



# **Requirements in Setting the Environmental Safety Quality of Recycled Materials in Construction**

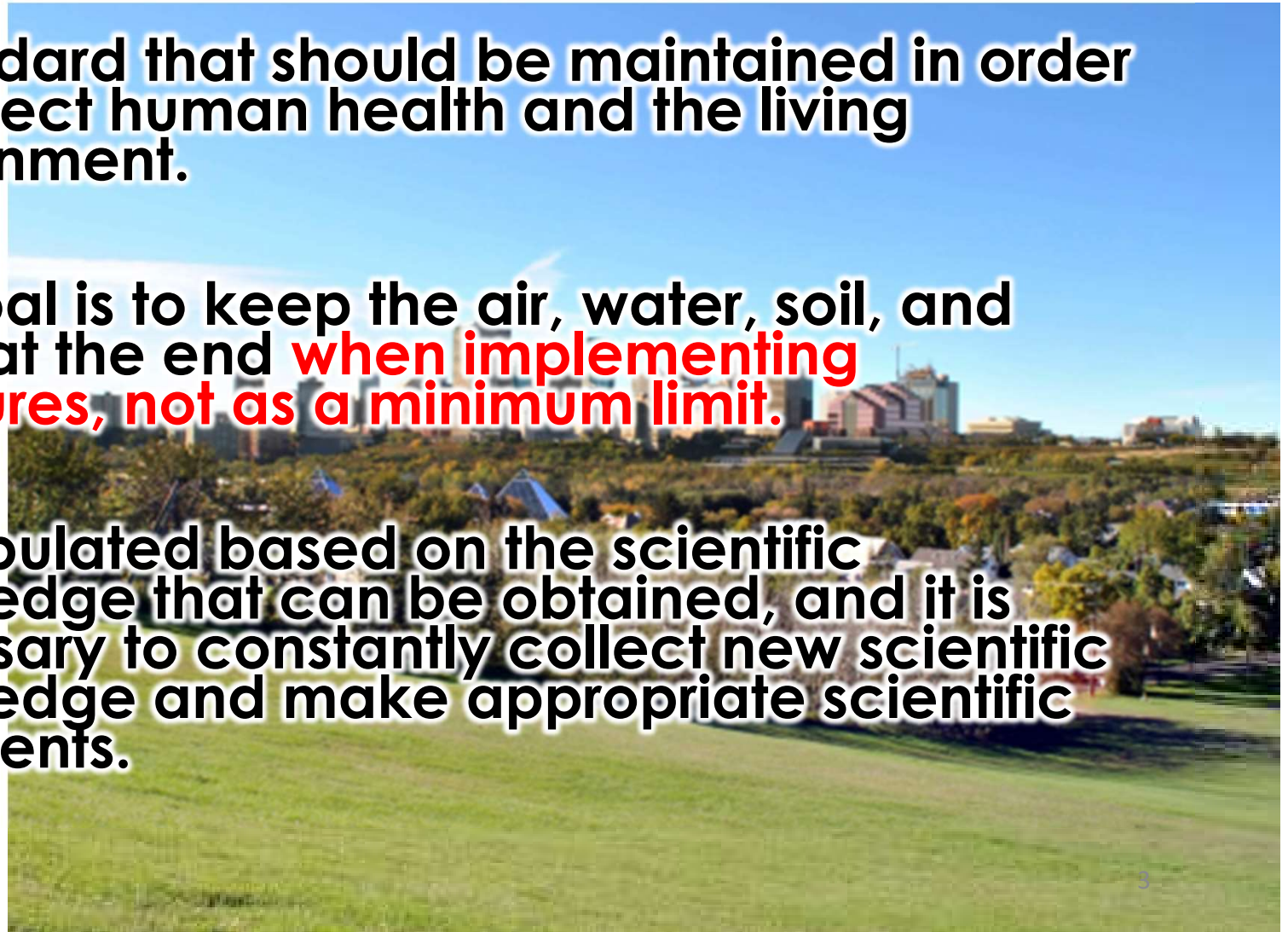
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National Institute for Environmental Studies**

# Contents

- **Environmental Standard, Countermeasure Law, and Test methods**
- **Environmental Safety Quality of Recycled Materials in Construction**
- **Standardization**

# Environmental Standard

- A standard that should be maintained in order to protect human health and the living environment.
- The goal is to keep the air, water, soil, and noise at the end **when implementing measures, not as a minimum limit.**
- It is stipulated based on the scientific knowledge that can be obtained, and it is necessary to constantly collect new scientific knowledge and make appropriate scientific judgments.



# Water quality standard (public water area)

- Concerning the environmental conditions related to water pollution in **public water areas** pursuant to Article 16 of the Basic Environment Law, it is desirable to maintain it in order to protect human health and preserve the living environment.
- \*Public water areas: rivers, lakes, harbors, coastal waters and other public water areas, and public waterways connected to them, irrigation waterways and other public water paths

# Groundwater quality standard

- Standards that should be maintained in order to protect human health regarding environmental conditions related to water pollution of groundwater pursuant to Article 16 Paragraph 1 of the Basic Environmental Law

**⇒ Prefectures regularly survey specific points and report to the national government**

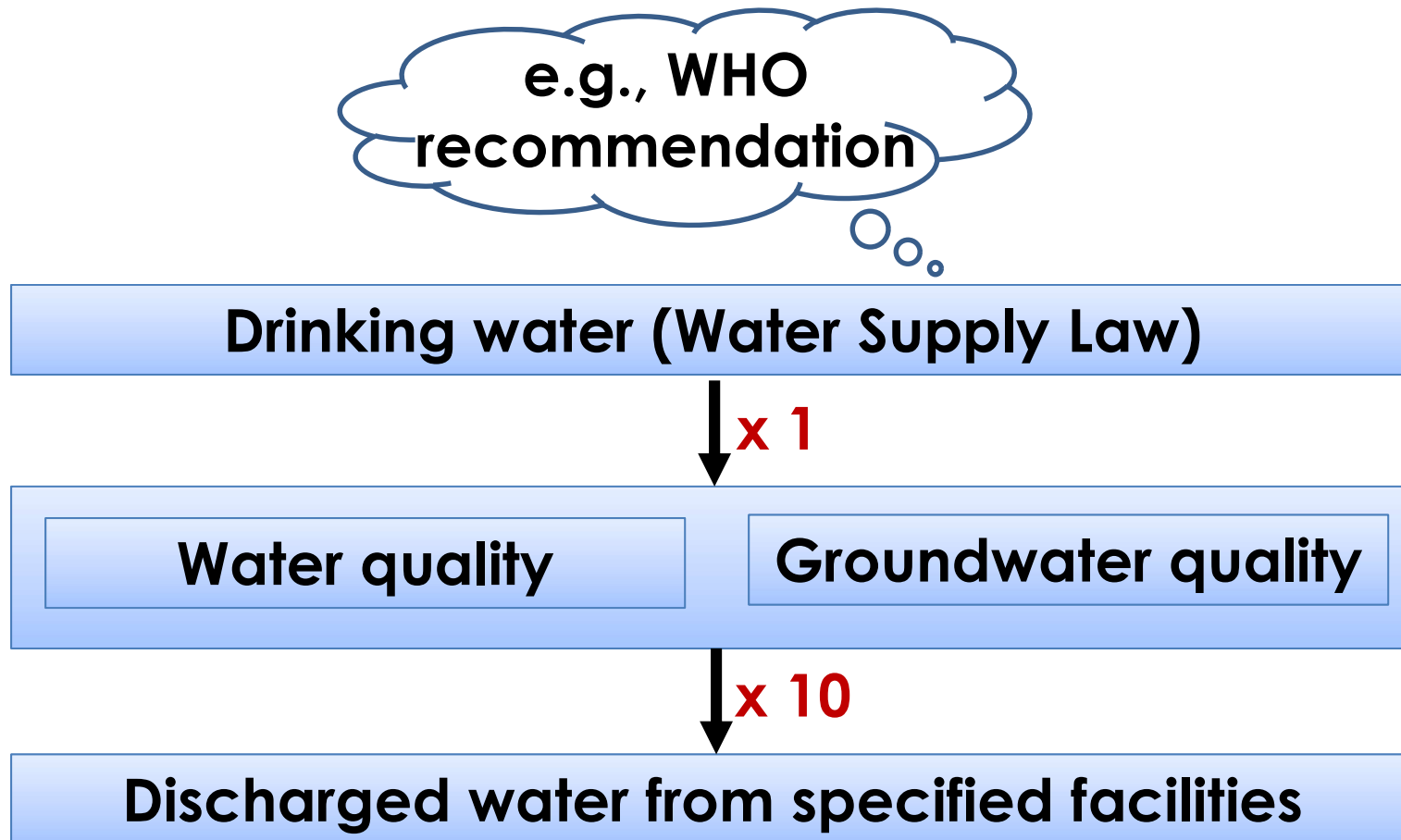
# Environmental Standard for Public water and groundwater for the protection of human health in Japan

Item	Standard Values	Item	Standard Values
Cadmium	0.003 mg/L	1,1,2-trichloroethane	0.006 mg/L
Total Cyanogen	not detectable	Trichloroethylene	0.01 mg/L
Lead	0.01 mg/L	Tetrachloroethylene	0.01 mg/L
Chromium (VI)	0.05 mg/L	1,3-dichloropropene	0.002 mg/L
Arsenic	0.01 mg/L	Thiraum	0.006 mg/L
Total Mercury	0.0005 mg/L	Simazine	0.003 mg/L
Alkyl Mercury	not detectable	Thiobencarb	0.02 mg/L
PCB	not detectable	Benzene	0.01 mg/L
Dichloromethane	0.02 mg/L	Selenium	0.01 mg/L
Carbon Tetrachloride	0.002 mg/L	Nitrate and nitrite	10 mg/L
1,2-dichloroethane	0.004 mg/L	Fluorine	0.8 mg/L
1,1-dichloroethylene	0.1 mg/L	Boron	1 mg/L
Sis-1,2-dichloroethylene	0.04 mg/L	1,4-dioxane	0.05mg/L
1,1,1-trichloroethane	1 mg/L		

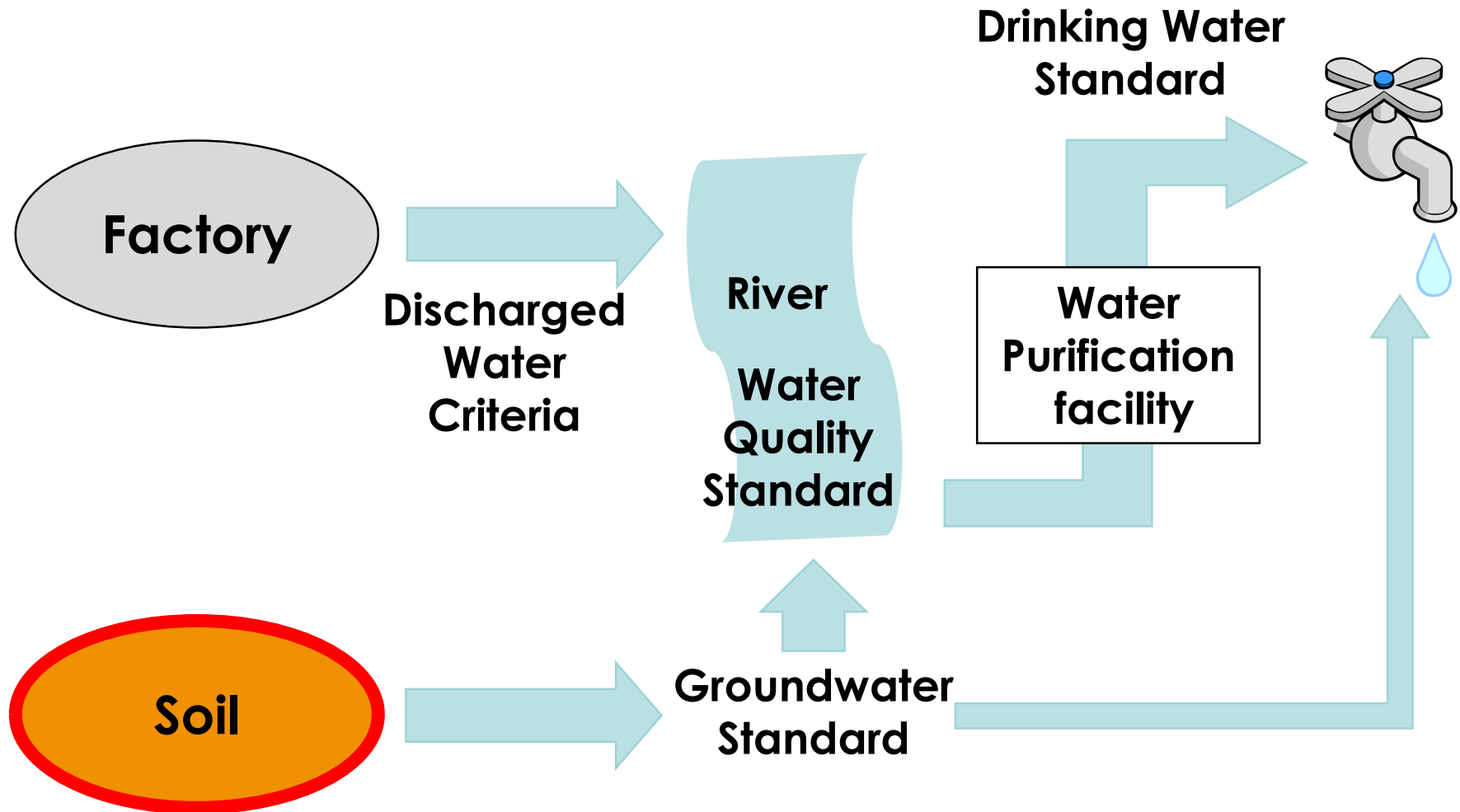
# Discharge Water Criteria in Japan (Hazardous substances)

Item	Standard Values	Item	Standard Values
Cadmium	0.03 mg/L	1,1,2-trichloroethane	0.06 mg/L
Total Cyanogen	1 mg/L	Trichloroethylene	0.1 mg/L
Lead	0.1 mg/L	Tetrachloroethylene	0.1 mg/L
Chromium (VI)	0.5 mg/L	1,3-dichloropropene	0.02 mg/L
Arsenic	0.1 mg/L	Thiraum	0.06 mg/L
Total Mercury	0.005 mg/L	Simazine	0.03 mg/L
Alkyl Mercury	not detectable	Thiobencarb	0.2 mg/L
PCB	0.003 mg/L	Benzene	0.1 mg/L
Dichloromethane	0.2 mg/L	Selenium	0.1 mg/L
Carbon Tetrachloride	0.02 mg/L	Nitrate and nitrite	100 mg/L
1,2-dichloroethane	0.04 mg/L	Fluorine	0.8 mg/L
1,1-dichloroethylene	1 mg/L	Fluorine (sea)	15 mg/L
Sis-1,2-dichloroethylene	0.04 mg/L	Boron	1 mg/L
1,1,1-trichloroethane	3 mg/L	Boron (sea)	230 mg/L
		1,4-dioxane	0.5mg/L

# Mutual Relationships of Water-related Environmental Standard/Criteria

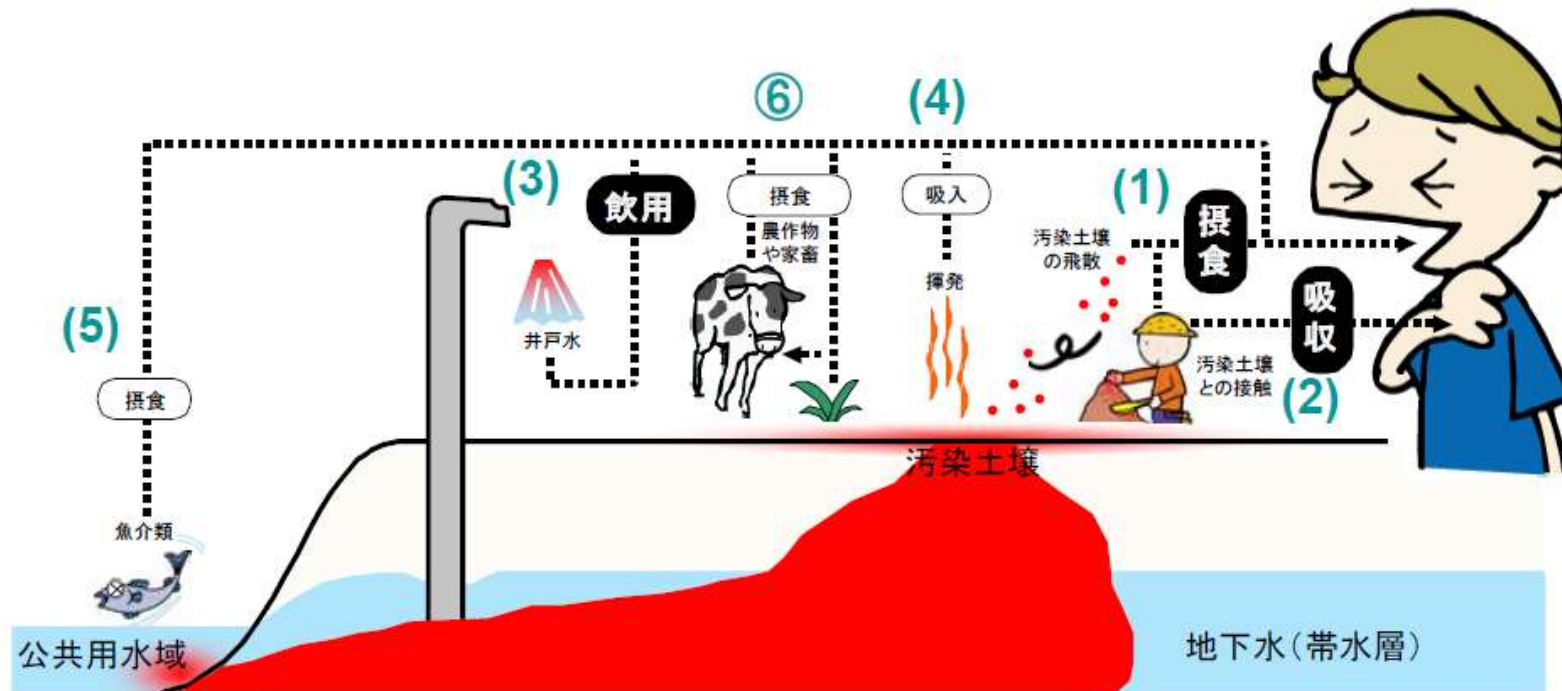


# Mutual Relationships of Water-related Environmental Standard/Criteria





# How soil contamination induces health risks



1. [Direct ingestion](#) of contaminated soil (including soil particulate)
2. Dermal absorption
3. [Ingestion of groundwater](#) contaminated by hazardous substances eluted from contaminated soil
4. Inhalation of hazardous substances emitted from contaminated soil to atmosphere
5. Discharge of soil containing hazardous substances to municipal waterways → accumulation in aquatic ecology → ingestion by human beings
6. Accumulation of hazardous substances in crops and livestock raised on contaminated land → ingestion by human beings

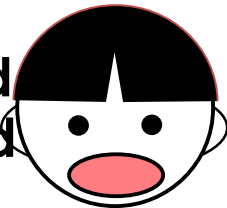
# Exposure pathways considered in Soil contamination countermeasure act

- **Direct Ingestion**
  - ⇒ **Extractable fraction in stomach**
  - “Acid extraction test”**
- **Ingestion of groundwater**
  - ⇒ **Released concentration in a liquid**
  - “Leaching test”**

# Acid extraction test (Content test)

MOE Notification No.19 (2003) for  
contaminated soil

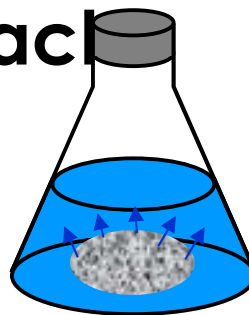
Kid 200 mg/d  
Adult 100 mg/d



Direct ingestion



Digestion in stomach



6 g of <2-mm soil  
200 mL of **1M-HCl**  
2 h horizontal shaking  
filtration by 0.45 um  
membrane filter

# Soil Leaching test (Batch test)

Japanese Environmental Agency Notification No.46, 1991 (JLT-46)

1



Drying and Sieving  
< 2 mm

2



Take > 50 g

3



Water

4



L/S = 10 (L/kg)

5



Leaching 6 hours by  
shaking

6



Centrifugation

7



Filtration  
using 0.45 mm  
membrane filter

# Criteria in Soil Contamination Countermeasure Act (Metals)

	EQS for Soil* (Leaching)	Soil Contamination Countermeasure act		
		Leaching		Content
		1 <sup>st</sup> Criteria	2 <sup>nd</sup> Criteria	
Test method	JLT46 (1991)	MOE Nff. No.18 (2003)		MOE Nff. No.19 (2003)
Unit	mg/L	mg/L	mg/L	mg/kg
Cadmium	0.01**	0.01	0.3	150
Lead	0.01	0.01	0.3	150
Cr(VI)	0.05	0.05	1.5	250
Arsenic	0.01***	0.01	0.3	150
Total-Hg	0.0005	0.0005	0.005	15
Alkyl-Hg	Not detected	Not detected	-	-
Selenium	0.01	0.01	0.01	150
Fluorine	0.8	0.8	24	4000
Boron	1	1	30	4000

\* Natural source, stock yard and waste landfill are excluded

\*\* Agriculture field: 1 mg/kg-rice

\*\*\* Rice field: 15 mg/kg-soil

# Contents

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- **Environmental Safety Quality of Recycled Materials in Construction**
- Standardization

# Recycled Materials in Construction



# Recycled Materials in Construction

## Construction and Demolition

Surplus Soil **140 Mm<sup>3</sup>**  
Demolished Asphalt Concrete **20 Mt**  
Demolished Concrete **30 Mt**  
Sludge **7.5 Mt**  
Discarded Plaster Board, etc. **1.8 Mt**



## Ferrous and Nonferrous Slag

Blast Furnace Slag **23 Mt**  
BOF Slag **10 Mt**  
EAF Slag **3.0 Mt**  
Copper Slag **3.0 Mt**  
Ferronickel Slag, etc. **2.3 Mt**



## Coal Combustion Ash **12 Mt**

Fly Ash  
Clinker (Bottom) Ash



## Municipal Wastes and Sewage Sludge **5.1 Mt**

**Incinerator Bottom Ash and Melt-solidified Slag**  
Sewage Sludge Treated Residue etc. **2.4 Mt**

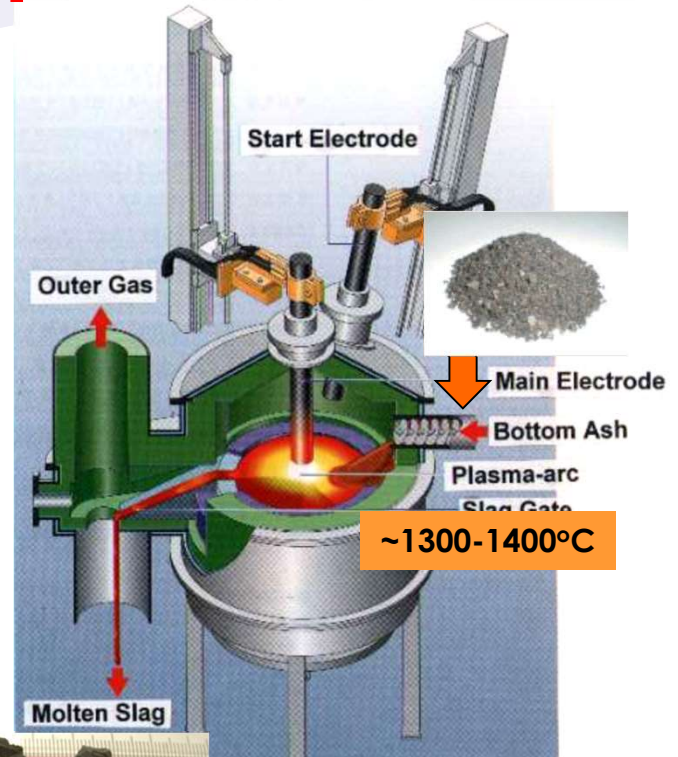
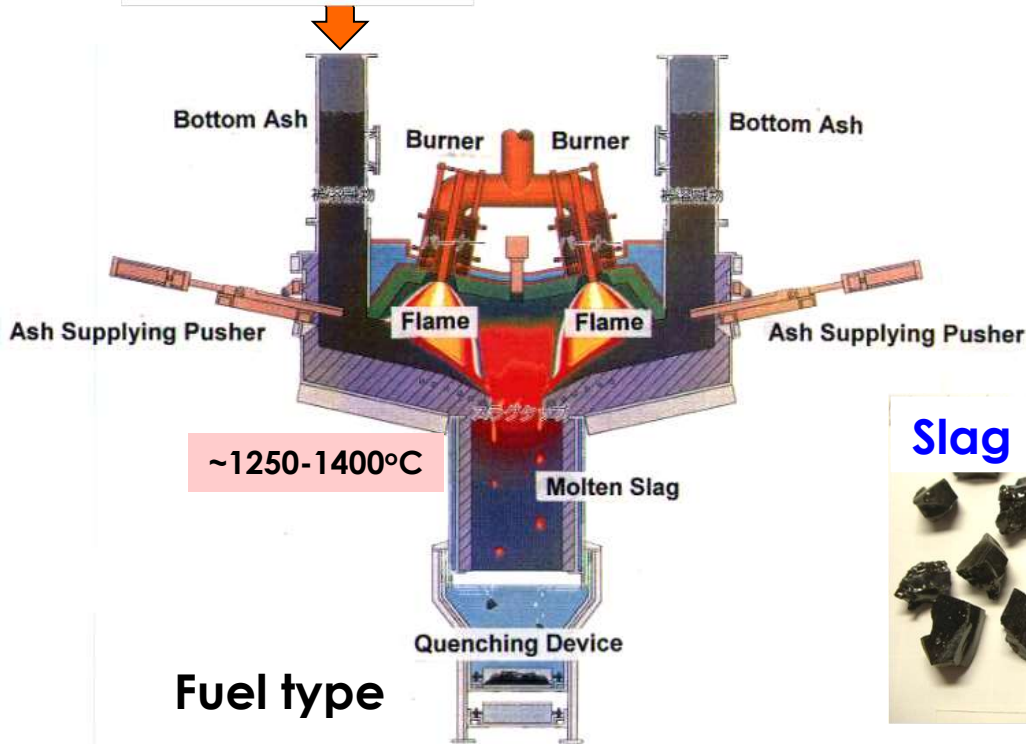




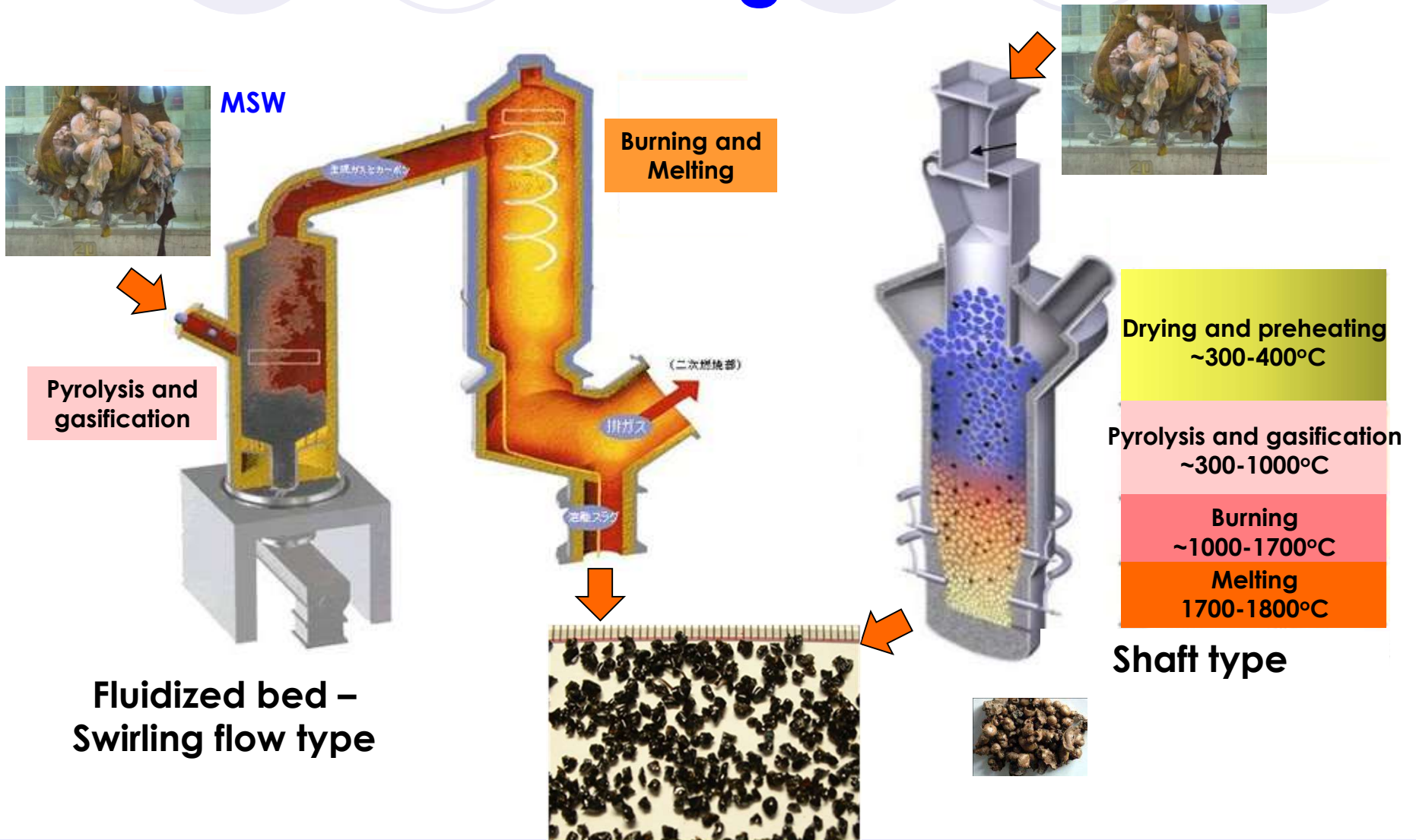
# Melt-solidified Slag from Bottom ash and Fly ash



- Decompose Organics
- Produce "Molten-Slag" for construction usage
- Recover Heavy metals - evaporated to fly ash or condense to metal phase



# Melt-solidified Slag from Gasification-Melting of MSW



# Recycling of MSW Slag



Water-quenched



Air-cooled



# JIS A 5031 “Melt-solidified slag aggregate for concrete”

- Coverage: Precast concrete
  - Coarse aggregate (MG20-05, MG20-15, MG15-05)
  - Fine aggregate (MS5, MS2.5, MS1.2, MS5-0.3)
- Quality
  - General
  - Environmental Safety Quality (Leaching and Content)
  - Chemical composition (CaO, S, SO<sub>3</sub>, Fe)
  - Expansiveness
  - Physical properties (Density, Water absorption, Stability, Solid content, and Amount of minute grain)
  - Alkali silica reactivity
  - Granularity and fineness modulus
  - Pop out

# JIS A 5032 “Melt-solidified slag material for road construction”

- Coverage: Hot asphalt mixture and base material
  - For hot asphalt mixture (SM-20, -13, -5, FM-2.5)
  - For base course material (MM-40, -30, -25)
  - For subbase course material (CM-40, -30, -20), etc.
- Quality
  - Externals
  - Environmental Safety Quality (Leaching and Content)
  - Physical properties (Granularity, Density, Water absorption, and Abrasion loss)
  - Corrected CBR (for base and subbase only)

# Recycled Materials – concerns about Env. Safety

## Construction and Demolition

Surplus Soil  
Demolished Asphalt Concrete  
Demolished Concrete **Cr(VI)**  
Sludge  
Discarded Plaster Board, etc. **As, Cd, F**



## Ferrous and Nonferrous Slag

Blast Furnace Slag **F**  
BOF Slag **F, Cr, (V, Mo)**  
EAF Slag **F, Cr, (V, Mo)**  
Copper Slag **As, Pb**  
Ferronickel Slag, etc. **(Ni)**



## Coal Combustion Ash

Fly Ash **As, B, F, Se, Cr(VI)**  
Clinker (Bottom) Ash



## Municipal Wastes and Sewage Sludge **Pb**

**Incinerator Bottom Ash and Melt-solidified Slag**  
Sewage Sludge Treated Residue etc.



# Background in establishing “Environmental Safety Quality” for recycled materials

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## Notice on enforcement after revision of Soil Contamination Countermeasure Act (2011)

“When slag and coal ash are used for civil engineering or road construction, and are used in distinction from the surrounding soil, they are not considered as soil”

- Recycled materials are excluded from the scope of soil environmental standards and soil contamination countermeasure law, so another procedure is necessary to ensure environmental safety quality.
- Management of environmental safety quality is indispensable for all recycled materials, and mutual consistency is important.

“Basic concept” that can be shared among all the recycled materials was proposed.

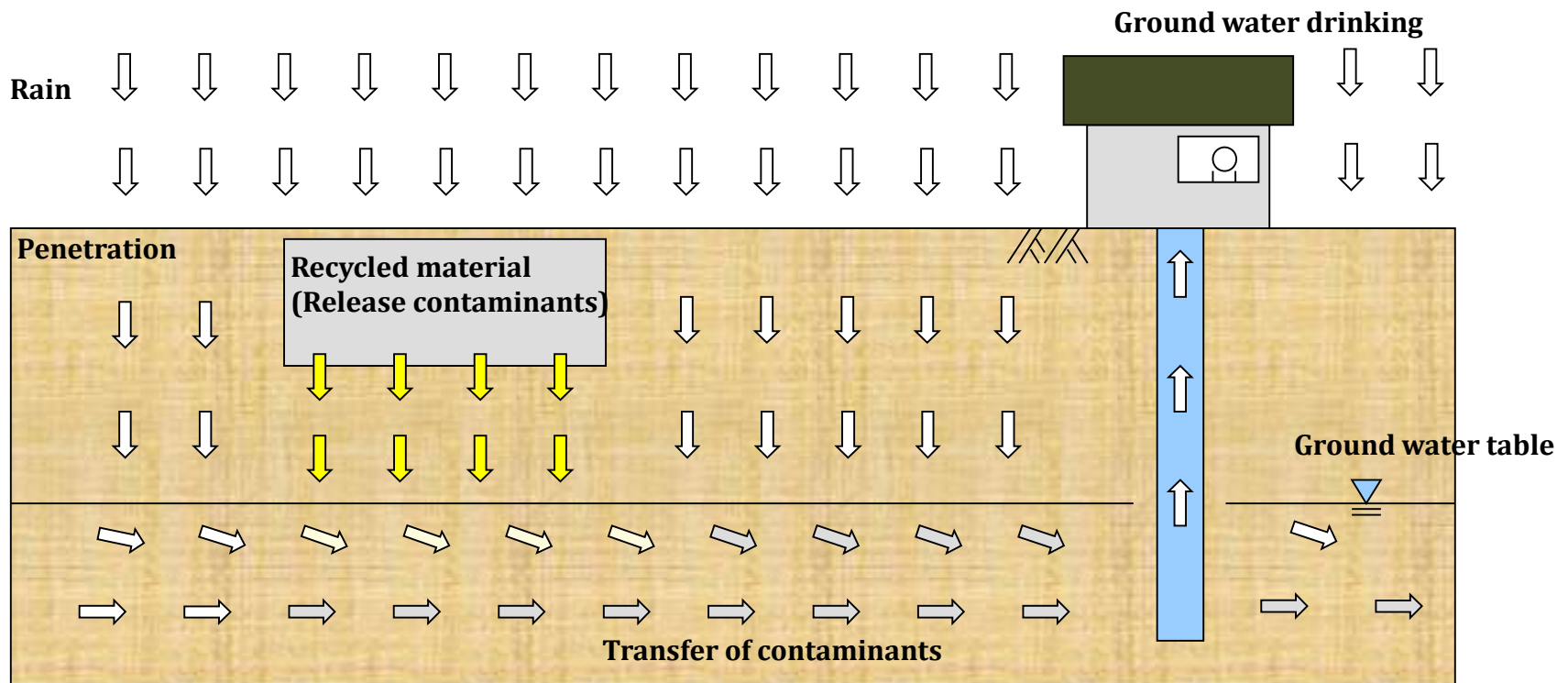
Comprehensive report by the committee on guideline for introducing chemical substance evaluation method to slags for concrete aggregate and road construction  
(March 2012 Japan Industrial Standards Committee)

## **Basic Concept** in Set Up of Environmental Safety Quality and Inspection Method for Recycled Materials

- (1) **Focus on the most dangerous situation** in the material's lifecycle including re-Recycling and landfilling
- (2) **Test Items** (leaching test, content test) corresponding emission pathways
- (3) **Test method** simulating utilization condition
- (4) **Quality standard** complying with the environmental standard of the surroundings
- (5) **Effective inspection system**



# Basic Concept 4/5: Quality standard complying with the environmental standard of the surroundings



**Environmental media around the recycled material (such as soil and groundwater) should satisfy the environmental standard**

# Environmental Safety Criteria for Recycled Materials

## General applications

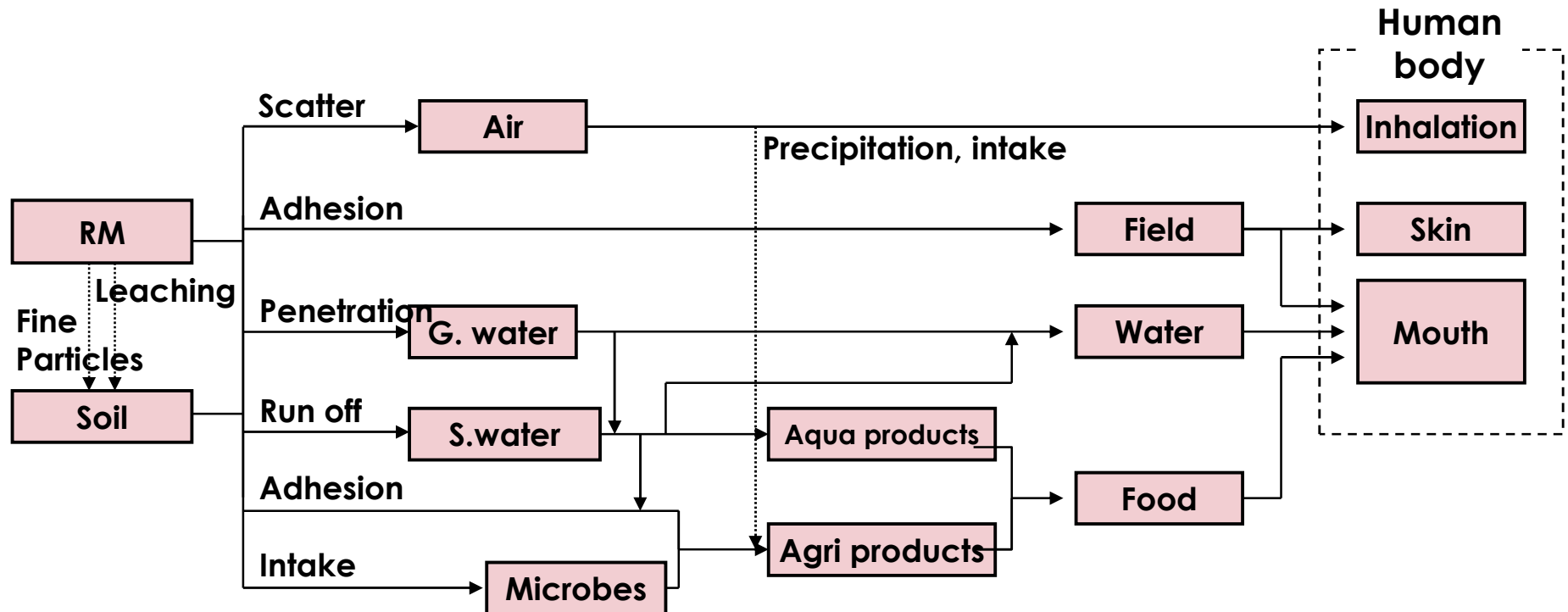
	Leaching (mg/L)	1M HCl-Extractable (mg/kg)
Cadmium	0.01	150
Lead	0.01	150
Hex Chromium	0.05	250
Arsenic	0.01	150
Mercury	0.0005	15
Selenium	0.01	150
Fluorine	0.8	4000
Boron	1	4000

## Port applications

	Leaching (mg/L)
Cadmium	0.03
Lead	0.03
Hex Chromium	0.15
Arsenic	0.03
Mercury	0.0015
Selenium	0.03
Fluorine	15
Boron	20

- ✓ **Criteria: Similar with Environmental Standard for Soil and Soil Contamination Countermeasure Act**
- ✓ **Test method: Different from Soil**

# BC2/5: Test Items (leaching test, content test) corresponding emission pathways

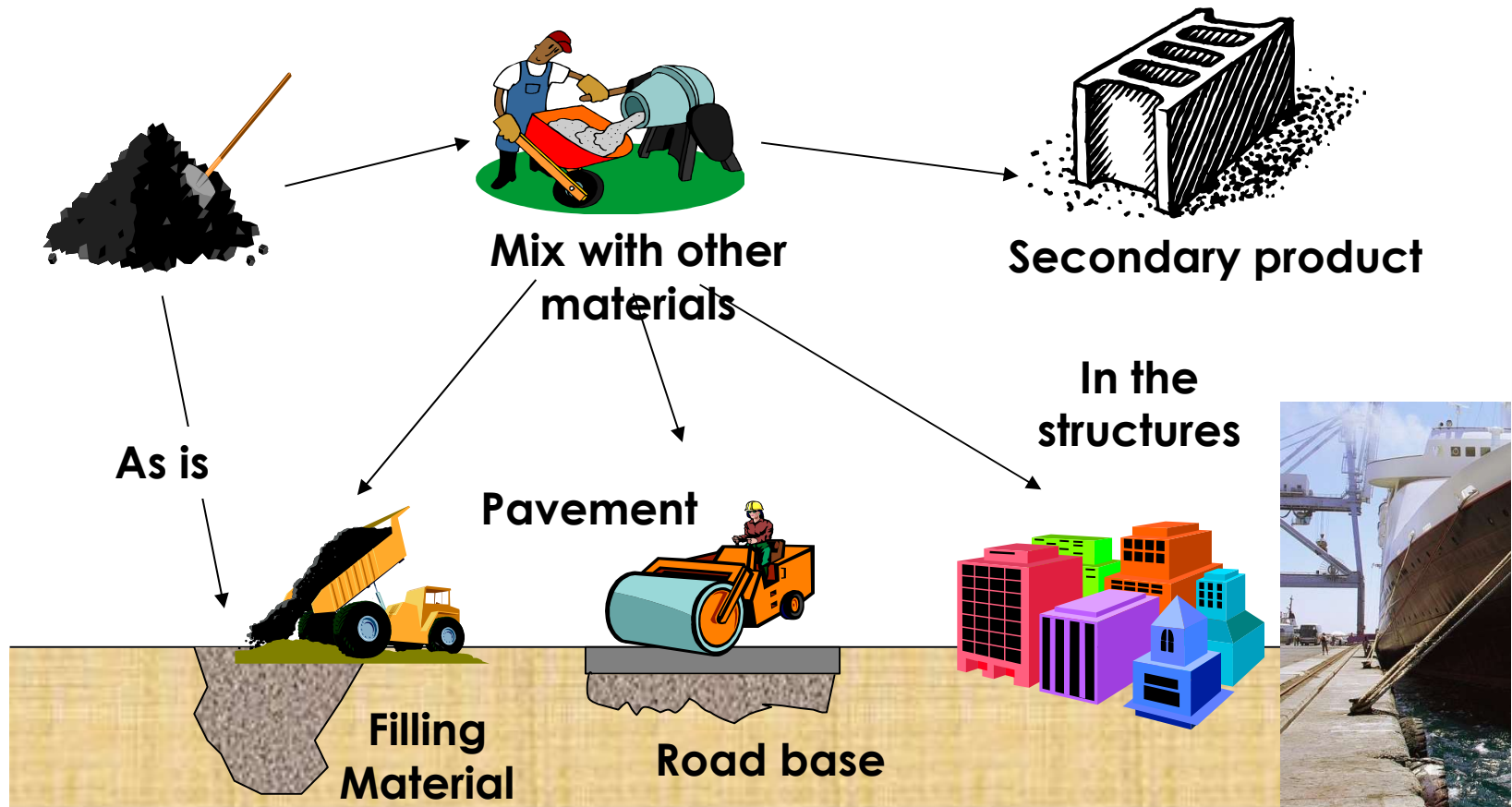


⇒ Pathways to human and the environment

Leaching

Direct Ingestion

# BC3/5: Test method simulating condition of the application



# JIS K 0058-1 clause 5. Propeller leaching test

Sample pretreatment:

- Granular material: **without size reduction**
- Monolith material:

Cement concrete: 100 mm-D x  
200 mm-H test piece

Asphalt concrete: 100 mm-D x  
63.5 mm-H test piece

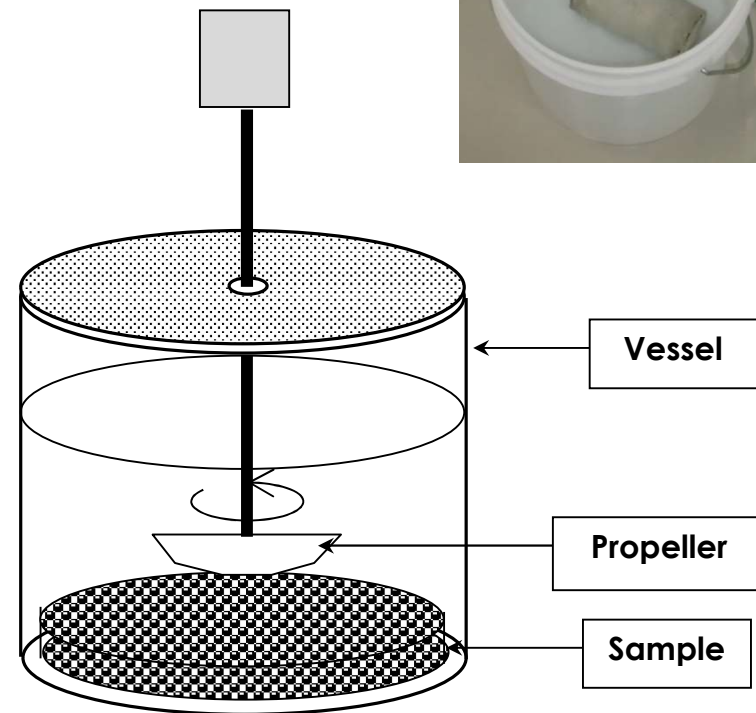
<5 kg product: as it is

L/S = 10 L/kg,

Leachant: pure water

Stirring 200 times/min

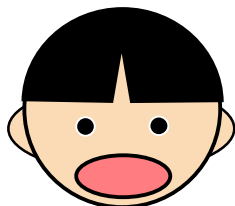
6 hours



# Acid extractable content test

MOE Notification No.19 (2003), JIS K 0058-2 (2006)

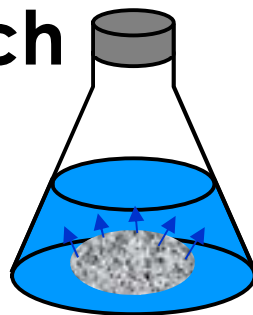
Kid 200 mg/d  
Adult 100 mg/d



Ingestion

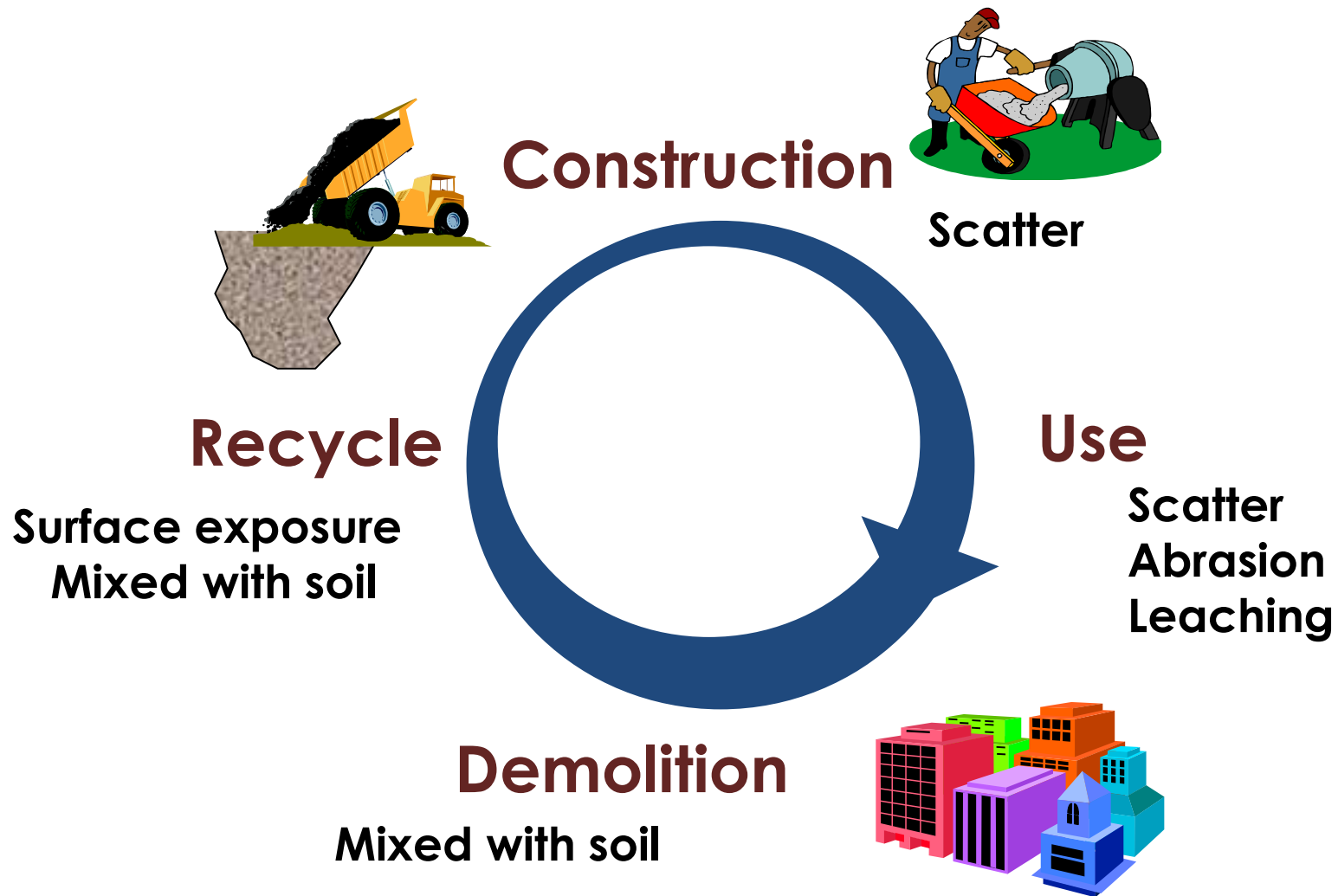


Digestion in stomach



3 g of < 2 mm sample  
100 mL of **1M-HCl**  
2 h shaking and  
filtration by 0.45 um  
membrane filter

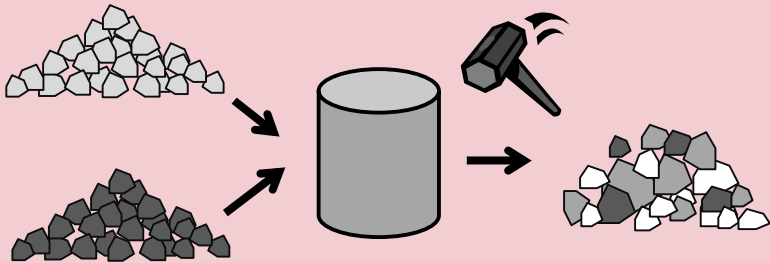
# BC1/5: Focus on the most dangerous condition through the material's lifecycle



# BC5/5: Effective Inspection System – Type Inspection and Delivery Inspection

## Type Inspection

Checking If the Material/Product  
Meet the Environmental Safety  
Quality Criteria



Sample Preparation and Test  
Method Simulating the Use  
Condition

**All items judgement**

## Delivery Inspection

Speedy Assurance of  
Environmental Safety Quality on  
Every Material/Product of the  
same manufacturing condition

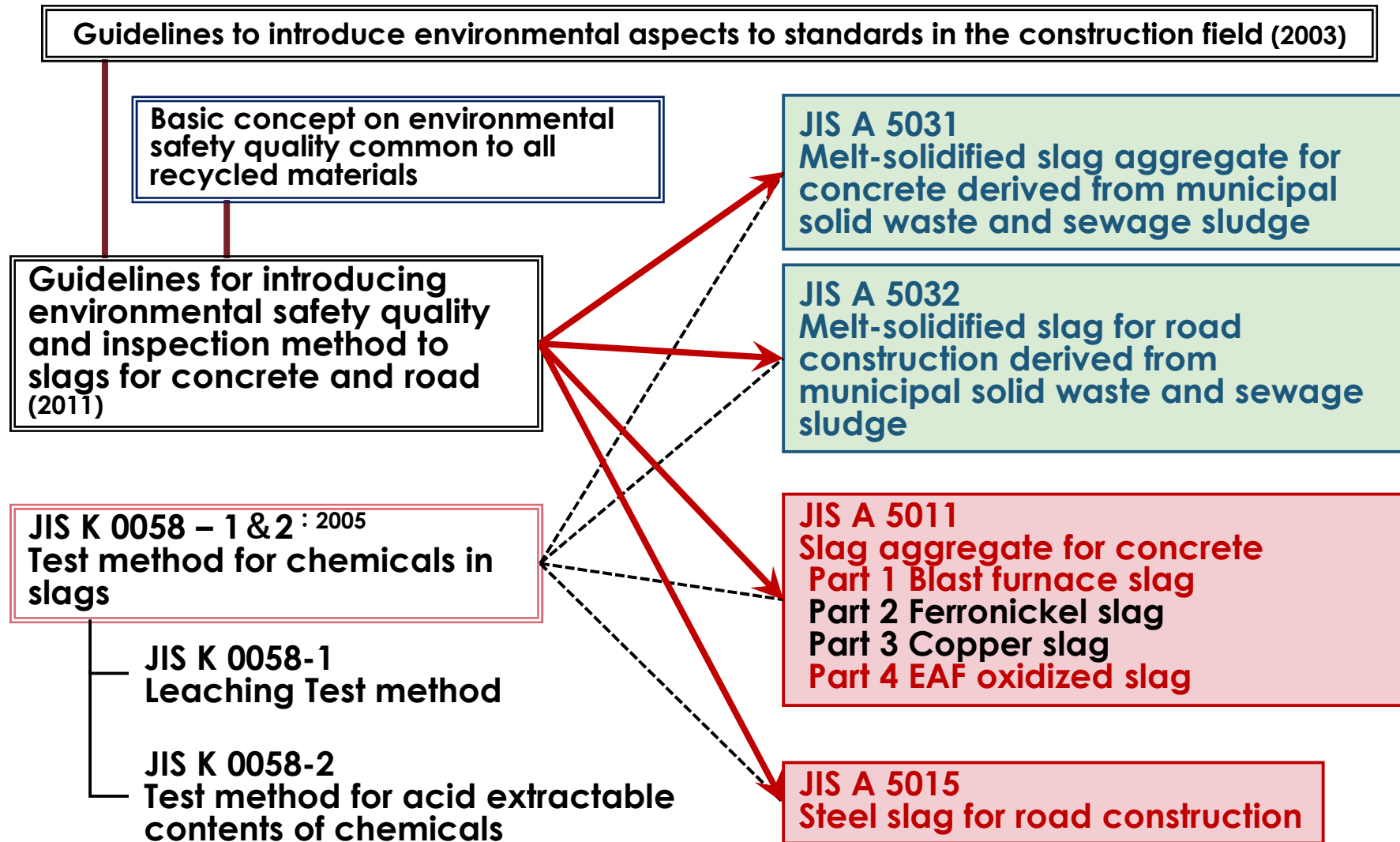


Use the Slag as is  
For Every Shipping  
Material/Product

**Items can be reduced**

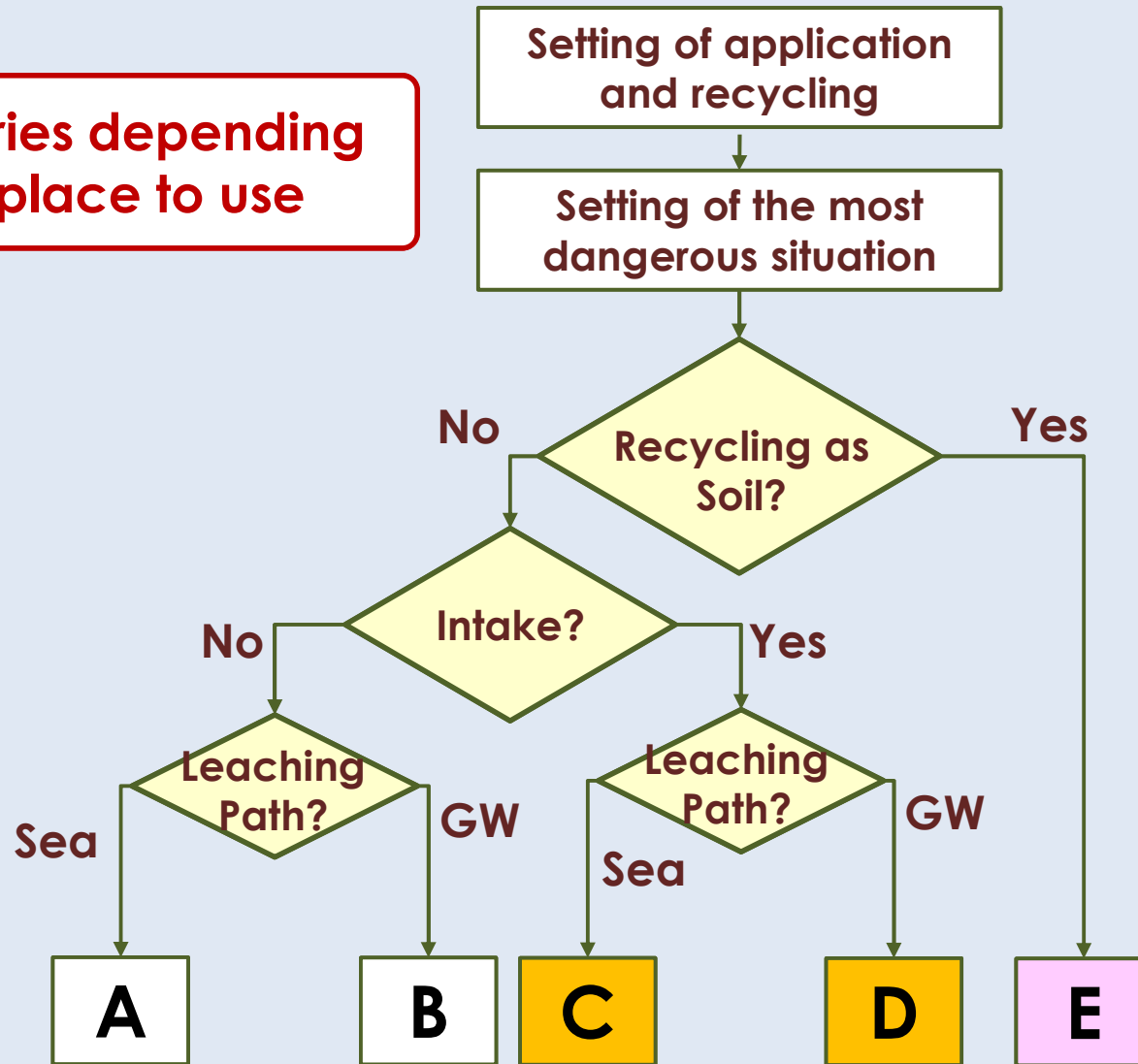


# Structure of Introducing Environmental Safety and Test Methods in “Slag-JIS”



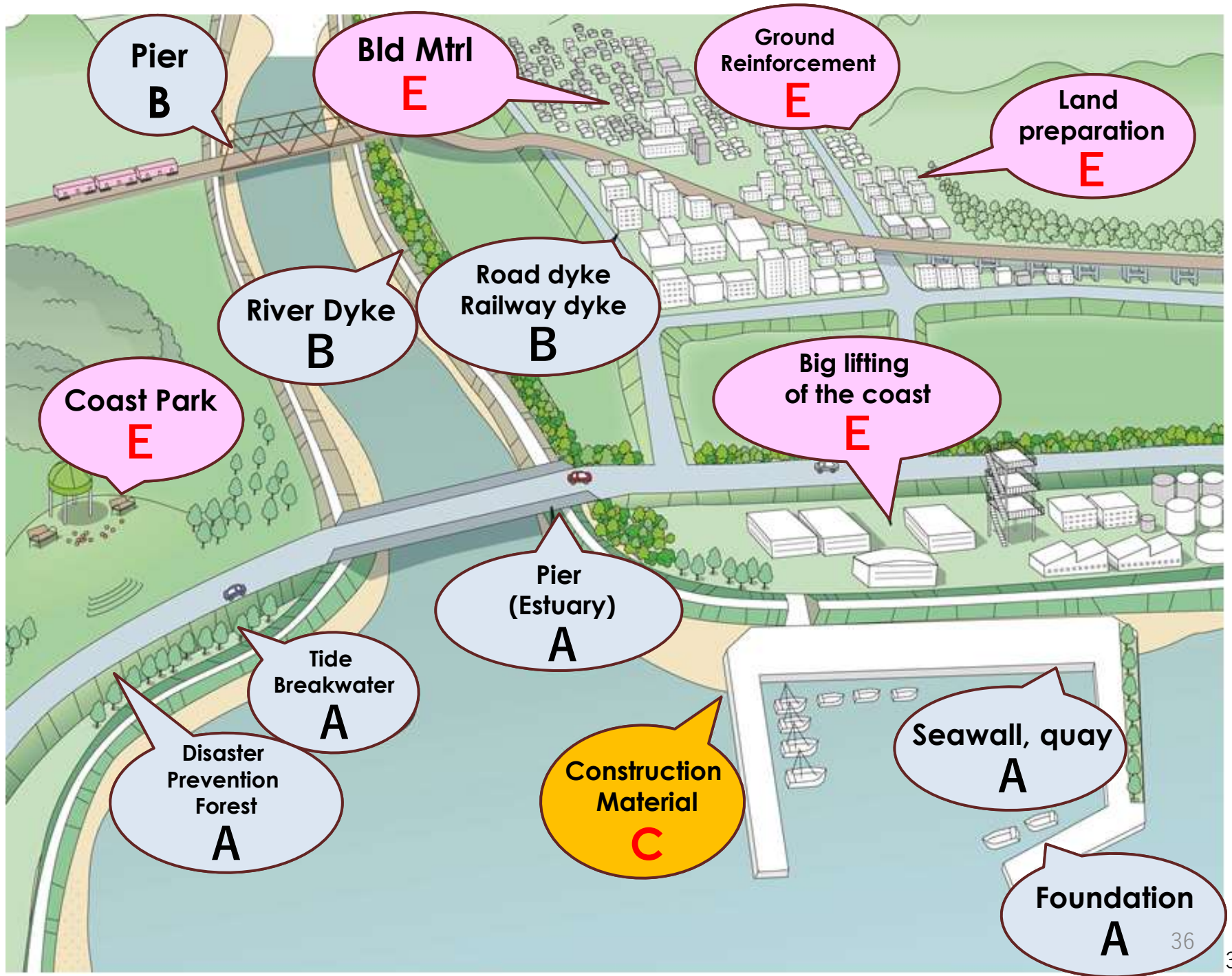
# Development to another applications

5 categories depending on the place to use



# Test method and Environmental Quality Criteria for Each Category

Category				Test item	Test method	Environmental Safety Standard
	Recycling as "Soil"	Intake	Leaching Path			
<b>A</b>	No	No	Sea	Leaching	JIS K 0058-1	Leaching Criteria for Port App
<b>B</b>	No	No	GW	Leaching	JIS K 0058-1	Leaching Criteria for General App
<b>C</b>	No	Yes	Sea	Leaching	JIS K 0058-1	Leaching Criteria for Port App
				Content	JIS K 0058-2	Content Criteria
<b>D</b>	No	Yes	GW	Leaching	JIS K 0058-1の5.	Leaching Criteria for General App
				Content	JIS K 0058-2	Content Criteria
<b>E</b>	Yes	Yes	—	Leaching	MoE Notification No.18	Leaching Criteria for General App
				Content	MoE Notification No. 19	Content Criteria

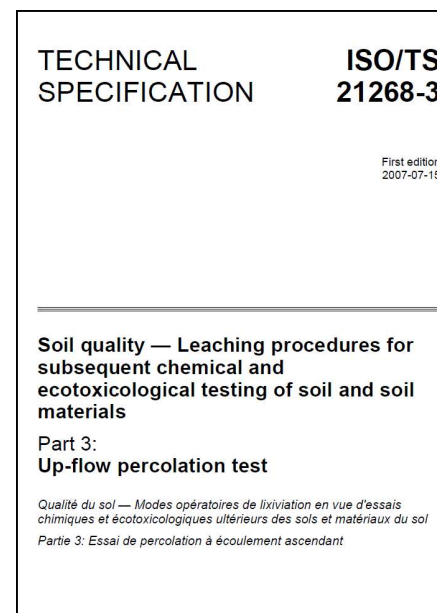
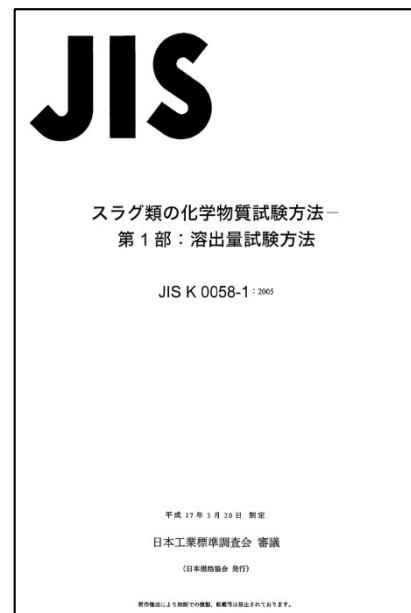


Coverage	Name of Standard, Guideline, etc		Publish Amend	Publisher
General	Comprehensive report on guidelines for introducing chemical substance evaluation method to slag for concrete aggregate or roads		2012	METI
	Recycling guidelines for port and airport maintenance		2015	MLIT
Ferrous Slag, Non Ferrous Slag, MSW Molten Slag	JIS A 5011-1	Slag aggregate for concrete – Part 1: Blast furnace	2013	Japanese Industrial Standard Committee
	JIS A 5011-2	Part 2: Ferro-nickel slag aggregate		
	JIS A 5011-3	Part 3: Copper slag aggregate	2016	
	JIS A 5011-4	Part 4: Electric furnace oxidized slag aggregate	2016	
	JIS A 5015	Steel slag for road	2013	
	JIS A 5031	Melt-solidified slag material for road construction derived from municipal solid waste and sewage sludge	2013	
	JIS A 5032	Melt-solidified slag material for concrete agregate derived from municipal solid waste and sewage sludge	2016	
	JSTM H 8001	Steel making slag crushed stone for civil engineering	2016	Building Material Testing Center
	Technical manual of steelmaking slag for ports, airports, coasts, etc.		2015	Coastal Technology Research Center
	Technical manual on utilization of nonferrous slag for port and airport construction		2015	
Coal Ash	Guideline of coal ash mix material in port construction		2011	Japan Coal and Energy Center
	Guideline of coal ash mix materials for earthquake reconstruction		2014	
	Guideline of coal ash mix material for high standard road embankment		2015	
	Guideline of coal ash mix material, aging ash version		2016	
Recycled Gypsum	Environmental safety guidelines for agricultural soil improvement material using recycled gypsum		2014	Gypsum Regeneration Cooperative Association
Disaster Waste	Evaluation scheme for the utilization of for recycled materials from disaster waste incineration ash as ground materials		2012	Japanese Geotechnical Society
	Guidelines for effective use of reconstruction materials recycled from disaster waste		2014	

# Contents

- Environmental Standard, Countermeasure Law, and Test methods
- Environmental Safety Quality of Recycled Materials in Construction
- **Standardization**

# Standardization of Leaching test



- International Standard
- Japanese Industrial Standard
- Academic Standard

# Leaching Tests in ISO/TC 190 Soil quality

ISO 18772:2008 Soil quality -- **Guidance** on leaching procedures for subsequent chemical and ecotoxicological testing of soils and soil materials

ISO 21268-(1-4):2019 Soil quality -- Leaching procedures for subsequent chemical and ecotoxicological testing of soil and soil materials

**Part 1: Batch test using a liquid to solid ratio of 2 l/kg dry matter**

**Part 2: Batch test using a liquid to solid ratio of 10 l/kg dry matter**

**Part 3: Up-flow percolation test**

**Part 4: Influence of pH on leaching with initial acid/base addition**



# Category of leaching test

## Basic characterization

- Short and long term leaching behavior
- Characteristic properties of materials
- L/S, leachant composition, factors controlling leachability (pH, ORP, DOC, aging, etc.) and physical parameters
- Time: long, e.g. months

## Compliance tests

- To determine whether the solid material complies with a specific behavior or with specific reference values
- Focused on key variables identified in the “basic characterization”
- Time: few days or a week

## On-site verification

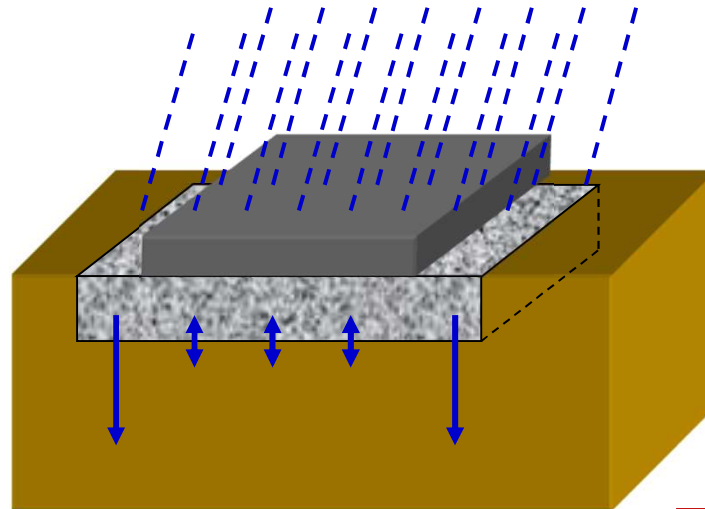
- Rapid check to confirm if the solid material is the same as that subjected to compliance test.
- Not necessarily leaching test
- Time: few hours

# Basic Characterization Tests

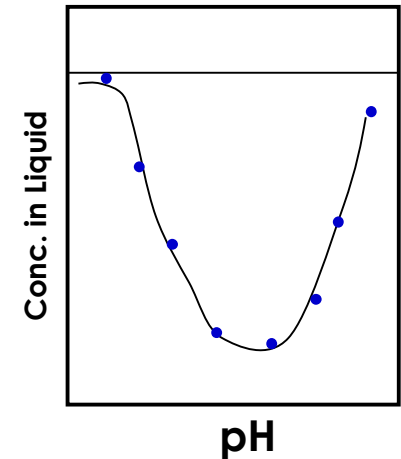
Long-term Cumulative Leaching Amount?

**Availability Test**

Milled sample  
pH4, 7, 12, own-pH



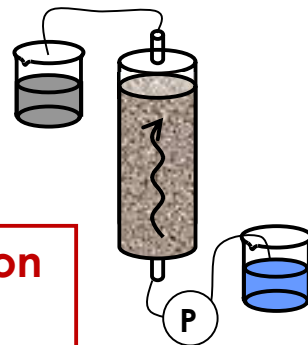
Effect of pH?  
(Acid rain, Cement)



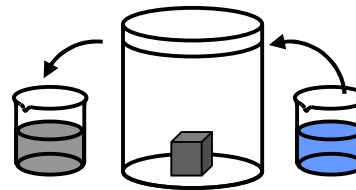
**pH dependence test**

Leaching Behavior  
Max. Conc?  
Decrease?  
Increase?

**Column Percolation Test**



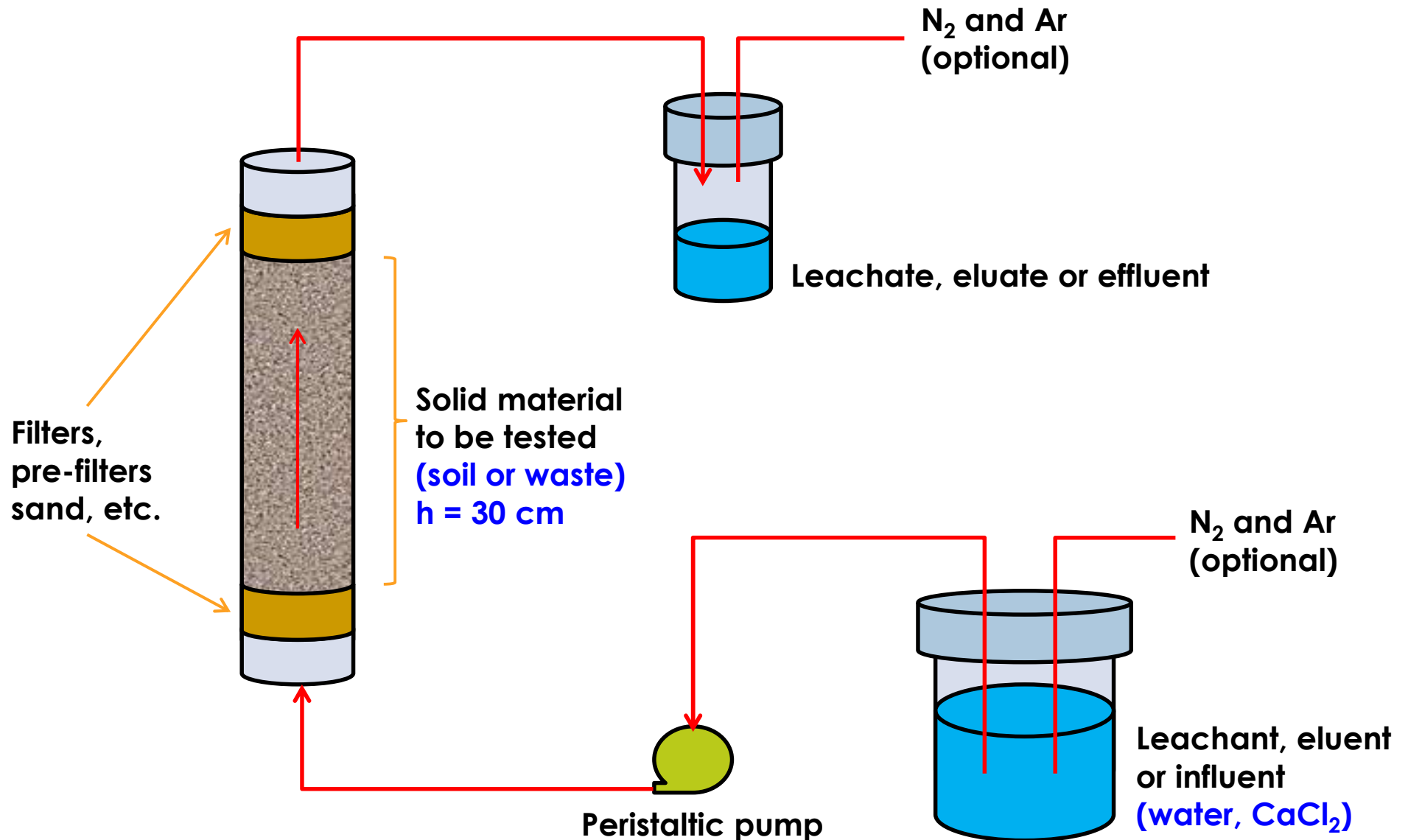
**Serial Batch Test**



Dry-Wet effect?  
Freeze-Melt Effect?

**Accelerated Exposure Test**

# Up-flow Column Percolation Test



# Standardization in ISO

NWIP (New Work Item Proposal)

⇒ WD (Working Draft)

⇒ CD (Committee Draft)

⇒ DIS (Draft International Standard)

⇒ FDIS (Final DIS)

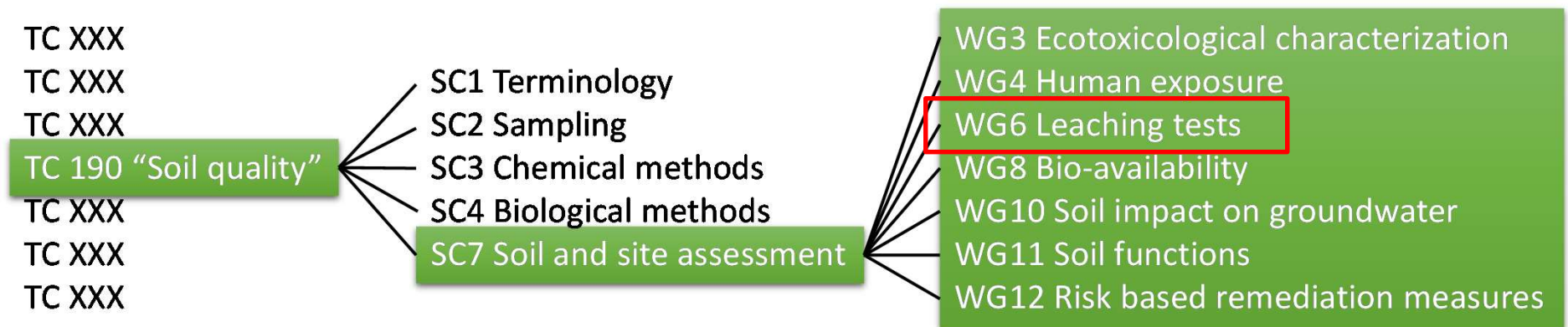
⇒ ISO

- One standard established in several years
- Project leader writes draft standard
- Ballots and recommendations on the web
- Amended draft to be discussed in annual meeting
- If failed and could not be in time, withdraw, suspend or go back
  
- Amendments conducted in annual and intermediate meeting
- Direct opinion at the meeting is important to adapt our opinion.
- Significant amendment – should be done at early stage
- Every 5 years review after admitted (TS: every 3 years)

# ISO/TC 190 Soil quality

## SC 7 Impact assessment

### WG 6 Transfer and mobility of components



..... Restructured and Renamed in 2019



# To enhance reliability of recycling

- **Appropriate inspection method**
  - Test method
  - Evaluated substances
    - Consistent with environmental standards
  - **Test frequency**
    - **Quality control**
- **Validity of the inspection**
  - **Certification, Third party check**
- **Traceability**
  - **Report and record of used location, amount, etc.**

# Recycling and Environmental Safety

## Promotion of recycling

Reduce the  
Consumption of Natural  
Resources

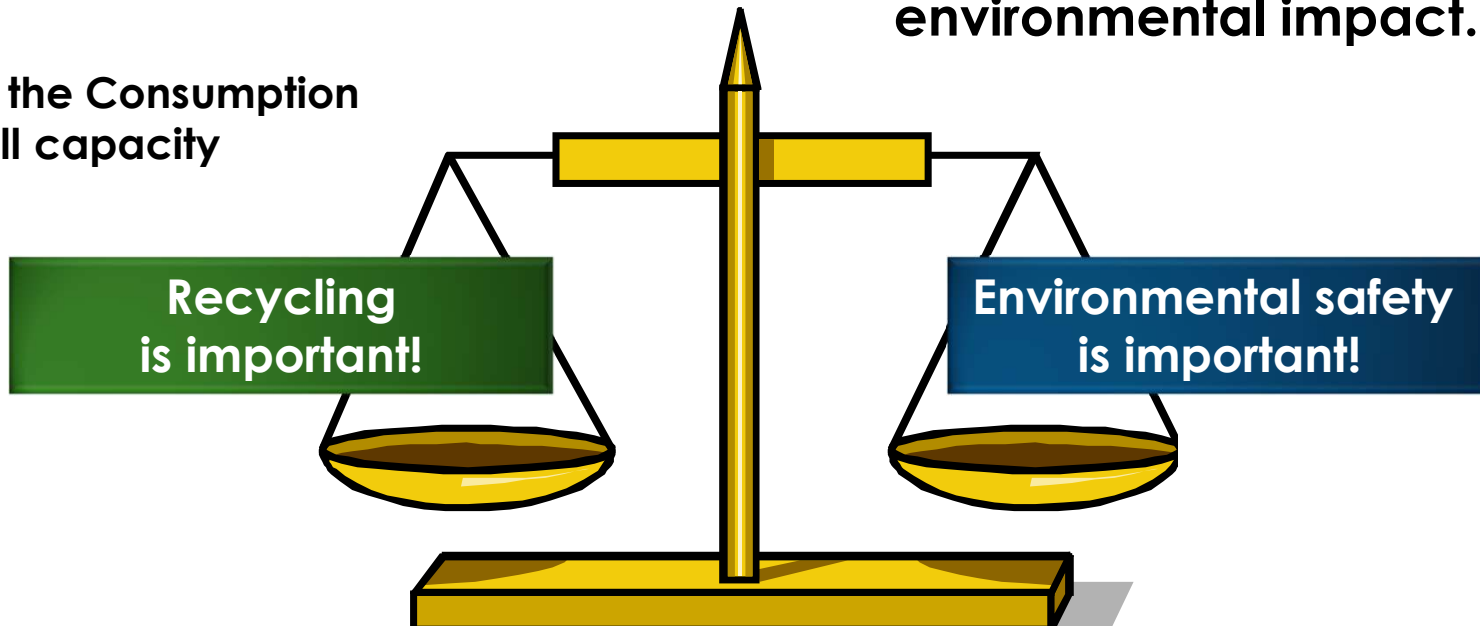
Reduce the Consumption  
of landfill capacity

Recycling  
is important!

## Control of recycling

They might have adverse  
environmental impact.

Environmental safety  
is important!



**Balance Is Necessary.**



**Thank you very much for  
your kind attention.**

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