REDUCING AFTERCARE FOR CLOSED LANDFILLS BY CONTROLLED WATER INFILTRATION AND/OR IN-SITU AERATION

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  - Drying effects
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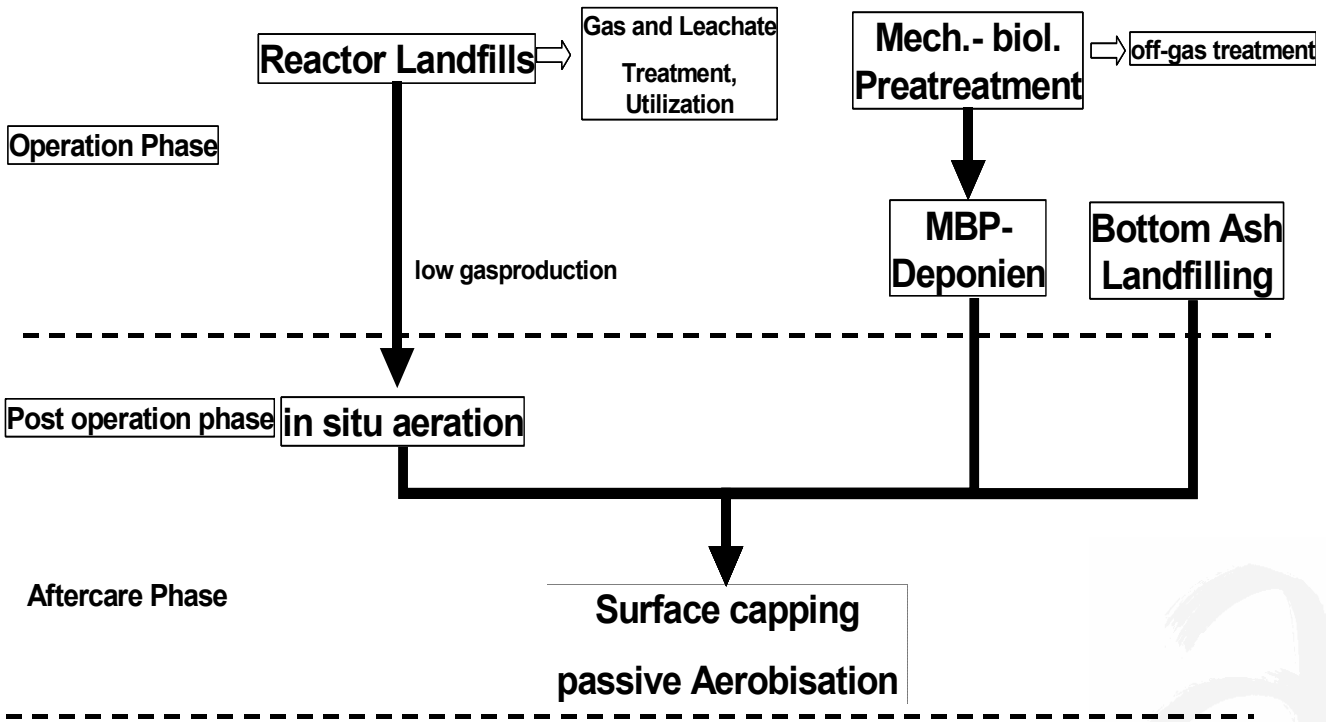
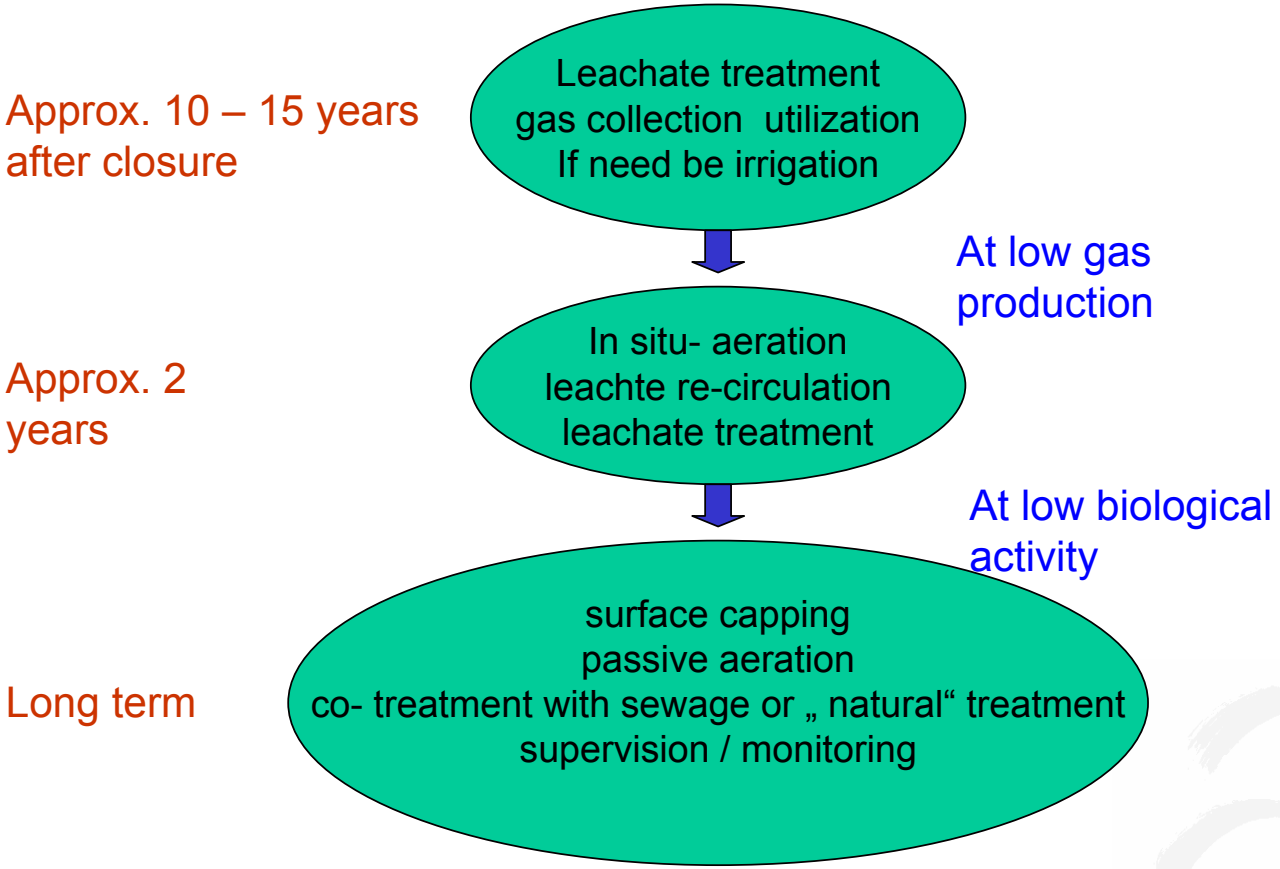
  - Lab scale investigations
  - General data of the old Kuhstedt Landfill
  - Operation and intermediate results

Longterm Landfill Concept
(sustainable Landfill)

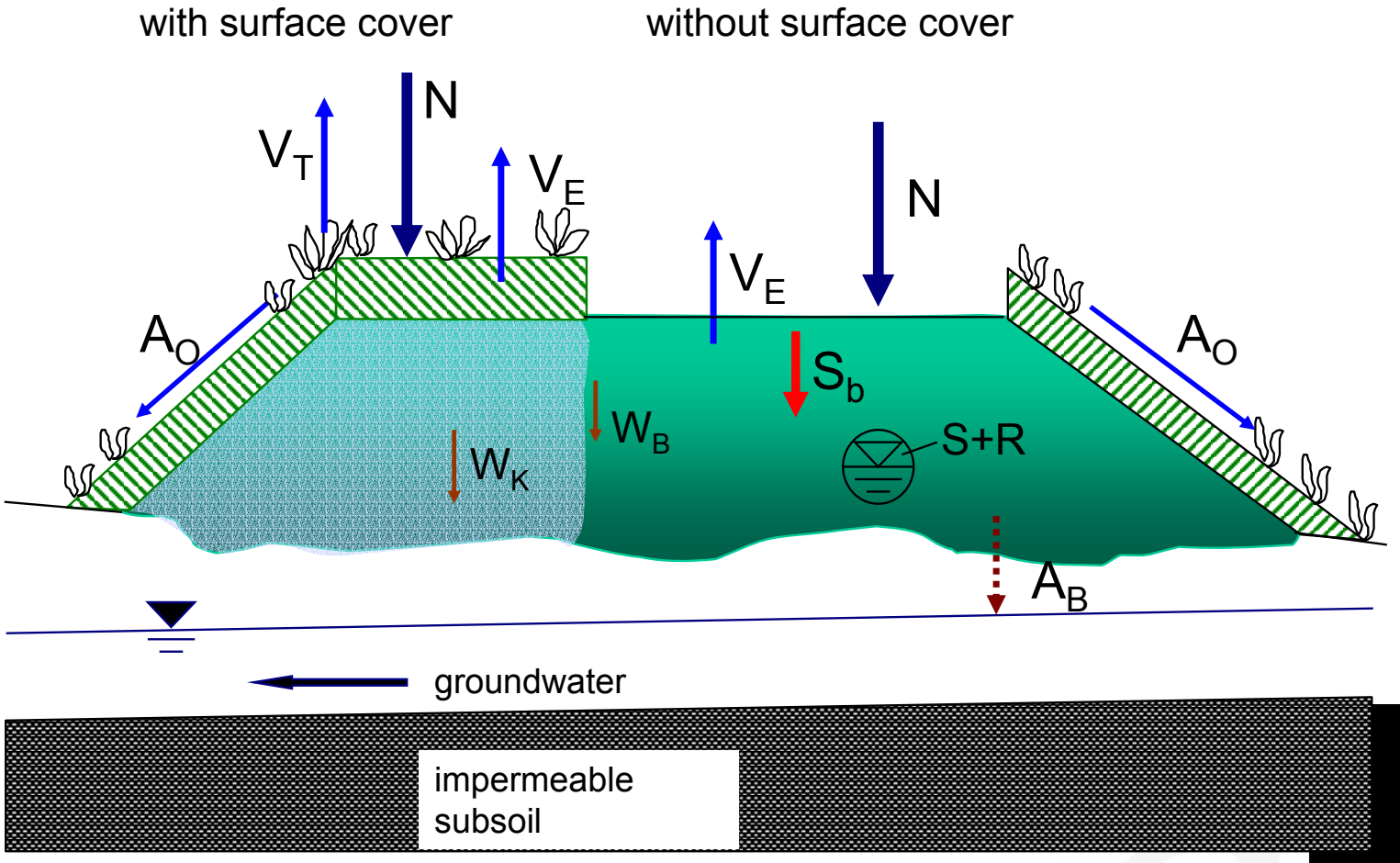


Operation scheme for closed Landfills

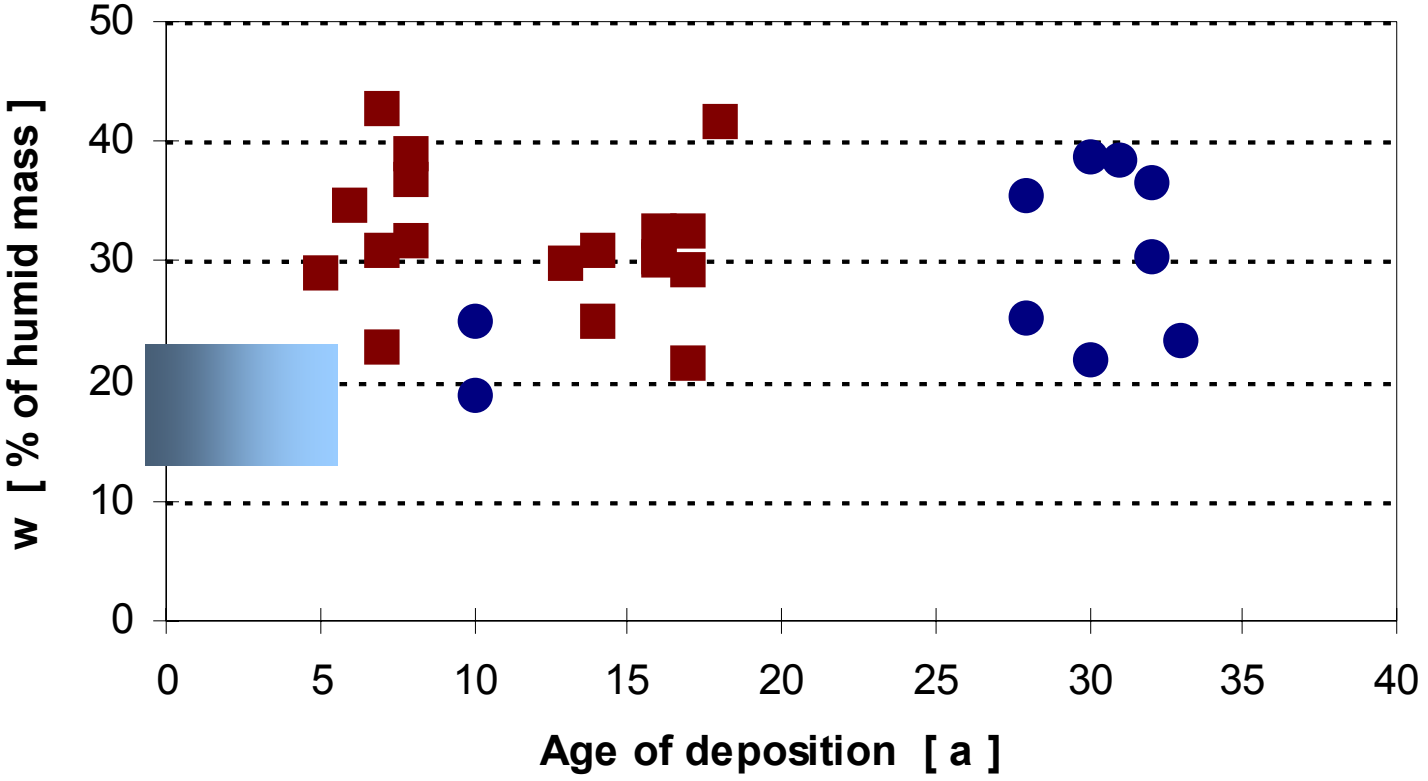


Drying effects in covered landfills

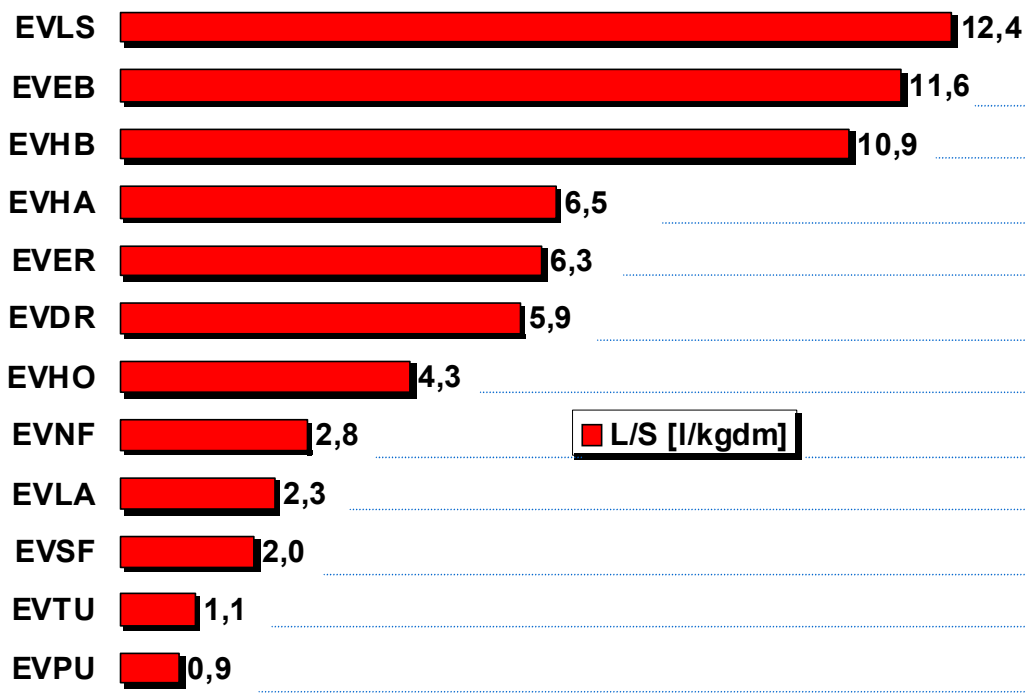
- undesirable conservation of the organic waste fraction,
  “dry stabilization”
- reduction of the gas production
- increasing long-term risks with regard to uncontrolled environmental pollution, necessity of remediation measures


with surface cover
without surface cover
N
V_T
V_E
A_O
W_K
W_B
N
V_E
S_b
S+R
A_O
A_B
groundwater
impermeable subsoil

Water contents of solid waste samples from landfills and old deposits

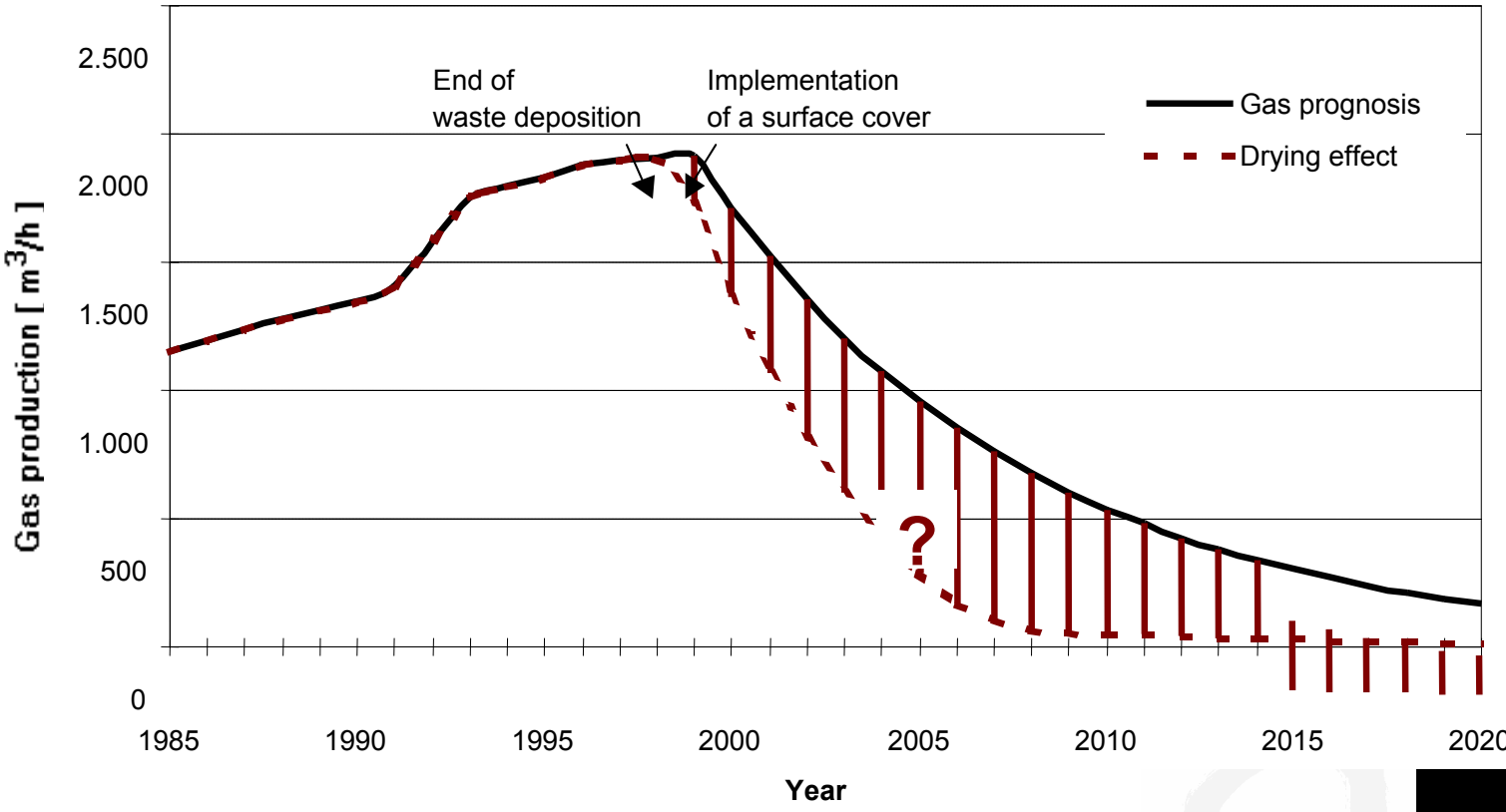


Liquid/Solid ratios of different waste samples from old landfills (25–38 a) vs. initial LSR- leachate concentrations



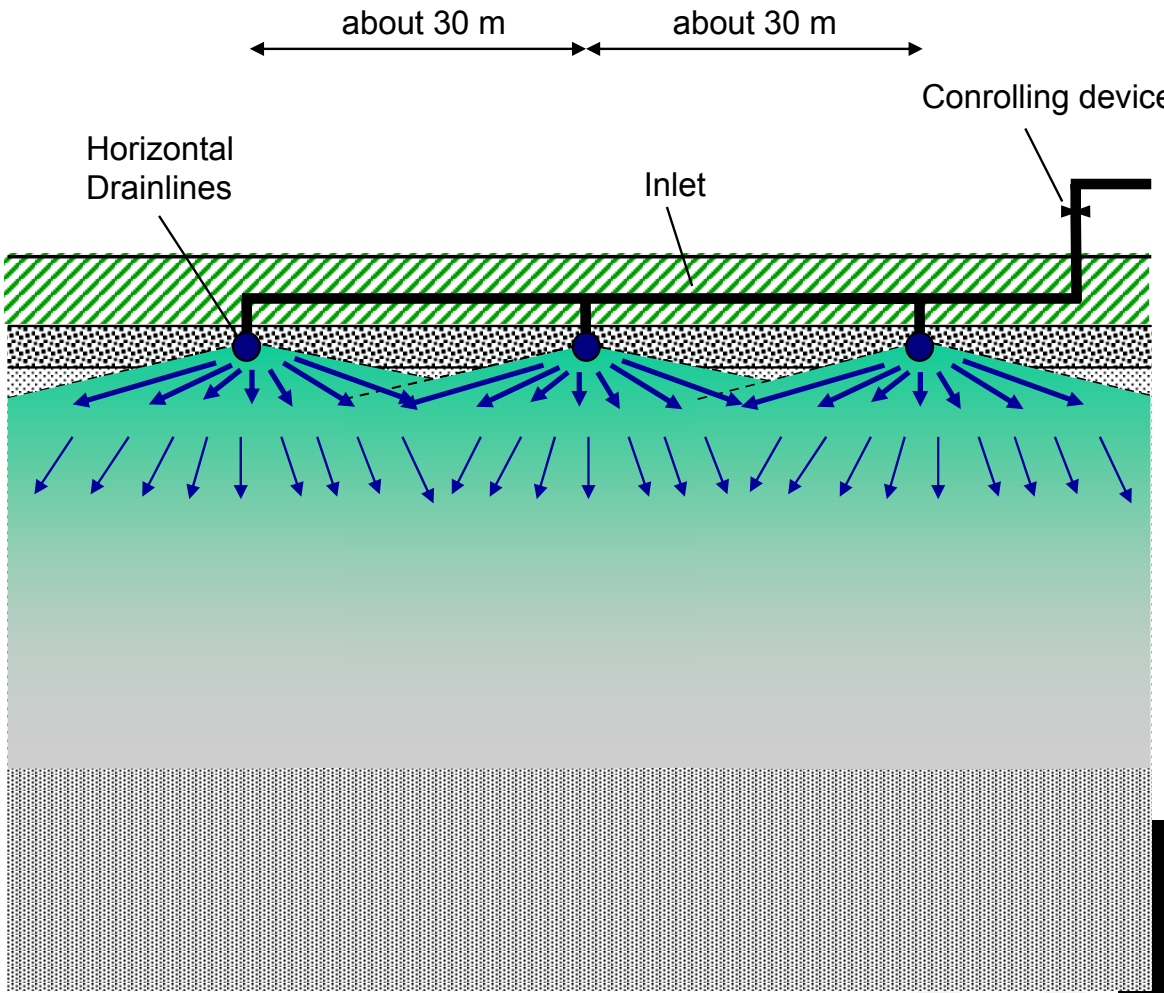
	COD [mg/l]	TOC [mg/l]	Cl [mg/l]	N-tot [mg/l]
EVLS	69	25	40	13
EVEB	200	80	29	54
EVHB	83	33	32	10
EVHA	200	77	40	10
EVER	84	33	27	10
EVDR	261	117	249	42
EVHO	99	37	91	17
EVNF	1138	450	632	300
EVLA	156	66	66	10
EVSF	833	306	676	
EVTU	803	323	579	
EVPU	1496	620	415	

Landfill gas prognosis and estimation of the drying effect

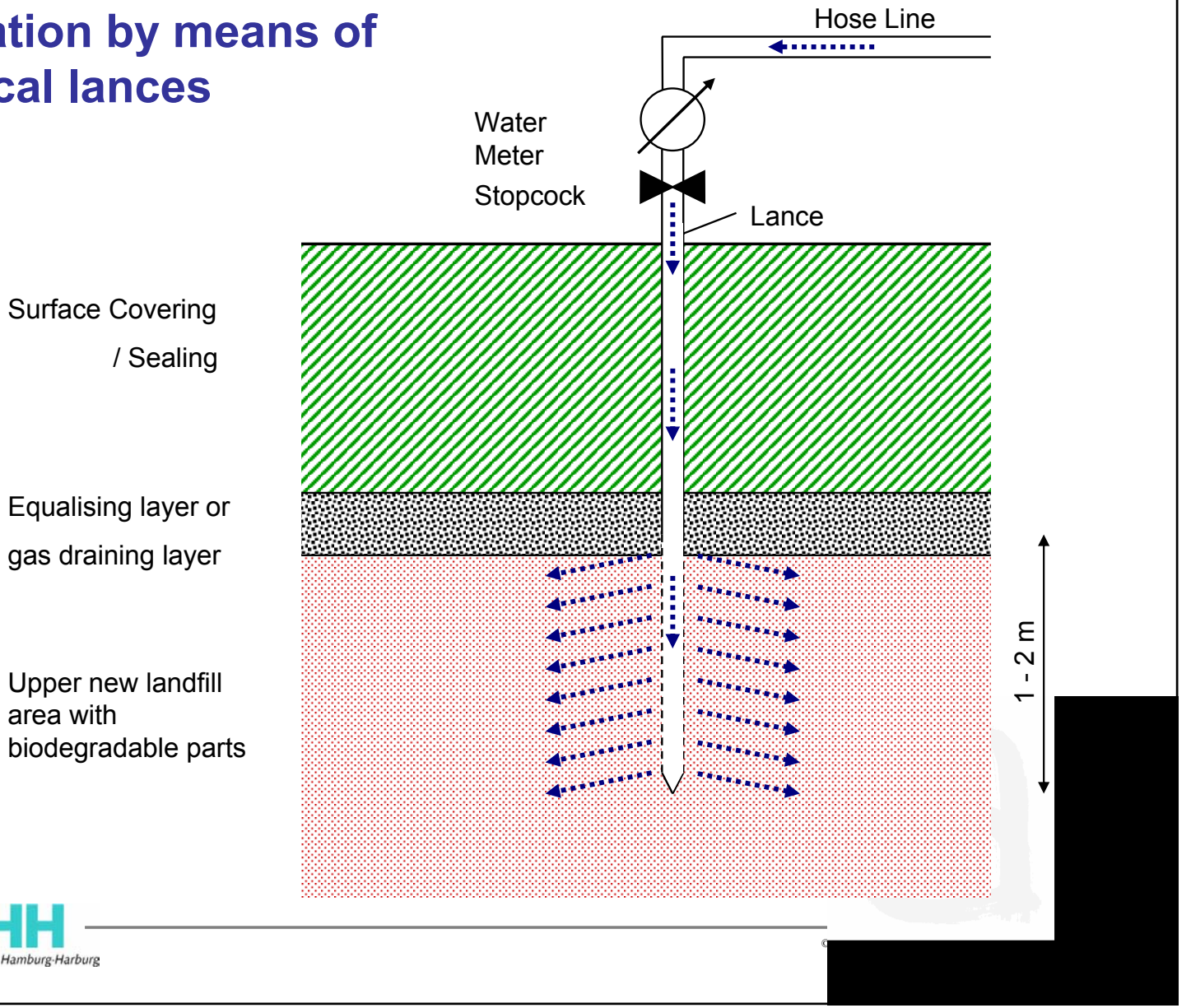


Objectives of controlled water infiltration on landfill sections

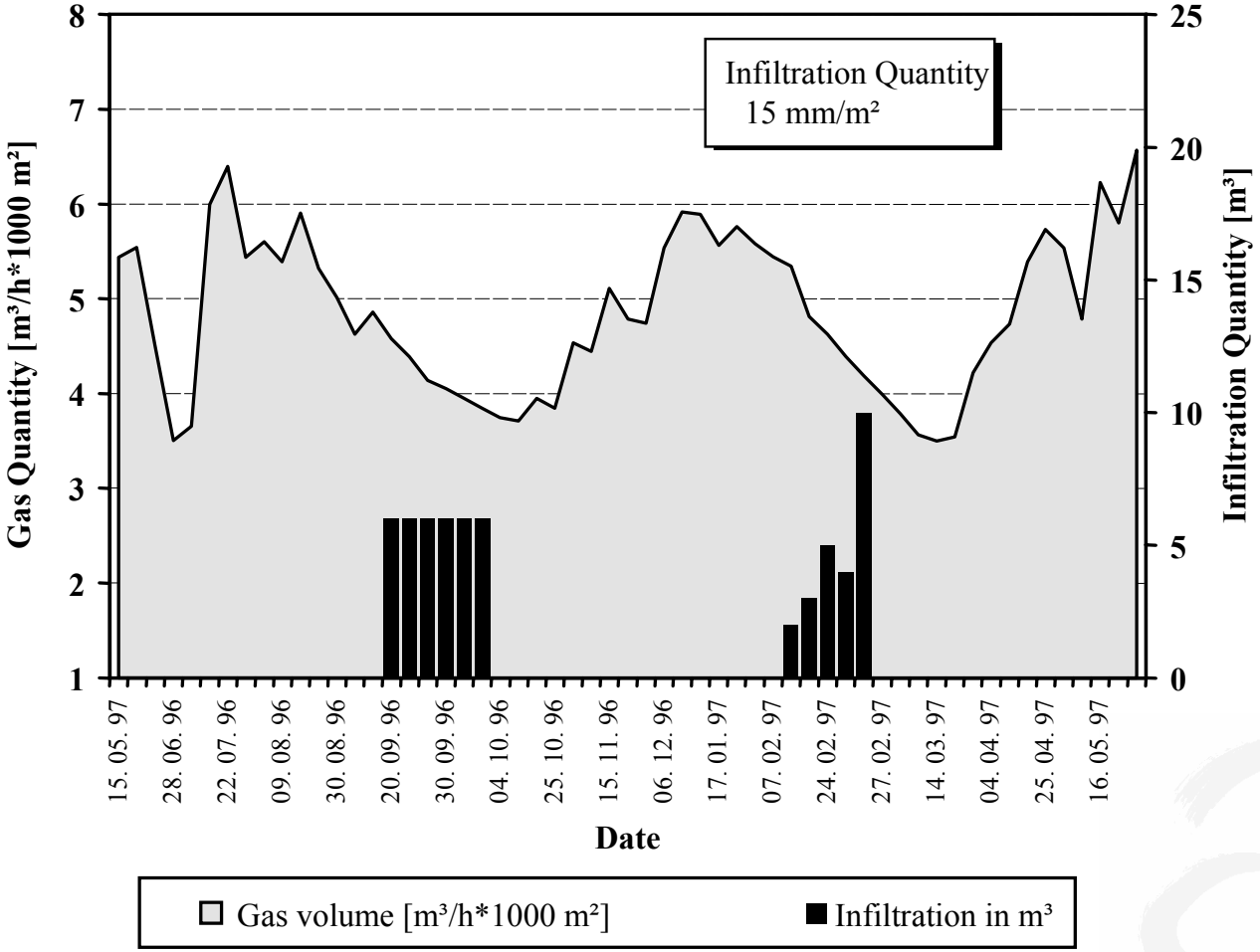
- Avoidance of drying effects
- Enhanced biological degradation processes
- Prolonged gas production and utilization
- Enhanced reduction of the emission potential
- Shorter aftercare period
- Cost savings


about 30 m
about 30 m
Conrolling device
Horizontal
Drainlines
Inlet
Surface cover / Sealing
Equalising layer / gas
draining layer
Upper new landfill
section with
biologically
degradable parts
Lower older landfill
section with
- to a large extent -
biologically stabilised
parts

Irrigation by means of vertical lances



Landfill "B": Gas quantity development after infiltration, field 5



Quelle: Krümpelbeck and Ehrig, 1998

Installation and operation of test fields on the German landfill Erbenschwang

	Test Field	Reference Field
irrigation system	vertical lances / horizontal drain pipes	-
water addition	≈ 160 l/Mg	-
water content at the beginning	25.2 % (8 % - 38.2 %)	27.9 %
water content at the end	35.5 % (20,3 bis 60,9 %)	27.9 %
gas production after 15 months	11,4 m^3/h	5,6 m^3/h
cumulated gas prod. after 15 months	≈ 160.000 m^3 LFG	≈ 40.000 m^3 LFG
added water used the increase of water storage capacity	83 % (17 % drained off)	-
additional leachate generation	11 %	-

Controlled water infiltration

Restrictions:

even water distribution not realizable

- water movements on preferential flow paths.
- heterogeneity of the deposited waste
- different permeabilities

- no built up of water tables
- examining the effects of the controlled moistening by means of an extensive monitoring program

Conclusions regarding the effect of controlled water infiltration

- reduction of the biodegradation processes on many
- landfills provided with an impermeable surface sealing
- acceleration by water addition

Cost-saving possibilities by moistening- and irrigation measures

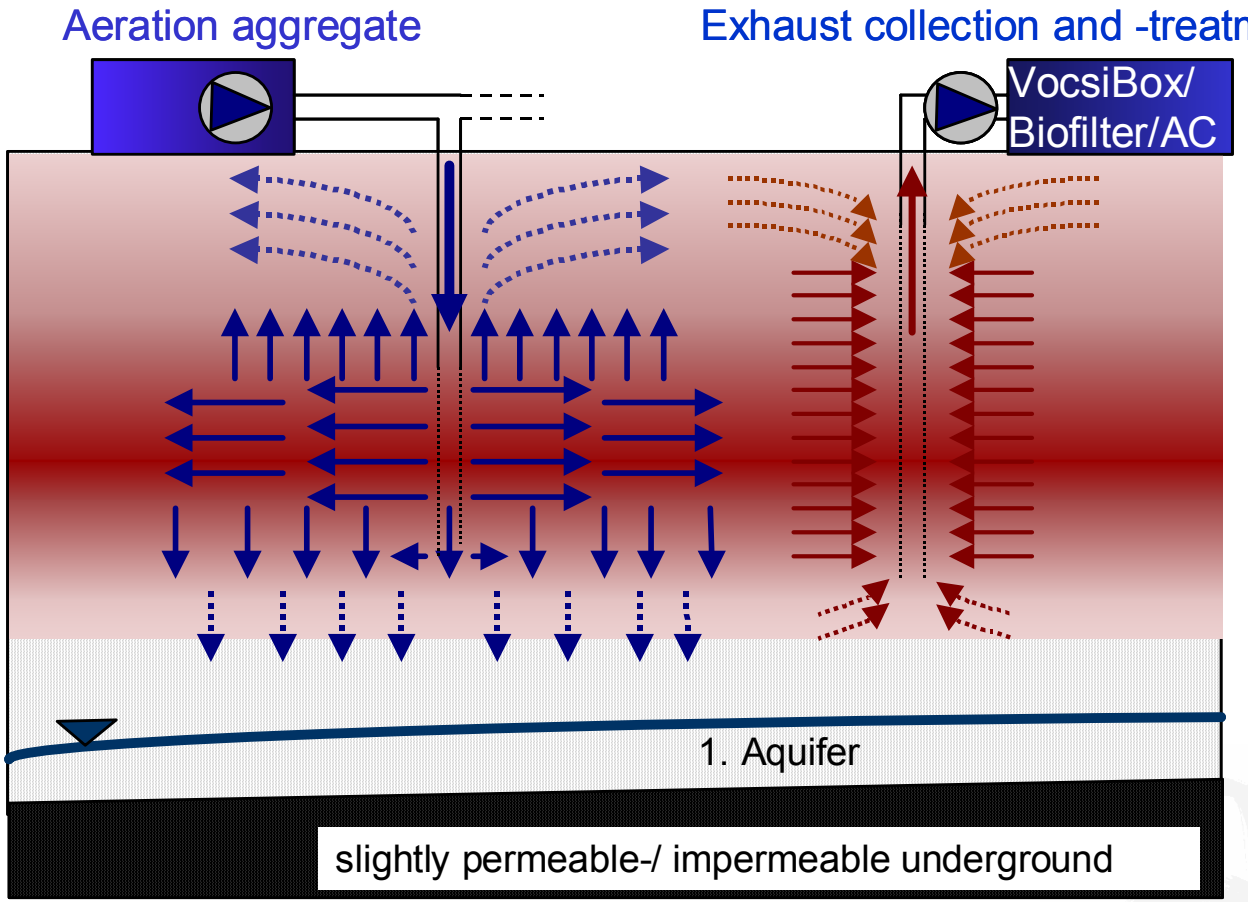
- reduction of long-term costs of the leachate treatment
- costs can be saved with regard to the ground water
- redevelopment and to additional securing measures on
- old landfills
- shortening of the whole aftercare period by several
- decades
- earlier recultivation and new utilisation

Fundamental processes during in situ aeration (I)

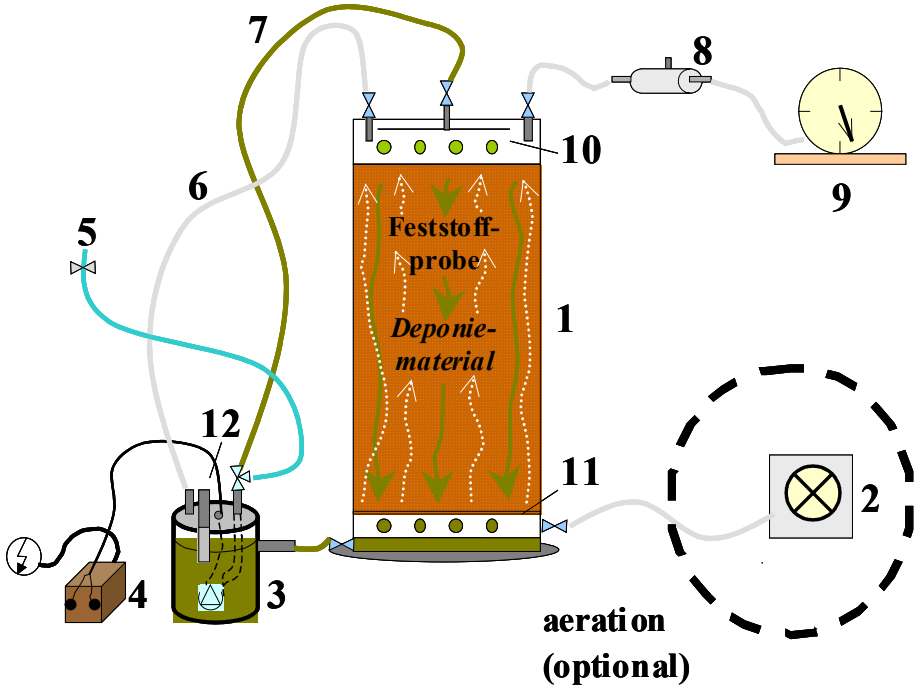
- **Conversion of the anaerobic milieu conditions in the landfill body to aerobic conditions**
- **Accelerated reduction of the biologically available organic substance (e.g. hydrocarbons) under aerobic conditions**
- **Formation of complex and relatively stable components similar to humic substances** (further research needed)

Fundamental processes during in situ aeration (II)

- „Dilution“ of the landfill gas, decrease in the relative CH_4- and CO_2-concentrations; increase in O_2 and N_2
- Reduction in the proportion O_2/N_2 by the partly metabolism of the added oxygen (oxygen consumption)
- Indication of Methane oxidation by a change in O_2/N_2 and CH_4/CO_2 proportion


Aeration aggregate
Exhaust collection and -treatment
VocsiBox/
Biofilter/AC
1. Aquifer
slightly permeable-/ impermeable underground

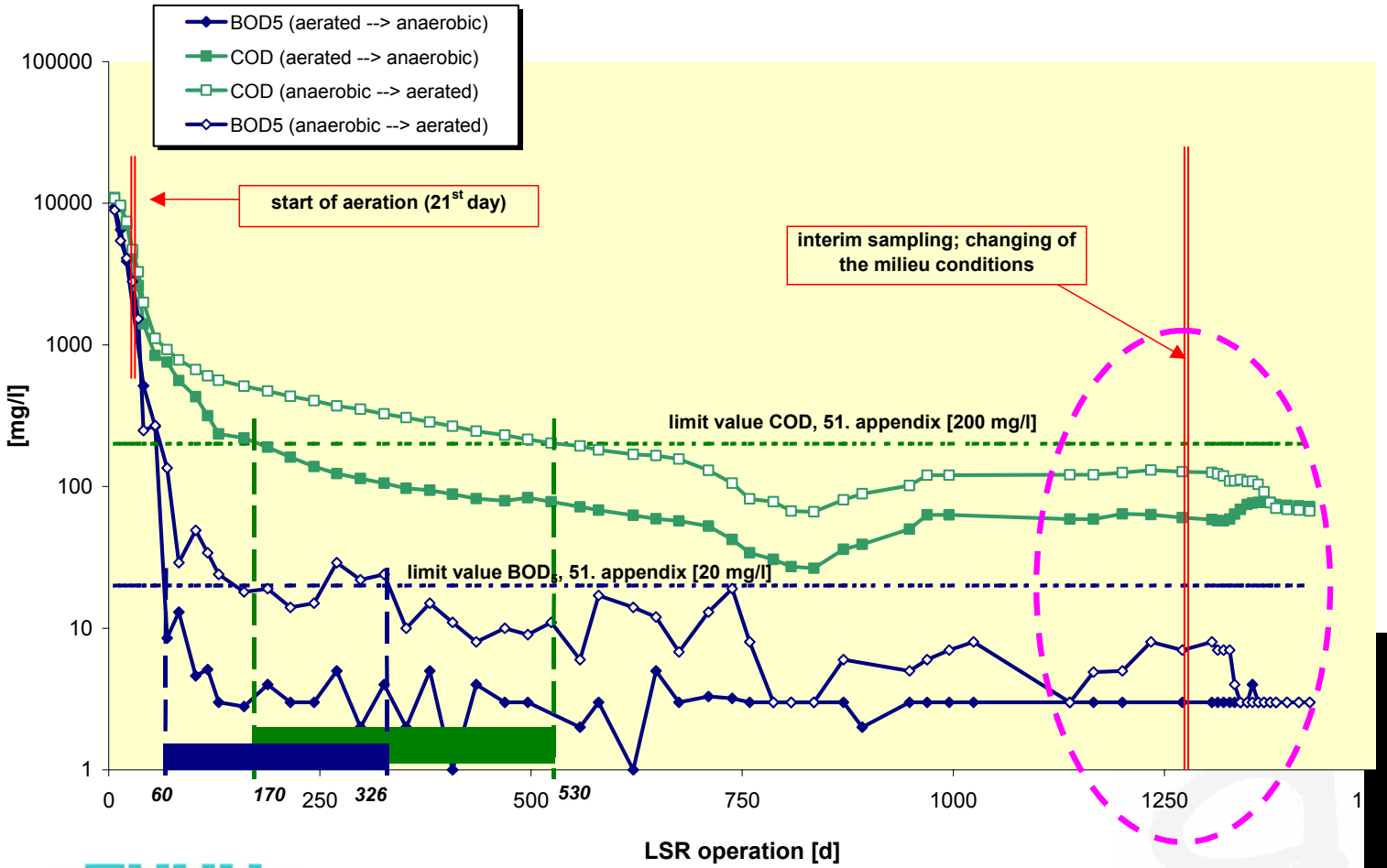
Principle scheme of the aerobic / anaerobic LSR



1 LSR
2 aeration (optional)
3 pump well (2 l)
4 transformator
5 leachate sampling and fresh water addition
6 pressure compensation
7 leachate circulation
8 gas sampling
9 volumetric gas analysis
10 leachate irrigation
11 perforated plate
12 Redox- and pH-measurement

Landfill Simulation Reactors (LSR)

Organic leachate concentrations under anaerobic and aerobic conditions in LSR



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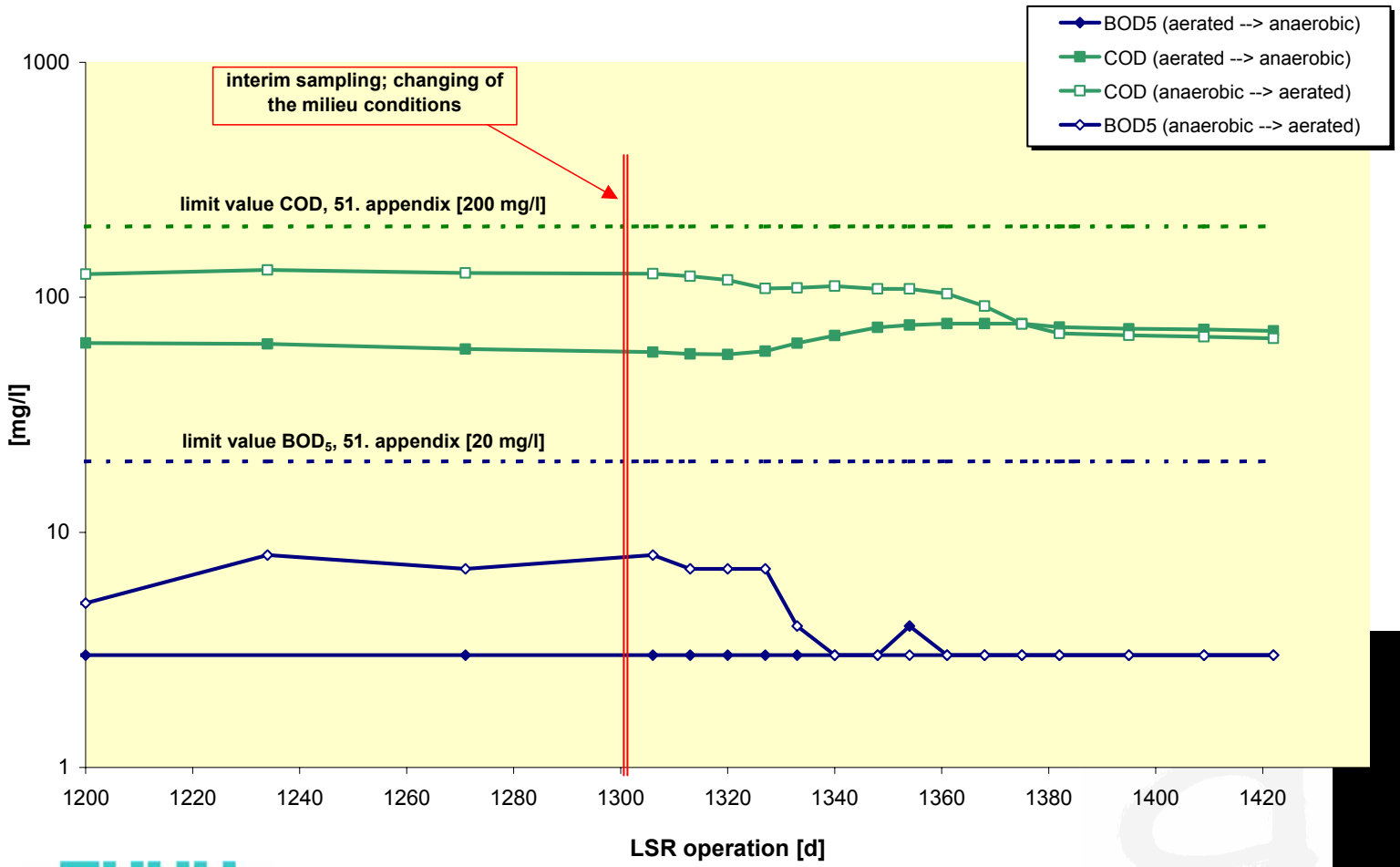
Organic leachate concentrations under anaerobic and aerobic conditions in LSR



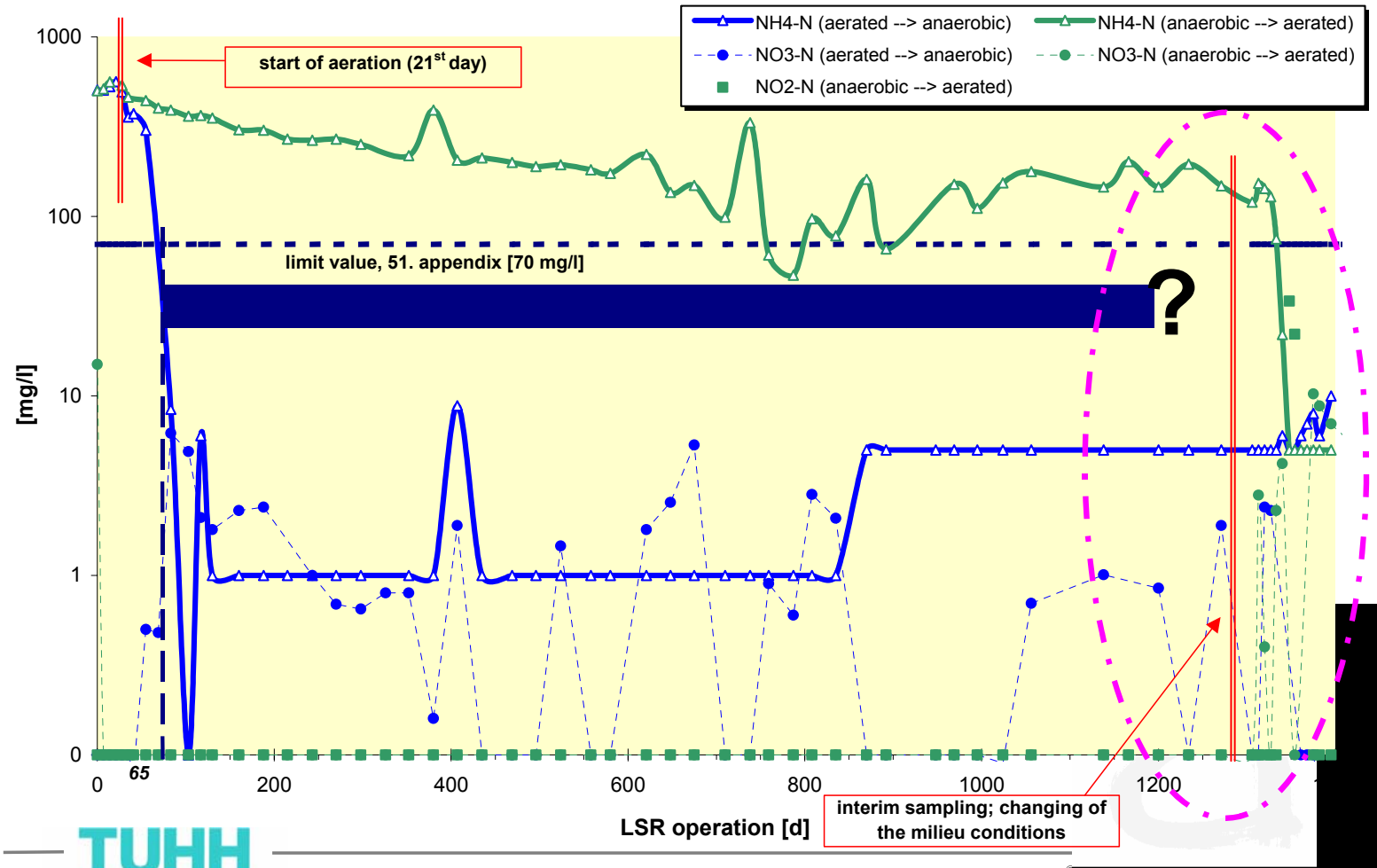
Reduction in the organic leachate concentrations under anaerobic and aerobic conditions in LSR

LSR	operation mode	TOC-Concentration after 130 days [mg/l]	BOD_5-Concentration after 80 days [mg/l]	Reduction compared with the inital concentrations ** [%]
Kuh-3	aerated	74	3*	**89 / 99**
Kuh-4	anaerobic	202	65	**65 / 82**
Kuh-6	aerated	51	5	**92 / 99**
Kuh-7	anaerobic	151	47	**69 / 93**

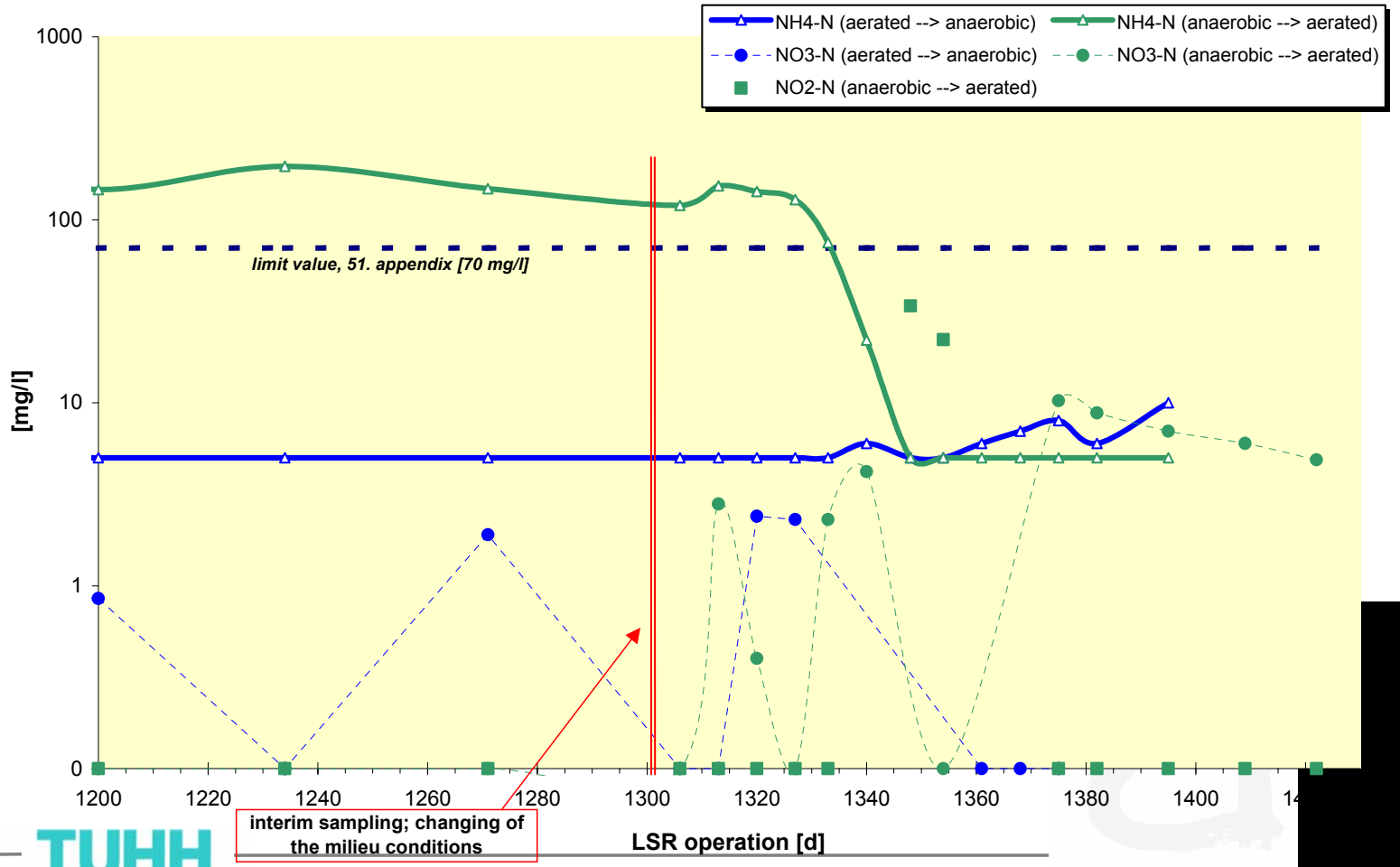
*) analytical accuracy

**) reference value one week after installation

Nitrogen concentrations under anaerobic and aerobic conditions in LSR (I)



Nitrogen concentrations under anaerobic and aerobic conditions in LSR (II)



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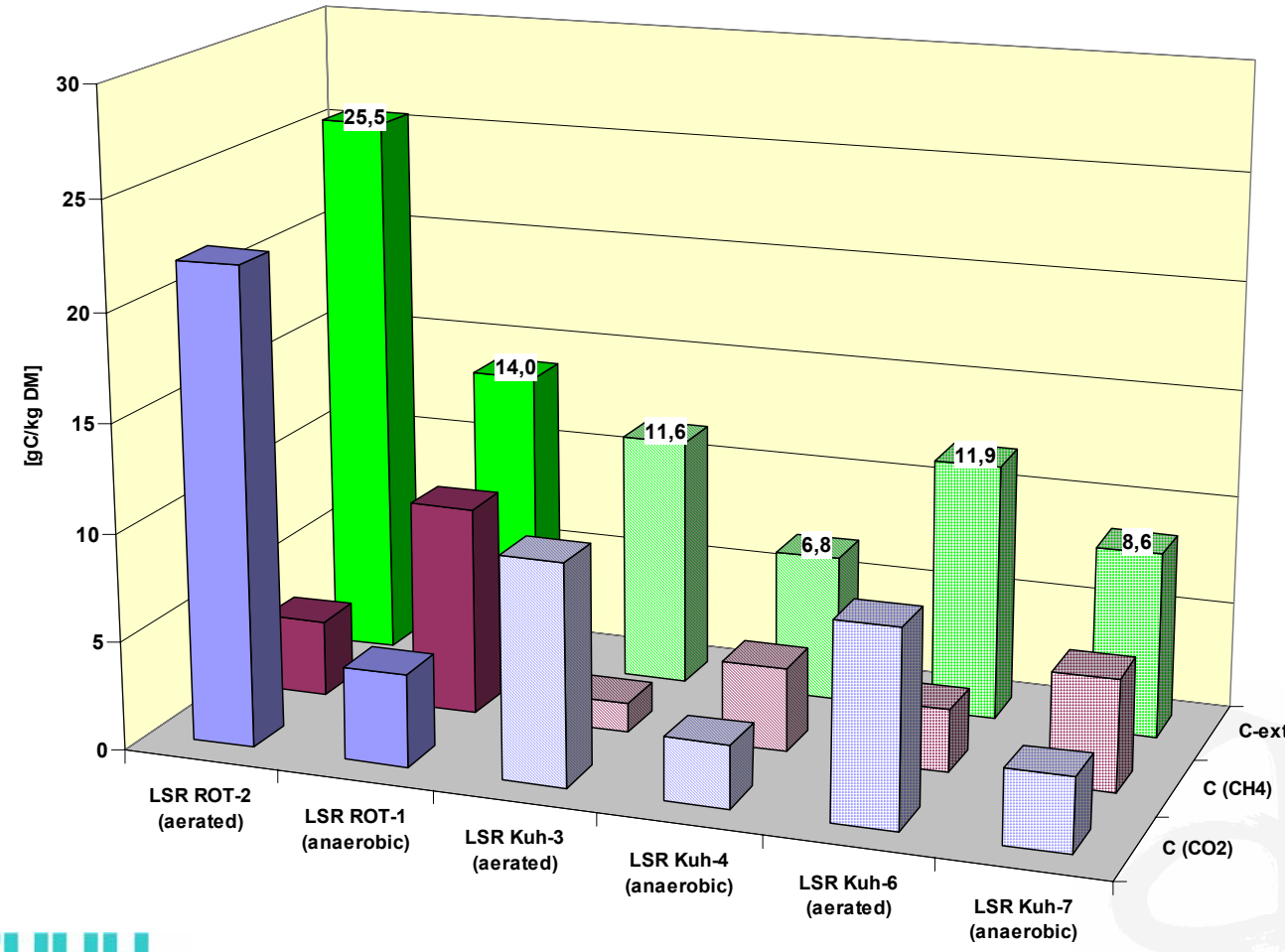
Reduction in the ammonia concentrations under anaerobic and aerobic conditions in LSR

LSR	operation mode	NH_4-N-Concentration after 100 days [mg/l]	Reduction compared with the initial concentrations ** [%]
Kuh-3	aerated	5*	**99**
Kuh-4	anaerobic	285	**1**
Kuh-6	aerated	5*	**98**
Kuh-7	anaerobic	339	**7**

*) analytical accuracy

**) reference value one week after installation

Comparison of the Carbon discharge under aerobic and anaerobic conditions in LSR



Waste samples after 44 months in the LSR

LSR ROT-1 (anaerobic)

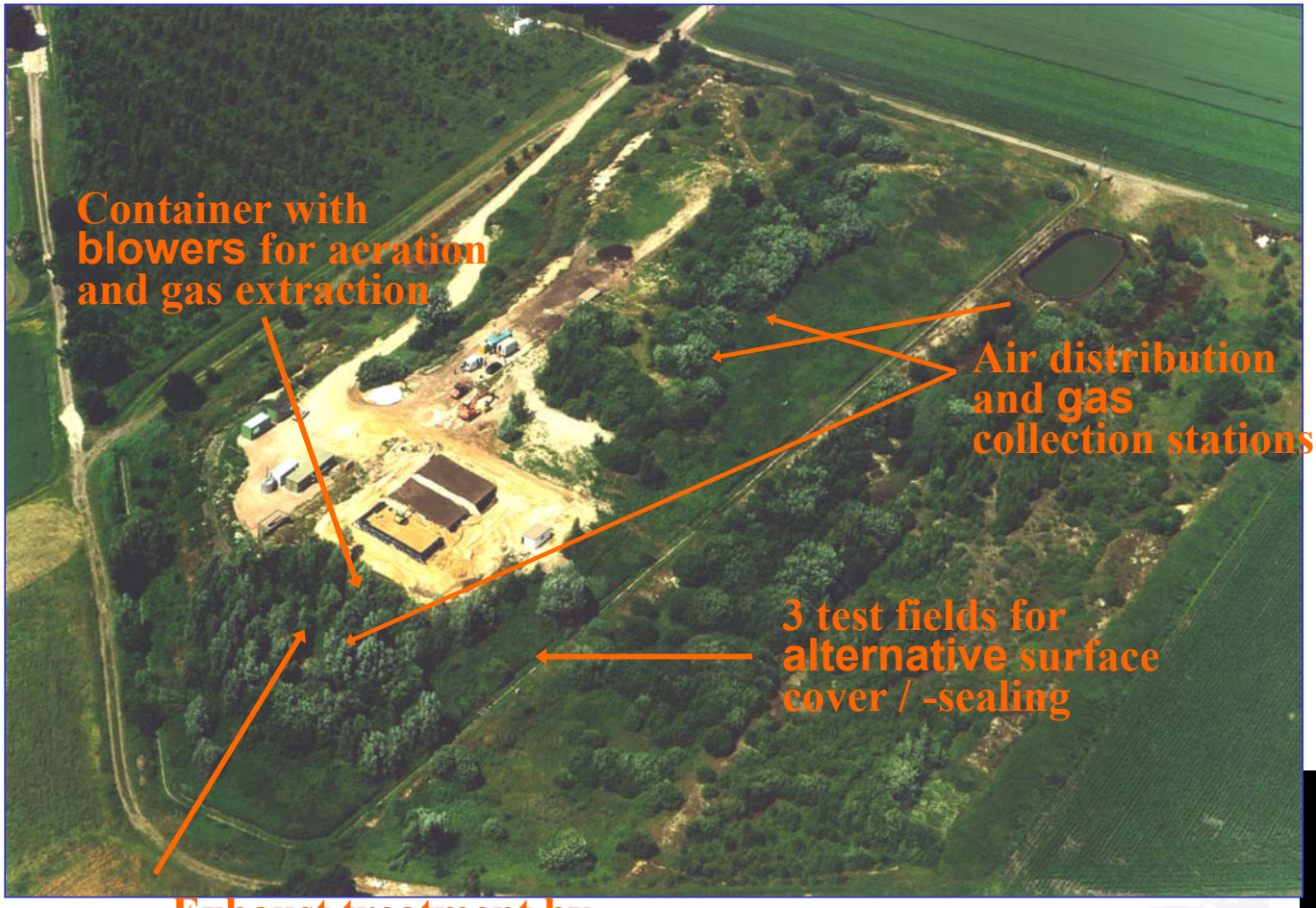
LSR ROT-2 (aerated)

General data of the Old Kuhstedt Landfill

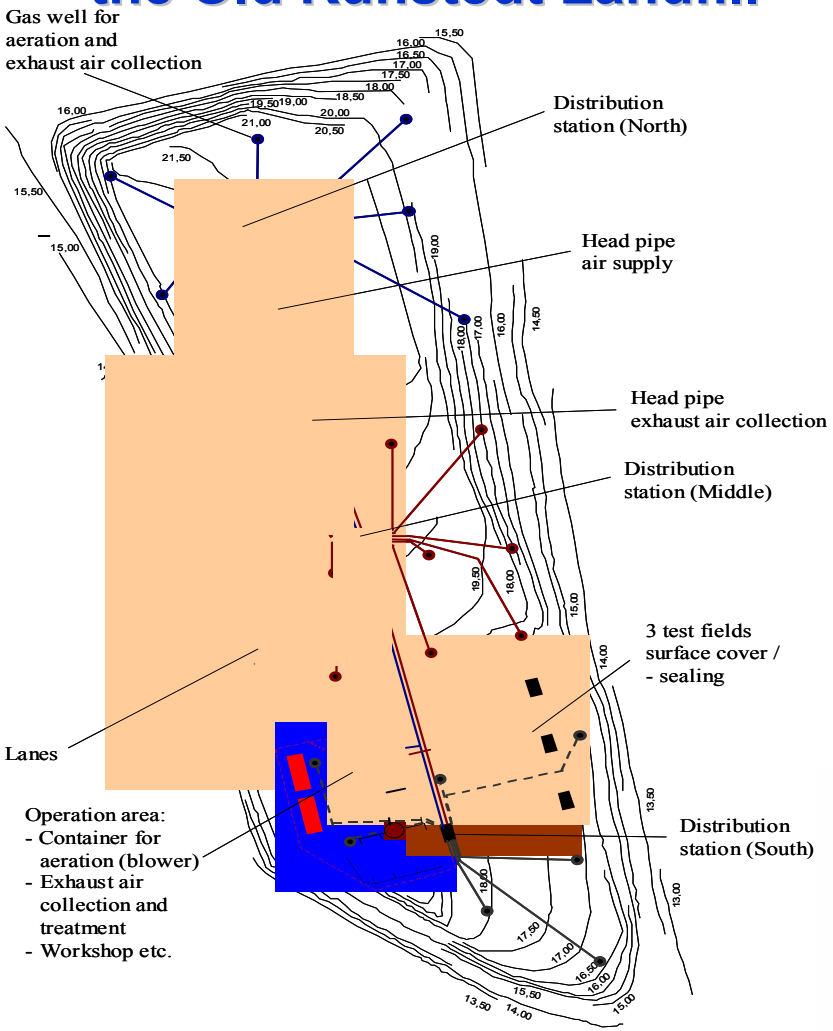
Operation	**Middle of the 60‘s until 1987: Landfill operation; deposition into a former gravel pit**

Deposited kinds of waste:	**Municipal solid waste, bulky waste, commercial waste similar to household waste, C&D-waste**
Total area:	**approx. 3,2 ha**
Height above ground level:	**approx. 8 – 10 m**
Volume:	**approx. 220.000 m³**
Depth into ground:	**approx. 2 – 3 m**
Base sealing:	**none**
Gasextraction:	**none**
Surface cover / -sealing:	**none; some areas were covered with soil no final cover until today**

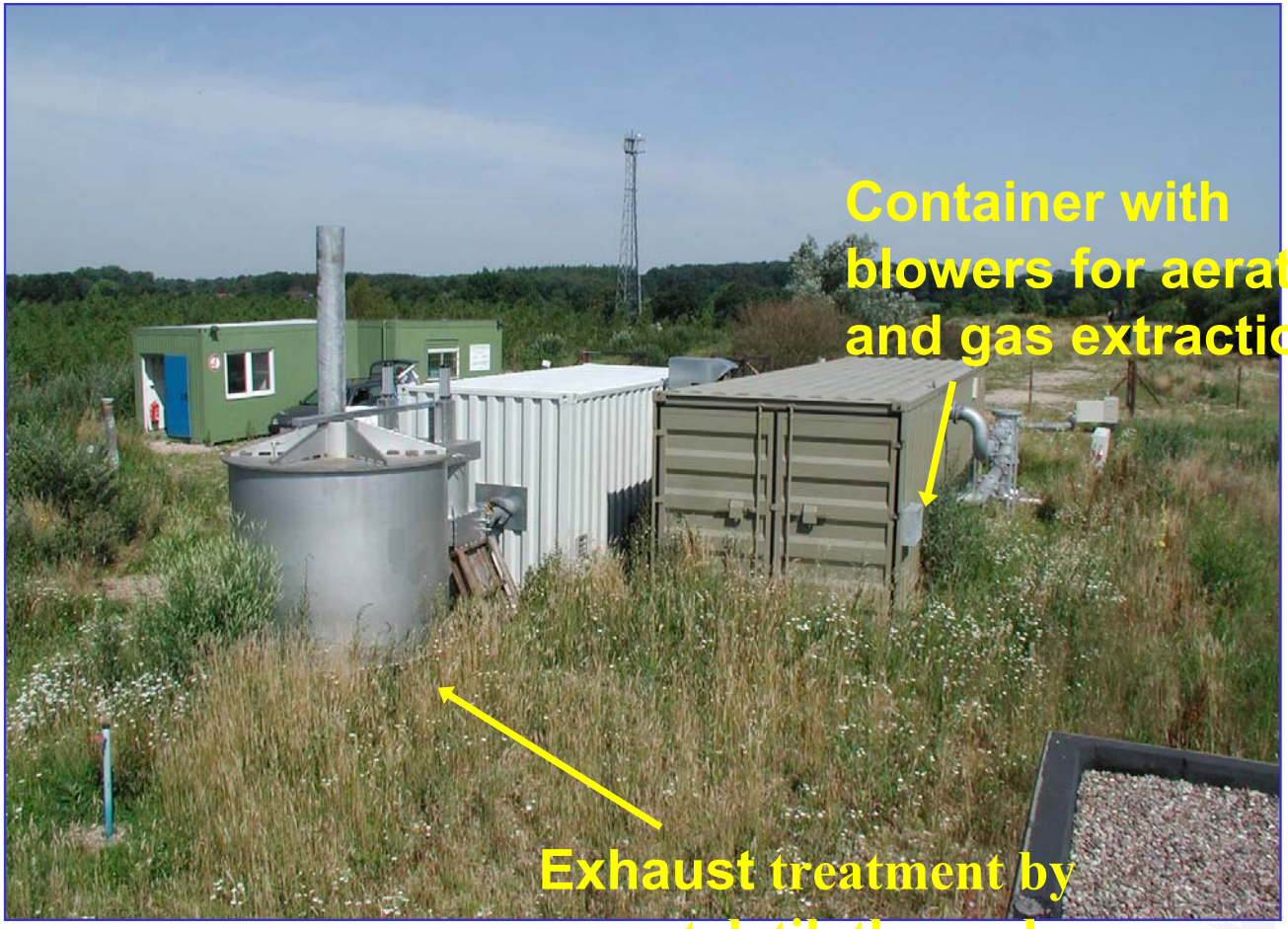
Aerial view on the Old Kuhstedt Landfill



Master plan of the installations for in situ stabilization at the Old Kuhstedt Landfill



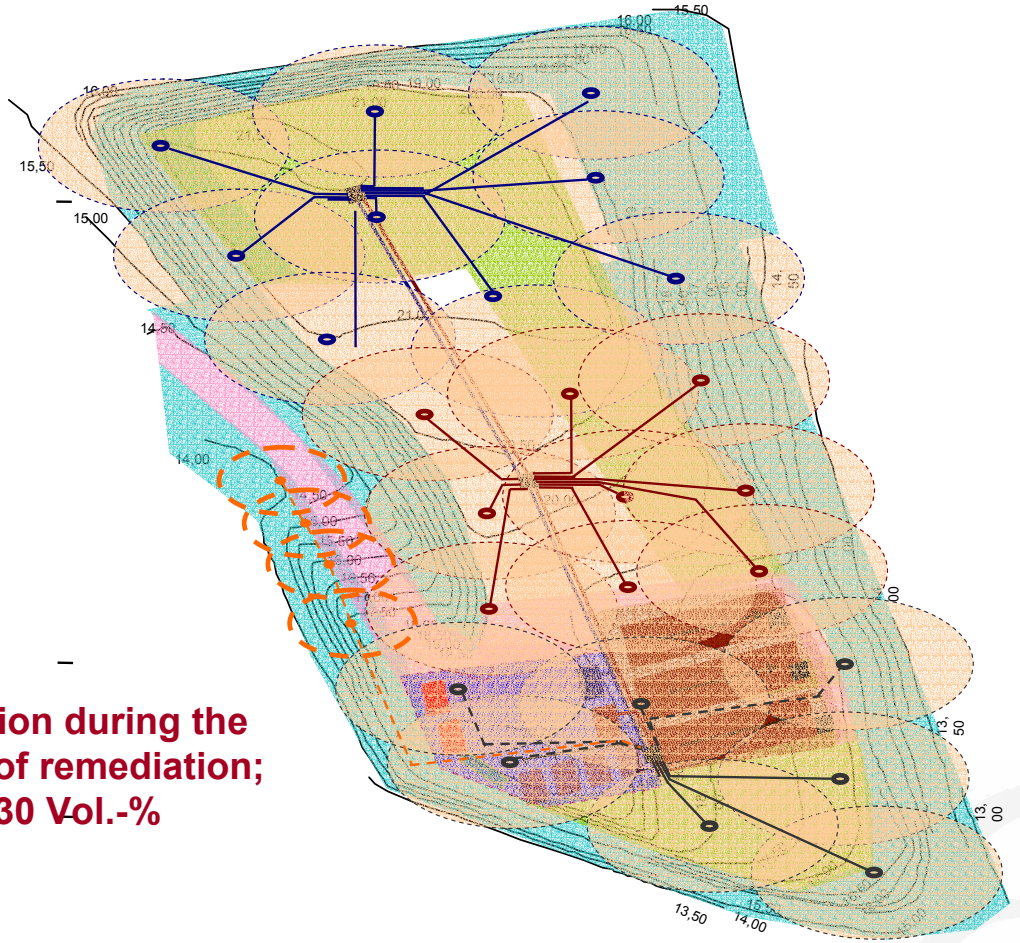
The Old Kuhstedt Landfill



Technical equipment at the old Kuhstedt landfill

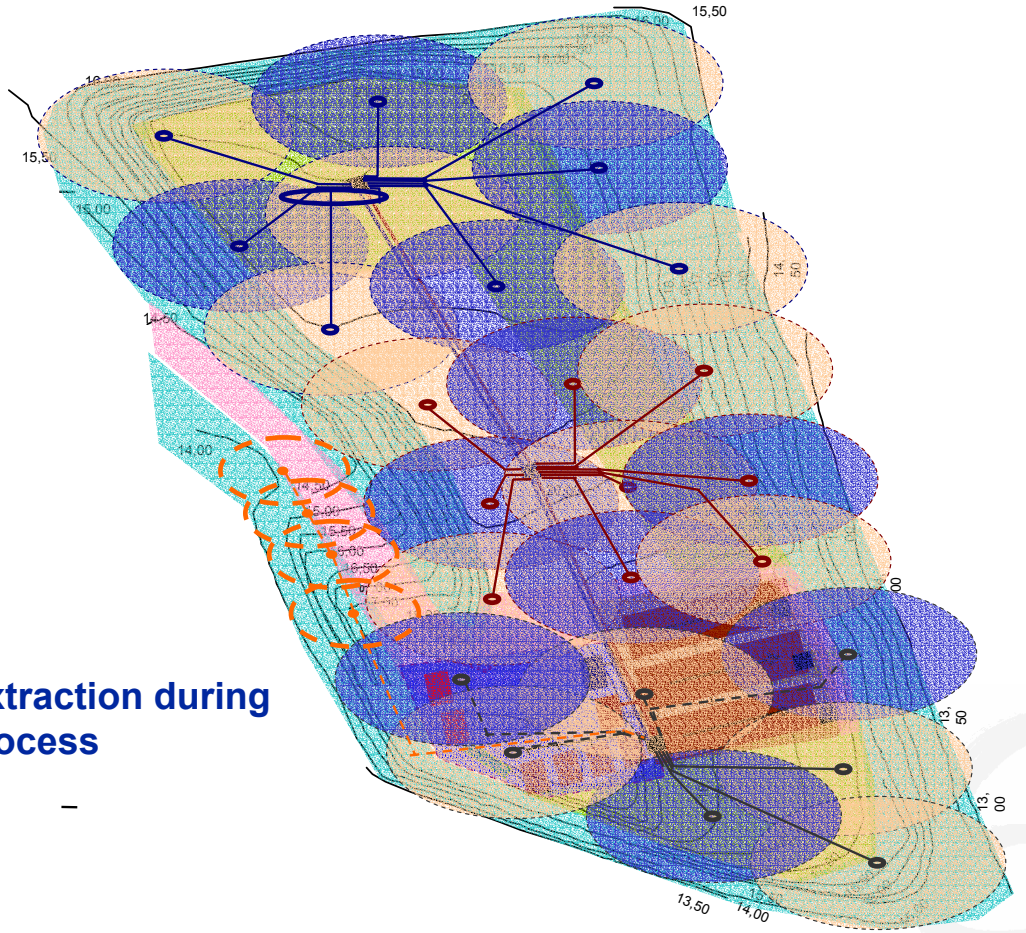
Gas distribution station and
valves for aeration / extraction

Operation of the aeration/gas extraction system



Gas extraction during the first phase of remediation; until CH_4 < 30 Vol.-%

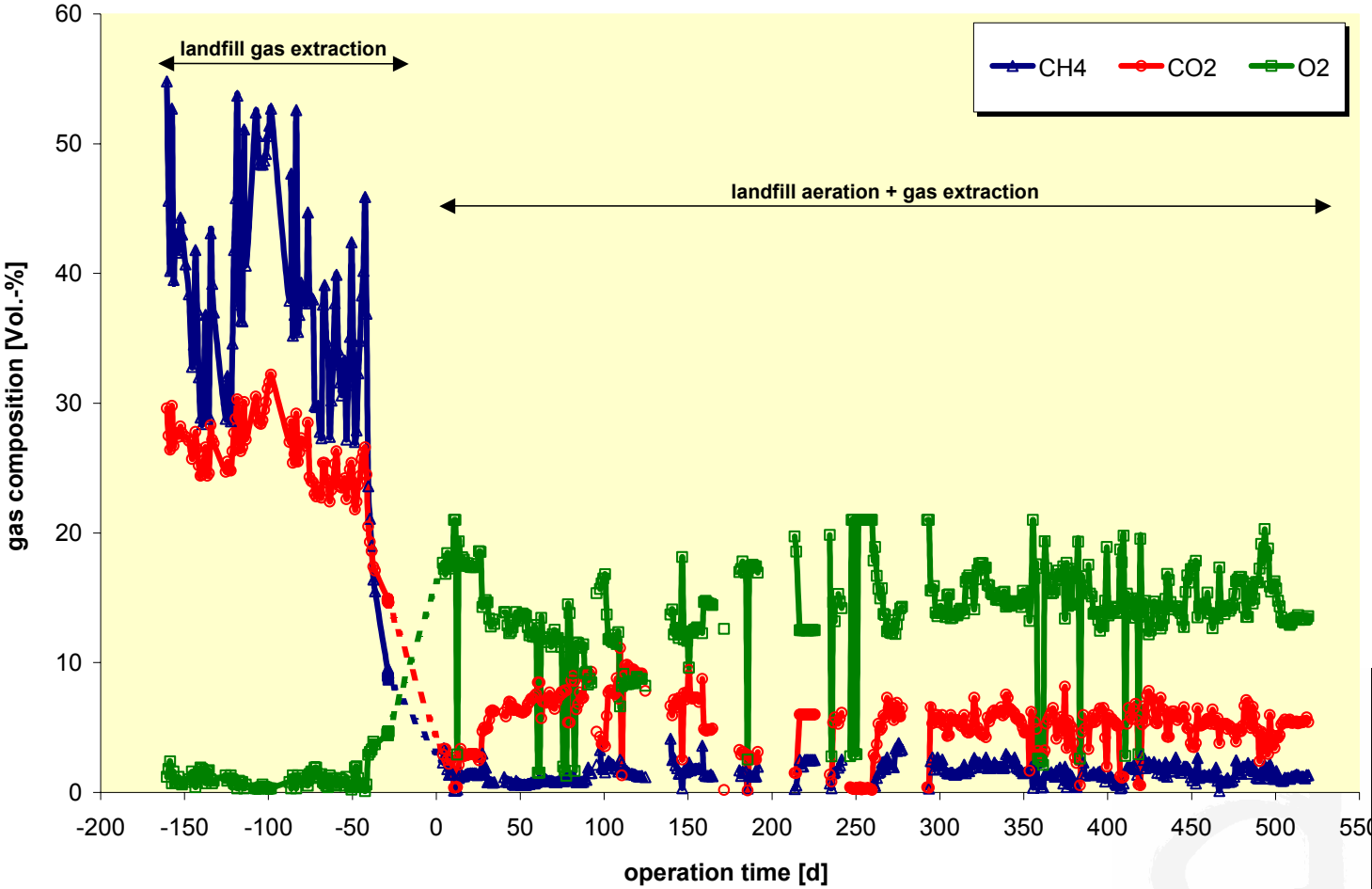
Operation of the aeration/gas extraction system



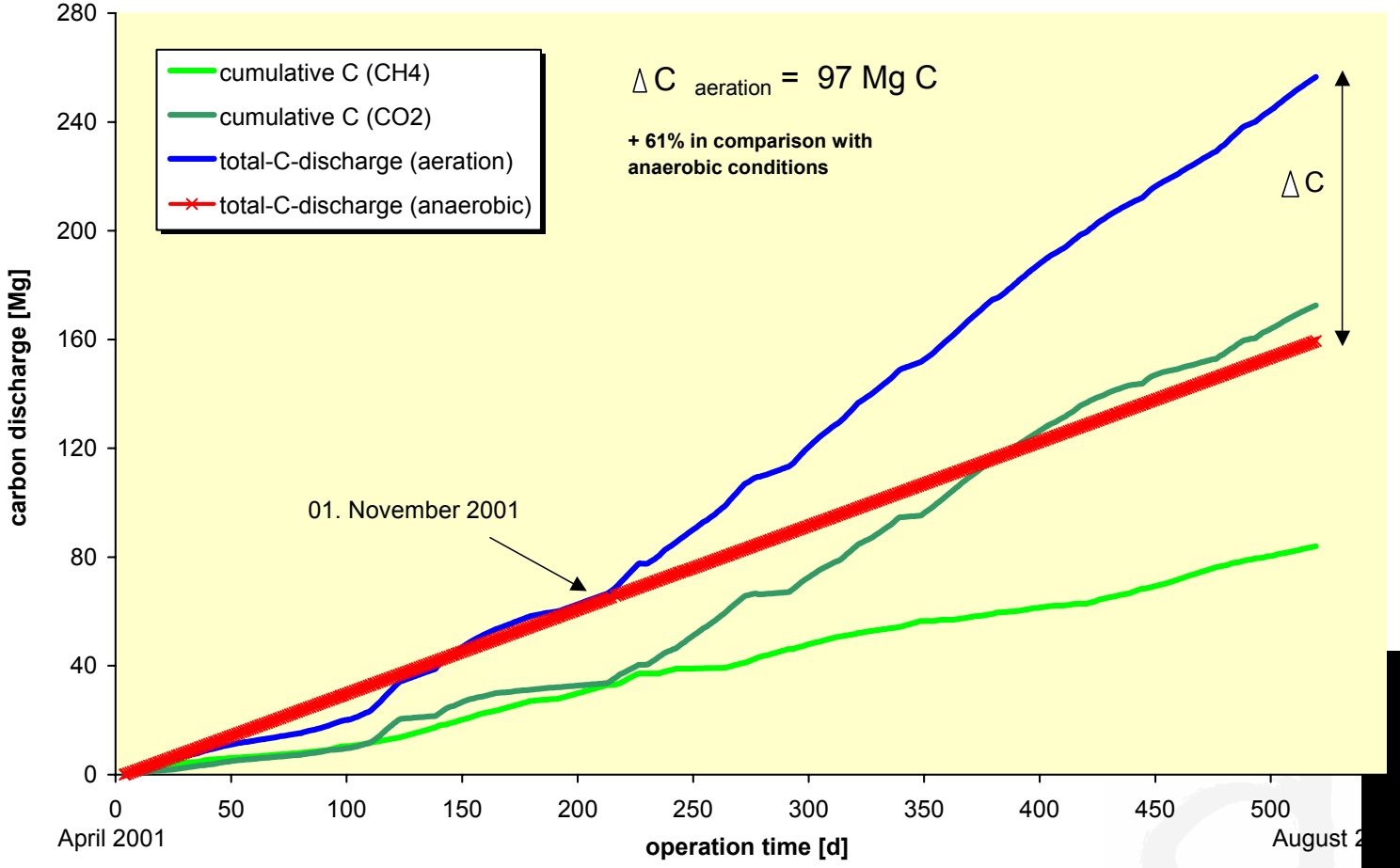
aeration and gas extraction during the remediation process

- CH_4 < 2 Vol.-%
- O_2 < 12 Vol.-%

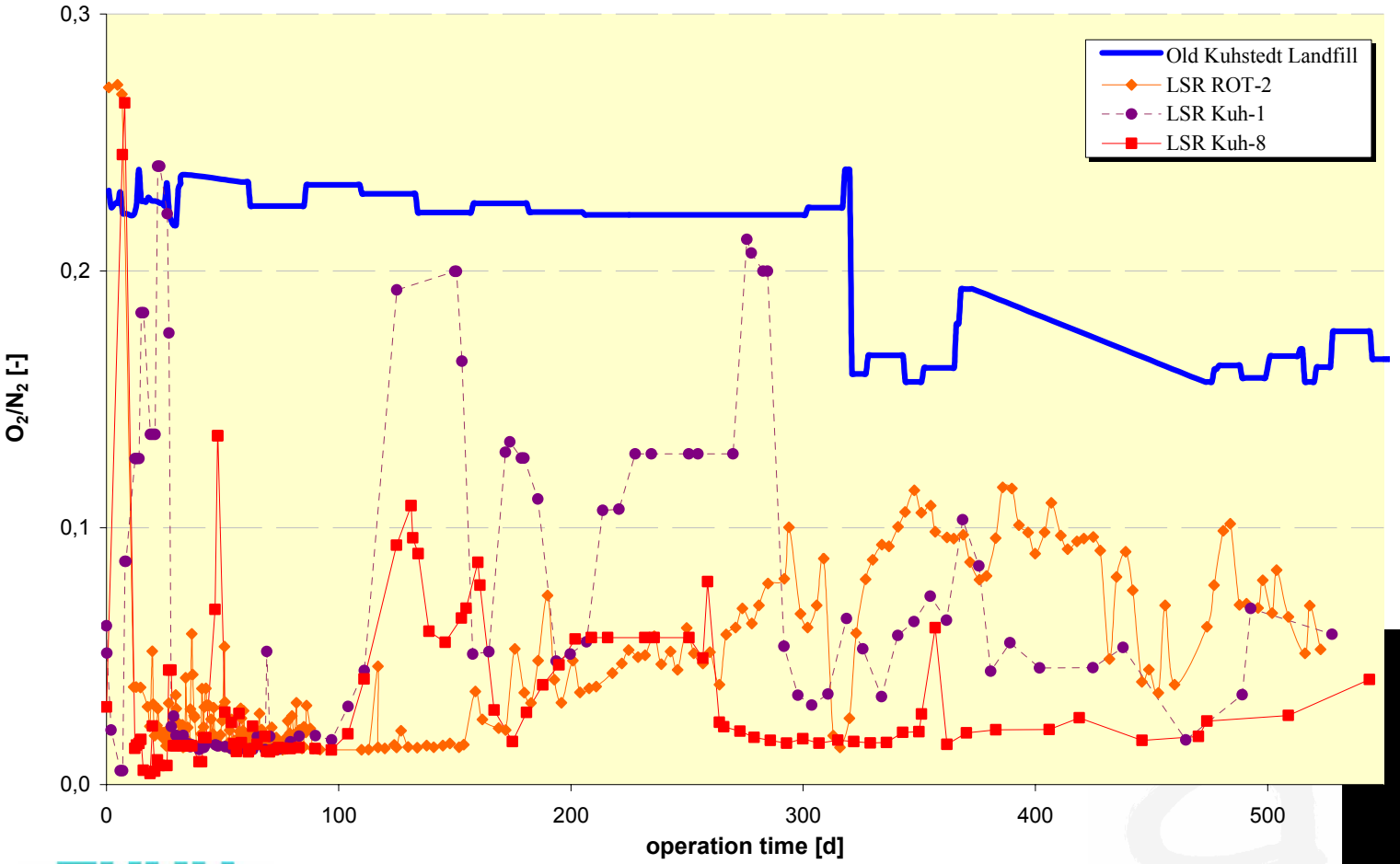
Change of the gas composition under the influence of aeration



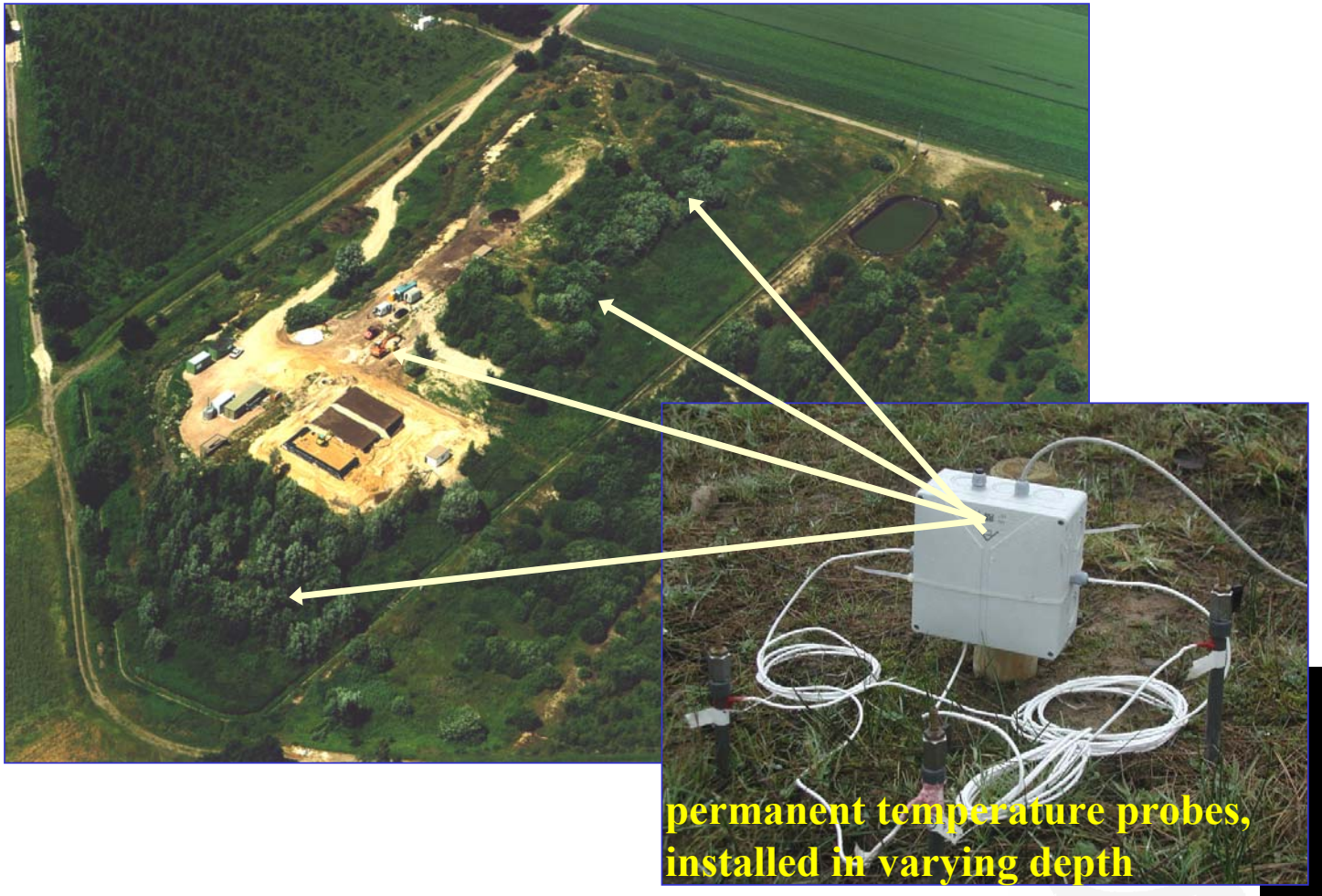
Accelerated carbon discharge as a result of the landfill aeration



Oxygen utilization
- comparison of landfill and LSR -

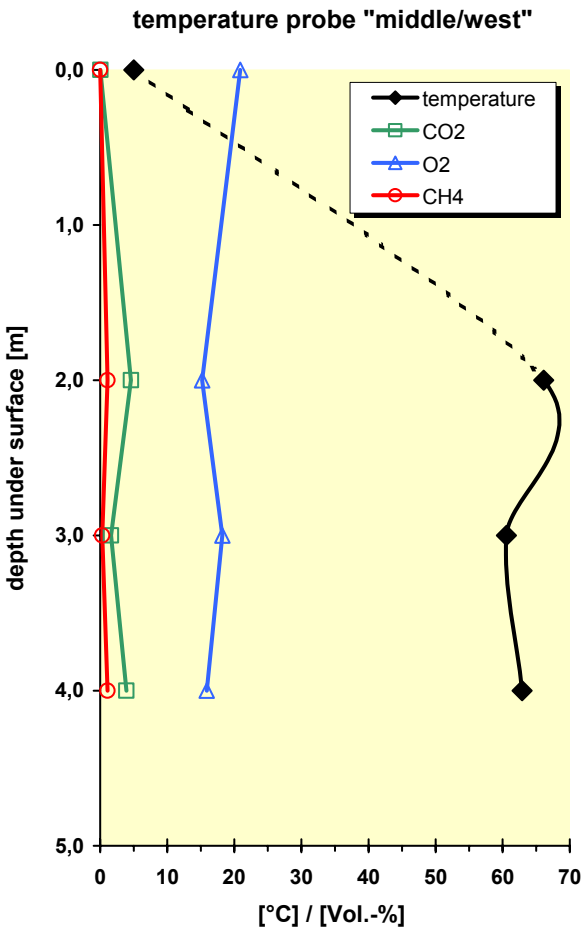


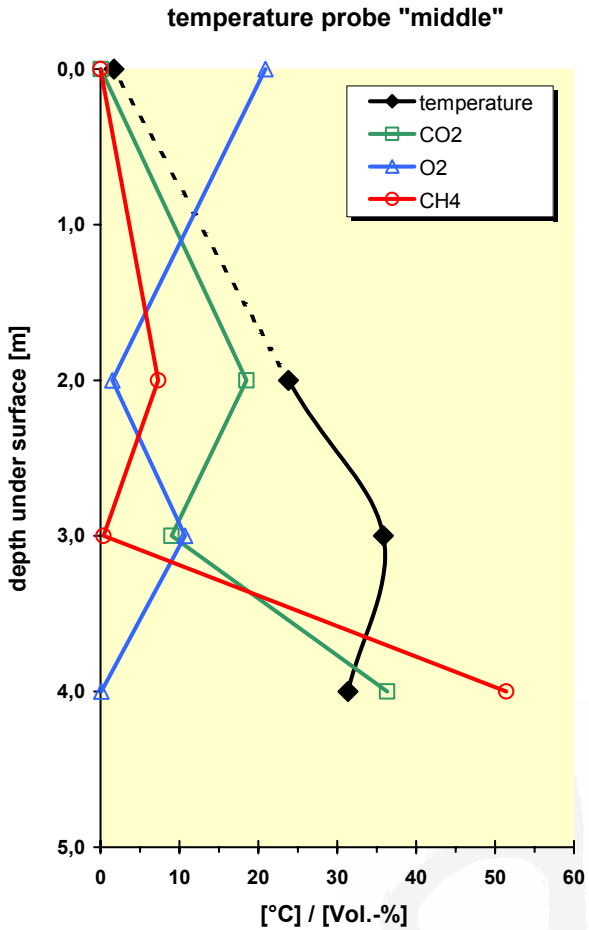
Installation of permanent temperature probes



permanent temperature probes, installed in varying depth

Temperature profiles and gas composition
(central landfill area)

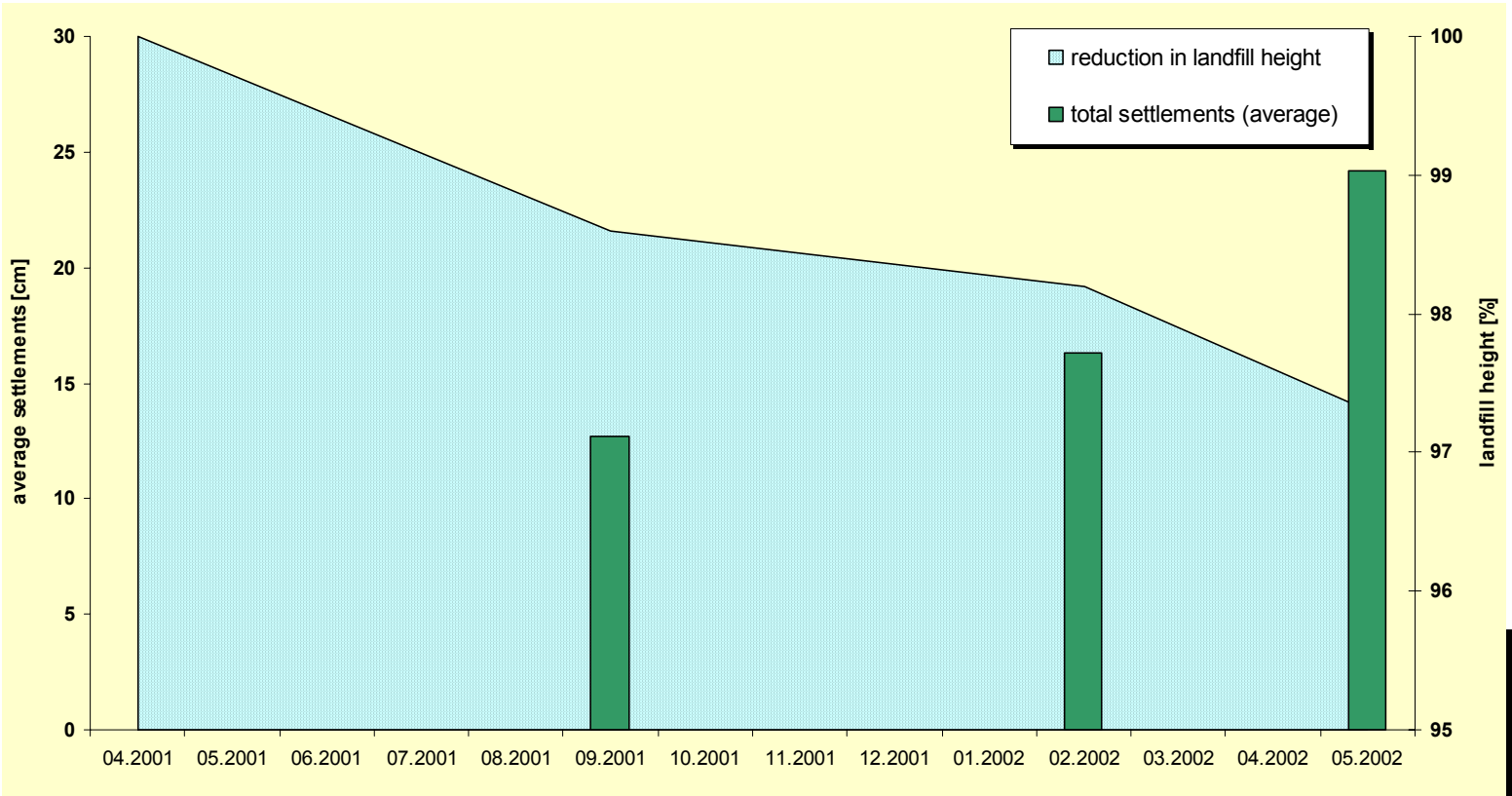




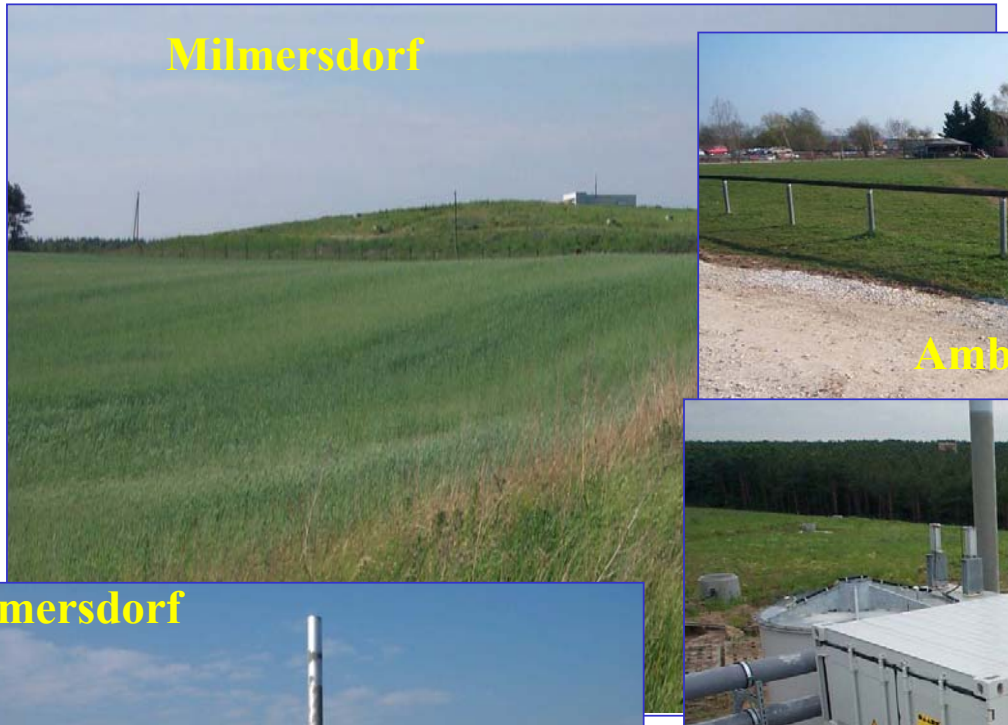
Settlements

- leachate monitoring well, southern area -

Gradient of settlements and reduction in landfill height during the aeration process



In situ aeration of the old landfills in Milmersdorf (Brandenburg) and Amberg (Bavaria)



The lab scale investigations demonstrate that

- a stabilization of the organic MSW substance and reduction of the emission potential of the waste material can be achieved;
  - *significant emission reduction*
- the carbon discharge via the gas- and leachate phase under aerobic conditions becomes accelerated;
- a significant reduction of the aftercare phase due to a reduction of the leachate emissions (especially nitrogen) seems highly probable.

The results of the full scale aeration indicate that

- the landfill body show a relatively high gas permeability;
- low pressures resp. vacuum allow the aeration of relatively wide areas of the landfill;
- the carbon discharge can be considerably increased compared with the anaerobic landfill;
- the biological available substances are converted faster by aerobic microorganisms
  - *increasing temperatures in the landfill body as well as considerably settlements*

Outlook and need for further research

- Continuation of the monitoring program for the supervision of the measures as well as control of success
- Optimisation of the aeration and gas extraction (aim: higher utilization rates of the added oxygen)
  - *Variation of aerated and extracted areas*
- Investigations of the microbiological processes in the landfill body during the changing of the milieu conditions (aerobic ⇒ anaerobic)
- Determination of the (more exact) air resp. oxygen distribution in the landfill body