MODELLING OF THE SOURCE TERM FOR A PREDOMINANTLY INORGANIC WASTE LANDFILL USING DATA OBTAINED FROM LABORATORY-SCALE TESTING, LYSIMETER STUDIES AND PILOT SCALE MONITORING.

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Sustainable Landfill Project (VVAV)

- VVAV - branche organization with most of the landfill owners in the Netherlands
- Motivation: concerns about long-term aftercare
- Pilot projects on sustainable landfill concepts
  - Predominantly inorganic waste landfill (in progress)
  - Stabilized waste landfill (starting October 2002)
  - Bioreactor (completed)
  - MSW leachate recirculation (in progress)
  - Waste recycling landfill (on drawing board)
- Testing at different scales with modelling to allow long-term predictions

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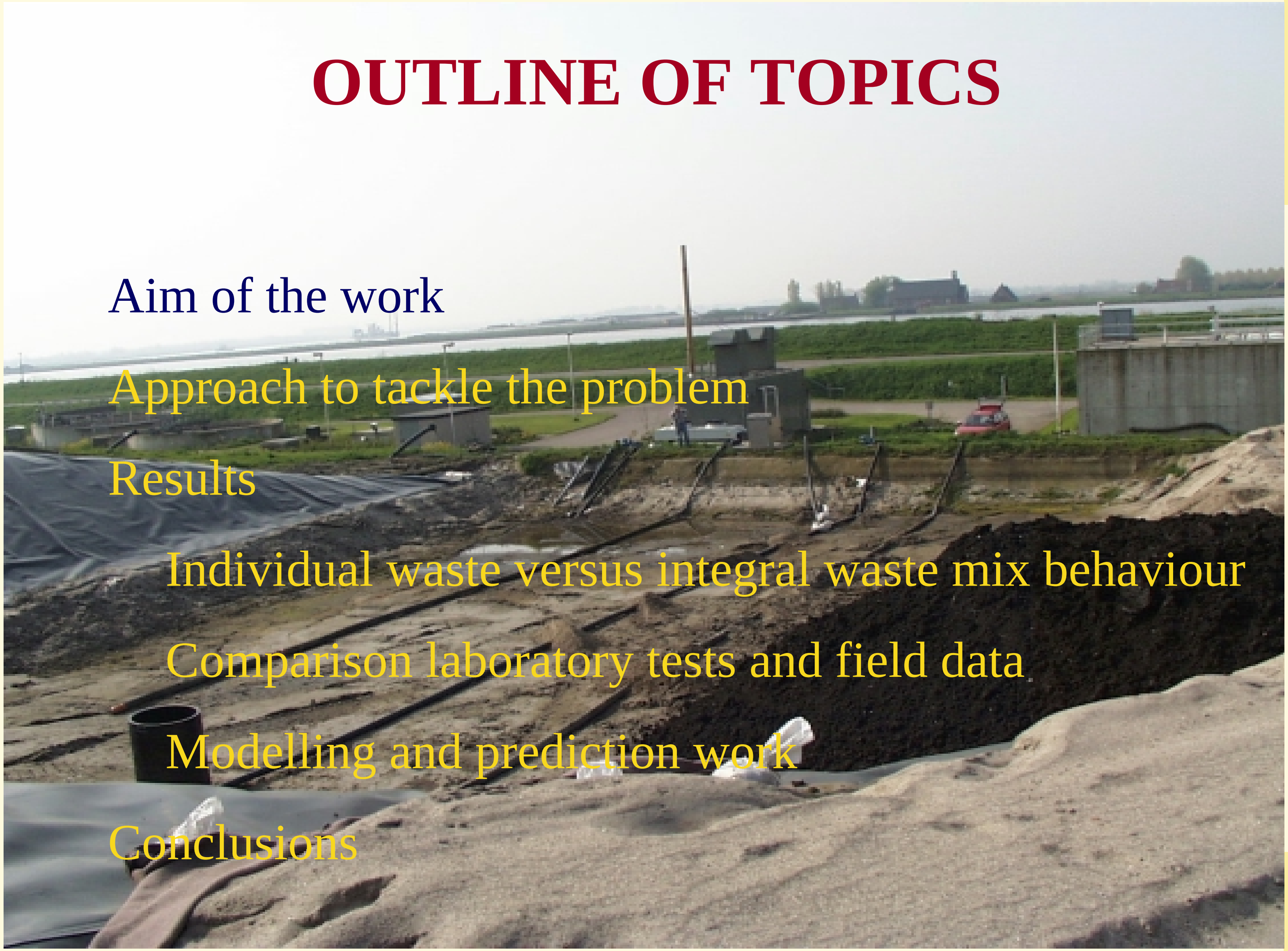
OUTLINE OF TOPICS



Aim of the work

Approach to tackle the problem

Results

- Individual waste versus integral waste mix behaviour
- Comparison laboratory tests and field data
- Modelling and prediction work

Conclusions

Start pilot

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MAIN OBJECTIVE

Create a sustainable landfill concept for predominantly inorganic waste by waste acceptance criteria focussed on reaching a long-term stable equilibrium condition in terms of pH (neutral), Dissolved Organic Carbon (DOC) level and other complexants.

Reduction of leachate concentrations to levels as close as possible to common levels in the natural surroundings, thus reducing the requirement for long term aftercare.

Avoid minor waste streams with an disproportionate high impact on overall leachate quality.

Provide better understanding of landfilled waste behaviour in the long term as isolation measures have a limited life span.

CHARACTERIZATION OF WASTE AND QUALITY CONTROL TESTING

NATURE AND ORIGIN OF THE MATERIALS

PHYSICAL PROPERTIES (e.g. density, porosity)

GEOTECHNICAL PROPERTIES (strength, permeability, stability)

CHEMICAL PROPERTIES (acid neutralization capacity, reducing capacity, degradable organic matter content, thermodynamic stability)

LEACHING BEHAVIOUR using pH dependence leaching test and percolation test

QUALITY CONTROL on site by testing pH (ANC), DOC, Cl, water soluble organic contaminants, mineral oil

CEN/TC 292
ENV 12920

Scenario Description

Material characterization

Controlling factors

Modelling leaching

Validation verification

Evaluation

Conclusions

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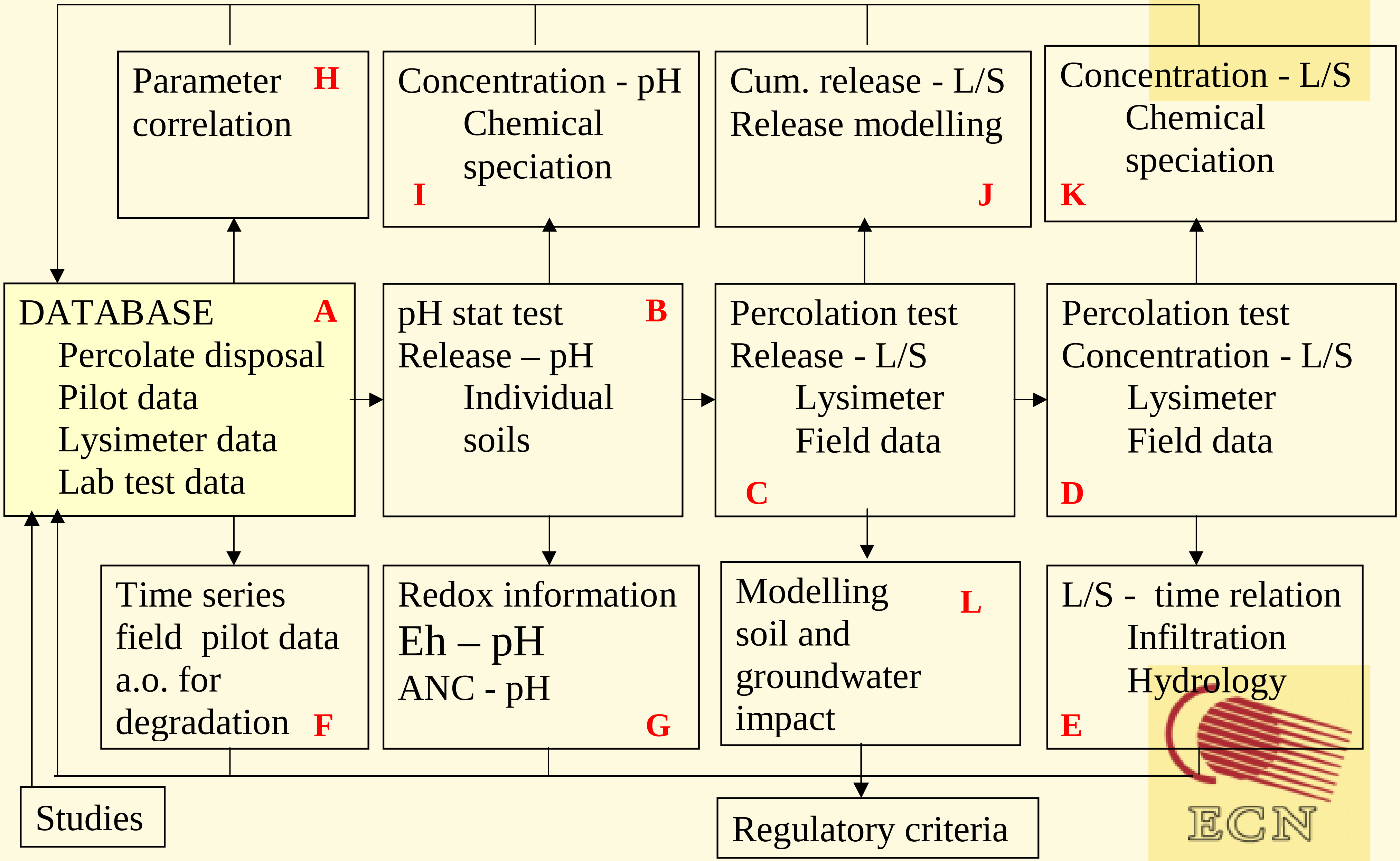
APPROACH TO TACKLE THE PROBLEM

DATABASE/EXPERT SYSTEM “LANDFILL SOURCE TERM AND IMPACT”



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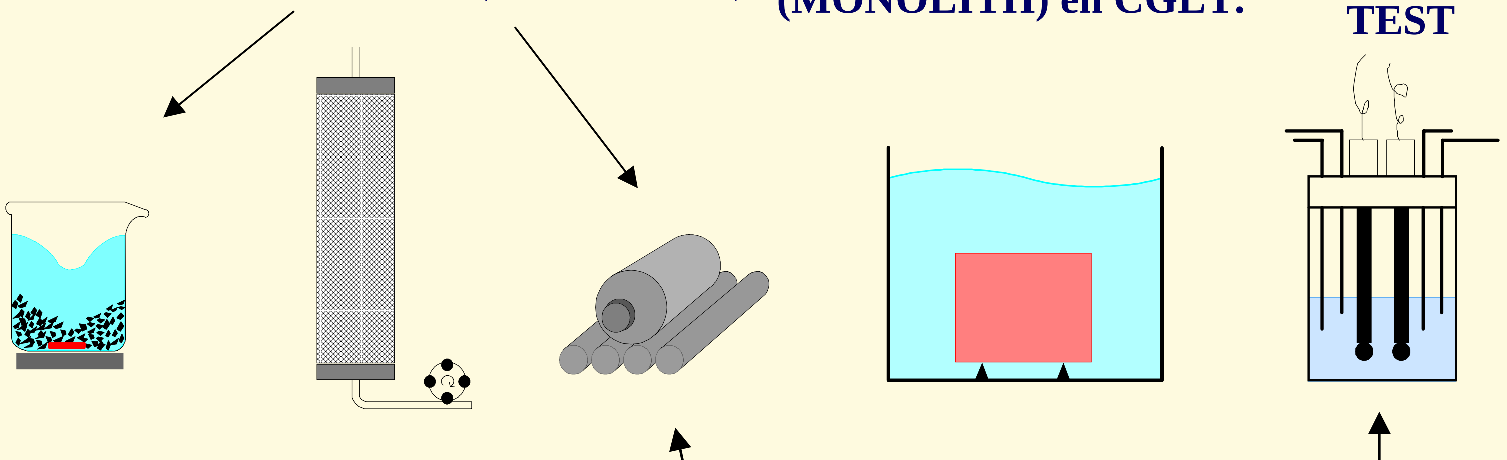
RELEVANT TYPES OF LEACHING TESTS

BATCH LEACHING TEST (GRANULAR)

TANK LEACH TEST (MONOLITH) en CGLT.

pH STAT TEST



PERCOLATION LEACHING TEST (GRANULAR PrEN 14405)

pH DEPENDENCE TEST:
BATCH MODE ANC and COMPUTER CONTROLLED
prEn 14429

pH, Eh DEPENDENCE

FACTORS CONTROLLING LEACHING BEHAVIOUR IN THE SPECIFIED SCENARIO

PERCOLATION TEST TO ASSESS LONG TERM RELEASE

Liquid to solid ratio (L/S) related to a time scale by infiltration rate, density and height of application.

TEST CONDITIONS:

Pre-equilibration after saturation for more than 24 hrs

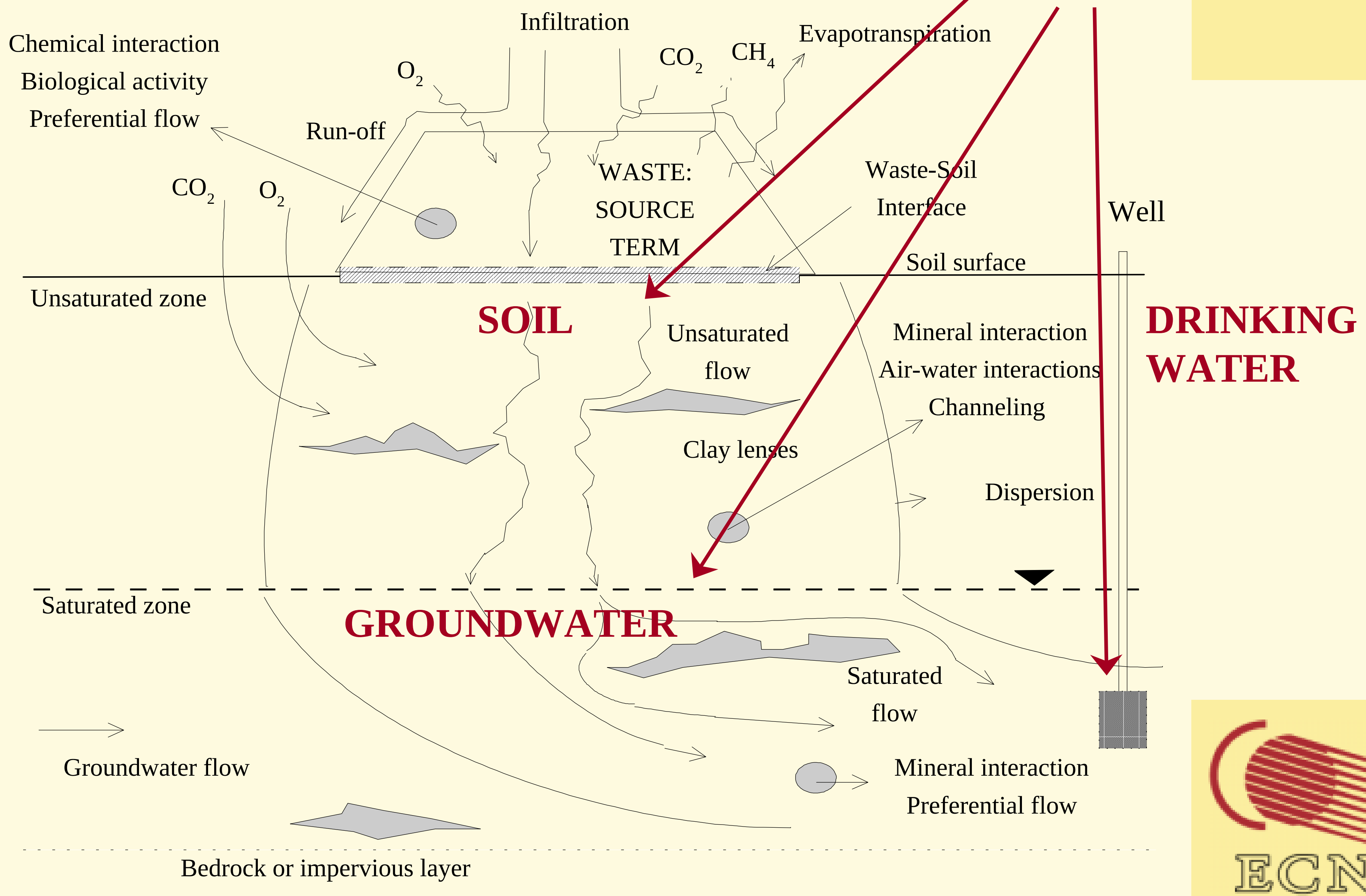
Up-flow

L/S range 0.1 - 10 (100 - 1000 yrs)

Test data in mg/l or mg/kg cumulative

LANDFILL IMPACT

POSSIBLE TARGETS



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LAB - FIELD VERIFICATION OF A SUSTAINABLE LANDFILL CONCEPT

Percolation test equipment

Lysimeters, Petten, NL

Pilot Nauerna (12,000 m3), NL

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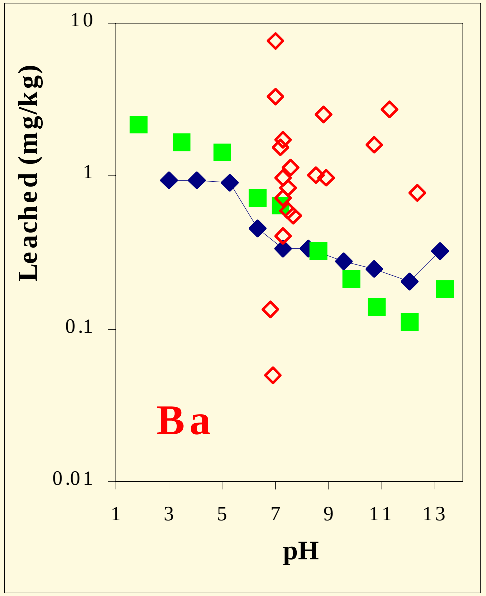
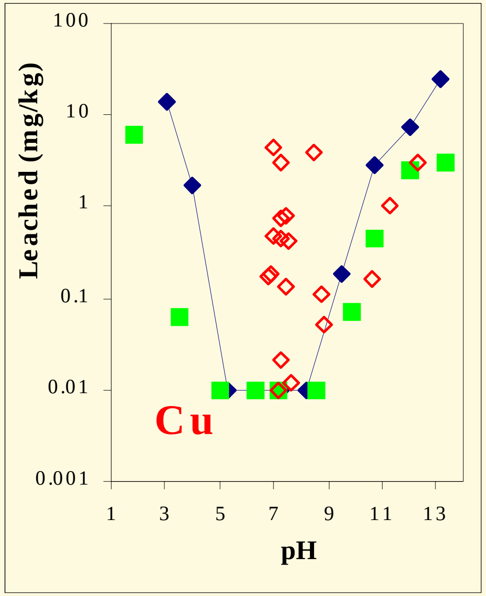
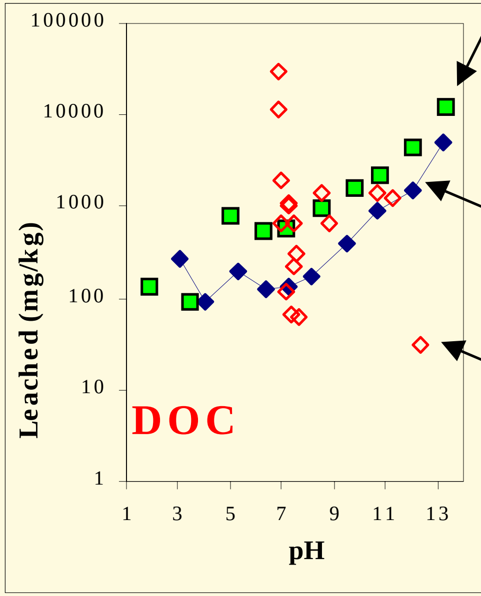
INDIVIDUAL WASTES VERSUS INTEGRAL WASTE MIX



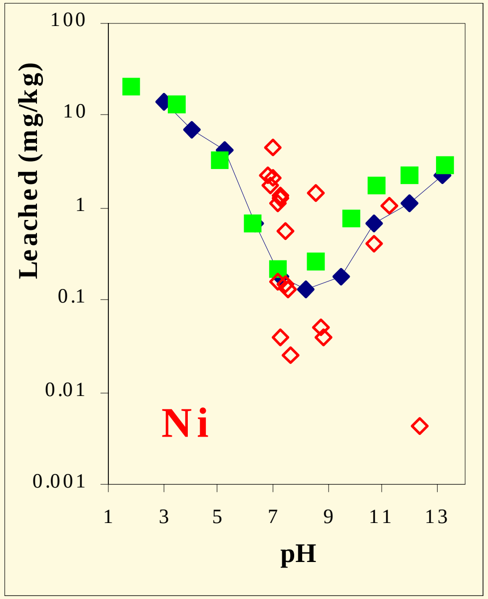


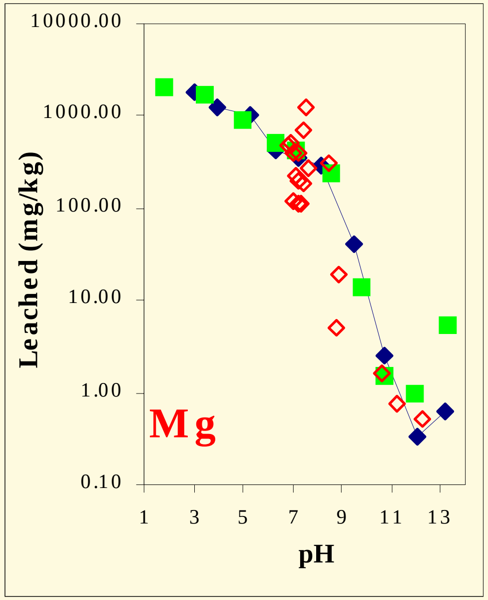


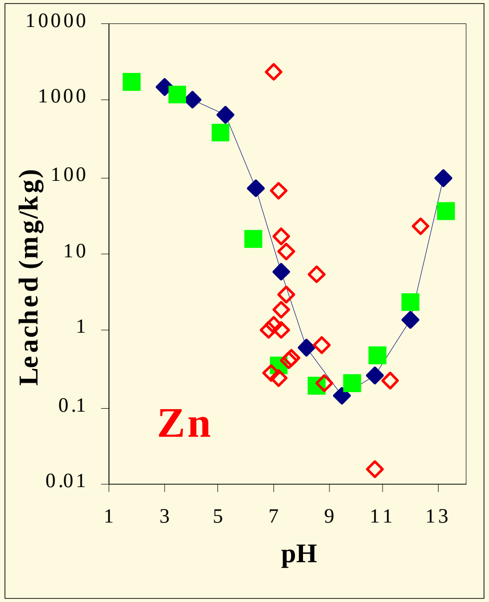
Integral waste mix enriched with organic rich waste

Integral waste mix

Individual wastes

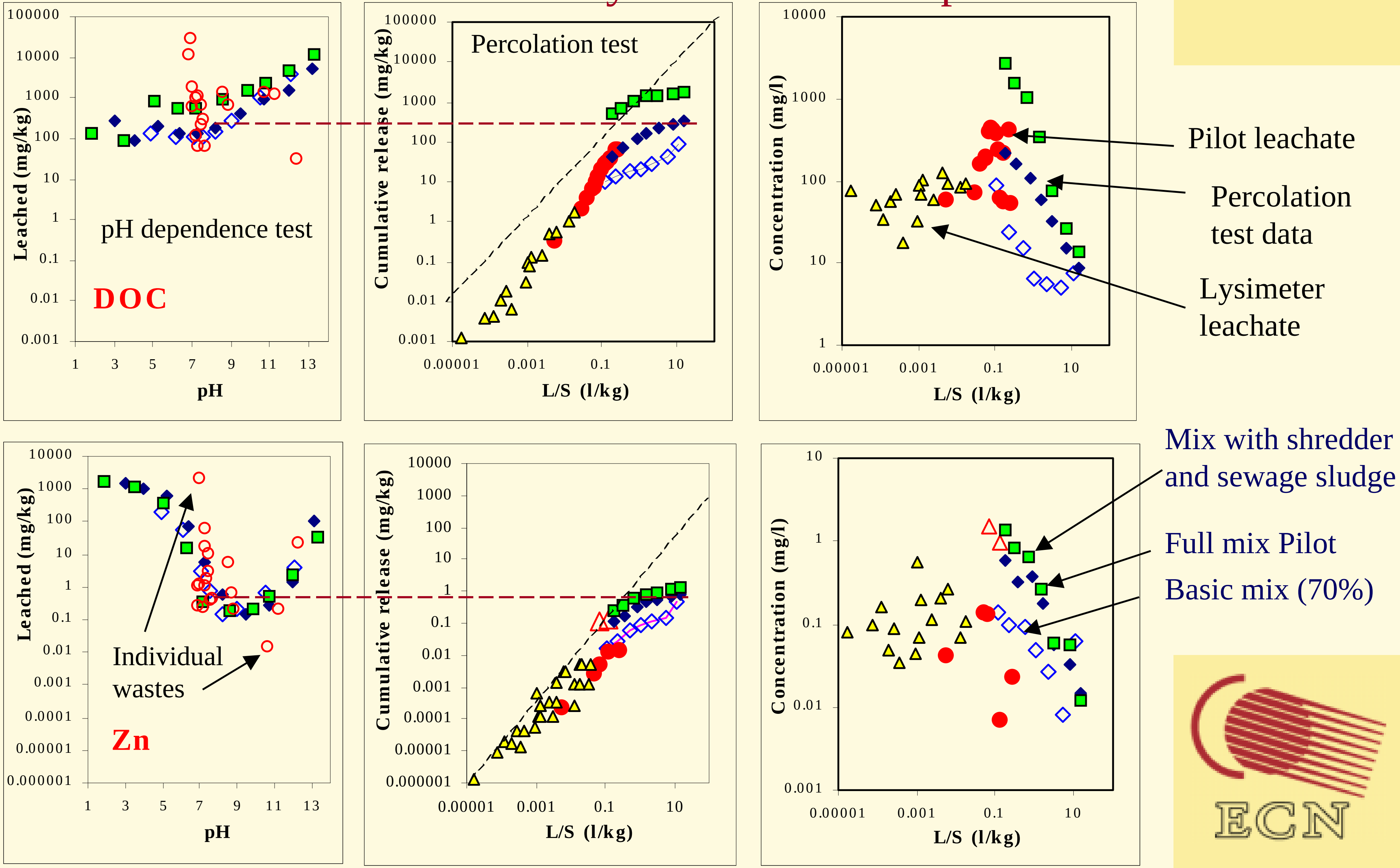






A waste mixture behaves quite systematic

Relationships between pH dependence and percolation test for a mixture of wastes disposed in a 12000 m^3 pilot cell with leachate data from 1.5 m^3 lysimeters and the pilot



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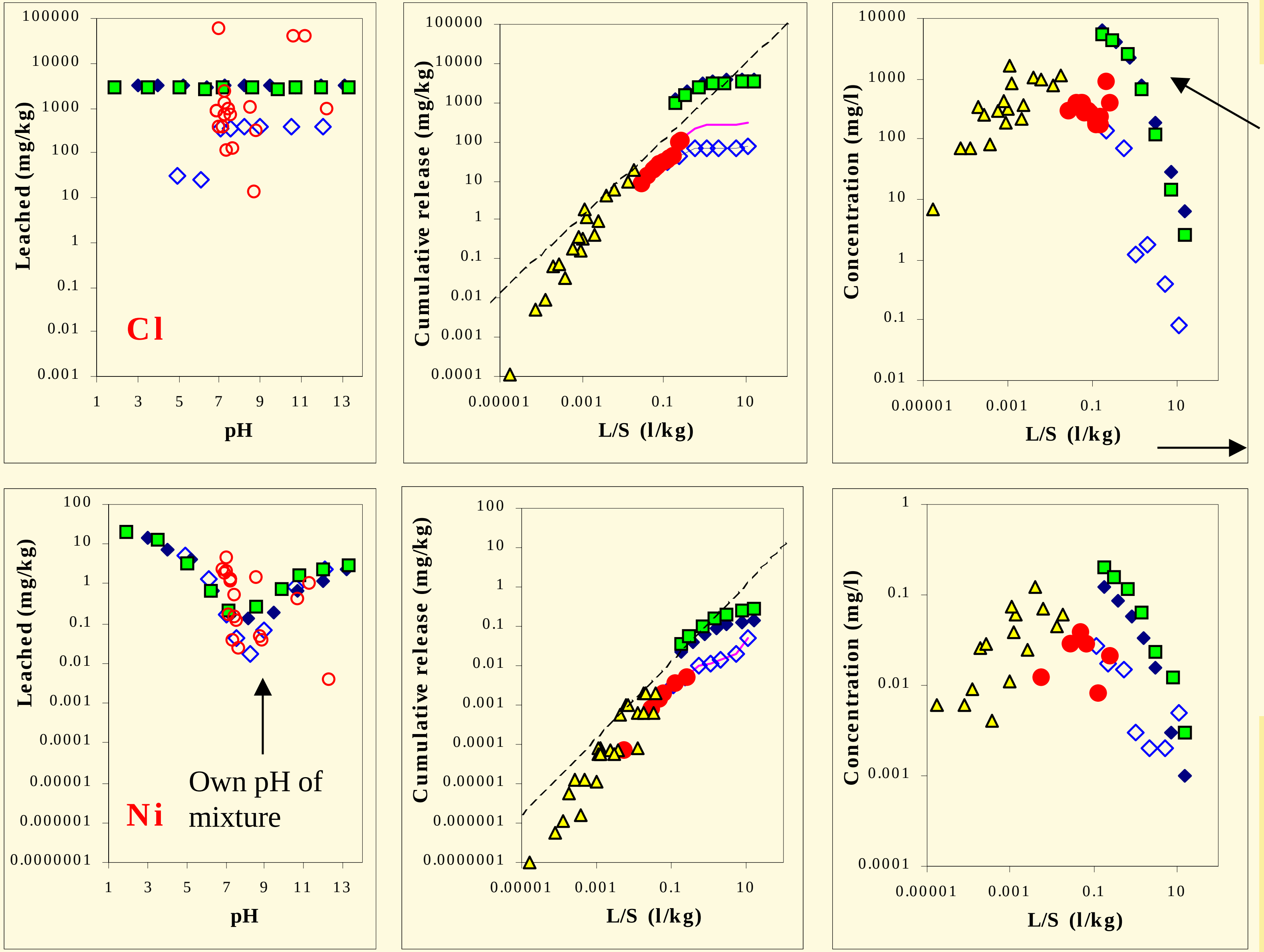
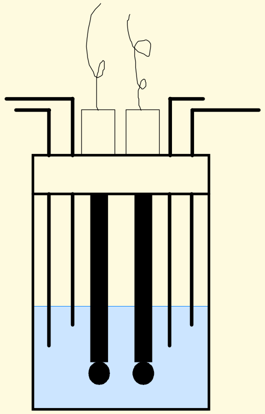
Relationships between pH dependence and percolation test for a mixture of wastes disposed in a 12000 m^3 pilot cell with leachate data from 1.5 m^3 lysimeters and the pilot

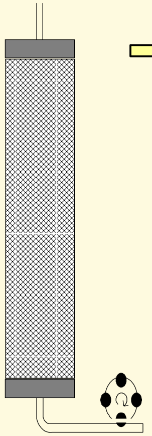


SOURCE TERM FOR GROUND-WATER IMPACT MODELING

L/S related to a time scale based on infiltration, waste density and height

GEOCHEMICAL MODELLING OF LEACHING TEST AND LEACHATE DATA



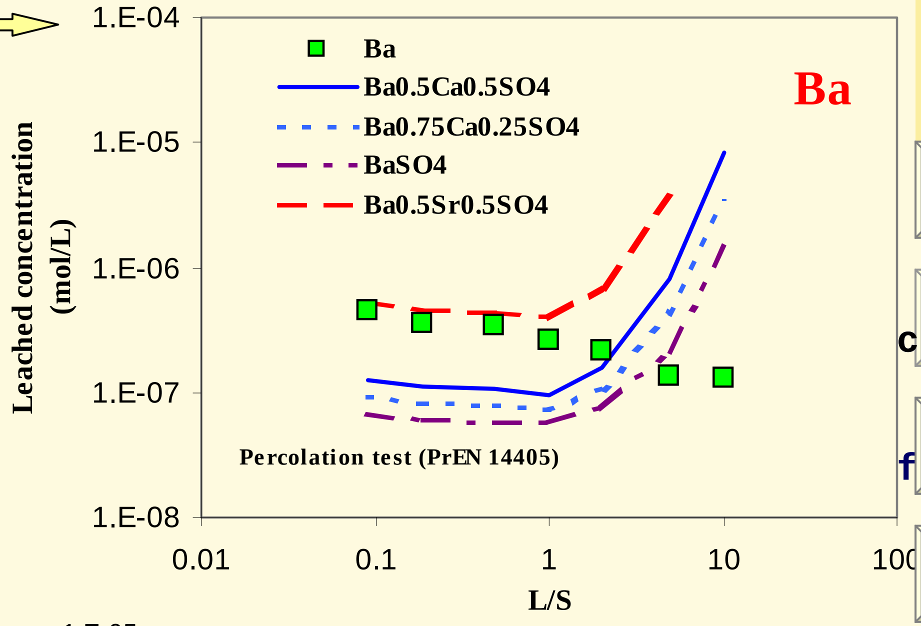


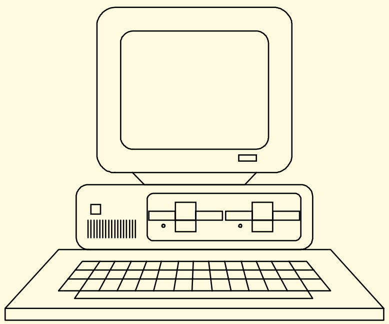
pH stat test and

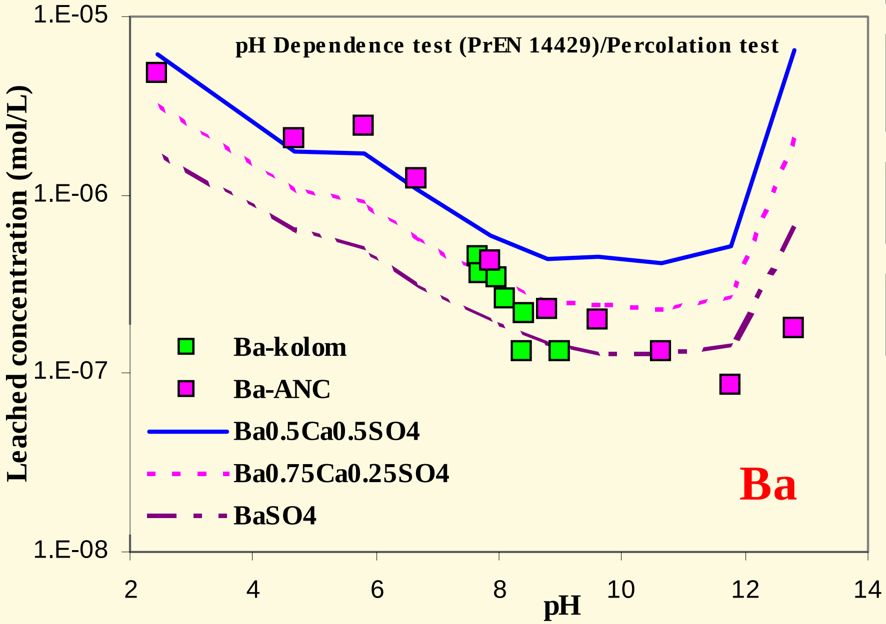
L/S = 10; t = 48 hr

percolation test

L/S=0.1-10







Geochemical modelling

ECOSAT extended MINTEQ database

- Scenario Description
- Material characterization
- Controlling factors
- Modelling leaching
- Validation verification
- Evaluation
- Conclusions

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SATURATION INDICES OBTAINED FROM ECOSAT USING MINTEQ DATABASE

Material	pH	Al(OH)3	BaCaSO4	BaSCrO4 77%	BaSrSO4 50%	CaCO3	CaSO4	MnCO3	Pb(OH)2	ZnCO3
Integral	13.17	-1.26				0.32			-0.75	
waste	12.01	-1.05	-0.37	-1.14	-0.83		-0.79		-0.23	
mix	10.7	0.11	0.17	-0.67	-0.33		-0.27		1.28	
Pilot	9.51	0.41	0.38	-0.66	-0.14	1.43	-0.03		0.37	
Nauerna	8.18	0.90	0.41	-0.59	-0.10	0.96	0.00	-0.50	-1.38	
	7.23	0.57	0.39	-0.66	-0.12	0.32	0.00	-0.57		-1.32
	6.36	1.22	0.43	-0.92	-0.11	-0.10	0.07	-0.81		-0.81
	5.27		0.48	-1.27	-0.08		0.15			
	4	-0.39	0.51		-0.07		0.20			
	3.02		0.40		-0.19		0.13			
Integral	13.3	-0.86				-0.54			-0.81	
waste	12	0.00				-0.33			1.04	
mix	10.74	0.61	-0.79		-1.42	1.35	-1.11		0.00	
Pilot	9.84	0.71	-0.09	-1.08	-0.64	1.39	-0.54		0.47	
Nauerna	8.57	0.88	0.26	-0.55	-0.25	1.15	-0.30			
with 10 %	7.16	0.08	0.48	-0.39	-0.05	0.41	-0.10	-0.58		
sewage	6.29	-1.30	0.54	-0.74	-0.03	-0.25	0.07	-1.02		
sludge +	5.02	1.13	0.58	-1.15	-0.01		0.14			
shredder	3.49		0.55	-1.45	-0.03		0.12			
waste	1.87		0.27		-0.31		-0.18			

Saturation index close to 0 implies potential solubility control

Percentage of the total dissolved concentration complexed with DOC as obtained from ECOSAT with Nicca-Donnan

Material	pH	Al	Cd	Cu	Fe	Ni	Pb	Zn
Integral	13.17	0	97	32	10	0	0	6
waste	12.01	0	100	74	56	2	0	71
mix	10.7	0	100	100	100	25	24	100
Pilot	9.51	2	100	100	100	26	59	100
Nauerna	8.18	30	97	100	100	12	37	89
	7.23	69	43	100	80	8	18	9
	6.36	65	10	100	35	4	13	2
	5.27	9	2	99	3	1	4	0
	4	0	0	8	1	0	0	0
	3.02	0	0	3	0	0	0	0
Integral	13.3	0	100	99	11	1	0	47
waste	12	0	100	100	89	40	3	100
mix	10.74	0	100	100	100	47	80	100
Pilot	9.84	3	100	100	100	48	84	100
Nauerna	8.57	44	100	100	100	34	75	100
with 10 %	7.16	92	69	100	38	19	38	59
sewage	6.29	100	34	100	13	12	34	8
sludge +	5.02	17	9	100	5	3	16	1
shredder	3.49	0	0	19	0	0	0	0
waste	1.87	0	0	1	0	0	0	0

Even in this predominantly inorganic waste DOC is apparently a very important controlling factor

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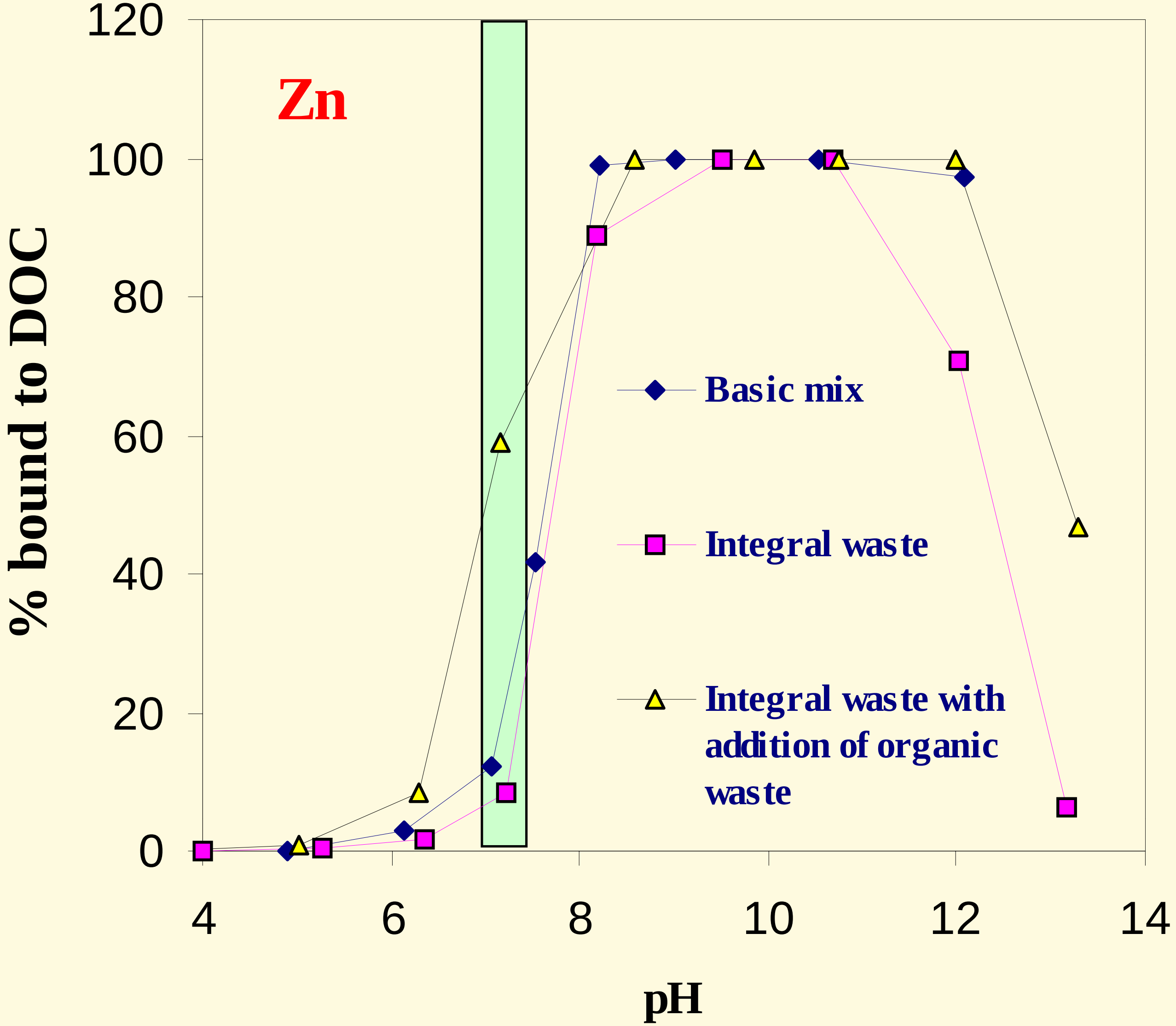
ASSOCIATION OF Zn WITH DOC FOR A BASIC MIX, THE INTEGRAL WASTE AND THE INTEGRAL WASTE ENRICHED WITH ORGANIC MATTER



Pilot NAUERNA with predominantly inorganic waste

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ORGANIC CONTAMINANTS IN PILOT NAUERNA

Comparison of lysimeter leachate and laboratory column eluate

		Organic contaminants in lysimeter leachate (microgram/l)		Lab data (ug/l)
		Integral waste	Integral waste enriched with organic matter	Column L/S=0.2
PAH (16)	22-2-02	1.05	2.28	
	29-8-02	0.07	0.12	0.33
	13-11-02	0.46	0.93	
BTEX/ VOX	Benzene	0.001	0.014	< 0.01
	Toluene	0.007	0.012	0.062
	Ethylbenzene	0.012	0.23	0.065
	M/p-xylene	0.017	0.23	0.025
	O-xylene	0.009	0.13	0.012
	VOX	0.055	0.672	151
Mineral oil		300	270	500

Significant difference between integral waste with and without additional organic matter.
Concentration levels between lab and field are quite similar for many components, except for VOX

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ORGANIC CONTAMINANTS IN PILOT NAUERNA

Comparison of laboratory column eluate with batch leaching test without and with pH control (pH=13)

		Organic contaminants in laboratory tests (microgram/l)		
		Column L/S=0.2	pH stat L/S=10 pH= 6.95	pH stat L/S=10 pH= 13
PAH (16)		0.33	36	794
BTEX/ VOX	Benzene	< 0.01	< 0.01	<0.1
	Toluene	0.062	0.064	0.116
	Ethylbenzene	0.065	0.040	0.139
	M/p-xylene	0.025	0.029	0.333
	O-xylene	0.012	0.031	0.468
	VOX	151	15	77
Mineral oil		500	356	3496
DOC		101	15	1027

Batch tests lead to higher release of PAH. At high pH significantly higher release of all organic contaminants probably largely in association with DOC

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DATABASE / EXPERT SYSTEM OF CHARACTERIZATION DATA FOR WASTE, SOILS, CONSTRUCTION MATERIALS

- Reference for compliance test data
- Basis for regulatory development
- Limit unnecessary duplication of work
- Avoid generation of useless data at great cost
- Focus on key parameters for specific materials
- Identify controlling factors for guiding the choice of treatment options/ recipes

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MATERIALS FOR WHICH MORE EXTENDED LEACHING INFORMATION IS AVAILABLE

Sources: Mammoet project, RIVM studies, EU Harmonisation work (ECN, DHI, INSA, WRc, IBAC,NNI,UB), ECN research, Building Materials Decree certification, others.

Synthetic Aggregates (coal fly ash, mining waste, etc)
Alkaline batteries
Al-production ash
Asphalt
Asphalt rubble
Basalt
Biomass ash
Bioreactor residue (after degradation)
Blast furnace slag
Bottom ash (coal)
Brown coal ash
Bricks (ceramic)
Cat. Cracker, Cat. ox. RVC
Chemical sludge (Electroplating Ni)
Clay bricks
Coal fly ash
Compost
Concrete
Concrete with coal fly ash
Construction debris
Contaminated soil
Crushing waste
Cryolite waste (Zeolite production)
Detox., neutralized dewatering sludge(filter cake)
Dredging sludge
Drinking water pipes
Drinking water product. sludge (ground water)
Dust form a sand blasting unit
Tannery Sludge
TBBA recovery sludge from production of te
Tiles (ceramic)
Sb containing sludge

Expanded clay pellets
Fe-Cr catalyst residue
Fe-norit waste from phamarceutic industry)
FeOH sludge needle factory
Filter cake MSWI
Filter dust (ceramic industry)
Flotation concentrate/sand blasting waste purific.
Fluor cont. dust from primary Al production
Flourescent Powder
Fly ash from isolation material prod.
Fly ash industrial waste and RDF incineration
Foundary sand (waste material)
Foundry Oven Dust
Galvanic sludge
Glass-oven rubble formglass production
Glaze/enamel sludge
Gravitational concentrate/sand blasting waste
HCH soil purific. res. (physical purification)
Incinerated sewage sludge
Jarosite
Sand blasting waste
Sediments (river, lake, canal)
Sewage sludge
Shredder waste
Sieve sand from demolition breaker
Soil (various types of natural soil: sand, loam, clay)
Soil amended with sewage sludge
Soil purific. extract. Residue
Spent Catatalyst (activated Al)
Stabilized galvanic sludge
Stabilized waste (various)
Steel slag

Lava stone
Lime stone
Light weight concrete
Lime silicate bricks
Metallurgical sludge (Cao-type)
Metalugical slag
Milling residues
Mine stone (coal)
Waste mixture (70% of landfilled waste largely inorg.)
MSWI residues (bottom ash, fly ash APC residues)
Municipal Solid Waste, fly ash
Natural gas production sludge
Ni sludge
Non-purificable sand blasting dust
Oven waste from primary Al production
PAH, PCB and metal polluted soil
Paper sludge
Pb/Zn slag
Phosphate slag
Phosphating Sludge
Phosphogypsum
Pigment Sludge
Plastic waste material
Preserved wood
Purification sludge from industrial purification
Purification sludge from textile paint product.
Purification Sludge polymer prod.
Refuse derived fuel ash
Vitrified MSWI fly ash
Zn-Fe-salt residue from Zn-varnish installation
Zn-MnO- batteries

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CONCLUSIONS

– Comparison between laboratory scale leaching tests on the same wastes going to a pilot cell of ultimately 12,000 m^3 and leachate measurements from pilot test are quite promising.

– Characterisation leaching tests, such as developed in CEN TC 292 WG 6, provide the source term for modelling long term release from landfills and contaminated sites.

– Quality control and acceptance on the basis of knowledge of interactions of different materials will lead to a more controlled release of contaminants from the landfill in the long term.

– Already, the concentration levels encountered in leachate for a variety of constituents are relatively low and would not require further treatment.

– A limited number of leaching tests can provide the crucial answers needed to assess impact.

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CONCLUSIONS

– Chemical speciation of mixed waste using mineral solubility and organic matter interactions provides a very revealing insight in release controlling factors

– Reduction of DOC levels in leachate by proper acceptance criteria will lead to significantly decreasing concentrations of contaminants in the leachate. This does not imply banning organic matter as residual, non-degradable organic matter is quite acceptable.

– The characterization of waste will allow identification of relatively small waste streams that disproportionately affect the quality of the leachate of the entire cell.

– Such waste require either pretreatment or disposal in another landfill concept (e.g bioreactor).

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ACKNOWLEDGEMENT

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