

ENVIRONMENTAL ASPECTS OF CEMENT-BASED MATERIALS, AGGREGATES AND PAVEMENT MATERIALS

Methodology for development of criteria

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**ECO-Serve project meeting
Sittard, 4-5 November 2004**

Work carried
out in the
framework of
ECRICEM I, II
and ECO Serve



Relevance of Cluster 1 work for EU regulations

Life Cycle Analysis (LCA) covers too many aspects to be feasible for regulatory decisions in the next decade. Environmental Impact Assessment (EIA) using results from leaching studies and interpreting data in relation to soil, groundwater, surface water impacts is feasible within a couple of years. This is in time for the second generation of product standards needed in the CPD.



CPD - Dangerous substances

Essential requirements nr. 3: Hygiene, health and environment:

- the giving-off of toxic gas,
- the presence of dangerous particles or gases in the air.
- the emission of dangerous radiation (e.g. Radon)
- **pollution or poisoning of the water or soil**,
- faulty elimination of waste water, smoke, solid or liquid wastes,
- the presence of damp in parts of the works or on surfaces within the works.

Which substances:

- Substances mentioned in EU directives and in National notified regulations linked with construction products

Note: CPD covers service life only



CPD - ER3 Dangerous substances

Mandate accepted by Standing Committee Construction on October 26 2004

Beginning 2005 mandate issued to CEN

Work plan to be drafted in 8 month

Start of the horizontal standardisation work on:

Sampling

Indoor air

Impact to soil and groundwater (ECRICEM/ECO Serve input)



Awareness of Cluster 1 developments in CEN, at regulatory level and in the industry

Consulted in the preparation of the Mandate for the CPD

Participation in CEN – Construction and CEN Environment contacts (CSNPE)

Direct involvement or close contacts with several CEN TC 's relevant for Environmental criteria in Construction TC 51, TC104, TC 164, TC 154

Contact with national regulatory agencies (NL, D, A, ..) and EU (Fuchs)

Contacts with research organisations CRIC, DTI, VTT, BYGGFORSK,...

Contacts with Industry and branche organisations (HOLCIM, NORCEM, ENCI, Dutch construction representatives, KIWA, ..)



Applicability of generic approach

Framework approach in environmental impact assessment to soil and groundwater has wider applicability than just concrete

- Construction materials
 - Concrete and cement based products (Cluster 1 and 2)
 - Asphalt products (pavement materials)
 - Bricks
 - Lime silicate bricks
 - Metallic plate materials (Pb, Cu, Zn)
 - Road base materials (aggregates, C&D, MSWI bottom ash SAMARIS)
- Preserved wood
- Drinking water pipes
- Soil
- Waste and stabilised waste
-



Making dbase/expert system available (not part of ECO Serve)

Public domain data

Web-based application (project in preparation)

Stand alone version

Through subscription fee access to the system

Timing

version for specialists this year

Version for end-users middle next year



LIFE CYCLE ISSUES IN SOIL & GROUND AND SURFACE WATER IMPACT

- Service life: different exposure scenarios
 - Constructions in water
 - Constructions on land
 - Drinking water pipes/basins
- Recycling stage (bound): same as service life
- Reuse stage (unbound): different exposure scenarios
 - Road base/embankment
 - Structural fill (dikes, soundbarriers)
- "End of life": Landfill scenarios
 - Inert landfill
 - Non-hazardous waste landfill

Characterisation testing provides information on the abovementioned life-cycle stages



NEW APPROACH

- Separate activities in parallel fields hinder the development of a **generic approach** to assess environmental impact from different materials in different applications (e.g. some 40 TC's in construction).
- Work in widely different fields following the same testing approach, points at **many similarities** in mechanisms, controlling factors for release and common aspects in exposure scenarios.
- The key towards the development of a unified environmental approach in assessing impact from materials is to focus on release mechanisms and controlling factors and to bring the relevant information together in a **database / expert system**.



FRAMEWORK

A robust and scientifically sound, while practical, **framework for characterisation of environmental behaviour** of soils, sludges, wastes and constructions materials in a range of applications and exposure scenarios is in development in EU and US

The framework is a **tiered approach**, allowing the user to select the level of testing and evaluation required based on the degree of conservatism needed, prior information available, and balancing costs of testing against benefits from more detailed information



ASPECTS ADDRESSED IN EXPERT SYSTEM/ DATABASE

SOIL, SLUDGE, SEDIMENT, WASTE, CONSTRUCTION MATERIALS, etc

Expert system /database

Data integration between fields and tests,
modeling and verification against field data

Problem definition and test selection

Lab, lysimeter, field data collection,
data management, data formatting, storage and retrieval

Management Scenario Description – configuration, design
specifications, infiltration, climate

Physical , chemical, biological properties

pH, L/S & time dependence - speciation, redox, DOC, EC, ANC

Release with time

Granular
Percolation

Monolithic
Surface area related

Source term description

Impact evaluation subsoil and groundwater

Judgement and decision making
QC; Regulatory aspects
Treatment, Disposal, Utilization, Remediation end-points, long-
term stewardship requirements

Not limited
to one
construction
material type



CONSTRUCTION PRODUCTS DIRECTIVE (CPD)

(MODULAR) PROPERTIES FOR CONSIDERATION IN RELATION TO REGULATED SUBSTANCES IN CONSTRUCTION PRODUCTS

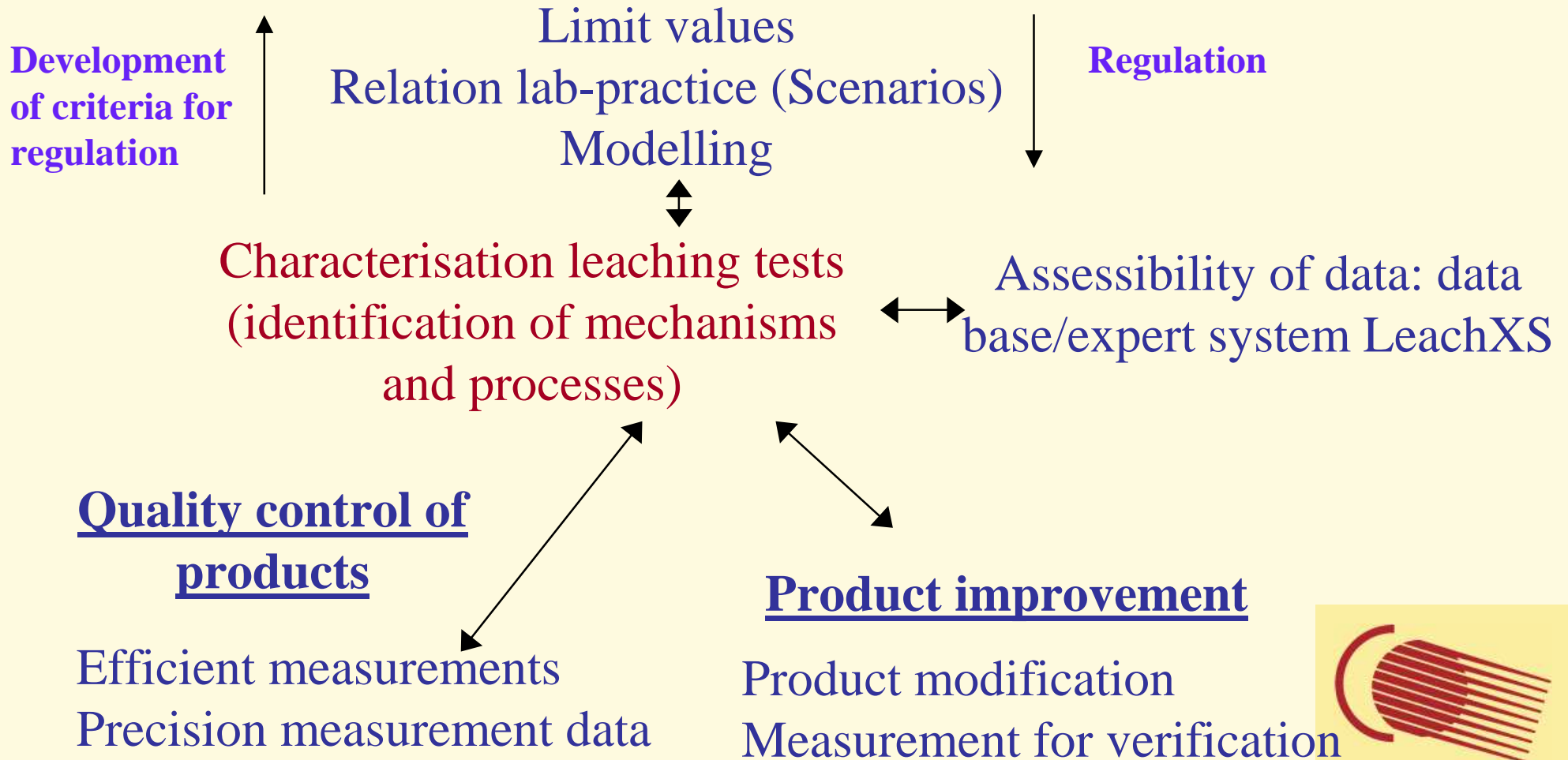
Main aspect	SAMPLING		RELEASE SCENARIOS			Release to Soil, Surface & Groundwater						END TO LIFE	ELUATE/DIGEST ⁵⁾
	Sample strategy	Pretreatment	Content ⁴⁾			Soil & groundwater		Drinking water		Soil & groundwater			
Target	Sampling ³⁾	Storage	Inorganic	Organic	Asbestos	Granular materials		Monolithic materials		Drinking water		Soil & groundwater	
Sub topics						Characterization ¹⁾	Compliance	Characterization	Compliance	Characterization	Compliance	Analysis	
Type						Soil protection, surface water quality, groundwater quality				Drinking water quality		Landfill/ soil like use	
Regulatory aspect													
PRODUCT FAMILIES IN CONSTRUCTION													
Aggregates						PrEN14405 PrEN14429	EN12457-2 EN1744-3					PrEN14429(pH=7) EN12457-2	
Aggregate in concrete (bound)								Wi292040	PrEn14429	Wi292010		PrEN14429(pH=7)	
Aggregate in road base (unbound)						PrEN14405 PrEN14429	EN12457-2 EN1744-3					EN12457-2 PrEN14429(pH=7)	
Aggregate as structural fill (unbound)						PrEN14405 PrEN14429	EN12457-2 EN1744-3					EN12457-2 PrEN14429(pH=7)	
Cements, Building limes and other hydraulic binders ²⁾													
Concrete, mortar, Grout and related products								Wi292040	PrEn14429	Wi292010		PrEN14429(pH=7)	
Construction adhesives						?	?						
Curtain walling						?	?					EN12457-2	
Doors, windows, shutters, gates and related building hardware												?	
External thermal insulation													
Fire stopping, fire sealing and fire protection products													
Fixed fire fighting systems													
Floorings												EN12457-2	
Geotextiles													
Glass products													
Gypsum products						PrEN14405 PrEN14429	EN12457-2					EN12457-3	
Internal & external wall and ceiling finishes													
Internal partition kits													
Light composite wood based beams and columns													
Liquid applied waterproofing kits													
Masonry and related products								Wi292040	PrEn14429	Wi292010		EN12457-2	
Membranes													
Metal anchors for concrete													
Metal injection anchors for use in concrete to fix lightweight systems													
Non-load bearing permanent shuttering kits													
Pipes, tanks and ancillaries not in contact with water													
Plastic anchors for use in concrete and masonry													
Post-tensioning kits for pre-stressing of structure													
Prefabricated stair kits													
Reinforcing and pre-stressing steel for concrete													
Road construction products						PrEN14405 PrEN14429	EN12457-2	Wi292040	PrEn14429	Wi292010		EN12457-2 PrEN14429(pH=7)	
Asphaltic products						PrEN14405 PrEN14429	EN12457-2	Wi292040 (kin.)	PrEn14429	Wi292010		EN12457-2	
Roof coverings, rooflights, roof windows an ancillary products													

Availability of Test methods for Construction products



ROLE OF CHARACTERISATION LEACHING TESTS IN ENVIRONMENTAL JUDGEMENT

Judgement of the application of materials

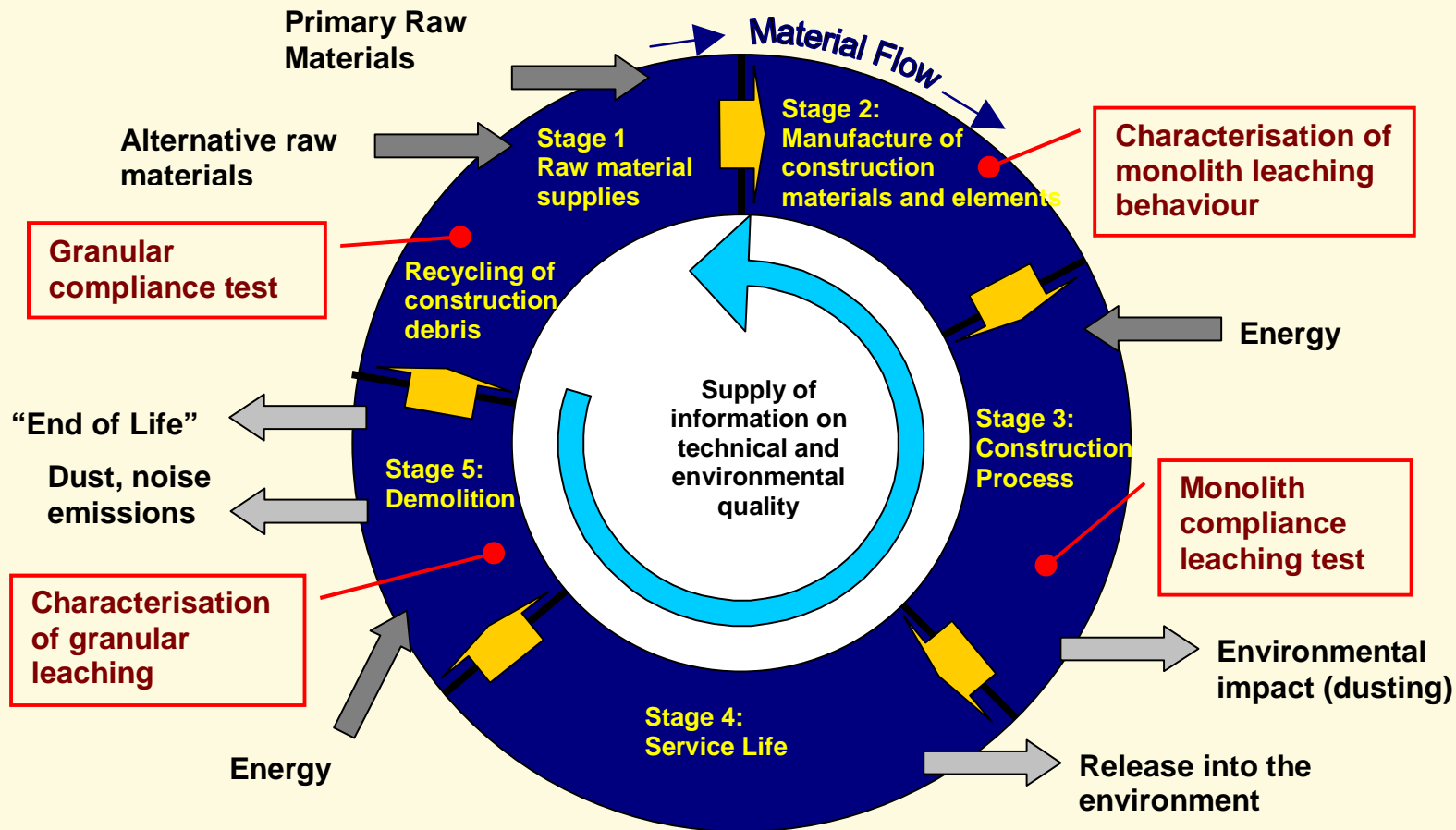


HIERARCHICAL APPROACH

- Conservative Estimates (over-estimation of release)
 - Total > Potential > Equilibrium \geq Mass Transfer limited
- Characterization Testing
 - Detailed baseline evaluation of leaching behaviour for a class of materials (data to be made available in expert system/database)
- Compliance Testing
 - Is the material tested the same as previously characterized class of materials? (Always characterisation data as background)
 - Prior characterization data available from similar material?
- Quality Control Testing
 - Is the material changing over time or from batch to batch?
 - Prior characterization data available, history with compliance testing (frequency of testing based on critical nature in view of regulation)



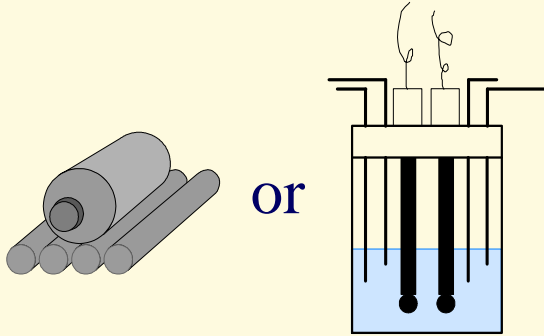
ROLE OF LEACHING TESTS IN THE BUILDING CYCLE



CHARACTERIZATION AND COMPLIANCE LEACHING TESTS IN DIFFERENT STAGES OF THE BUILDING CYCLE

BASIC CHARACTERISATION TESTS

GRANULAR MATERIALS

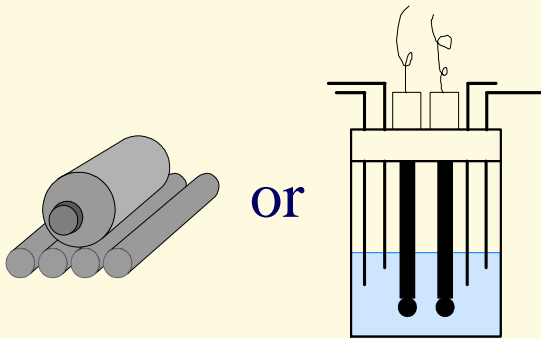


pH DEPENDENCE TEST : BATCH MODE ANC prEn 14429 or COMPUTER CONTROLLED

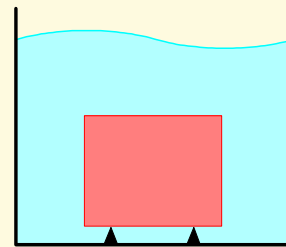


PERCOLATION LEACHING TEST (PrEN 14405)

MONOLITHIC MATERIALS



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



TANK LEACH TEST (MONOLITH) and COMPACTED GRANULAR LEACH TEST.

Chemical speciation aspects

Time dependent aspects of release

CEN/TC 292
ENV 12920

Scenario
Description

Material
characterization

Controlling
factors

Modelling
leaching

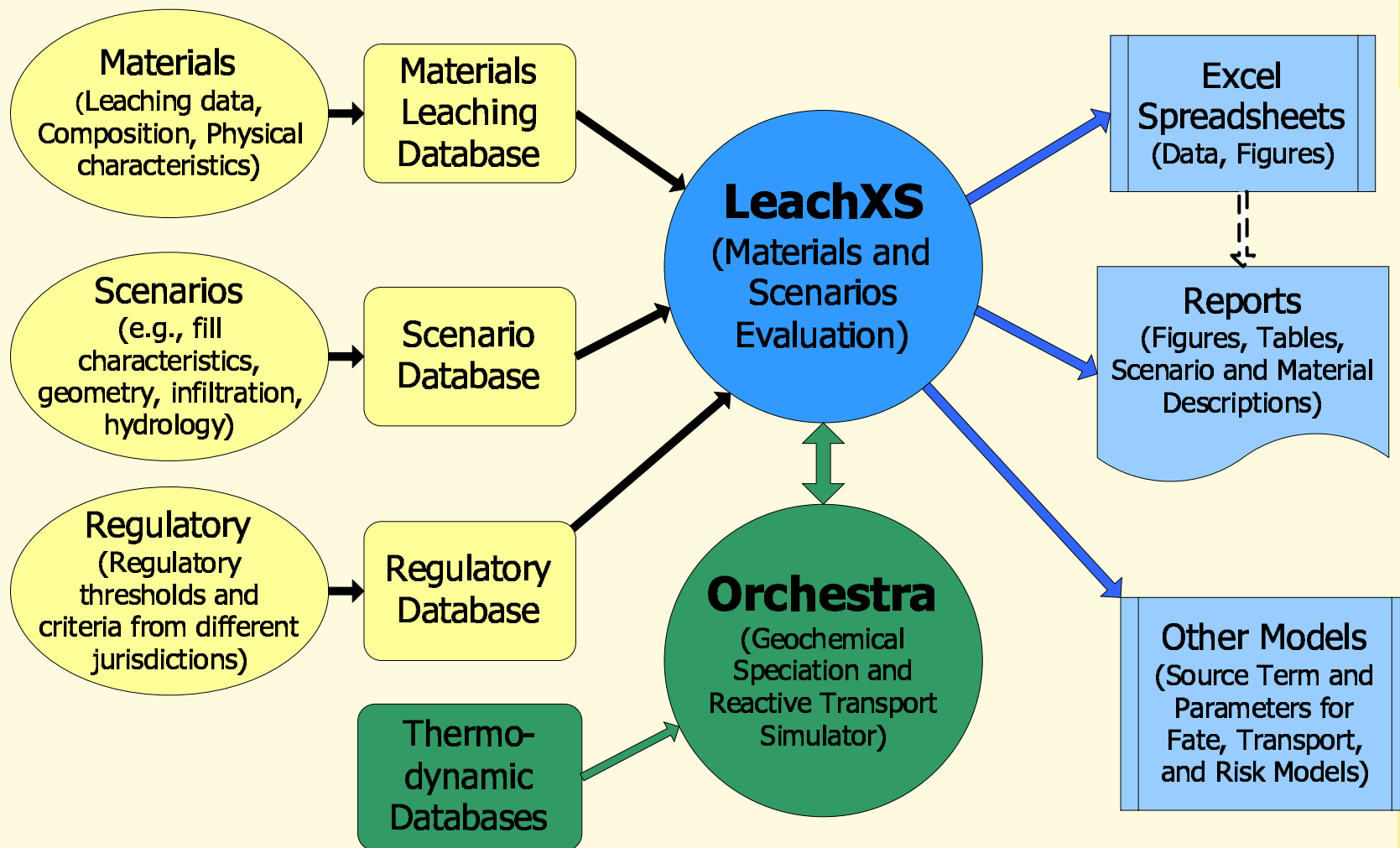
Validation
verification

Evaluation

Conclusions



Structure Database/expert system LeachXS



ALREADY AVAILABLE DATA

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) Lava stone
Asphalt Lime stone
Asphalt rubble Light weight concrete
Basalt Lime silicate bricks
Blast furnace slag Mine stone (coal)
Bottom ash (coal) MSWI residues (bottom ash, fly ash APC residues)
Brown coal ash Phosphate slag
Bricks (ceramic) Phosphogypsum
Clay bricks Preserved wood
Coal fly ash Steel slag
Concrete Soil (various types of natural soil: sand, loam, clay)
Concrete with coal fly ash Tiles (ceramic)
Construction debris Expanded clay pellets
Drinking water pipes



IMPACT EVALUATION FOR DIFFERENT SCENARIOS

Key aspect is the release as a function of time during the life cycle phase under consideration, based on laboratory test results and verified against field observations

Impact to soil, groundwater and surface water can be addressed uniformly independent on the type of material placed on/in soil or in permanent contact with water (traditional, alternative material, etc)

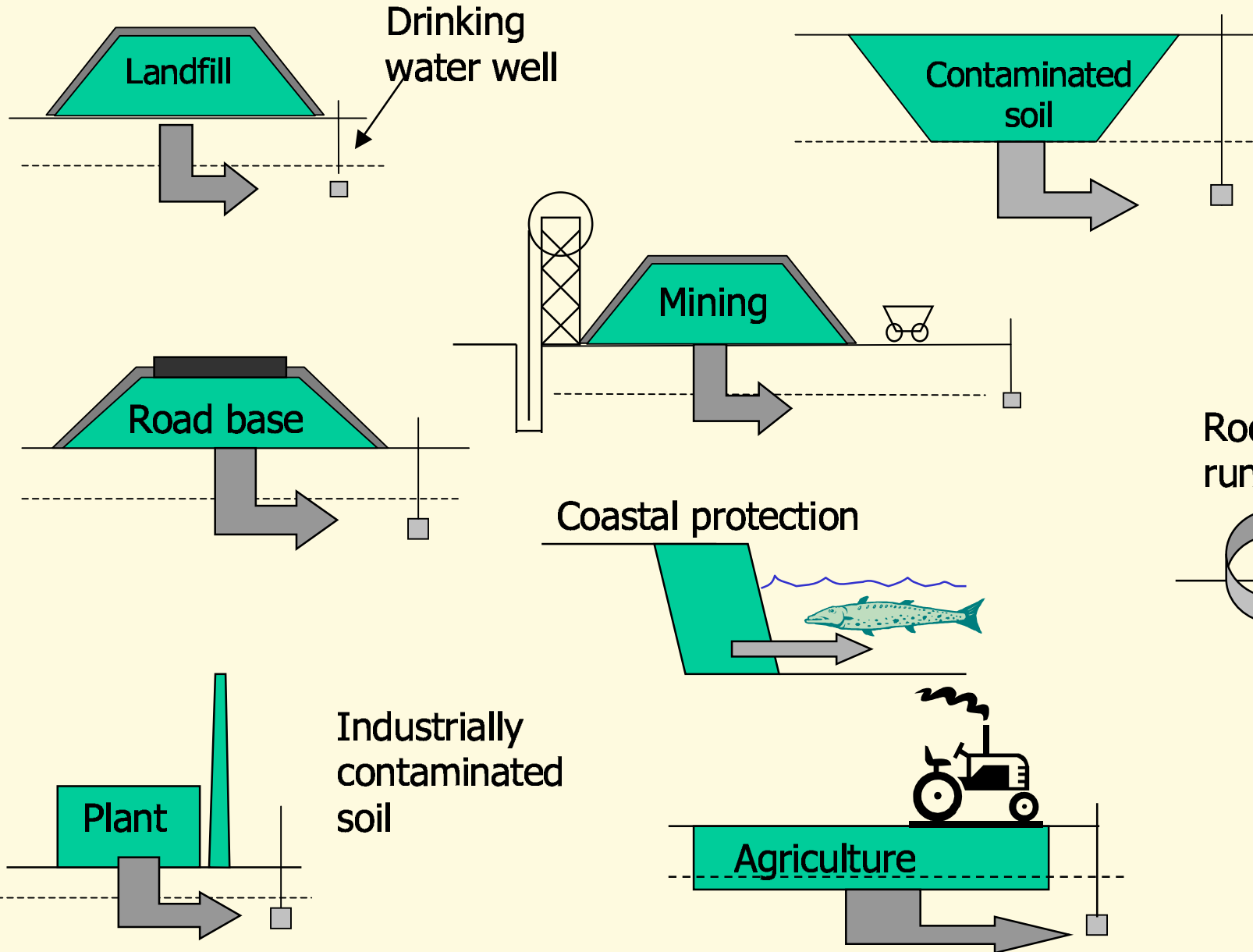
Target can be subsoil, groundwater, surface water or drinking water at a location to be specified and with criteria for quality at the defined target

A similar type of scenario approach was used for the development of Annex II of the EU Landfill Directive

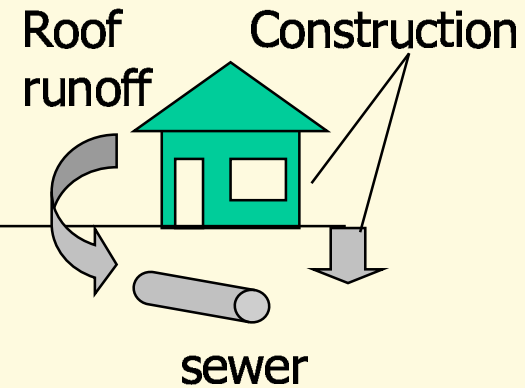
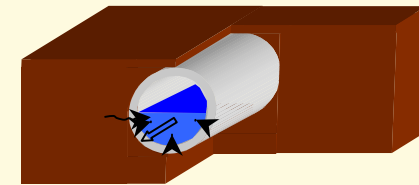


DIFFERENT IMPACT SCENARIOS.....

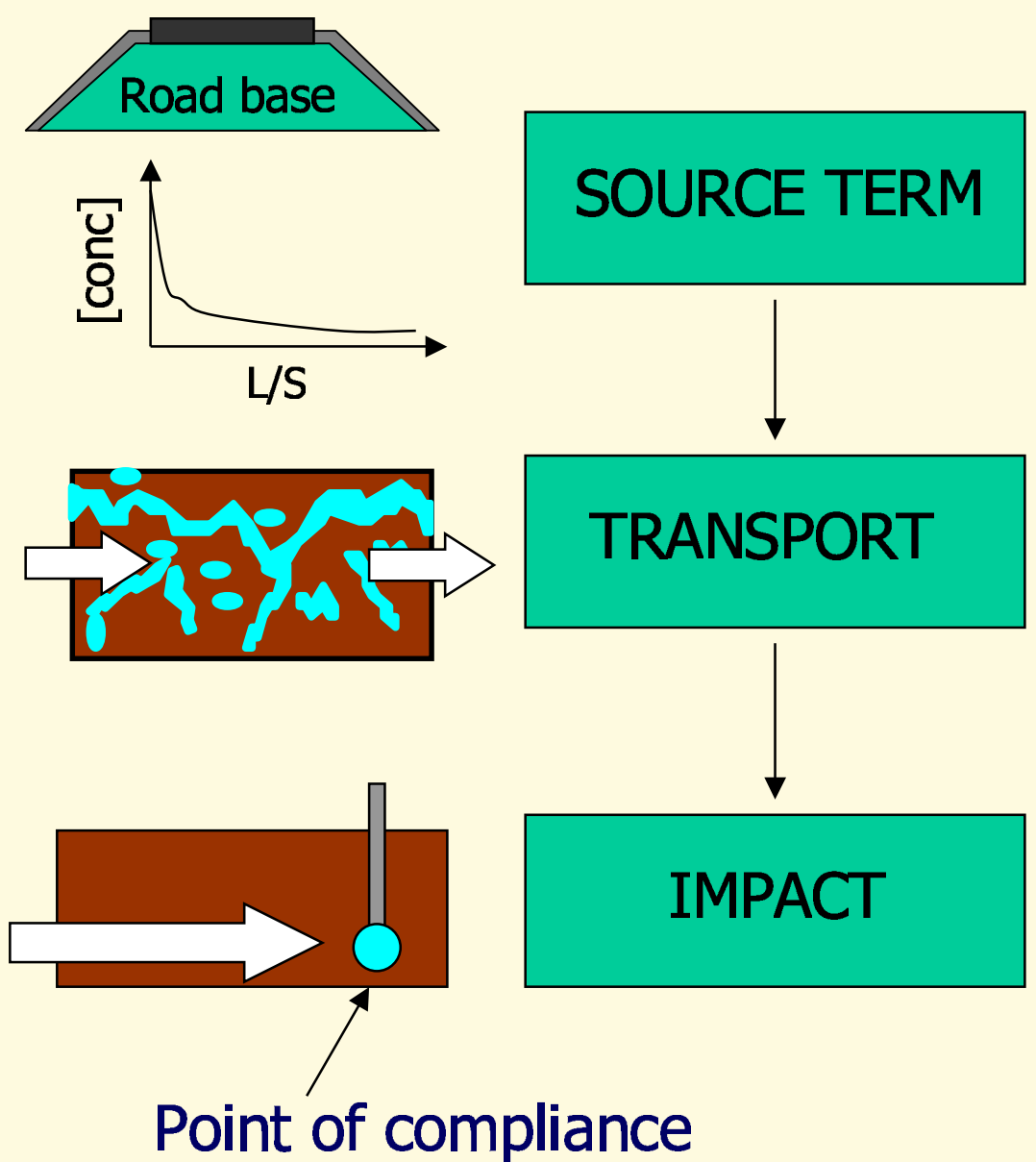
16 Dec. 2003
DG ENV



Drinking water pipes



..... SIMILAR PROBLEM



Different for each scenario, material, changes over time (carbonation, redox), etc.

Transport in unsaturated zone and saturated zone to point of compliance similar for each scenario



DEVELOPMENT OF REGULATORY CRITERIA (OUTSIDE CEN WITH TOOLS PROVIDED BY CEN)

- Selection of relevant scenarios for impact assessment
- Description of the time dependent release during service life based on laboratory testing
- Forward modelling of impact at an agreed specified target
- Comparison between modelled impact and agreed quality criteria at point of compliance (POC)
- Back calculate acceptance values for application using attenuation factors obtained from the impact modelling
- Evaluation of the consequences of limit setting for market sectors
- EU and Member States negotiate limit values



ECRICEM I and II and ECO Serve Cluster 1 Environmental Criteria for Cement based Materials

- Evaluation of the use of alternative fuels and alternative materials in cement production (company private info)
- Testing of leaching behaviour of cement mortars, blended cements and concrete (approach more widely applicable)
- Scenario descriptions for different uses
- Field verification by testing long term field exposed cement-based products (50 - 200 years)
- Development of an approach to quantify impact in different life cycles of cement-based materials
- Development of a methodology to derive acceptance criteria



CONCLUSIONS

- Scenario approach most suitable to meet the requirements of CPD and the regulatory needs associated with it
- For the wide range of construction products the focus should be on the release mechanisms rather than on the individual material properties
- Hierarchy in testing advised – start with proper characterisation of material classes and then select the relevant parameters and compliance method for QC and WFT (without further testing)
- For more than 90% of the material – scenario combinations with existing methods can be adopted
- The proposed methods can be used to assess behaviour in service life, recycling and for end-of-life evaluation.



CONCLUSIONS

- Measurement of intrinsic leaching parameters permits estimation of constituent release for default or site-specific scenarios and comparison of treatment or management options.
- Cement composition has very limited relationship with release
- Until now the range in leaching of cement mortars with alternative materials and alternative fuels in cement production does not differ from the range observed in world-wide cements produced from natural materials. Any limitations will be related to recycling and reuse stages of concrete and not in service life. Oxyanions (e.g. Cr, Mo, V and sulfate) are more critical than metals in this respect.
- Although a very significant amount of work has been done on cement mortars, similar observations will apply to a range of other construction materials relevant to the CPD.



CONCLUSIONS

- After appropriate characterisation simple compliance tests can be selected for quality control (frequency still to be decided) on crucial parameters identified in the characterisation or initial type testing.
- Modelling capabilities of release are advancing rapidly as shown by the results for field exposed concrete using ORCHESTRA
- If modelling works so well scenario specific models can be developed to assess impact under a wider range of conditions than can be tested experimentally and in addition allows evaluating design aspects on release.
- Based on the systematic approach development of regulatory criteria can be related closer to practice, thus minimising the need for arbitrary choices.



CONCLUSIONS

- A tiered evaluation framework can allow the user to determine the appropriate balance between assessment complexity, cost and conservatism for management decisions.
- Use of a more robust evaluation framework can facilitate better management decisions, while reducing overall management costs, potential future liability and improving environmental protection.
- The primary cost benefits are from greater flexibility in management options.
- Establishment of standardised protocols and an (web-based) international database would extensively leverage resources.



RELEVANT INFO

LEACHING BACKGROUND

www.leaching.net (Wascon 2003 workshop)

CEN Construction and CEN Environment
Workshop - Coimbra, Portugal (Sept 2003)

www.cenorm.be/cenorm/workarea/sectorfora/construction+sector+network/conference.asp

LEACHING IN PROJECT HORIZONTAL

www.ecn.nl/library/horizontal

