1. Introduction, Waste Law
2. Types, amounts and composition of waste
3. Logistics (Collection + Transport)
4. Processing I+II
5. Basics of Biological Treatment Methods
6. Mechanical-Biological Treatment/ Immission Protection
7. Planning of a Composting Plant (Tutorial)
8. Process Technologies of Bio-Waste Treatment/ Dimensioning of a Fermentation Stage
9. Thermal Treatment of MSW I+II
10. Depositing I+II
11. Landfill Construction and Emission (Tutorial)
12. Landfill Leachate treatment
13. Contaminated Sites
14. Recycling - Processing and Utilisation (Glass, Paper, Plastics, Construction Waste, Scrap Wood)
15. Excursions to MBT

- General information

Institut für Siedlungswasserwirtschaft und Abfalltechnik
Course: Solid Waste Management
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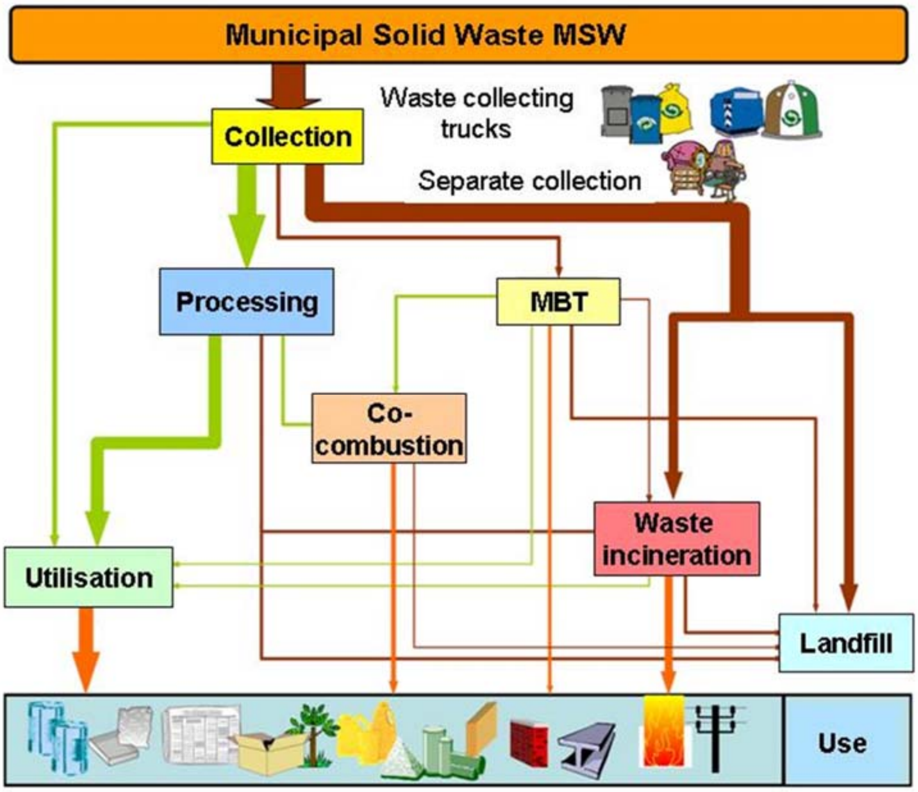
General Scheme of the Disposal Ways for Municipal Solid Waste



Significance of Waste Management

Specific Waste Amount in kg/(inh. * a)						
	2003	2004	2005	2006	2007	2008
Domestic Waste	192	189	169	173	167	174
Bulky Waste	32	31	26	27	28	30
Bio-Waste	42	44	46	46	46	48
Green Waste	47	51	48	49	55	54
Seperated	217	205	210	201	212	222
recovered Paper	102	94	96	98	99	104
Glas	40	38	43	23	27	30
LWP	60	57	56	55	61	60
electric Devices	1	1	1	5	5	6
others	15	15	15	19	20	22
Total	529	520	498	496	508	527

Waste Prevention and Utilisation

- Waste amounts can be reduced (= **waste prevention**) through:
  - low-waste production, reduced consumption, multi-cycle systems, durable products
- Residual waste amounts (waste for disposal) can be reduced and substituted through **material or energetic utilisation**:
  - Products which are suitable for utilisation, optimised separation of waste, stripping, processing, markets and quality requirements for recyclings (secondary resources)

Mass Preservation

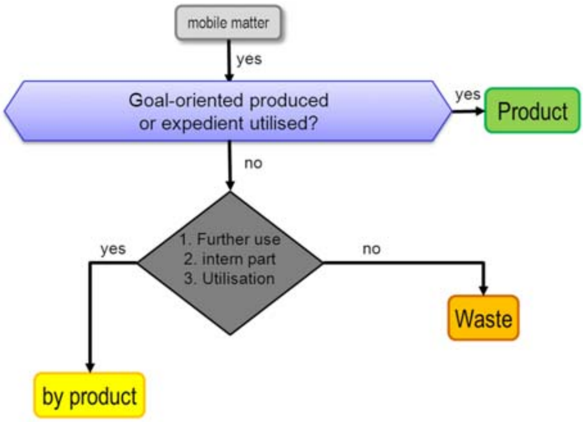
- Waste can not be eliminated,
  but only be re-used, utilised, treated, deposited.

- All processes of this kind are bound to cause environmental loads - „load packages" – (which can technically be minimised extensively), such as
  - land consumption for dumping grounds
  - ground water pollution loads below dumping grounds
  - air pollution through waste incineration
  - accumulation of pollutants in substance cycles

- Instead of emphasising technically high-grade end-of-pipe-technologies:
  - low-waste production
  - low-pollutant and recyclable products

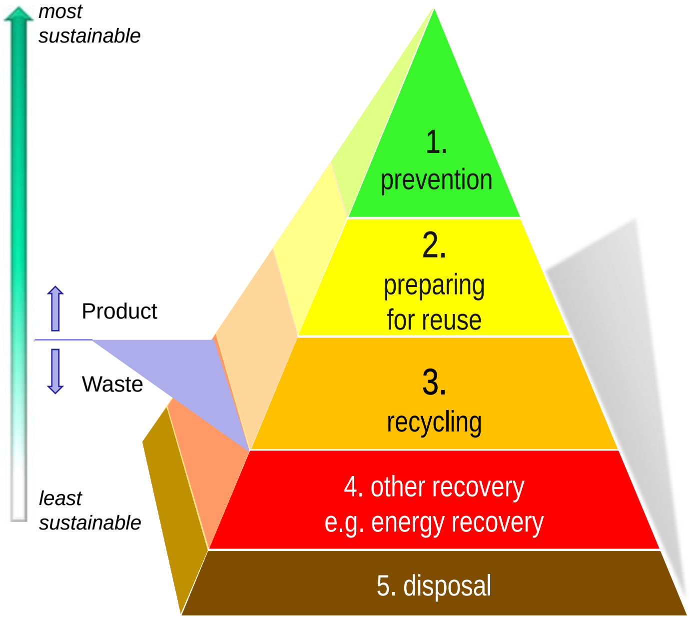
Legislation -EU Directive 2008/98/EC

- Classification of the waste item-



- subjective item

- waste hierarchy -



- Collection and Transport

Impacts on the Collection System

- The organisation of waste collections from households and collecting systems must be geared to the following influence parameters:
- Area structure; locations
- Economic structure
- Size of the collection area
- Amount of the waste per container or location and bulk weight
- Concept of separate collection of resources and pollutants
- Quality requirements of the ensuing disposal (e.g. sortability)
- Guarantee that the individual usage of the disposal services can be identified for the accounting of fees

Area Structures

Superior regional affiliation				**A. Metropolis; B. Mid-size town; C: Rural district**
Area structure	A	B	AS	Differentiation and explanation of the area structures and housing types
City-areas		> 1.000	I	compact intra-urban housing, marked by the high ratio of businesses with mainly mixed container usage
closed multi-Family housing			II	closed intra-urban housing with at least three, at most five storeys proper
	> 2.000 PE/sq. km		II a	Block housing with larger inner yards or open spaces, partly with small front gardens. Usage of the open spaces as flower gardens with larger lawn areas.
			II b	Terraced houses with smaller, partly sealed courtyards and little green
open multi-family housing		500 – 1.000 PE/sq. km	III	anonymous housing estates with single high-rise buildings and high ratio of council housing, greens, if any, limited to the areas between the buildings
			III a III b	3 to 5 storeys proper > 5 storeys proper
Detached and terraced house areas	1.000 – 2.000		IV	Residential areas with one to six family houses, mainly with their own gardens; subdivision according to accommodation units per lot
			IV a IV b	3-6 accommodation units per lot 1-2 accommodation units per lot
Low density housing			V	Low density housing in rural structures (single farmsteads, dispersed sttlements, rural settlements centres)
	< 1.000	< 500	V a V b	dispersed settlements rural settlement centres

Collectable Amounts/Bulk Weights/Container Volumes

Resource fraction or collection system	collectable amount kg/ (P·a)	Bulk weight kg/m³	Filling level %	Volume weight kg/m³	Specific container volume in relation to re-moval intervals (e.g. 2w = twice per week) L/(P·1w)	 L/(P·2w)	 L/(P·3w)	 L/(P·4w)
Recovered paper (mono-substance container)	(40-60) 50	100	80 90	80 90	12	24	 33	 43
Light material container DSG for SP, scrap metal and composite packing material	(10-25) 20	(25-70) 45	80	36	11	21	32	43
Bio-waste and green waste Delivery system green waste Collection system Bag+Bag **Bio-waste container** kitchen waste only Bio-waste (kitchen + garden waste) Bio-waste	 5 - 30 (20-60) 40 (30 -70) 65 115 180	 200 300 250 220	 90 70 60 70	 - 210 150 154	 4 6 15 22	 9 (12) 30 45	 13 - - -	 17 - -

Locations and Container Volumes

- Locations → < 15m; Building Code; area demand for separate collection
- Calculation of the required container volume

$$V_{B,min}(L) = \frac{w_p \cdot P}{\rho \cdot 52 \cdot R_w} \cdot S$$

$V_{B,min}$ [L]	mathematical minimum container volume
w_P [kg/(I·a)]	waste weight per inhabitant (person) per year
P [-]	inhabitants/persons connected to the collection container
ρ [kg/L]	bulk weight of the waste (contents weight/filled container volume)
52 [-]	weeks per year
R_W [1/W]	removals per week
S [-]	peak factor (peak amount/average amount) or = 1/average filling level with residual waste= ca. 1,2 -1,3 with bio-waste (seasonal) = up to approx. 2

- Comparison $V_{B,min}$ with standardised container sizes and container selection
- available container volume $V_{B,Person}[L/(P \cdot week)] = \frac{V_B}{P} \cdot R_W$

Example

Collection Rates- Potentials beyond DW/RW

Recycling **potential** =

$$\mathbf{R + (R_{fraction}(DW)\% \cdot DW)} + (R_{fraction}\%(BW) \cdot BW) \qquad [kg/(Inh \cdot a)]$$

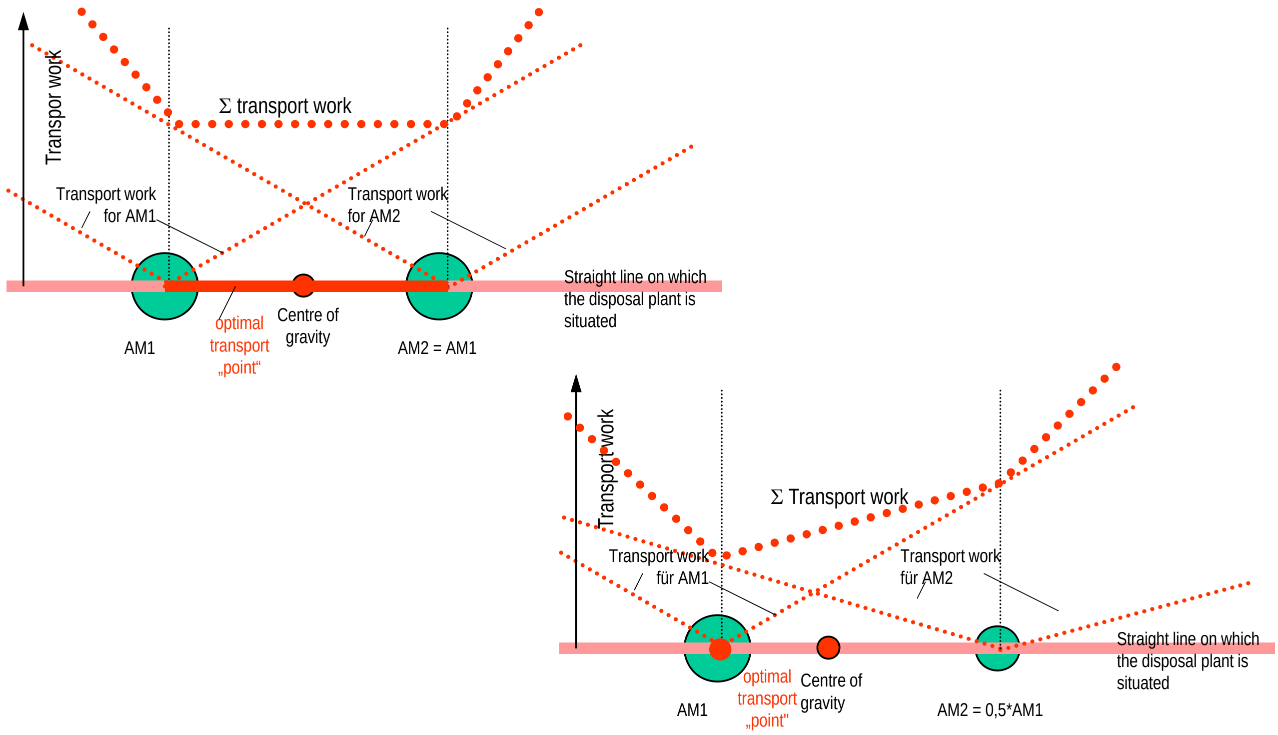
$$\text{Collection rate} = \frac{\text{separately collected resource amount}}{\text{Recycling potential}} \qquad [\%]$$

$$\text{Utilisation rate} = \frac{\text{utilised amount of resource}}{\text{Recycling potential}} \qquad [\%]$$

$$\text{Pollutant content} = \frac{\text{not utilised ratio of resource}}{\text{entire collected amount of resource}} \qquad [\%]$$

R = resource amount, DW = domestic waste, BW = bulky waste

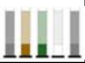
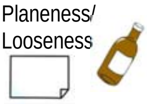
no centre, but point of lowest transport work



- Treatment

Survey of Processing Methods

- Waste = used products; unstructured, mixed, soiled;
- Separate collection + processing
- Waste processing methods have mainly been copied from the processing of original raw materials and, if necessary, been modified for waste processing. Only a few of these methods have been specifically developed for waste processing

Distinguishing mark	Single methods or aggregate	Environment	Exploited material properties	Application examples for the sorting of potential recyclables
Grain size 	Comminution with mills, shears, cutting and screw rollers, crushers	dry	Hardness, brittleness, elasticity	Separation of (elastic) metals from (brittle) ceramic and glass parts
	Pulper with tearing, grinding and suspending	wet	Loss of bonding	Suspension of cellulose fibres and separation of non-fibrous materials
	Sieving	dry wet	Grain size	Vibrating screen, tension screnn, drum screen, bucket screen Rake, arc or drum sieve
Suspension velocity 	Air sorter Hydraulic sorter	dry wet	Size, density, shape, inertia, wettability	Vertical, zigzag and ballistic sifters, jigging machine, oscillating table; float/sink sifter, flotation, hydraulic jigging machine and oscillating table
Planeness/ Looseness 	Rolling goods separator, Slanting belt sorter	Dry	Rolling movement of round parts, adhesion of flat, lighter parts	Separation of round glass and plastic containers from paper, cardboard, and of round building rubble from flat light materials

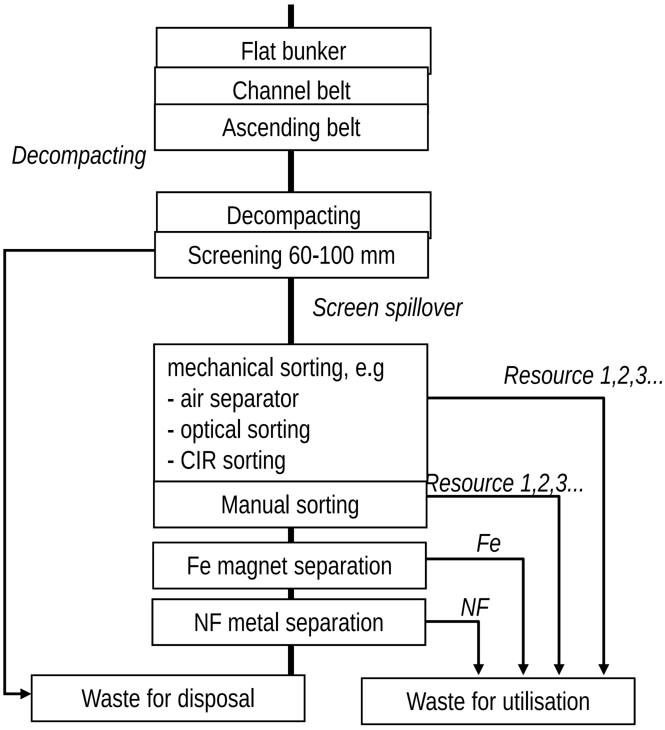
Survey of Processing Methods

Distinguishing mark	Single method or aggregate	Environment	Exploited material property	Application examples for the sorting of potential recyclables
Magnetic and electric properties 	Magnetic separator	dry	Magnetisability	conveyer belt and drum magnet for the separation of magnetisable metals
	Electro-static or	dry	Surface conductivity	Separation of plastic and paper
	electro-dynamic methods	dry	Conductivity for the production of an eddy-current	Separation of materials with different conductivity, for instance metal and glass
Optical properties 	Optical recognition and sorting	dry	Light transmission and -reflection; colour spectrum	Separation of glass/ceramics; sorting of glass according to colours, diamonds, peas
Visual/optical appearance 	Picture recording, picture evaluation for manual/mechanical picking methods	dry	Colour, size, type, shape, quality	Manual sorting of glass according to colours, wastepaper according to quality, sorting of commercial waste
Chemical or physical properties	Analysers with EDP evaluation and ensuing picking methods	dry	Material properties	Separation of plastic types; extraction of extraneous material

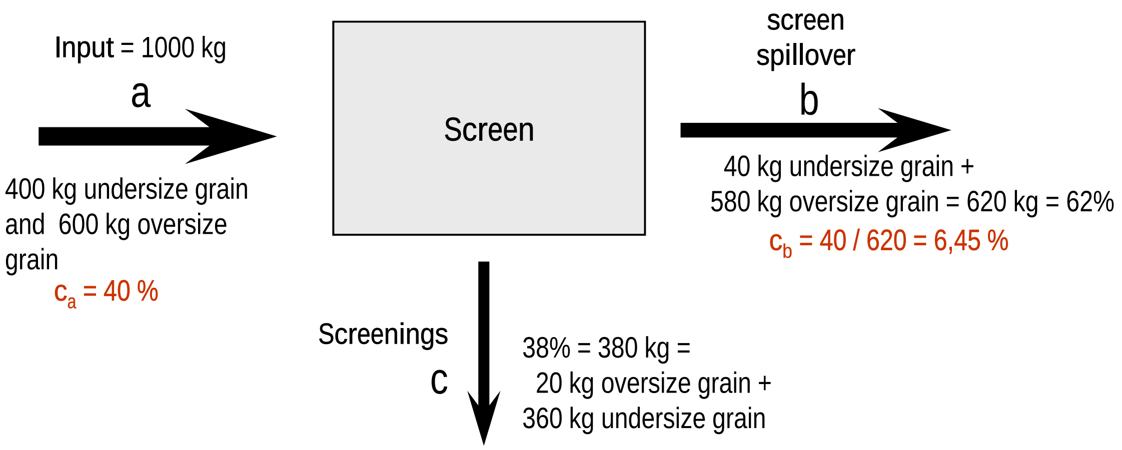
Processes and Techniques

- Communition (Mills, Grinder, Breaker, etc.)
- Separation (Sieves, Screens, Classifier (wind, magnetic, induction, ballistic)), NIR-Sorting
- Treatment (mechanical, biological, chemical)
- Reuse (material, energetical)

Typical Components of a Resources Sorting Plant



Example Sieving Quality Grade



c_c = 360 / 380 = 94,7%

Screening quality grade s (%) = $\frac{(c_a - c_b) \cdot (c_c - c_a) \cdot 100}{(100 - c_a) \cdot (c_c - c_b) \cdot c_a} \times 100$

c_a = undersize grain contents (%) of the charging goods
c_b = undersize grain contents (%) of the screen spillover
c_c = undersize grain contents (%) of the screenings

s = (40 - 6,45)·(94,7 - 40) · 100 · 100% / ((100 - 40) · (94,7 - 6,45) · 40)
= 86,6 %

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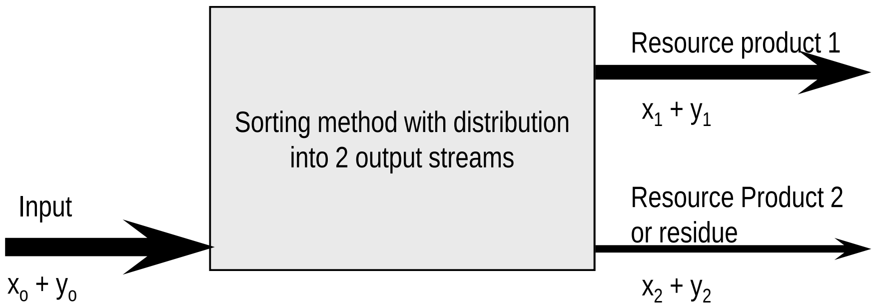
Evaluation of Sorting Methods – Distribution to 2 Sorting Streams



x_0 = Mass flow of product x in the input = $x_1 + x_2$
y_0 = Mass flow of product y in the input = $y_1 + y_2$

Mass output rate M_{x1} (%) = $100 \cdot x_1/x_0$; ideal $x_2 = 0$, then $M_{x1} = 100\%$

If one calculates in concentrations $c_0 = x_0/(x_0+y_0) = x_0/m_0$ etc.,

the mass output rate amounts to $M_{x1}\ (\%) = \frac{m_1 \times c_1}{m_0 \times c_0} \cdot 100$

Purity grade P_{x1} (%) = $100 \cdot x_1/(x_1+y_1)$

- Biological Treatment and MBT

Process Targets / Differences between Types of Biological Treatment

- Target of Composting: Conversion of low-pollutant bio-chemically treated waste for utilisation into marketable products for application on soils (for requirements, see BioAbfV (Bio-Waste Ordinance)
- Target of the mechanical-biological preliminary treatment (MBT) of (residual) waste: stabilisation of the bio-degradable organic substances in the waste, low-emission material for depositing (dumping), no utilisation
- (for requirements, see ...AbfAblV)
- **aerobic** biological treatment: Composting or rotting as exothermic bio-checmial oxidation of organic substances under aerobic conditions with addition/admission of air (oxygen) with conversion into humus complexes and CO_2, H_2O, and NH_3/NO_x as well as biomass.
- **anaerobic** biological treatment: fermentation as endothermic bio-chemical conversion under anaerobic conditions without admission of air or O_2 into CH_4, CO_2, and NH_3/NH_4 biomass (little)

Degradation of Organic Substance

- Compostable organic substance is classified according to its degradability degree:
  - **easily degradable** substances: sugar, starch, cellulose, hemi-cellulose, pectin, protein compounds
  - **persistent** substances: lignin, resins, waxes, some fats
  - **hardly degradable** substances: rubber, plastic
- Time-dependent degradation of the organic substance is often described with First Order degradation kinetics (here not differentiated according to different degradability degrees):

$dc/dt = k \cdot c$, or.

$c_t = c_0 \cdot e^{-k \cdot t}$. i.e. $\mathbf{oDM_t = oDM_0 \cdot e^{-k \cdot t}}$

$e^{-k \cdot t} = (IL_t \cdot IR_0) / (IL_0 \cdot IR_t)$

with:

IL_0	Ignition loss (%) at the begin of the rotting
IL_t	Ignition loss (%) at a point of time t
k	Velocity coefficient = f (moisture, temperature, substrate, grain size, nutrient salt contents, conversion frequency, etc.
IR_0	Ignition residue (%) at the begin of the rotting
IR_t	Ignition residue (%) at a point of time t

Mass Balances from Analysis Values

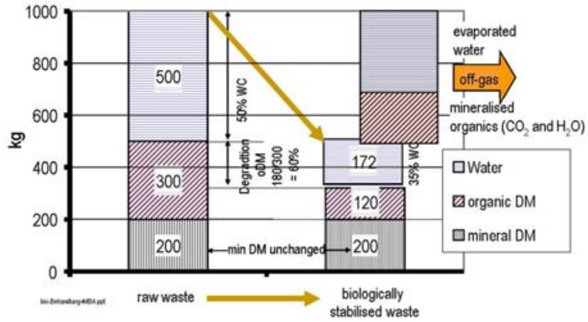
Normally, it is not possible to fully weigh the partial masses; these value are calculated from analysis values:

MOIST SUBSTANCE DEGRADATION (%)	$= \left[1 - \frac{DM_0(\%) \cdot IR_0(\%)}{DM_t(\%) \cdot IR_t(\%)}\right] \cdot 100$	example: [1-(50·40/ 65·62,5)] · 100 = 50,8 %
DRY MATTER DEGRADATION (%)	$= \left[1 - \frac{IR_0(\%)}{IR_t(\%)}\right] \cdot 100$	example: [1-(40/ 62,5)] · 100 = 36 %
ORGANIC DRY MATTER DEGRADATION (%)	$= \left[1 - \frac{IL_t(\%) \cdot IR_0(\%)}{IL_0(\%) \cdot IGR_t(\%)}\right] \cdot 100$	example: [1-(37,5·40/ 60·62,5)] · 100 = 60%

with:
Dry matter DM being calculated in % of the moist substance MS, and
Ignition Residue IR and Ignition Loss IL in % of the DM..

Through degradation of the oDM, non-degradable ingredients (such as heavy metals and other non-degradable substances) accumulate in the remaining DM:

ACCUMULATION:	= 100 / (100 – Dry matter degradation (%))



Necessary Air Volumes (1)

The aeration of the composting has the following functions and effects:

- **Oxygen supply**,
- **Transport of surplus heat** = cooling (often necessary so that maximum temperatures are not exceeded)
- **Moisture output** with the heated rotting exhaust air (mostly undesirable; it must thus be equalixed through secondary moistening to prevent the drying up of the rotting material)
- **Air exchange rates** in the rotting areas (necessary and often required for reasons of occupational safety).

Oxygen demand with assumptions:

1,714 kg O_2 / kg oDM degradation

15 Vol.-% O_2 (surplus air λ = 21/ (21-15) = 3,5) in the exhaust air

Oxygen demand (kg O_2 / Mg moist waste)
= 1,714 (kg O_2 / kg oDM degradation) * 300 kg oDM / Mg MS * 60% oDM degradation
= **308 kg O_2 / Mg MS**

necessary supply air amount (m_n^3/ Mg MS) $= \frac{Oxygen-demand}{0{,}21 \bullet (32/Mol-volume)} * \frac{21}{21 - Residual-oxygen-contentses}$

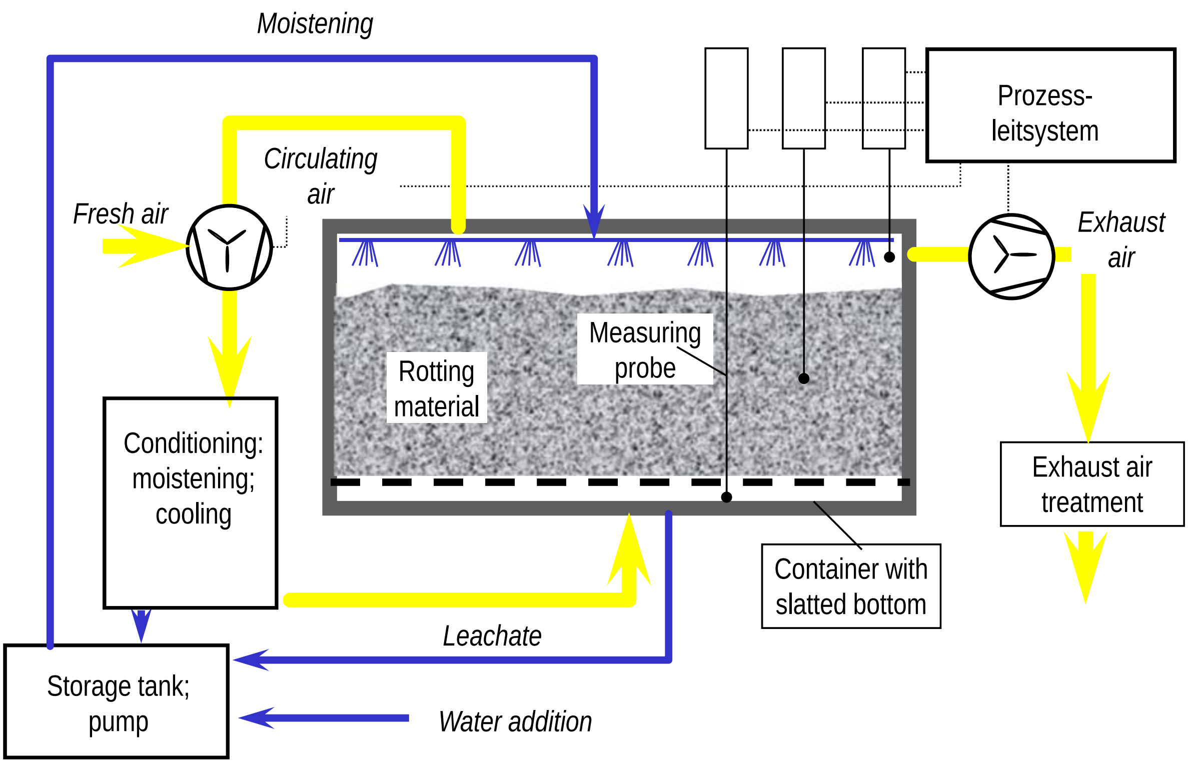
$$= \frac{308}{0{,}21 \bullet 32/22{,}4} * \frac{21}{21-15} = \mathbf{3593\ m_n^3/\ Mg\ MS}$$

or with 10 weeks rotting period on average: 3593 / 10 * 7 * 24 = **2,145 m_n^3** dry supply air / (Mg MS * h)

Systematics of Composting Methods

- closed
  - active aeration
    - dynamic
      - drum
    - quasi-dynamic
      - Multi-storey reactor
      - Tunnel
      - Tower
      - Containers; Boxes
    - static
      - Tower
      - Containers; Boxes
  - passive aeration
- housed- in
  - active aeration
    - static
      - Planar/trapezium heaps
      - Terraced heaps
      - Triangular heaps
  - passive aeration
    - static
      - Planar/trapezium heaps
      - Terraced heaps
      - Triangular heaps
      - Bricollare briquettes
- open or canopied
  - active aeration
    - static
      - Planar/trapezium heaps
      - Terraced heaps
      - Triangular heaps
  - passive aeration
    - static
      - Planar/trapezium heaps
      - Terraced heaps
      - Triangular heaps
      - Bricollare briquettes

Process Components of Closed Intensive Rotting



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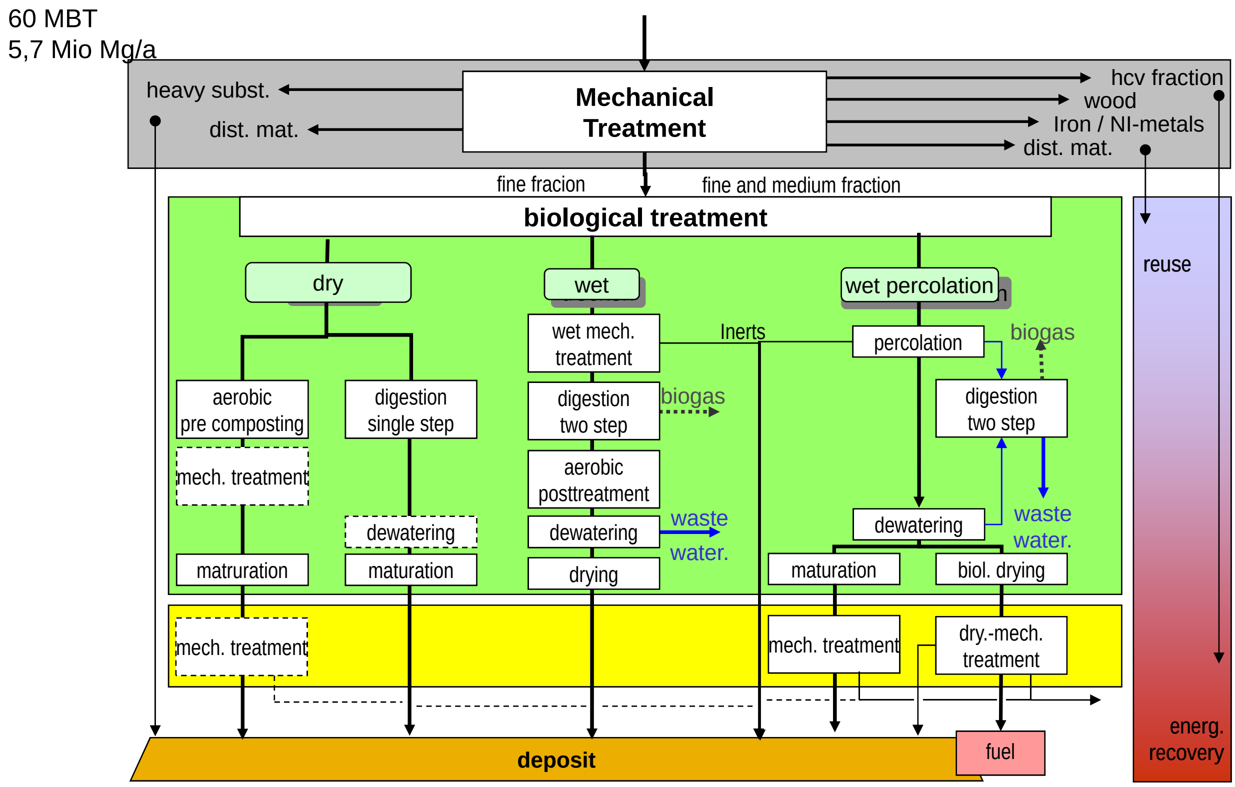
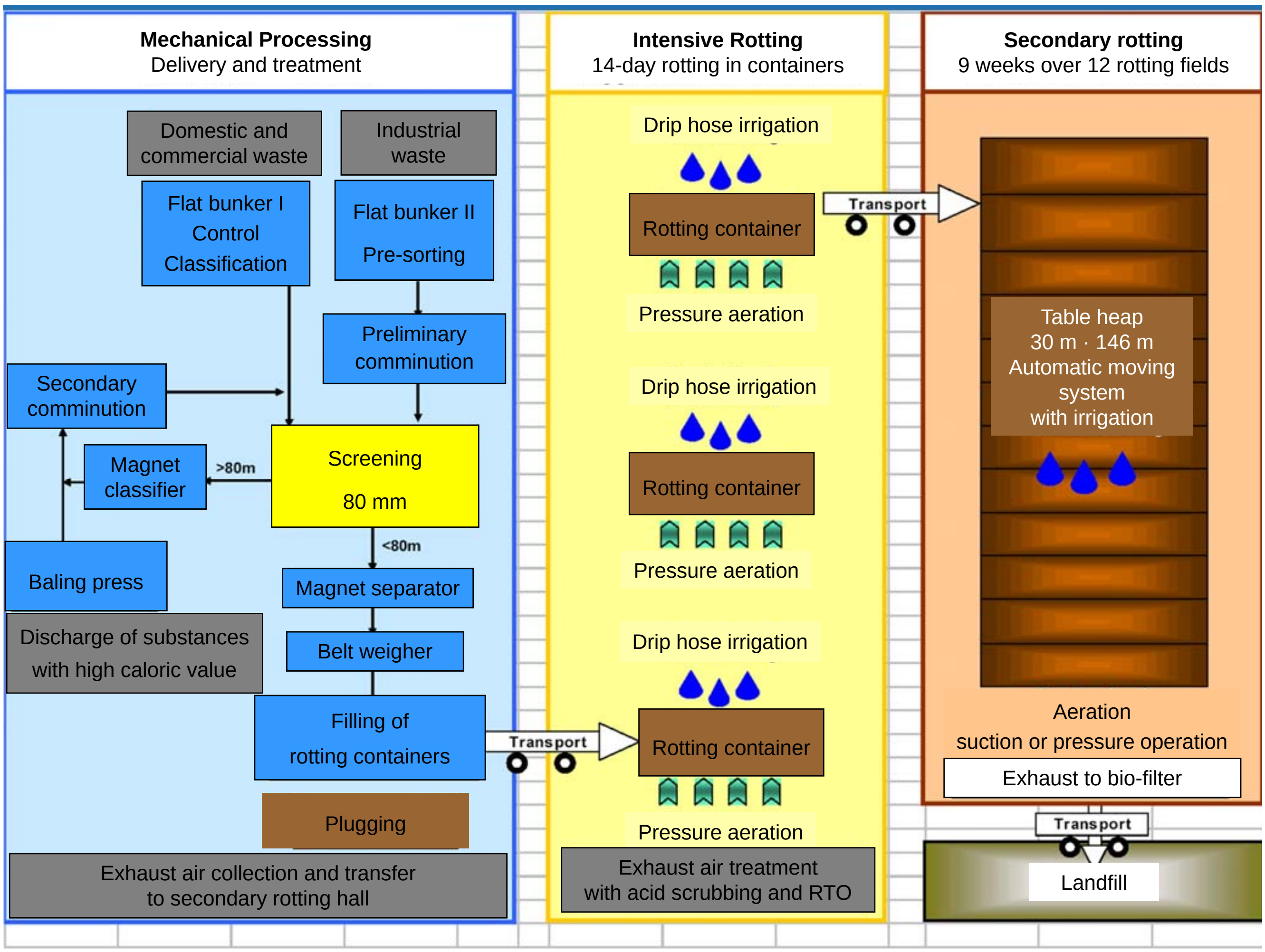
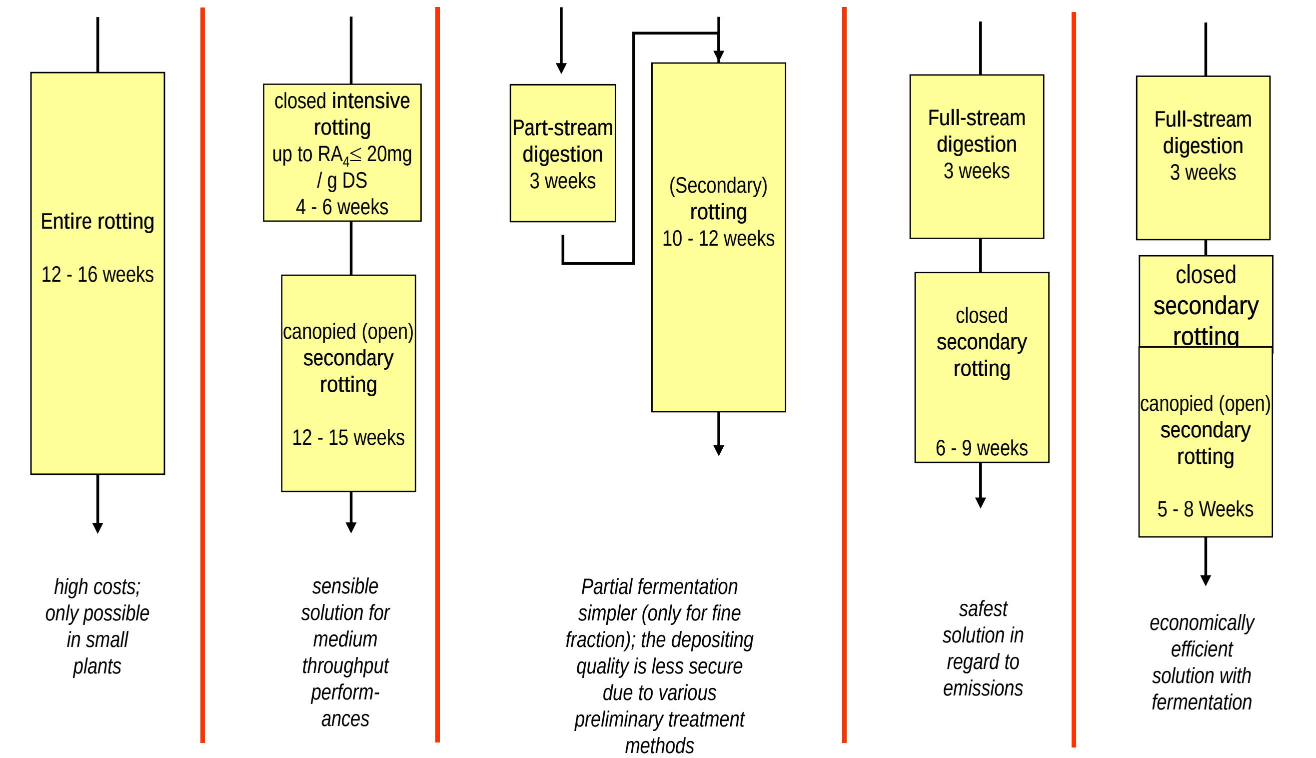
MUNICIPAL Solid Waste (MBT) (HW+TW; BW; hs TW, org. ind. waste, sewage sludge)



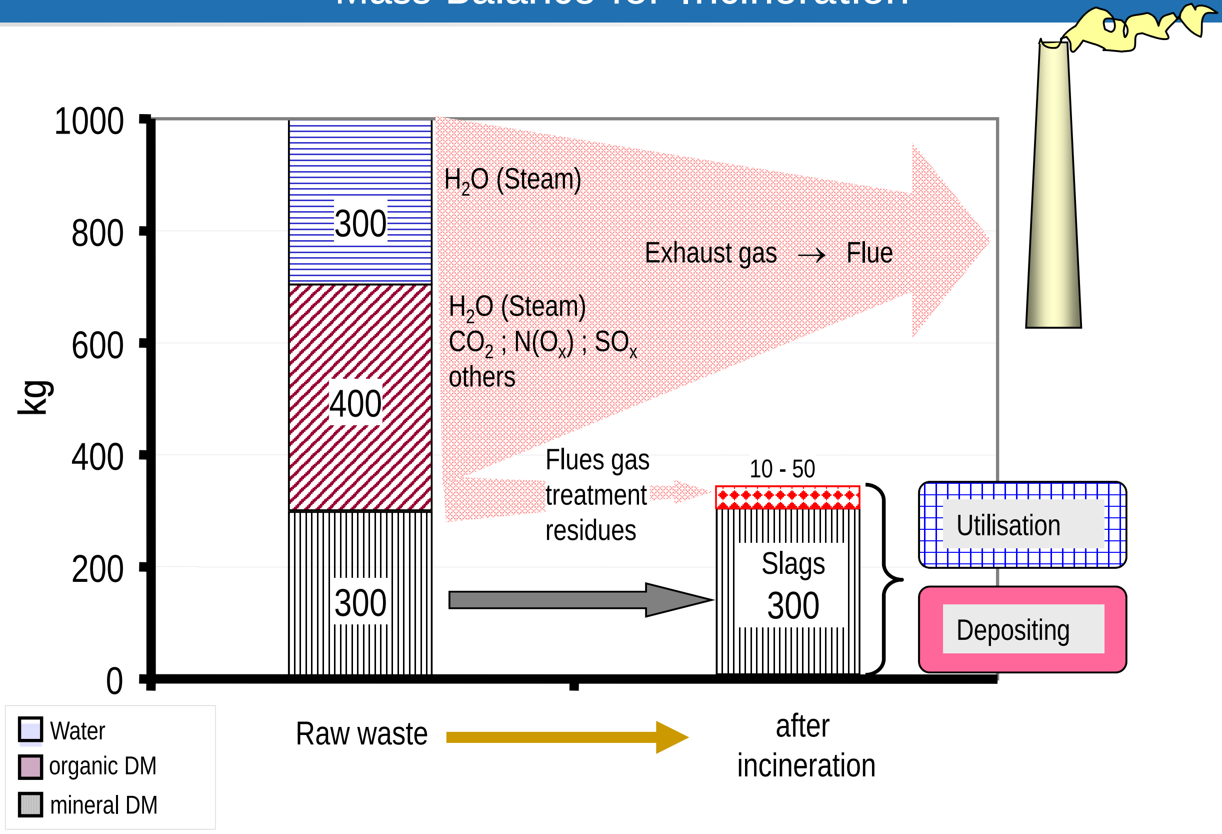


MBT Concepts for Biological Treamtent of Deposit Waste according to Waste Depositing Ordinance

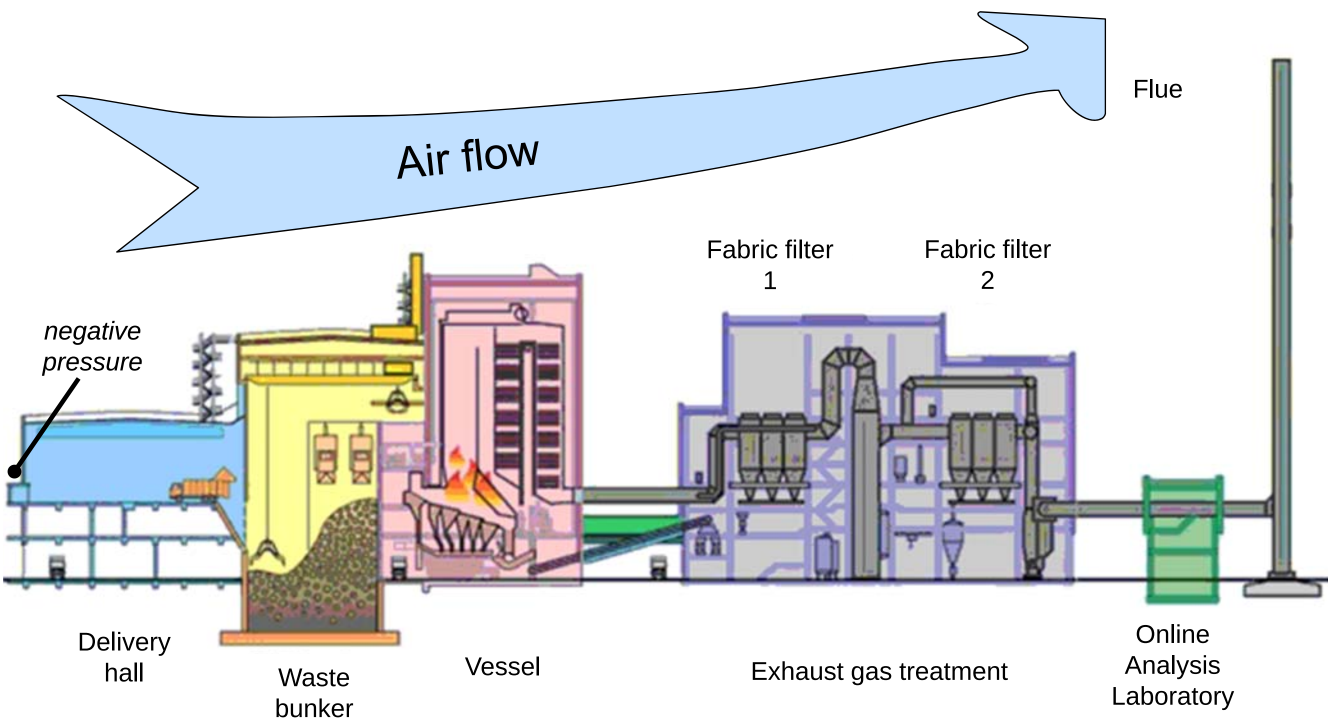


- Thermal Treatment

Mass Balance for Incineration



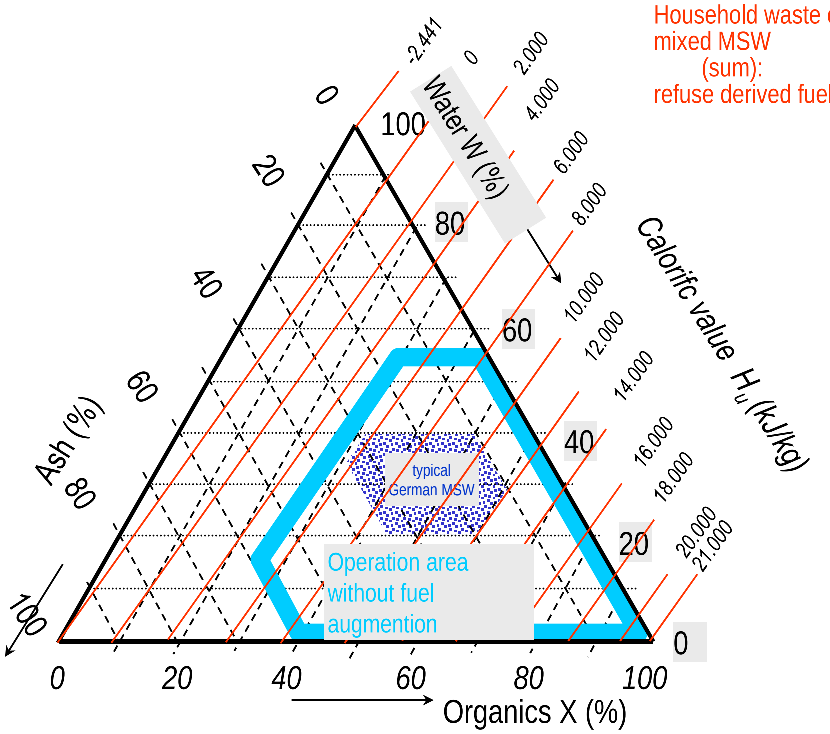
Main Processes at Waste Incineration Plants



Exhaust Gas Volumes – Calculation Example

		C	H	S	O	N	Water W	Ash A	Off gas	total
Waste components	kg/kg	0.25	0.04	0.0015	0.03	0.015	0.3	0.32		1.00
Factors for Lmin	m³/kg	8.88	26.44	3.32	-3.32	0	0	0		
Incineration air L_{min}	m³/kg	2.22	1.058	0.005	-0.100	0	0	0		3.18
Excess air coefficient λ=1,6	-									1.6
Incineration air L	m³/kg									5.09
Factors for dry exhaust air mass	m³/kg	1.85		0.68		0.80			λ–0.21	
dry exhaust gas amount $V_{a,tr}$		0.463		0.001		0.012	+ 3,18*(λ-0.21) =			4.90
Factors for moist exhaust gas amount	m³/kg		11.11				1.24			
moist exhaust gas amount $V_{a,f}$	m³/kg		0.4444				0.372			5.72
Water in supply air	kg/kg						0.01			
Factors for moist exhaust gas amount	m³/kg						1.6			
Steam from supply air moisture	m³/kg								0.08	0.08
total exhaust gas amount	m³/kg									5.80
O_2 contents in exhaust gas	Vol-%	((λ-1) * 3.18 *0 .21 * 100)/total exhaust air amount =								6.92
Factors for H_u (cf. Ch. 2)	kJ/kg	34,000	121,500	10,500	-15,188		-2.441			
Calorific value acc. to Association **Formula** cf. Section 2.5.8	kJ/kg	8,500	4,860	16	-456		-732			12,188
$L_{min,Reimer}$	m³/kg	0.241 * (Hu (kJ/kg)+ 2,300)/1,000								3.49
$L_{min,Recknagel}$	m³/kg									3.44
$V_{a,min,Reimer}$	m³/kg	1.17 + 0.216 * (Hu (kJ/kg)+ 2,300)/1,000								4.30
$V_{real,min,Reimer}$	m³/kg	1.17 + 0.216 * (Hu (kJ/kg)+ 2,300)/1,000 + (? – 0.21) * $L_{min;Reimer}$								6.39

Incineration Triangle of MSW



Household waste only	$H_{u,raw}$ = ca. 7,000 – 9,000 kJ/kg
mixed MSW	$H_{u,raw}$ = ca. 8,000 – 11,000 kJ/kg
(sum):	$H_{u,raw}$ = ca. 5,000 – 12,000 kJ/kg)
refuse derived fuel (RDF)	$H_{u,raw}$ = ca. 11,000 – 20,000 kJ/kg

Furnace Systems and their Suitability for Waste Incineration

Waste quality	Grate incinerator	Multi-hearth furnace	Fluidised bed reactor	Rotary furnace	Combustion chamber
solid	2	1	1	3	0
coarse	0	0	2	3	1
low melting point	2	3	3	3	0
grainy	2	3	3	3	0
high ashes ratio	2	0	0	3	0
pasty, highly viscous	0	0	2	3	1
water organic sludge	0	2	3	3	0
liquid organic	0	0	2	2	3
halogen-organic	0	0	2	2	3
Gases	0	0	2	2	3

0 = not suitable 1 = suitable after preliminary treatment
2 = suitable 3 = highly suitable

- Grate incinerators only for solid waste, such as domestic waste, bulky waste, domestic waste-like commercial waste
- Fluidised bed reactors for homogeneous small-size and sludge-like waste, such as sewage sludge mono-incineration
- Rotary furnaces for almost any consistency, thus usable for special waste with very heterogeneous consistency

- Disposal

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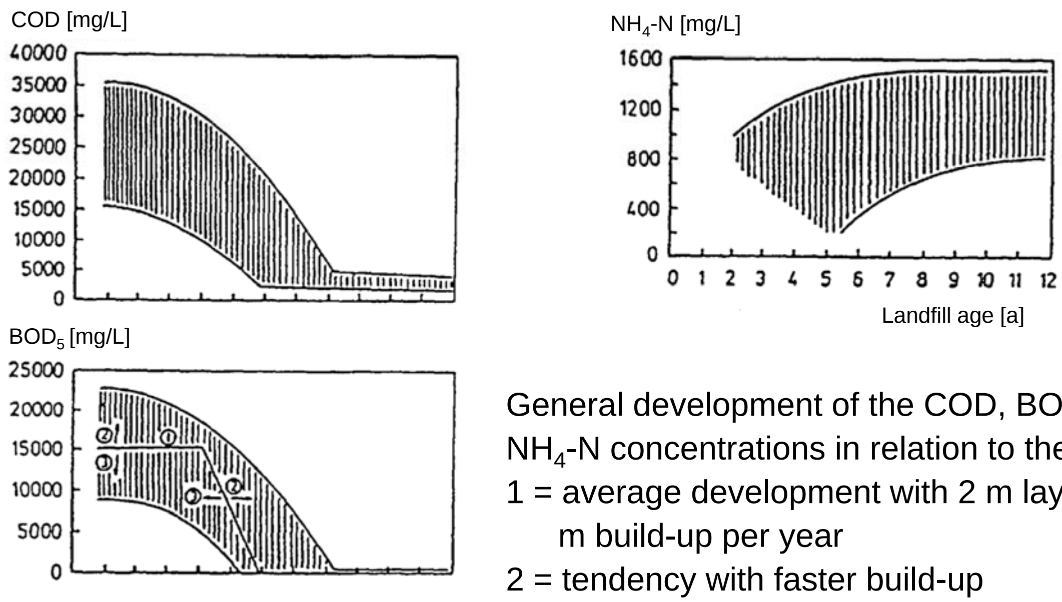
General Development of the COD, BOD_5 and NH_4-N Concentrations

in Relation to the Landfill Age and the Landfill Operation



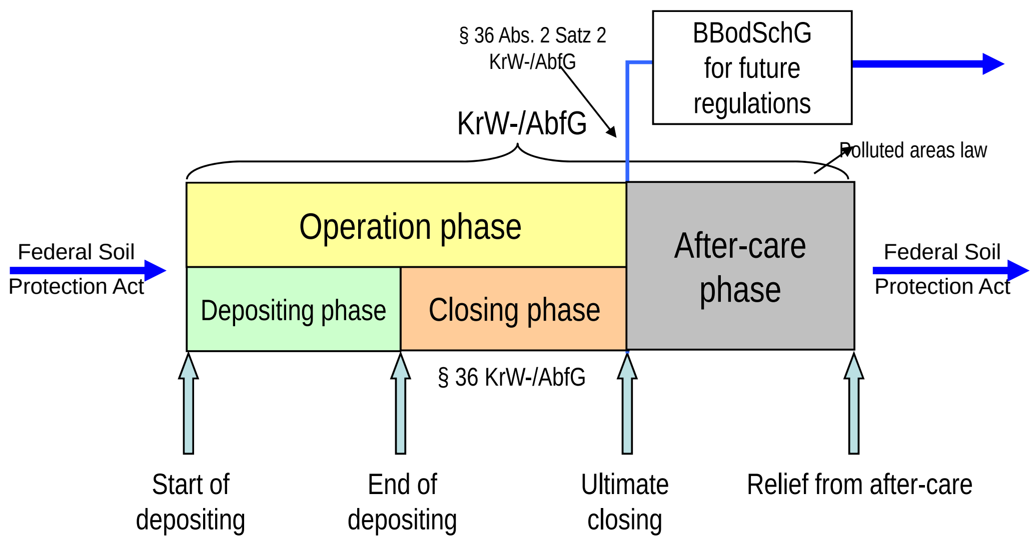
General development of the COD, BOD_5 and NH_4-N concentrations in relation to the landfill age

1 = average development with 2 m layers and 2-4 m build-up per year

2 = tendency with faster build-up

3 = tendency with slower build-up or recirculation

Relation of Waste Law (Landfill Directive) to Soil Protection Law

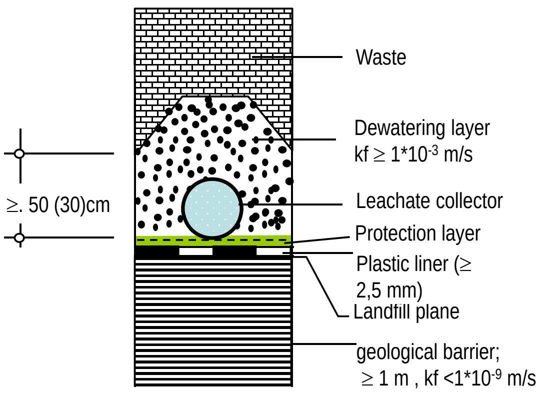


- §3 Section 1, No. 2 BBodSchG (Federal Soil Protection Act) states that the BBodSchG is applied for regulations of the KrW-/AbfG (Recycling Waste Management Law) on the licensing and operation of waste depositing plants and on the closing of landfills as fas as these directives do not regulate effects on soils.

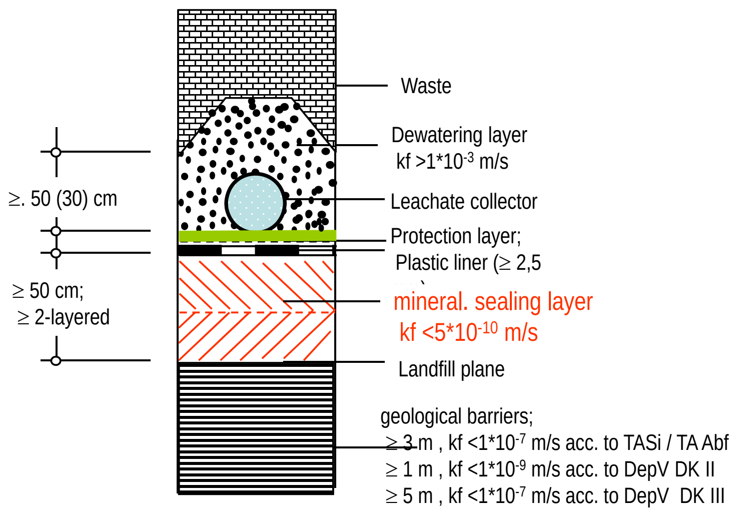
Landfill Categories

DK 0	DK I	DK II	DK II	DK III	DK IV
A	B1a & B1b	B2	B3	C	D_{Haz}
Landfill for inert Waste	Landfill for non-hazardous waste Sub-category for **non-organic** waste with low organic/ bio-degradable substances (specific criteria may apply)	Landfill for non-hazardous waste (*) Sub-category for **mainly organic** waste. can be sub-divided into bio-reactor landfill and landfill for pre-treated organic waste. (specific criteria may apply)	Landfill for non-hazardous waste (*) Sub-category for mixed waste with high ratio of organic/ bio-degradable and inorganic substances (specific criteria may apply)	Landfill for hazardous waste. The waste can be compacted in a stable or a loose way	Underground landfill for hazardous Waste

Landfill Bottom Sealing according to DepV (and TASi)

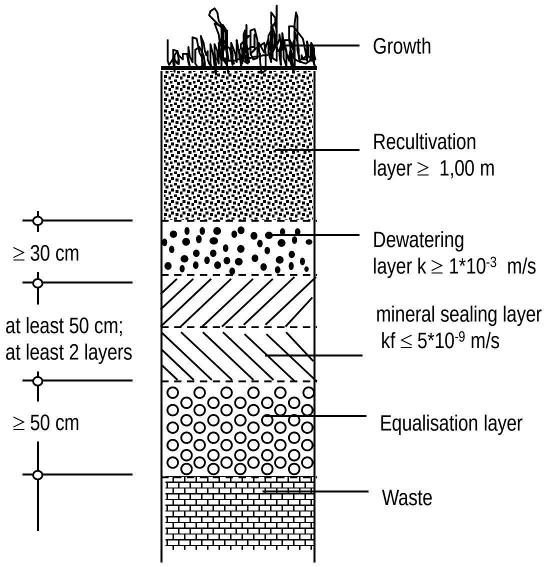


Bottom sealing
Landfill Category I

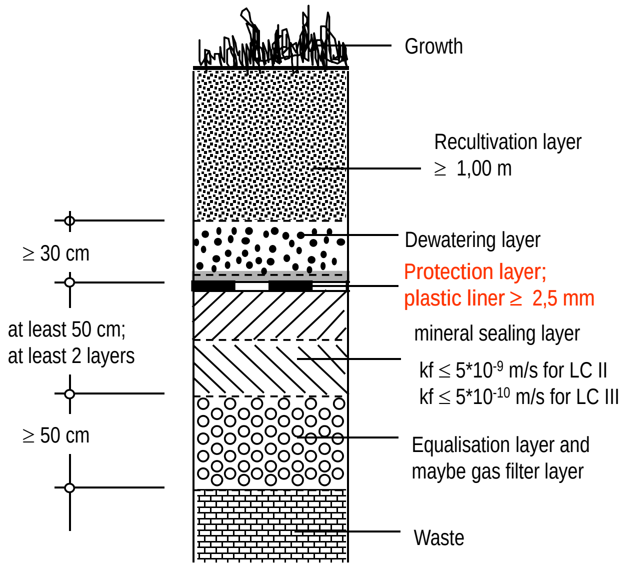


Bottom sealing
Landfill Categories II and III

Landfill Surface Sealing according to DepV



Surface sealing
LC I



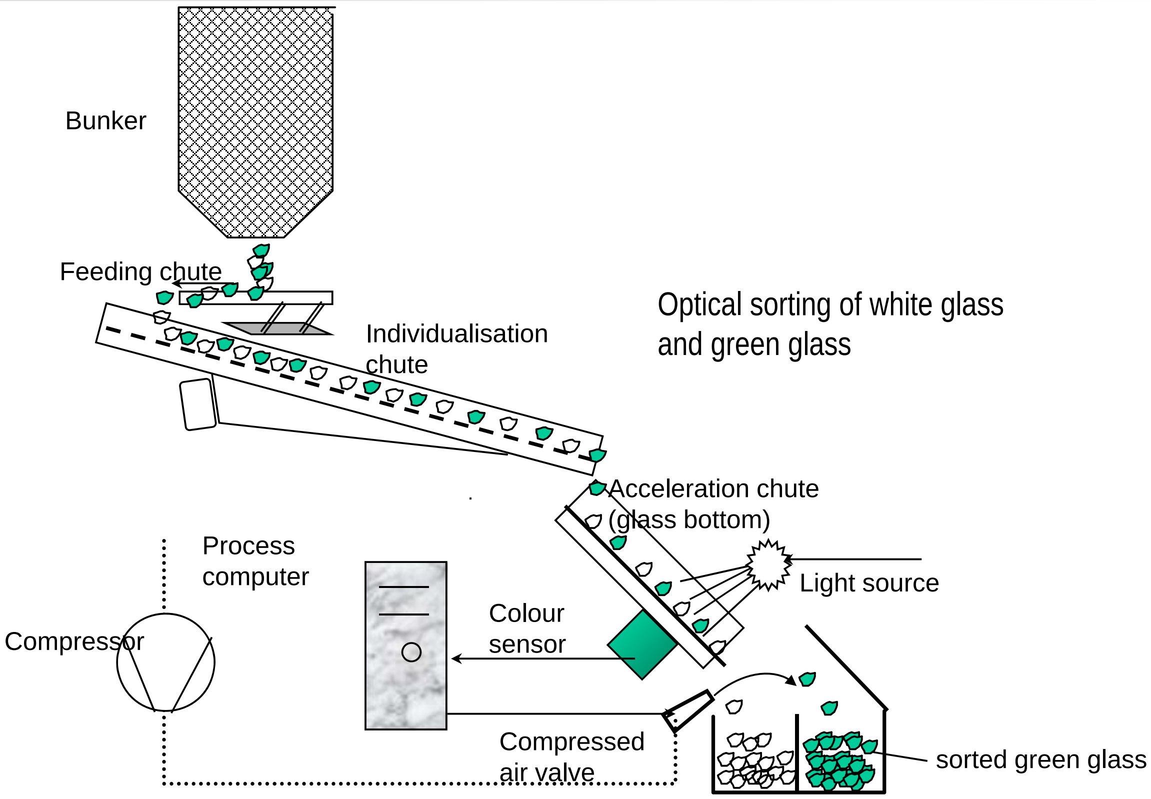
Surface sealing
LCs II and III

Landfill Gas Components

COMPONENT		CONCENTRATION RANGE	
Methane	CH_4	0- 70	Vol.-%
Carbon dioxide	CO_2	0- 50	Vol.-%
Hydrogen	H_2	0- 3	Vol.-%
Oxygen	O_2	0- 21	Vol.-%
Nitrogen	N_2	0- 78	Vol.-%
Carbon monoxide	CO	0- 3	Vol.-%
Ammoniac	NH_3	0-100	Vol.-ppm
Ethene	C_2H_4	0- 65	Vol.-ppm
Ethane	C_2H_6	0- 30	Vol.-ppm
Acetaldehyde	CH_3CHO	0-150	Vol.-ppm
Acetone	C_2H_6CO	0-100	Vol-ppm
other HCs, without aromatics	C_2-C_{11}	each 0- 50	Vol-ppm
Hydrosulphide	H_2S	0-100	Vol-ppm
Ethyl mercaptan	C_2H_5SH	0-120	Vol-ppm
Benzol, Toluol, Xylol	C_nH_m	0- 15	Vol-ppm
HFC	$C_wH_xCl_yF_z$	0-600	mg/m^3

- Recycling and Reuse

Optical Sorting of White Glass and Green Glass

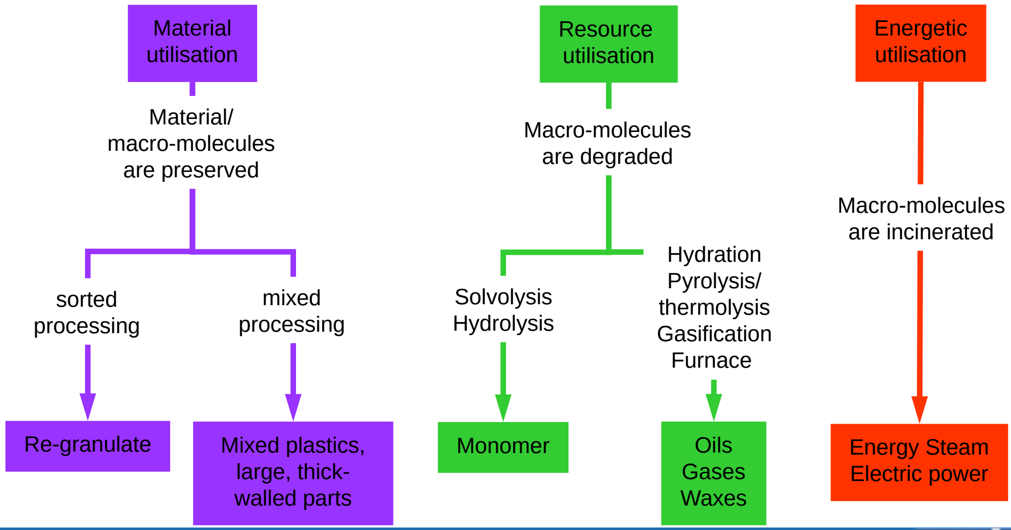


Optical sorting of white glass and green glass

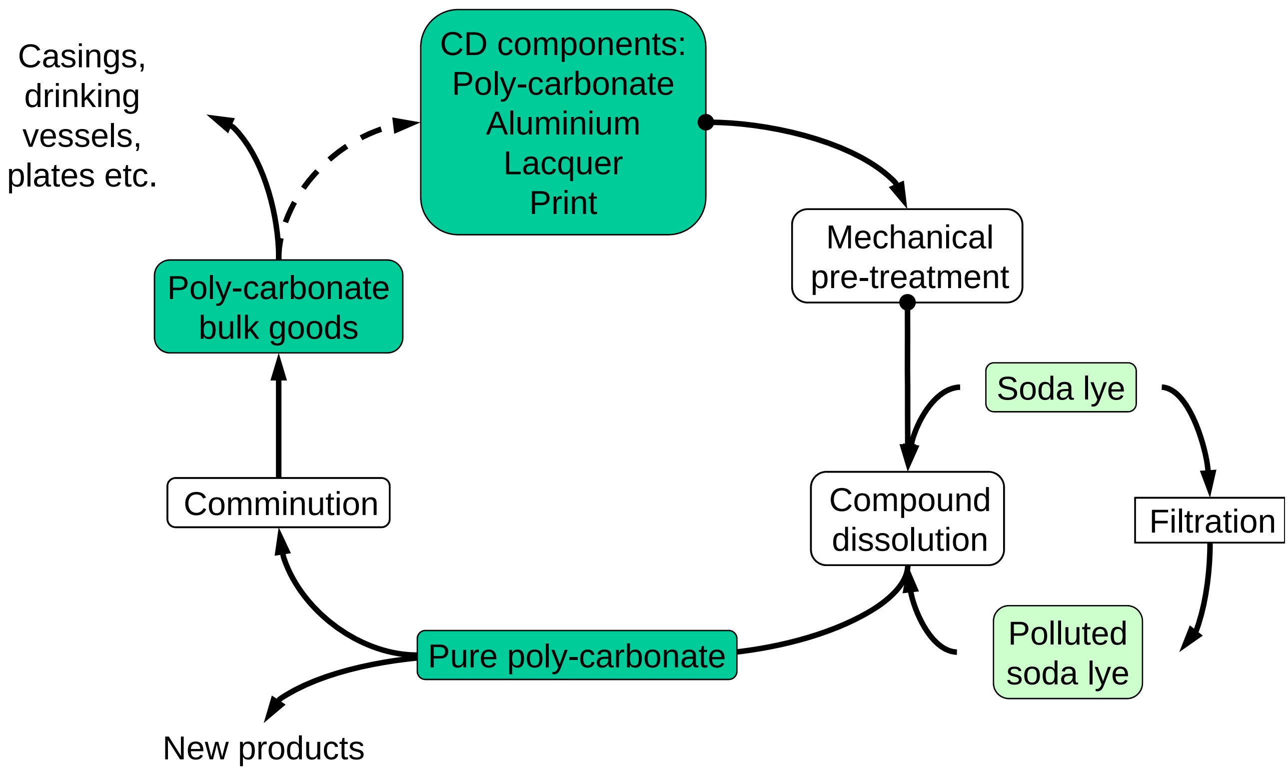
Institut für Siedlungswasserwirtschaft und Abfalltechnik
Course: Solid Waste Management
Dr.-Ing. Dirk Weichgrebe
Leibniz Universität Hannover

Recycling of Plastics

Production and Utilisation Amounts of Plastic Waste in the Different Waste Production Areas			
Point of origin	**Waste amount** in kt	**Utilisation amount** in kt	**Utilisation rate** in %
Plastic production	86	81	94
Plastic processing	802	710	89
commercial final consumption	1.402	714	51
private final consumption	1.715	833	49
Total	4.005	2.338	58,4



CD Recycling



Recycling of construction waste

Significance of the LAGA-Z Values

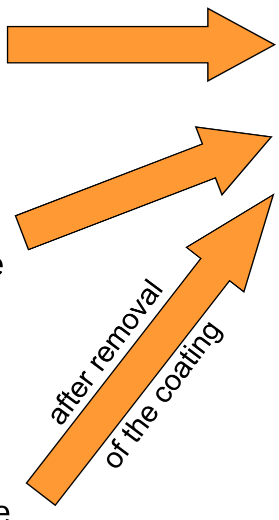
- Utilisation of mineral waste depending on components and eluatability (Pollutant classes Z.....)

Z 0	Unrestricted emplacement (comparable to natural soils))	No impairment to be expected; still: no application on particularly sensitive areas
Z 1.1	Restricted (usage-related) open emplacement	Exceptions: water-protection areas, nature reserves, biotope areas
Z 1.2	Restricted (usage-related) open emplacement	Exceptions: agricultural areas; hydro-geologically unfavourable areas; necessary: protection against erosion (closed plant cover); >1m distance to groundwater
Z 2	Restricted (usage-related) emplacement with defined technical safety measures	Under upper sealings (d>0,50 m kf <$1 \cdot 10^{-8}$m/s) or little or non-permeable cover layers

Scrap Wood Category A I: Natural or only mechanically treated used wood, which during its usage was not more than insignificantly polluted with substances which are foreign to wood

Scrap Wood Category A II: Bonded, painted, coated, varnished, or otherwise treated scrap wood without organic halogen compounds in the coating and without wood preservatives

Scrap Wood Category A III: Scrap wood with organic halogen coumpounds in the coating without wood preservatives



Material Utilisation

- Derived timber products
- Synthetic gas
- Wood oil
- Activated carbon/ industrial charcoal

Requirements on the application of derived timber products

	[mg/kg DM]
Arsenic	2
Lead	30
Cadmium	2
Chromium	30
Copper	20
Mercury	0.4
Chlorine	600
Fluorine	100
PCP	3
PCB	5

Scrap Wood Category A I

Scrap Wood Category A II

Scrap Wood Category A III

Scrap Wood Category A IV:
Scrap wood treated with wood preservatives, such as railroad sleepers, telephone posts, hop poles, vine poles, and other scrap wood which due to its pollutant load cannot be allocated to Scrap Wood Categories A I, A II or A III, excluding PCB scrap wood

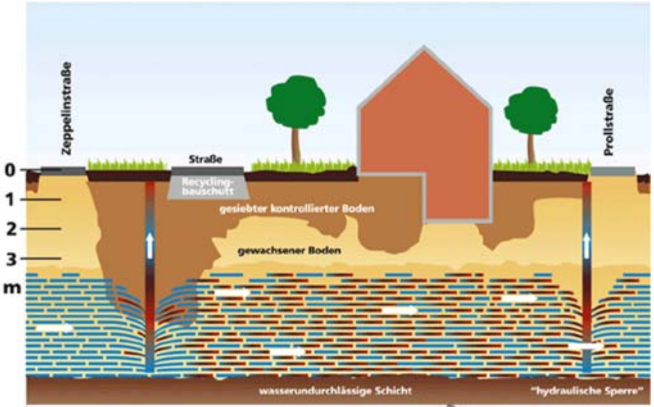
Energetic Utilisation

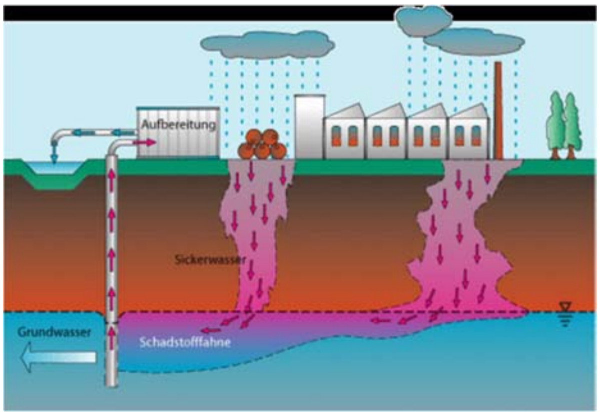
Small heating systems

plants approved
according to the 4th BImSchV

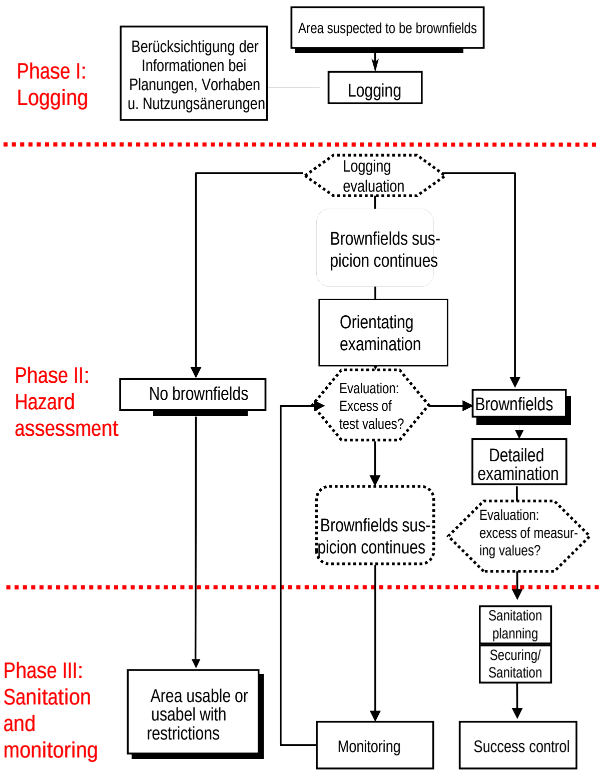
plants approved according to the 4th BImSchV with flue gas scrubbing according to the 17th BImSchV

- Contaminated sites and polluted areas





Flow Chart Logging – Evaluation – Sanitation according to SRU, 1990; LAGA,1989; BBodSchV



- In Germany in 2011:
  - 121.231 old deposits
  - 322.298 sites suspected to be brownfields

(http://www.umweltbundesamt.de/boden-und-altlasten/index.htm)

- In the USA in 2011:
  - There are an estimated 450,000 abandoned and contaminated waste sites in America

(source www.epa.org/brownfields/)

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Examples of sites suspected to be brownfields and possible relevant substances

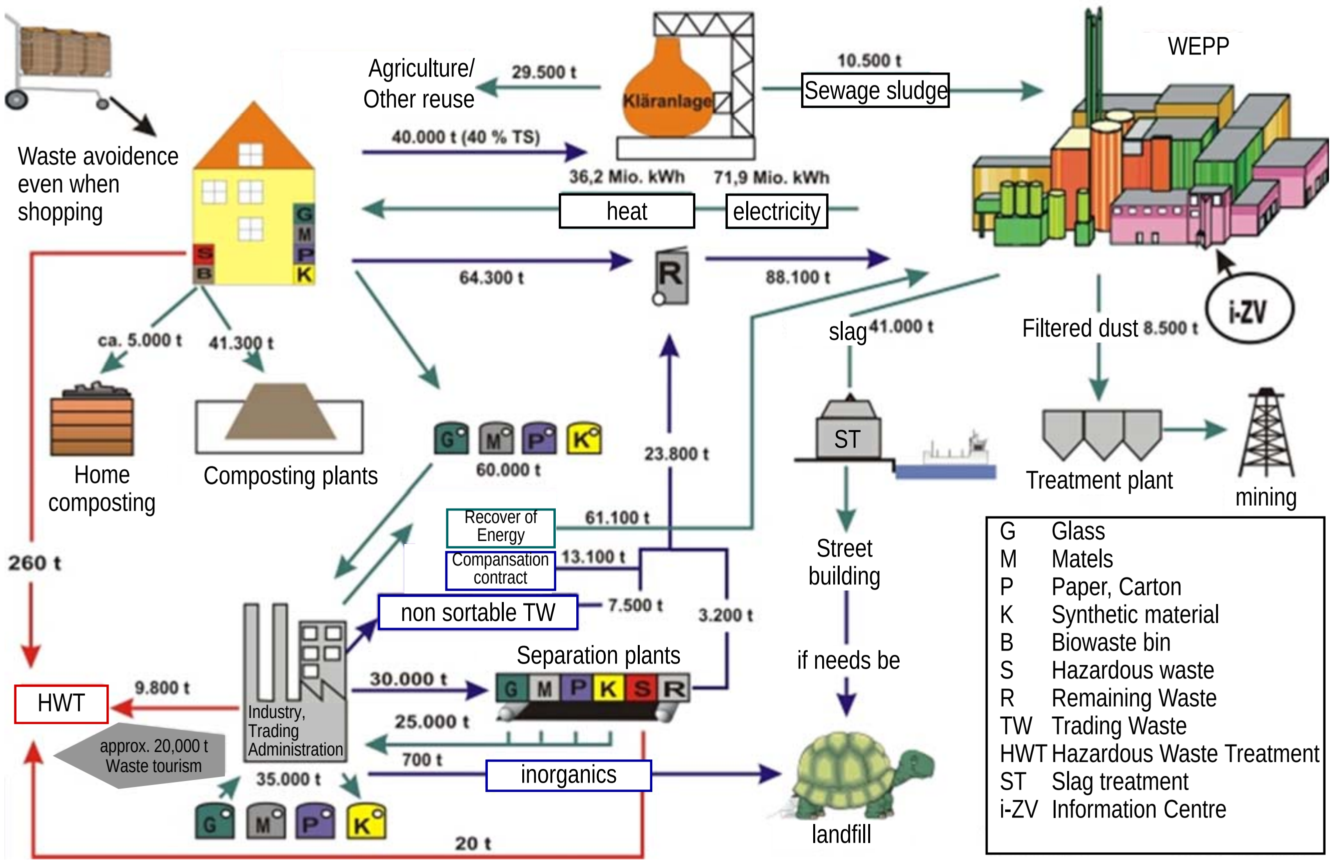
- generally relevant substances and branch-specific substances

Branch	Typical pollutants
Dry cleaning	gasoline, benzene, dichloroethane, tetrachloroethane, trichloroethane, trichloroethene, trichloromethane
Hard coal mining, gas works, coking plants	ammonium, anthracene, arsenic, (asbestos), benzo(a)pyrene, benzene, lead, chromium, cyanides, ethylbenzene, fluorene, fluorene, cresol, mesitylene, mineral oil, naphthalene, PAH, phenole, acids, lyes, creosote, thiocyanate, toluol, xylol

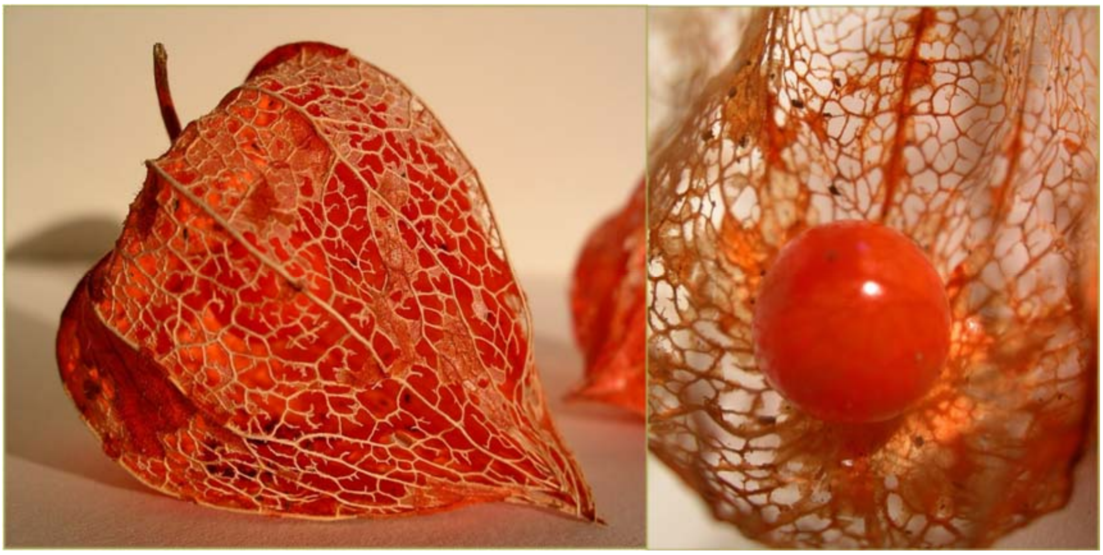
- Waste Management Concepts

Waste Management Concept of the joint body of Würzburg Community

City of Würzburg, District of Würzburg and Kitzingen; 300,000 Inh.
Contracting parties: City and District Ansbach, District Weißenburg-Günzhausen 320,000 Inh.
Dioxine ~0.002 ng TE/m³



- Many thanks for attending this course and your interest in this topic
- All the best for your preparations, your exam and further studies



...and keep looking under the surface.