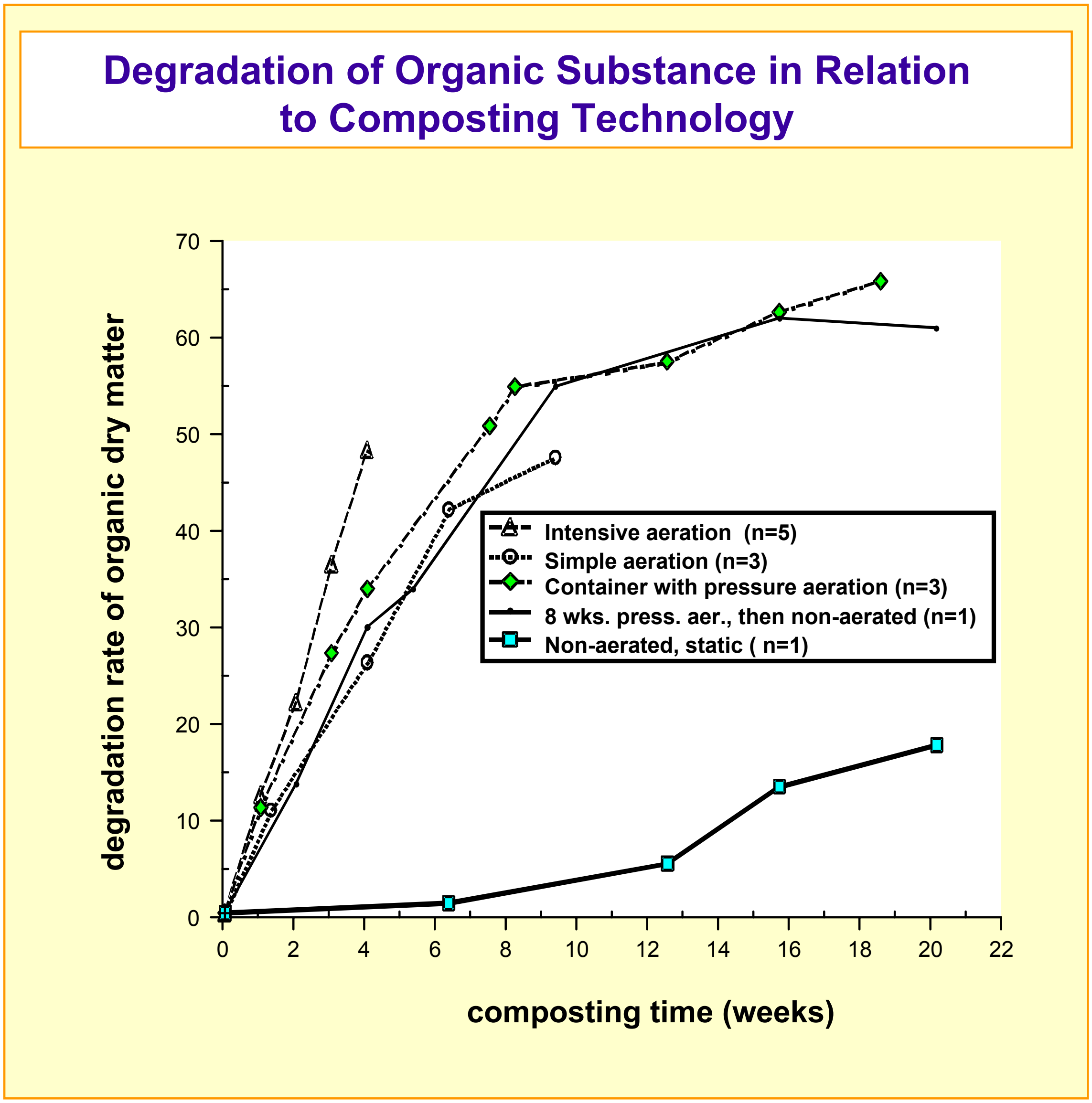


Figure 3: Alterations of Respiration Activity during the Composting Process.

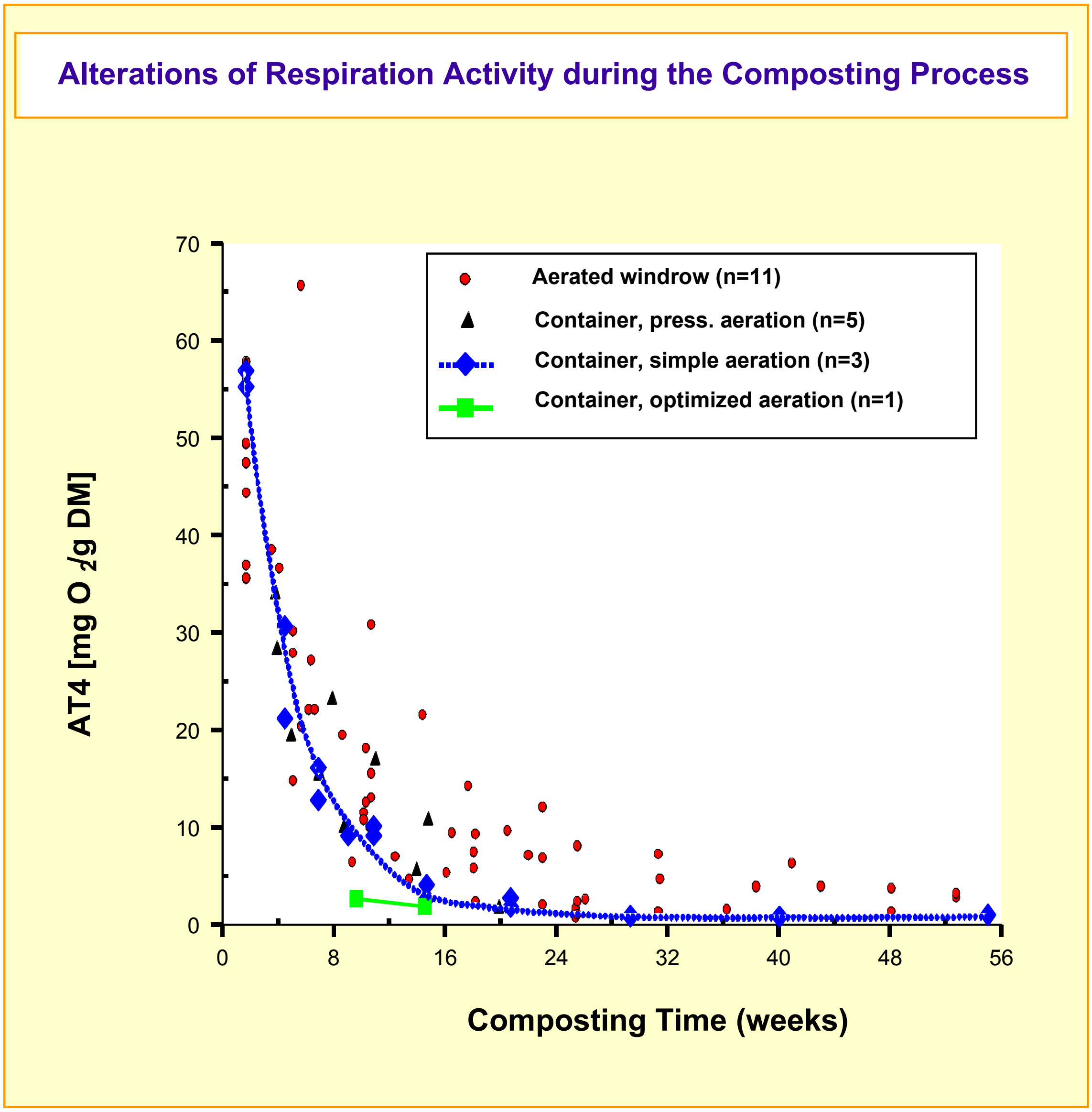


Figure 4: Methane Oxidation Rate of Various Material.

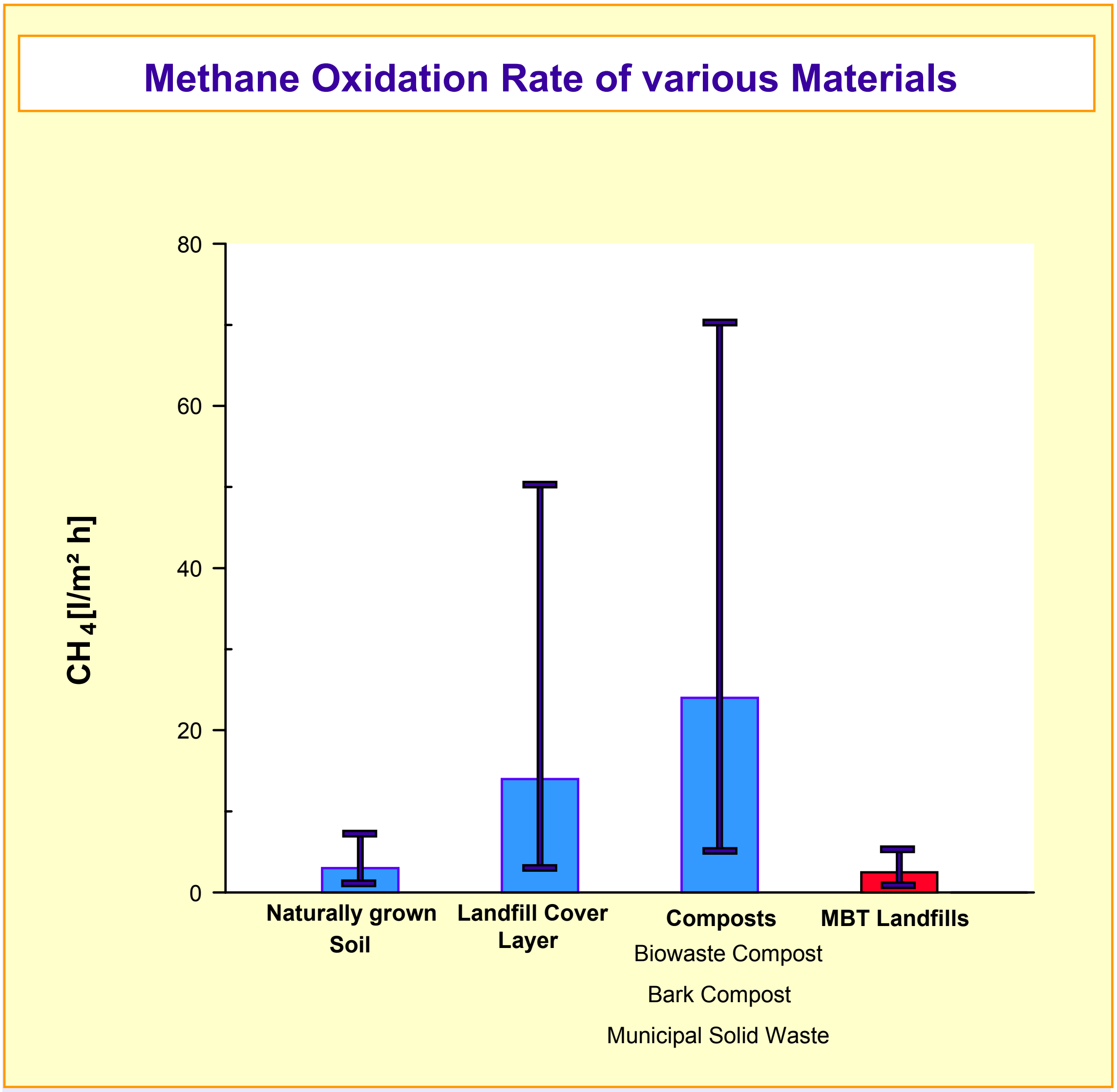


Figure 5: Alterations of Gas Formation during Composting Process in Relation to Low and High Composting Technology Options.

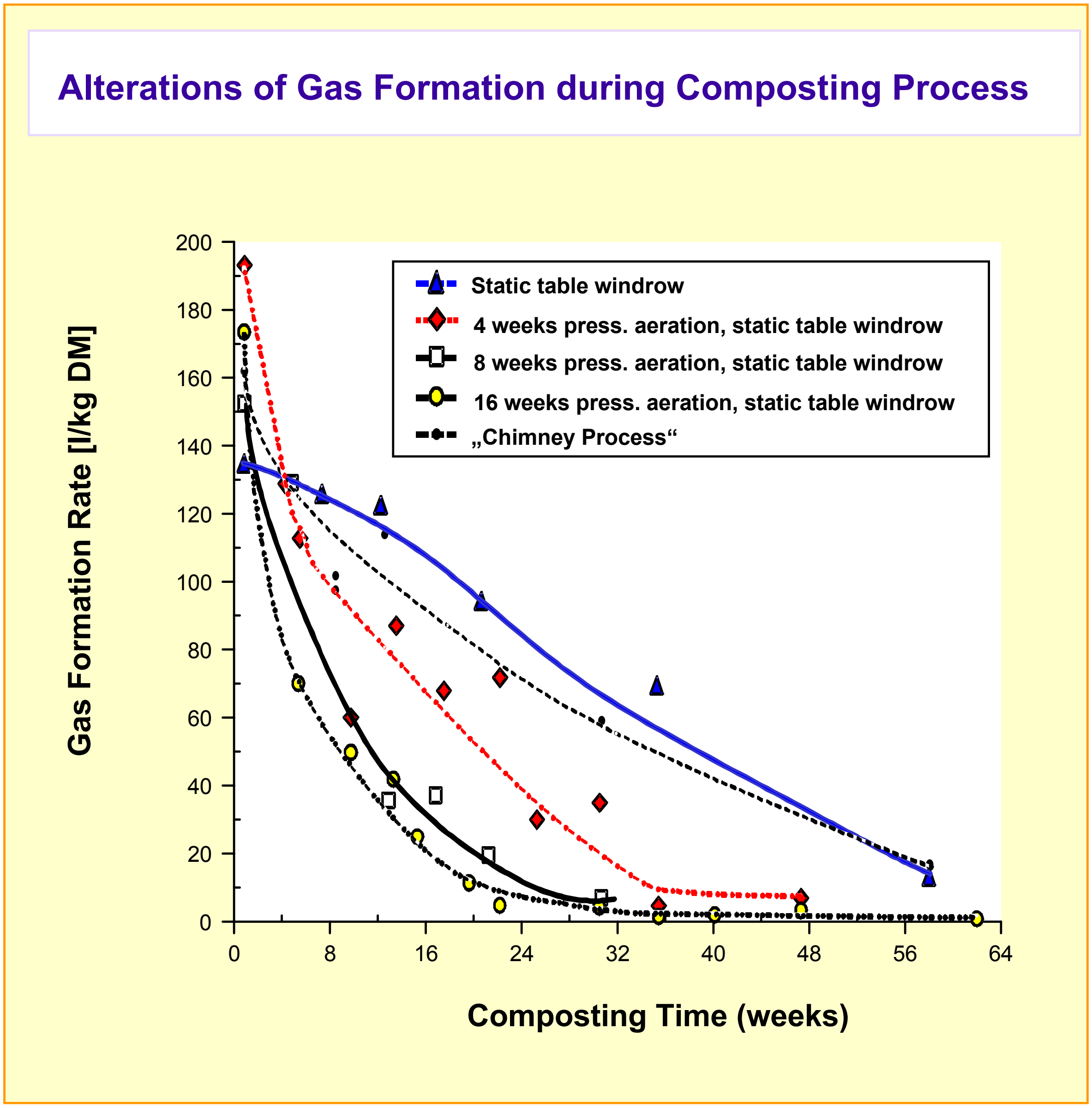
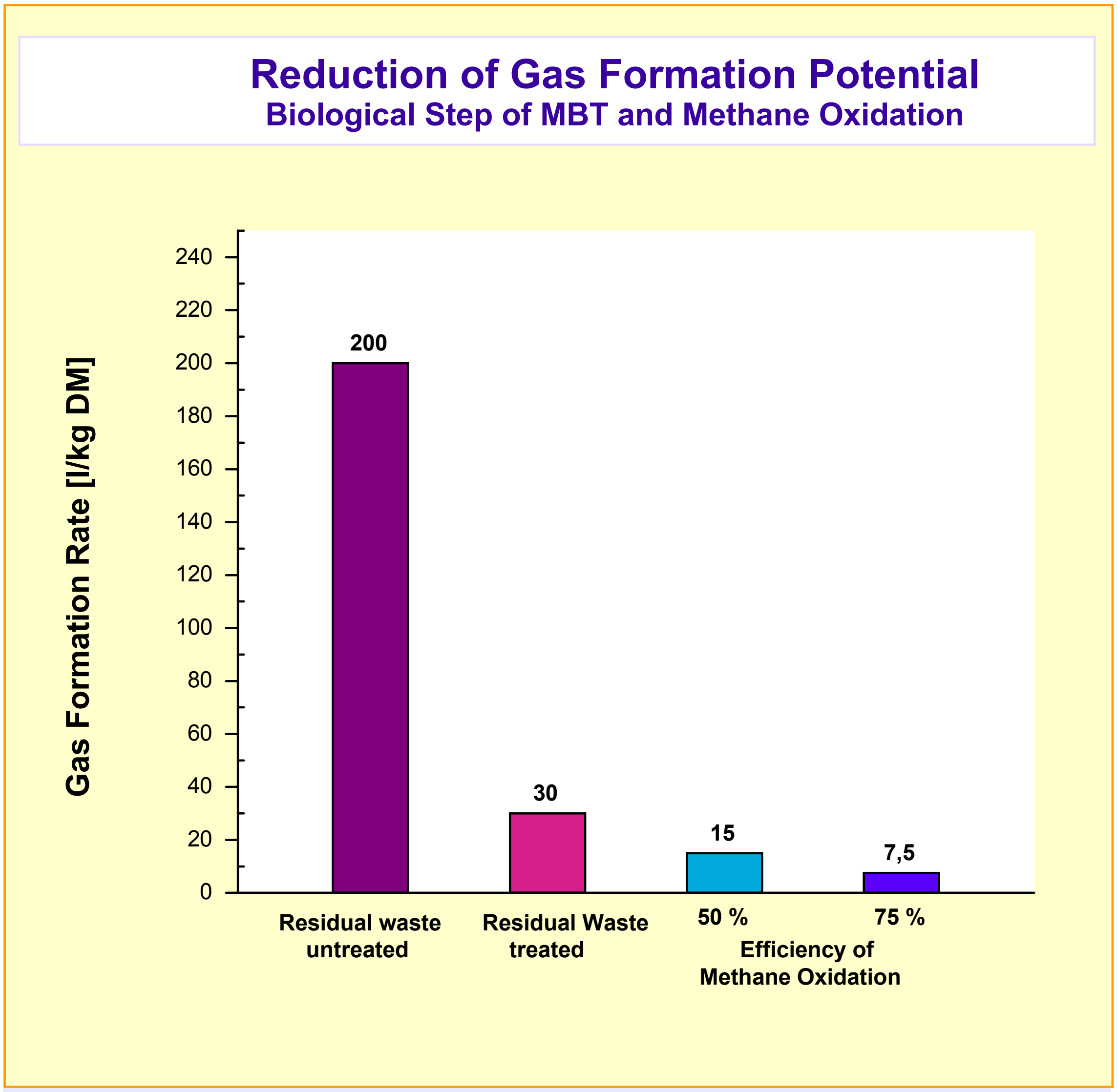


Figure 6: Reduction of Gas Formation Potential as a Result of Mechanical Biological Waste Treatment



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