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Feedback on the contribution of the use of a new approach to integrate the oral bioaccessibility of lead in a pilot area

Intersol – March 26, 2025 – Lyon

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R&D Tesora

Aurélie Pelfrêne (Junia, ISA) – **Benjamin Pauget** (Tesora) – **Corinne Hulot** (Ineris)

- Ile-de-France soils are heavily contaminated with Pb in some places
- It is the result of a combination of activities, including an important industrial past, sludge spreading in the 19th century, the Notre-Dame fire in 2019 and leaded gasoline vehicles
- Pb is of particular concern because of the many health problems it can cause

Problem:

The management of contaminated sites is often very expensive, but necessary to ensure the safety of populations and public health



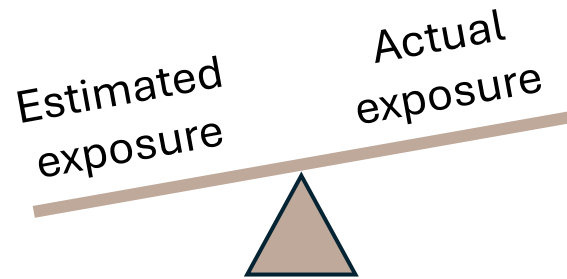
ACTUALITÉ
**Paris présente son plan
d'actions contre le plomb**

Mise à jour le 04/12/2019

www.paris.fr



Significant gap between estimated exposures (i.e. total pollutant concentrations in soil) and actual population exposures



Risk assessment

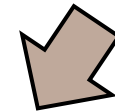
Management costs
Restrictions/concerns for residents

Safe

Based on total soil concentration

More realistic

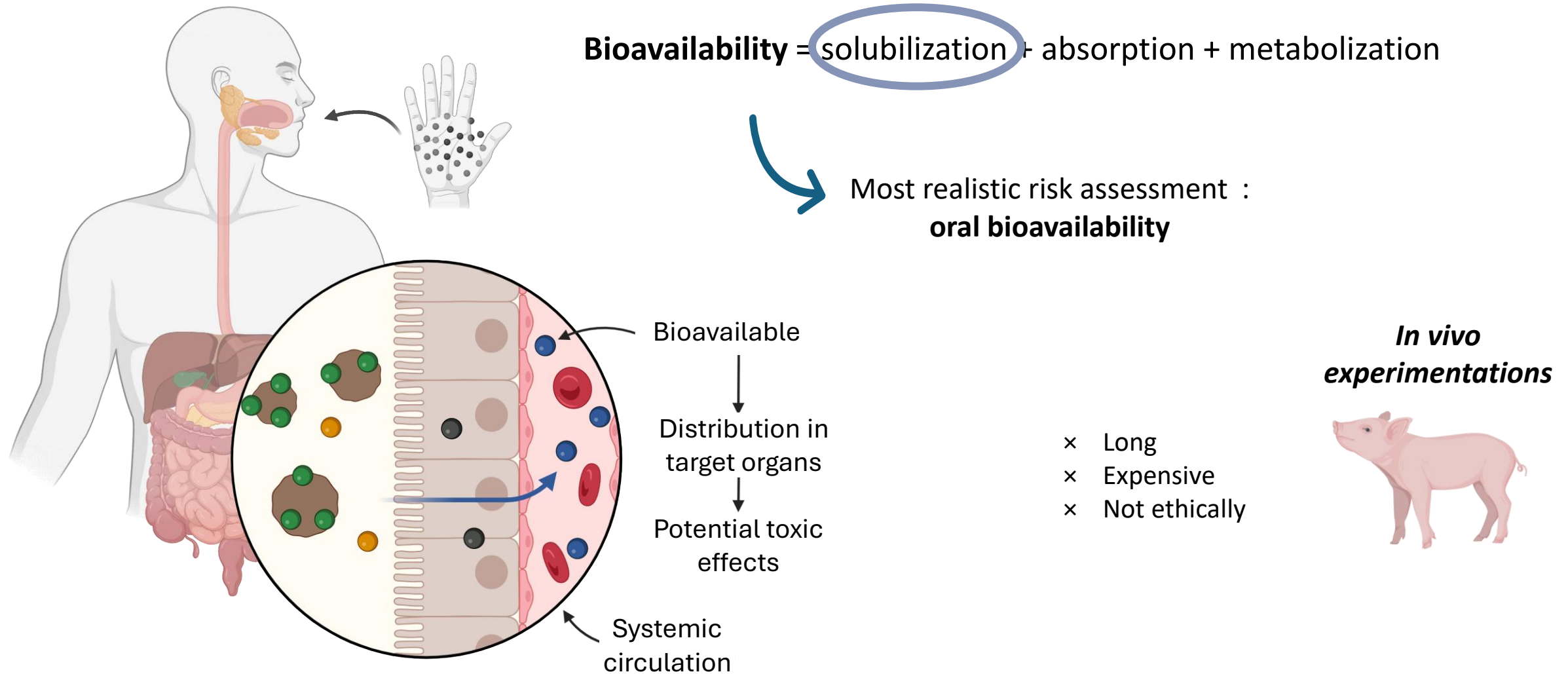
Based on the fraction able to generate a toxic effect



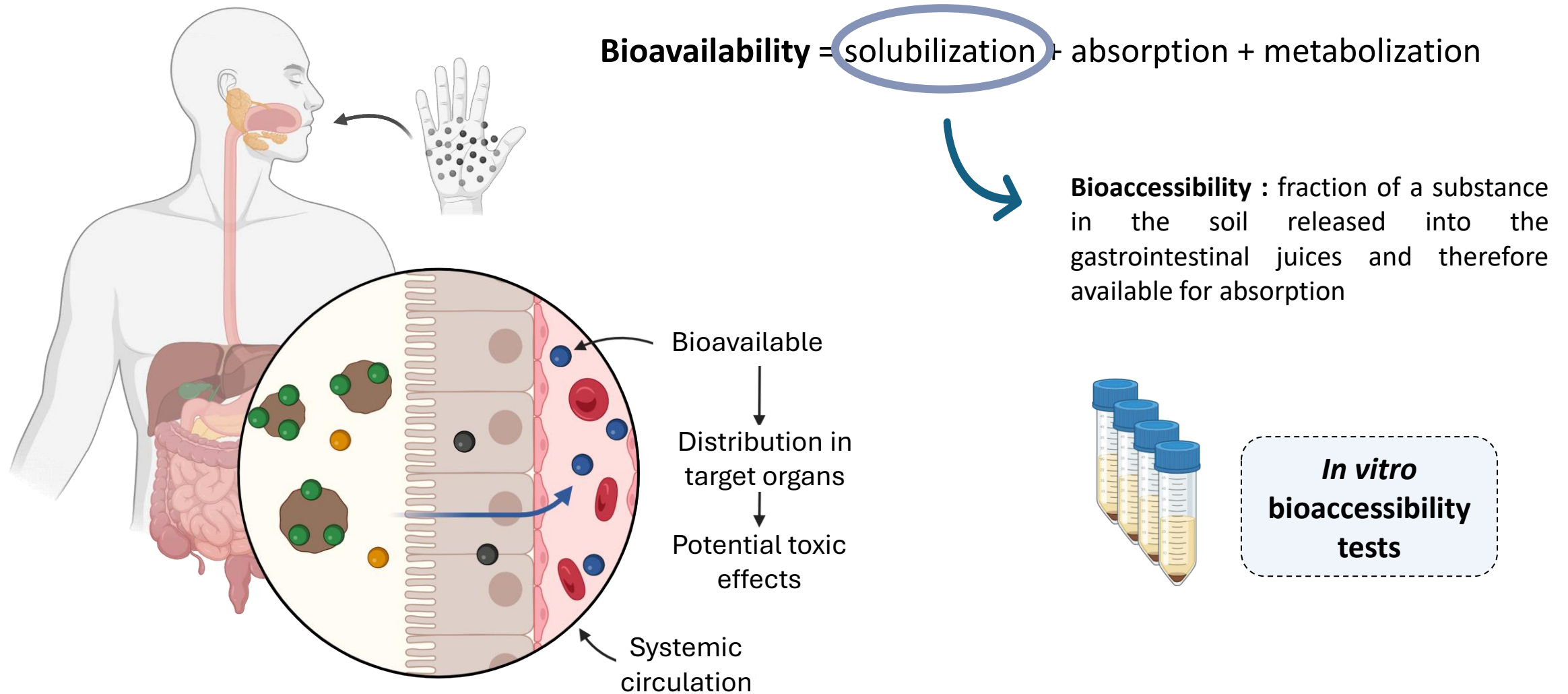
Need to develop tools and methods to improve the representativeness of human exposure characterization



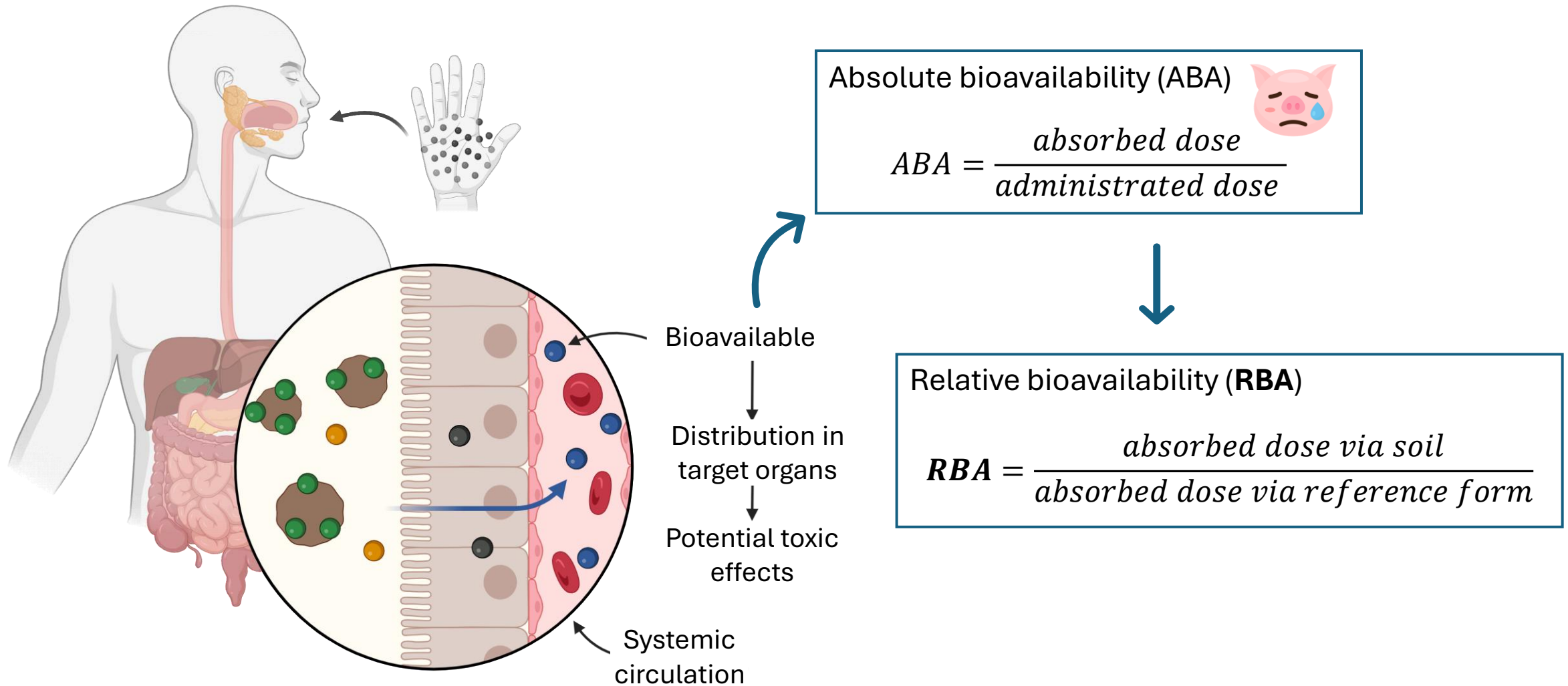
Oral bioavailability and bioaccessibility



Oral bioavailability and bioaccessibility



Oral bioavailability and bioaccessibility



Bioaccessibility measure

France reference method : **UBM test**

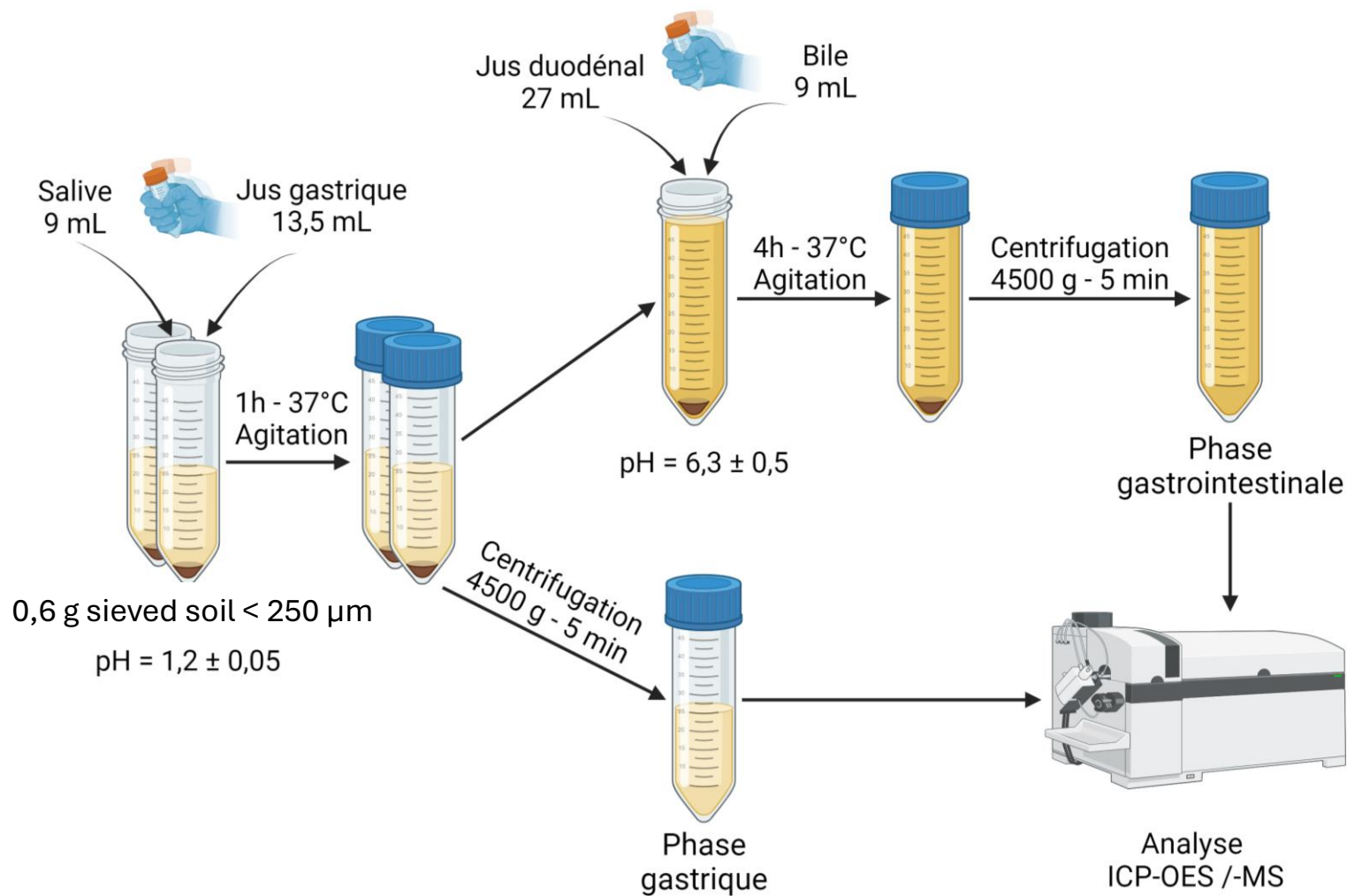
- ✓ Validated / *in vivo* (As, Cd et Pb)
- ✓ Standardized (ISO 17924)
- ✓ Recommended in the national methodology for managing polluted sites and soils (MTES, 2017)

Bioaccessibility (BAc)

$$BAc (\%) = \frac{BAc \text{ soil } (mg/kg)}{Total \text{ soil } (mg/kg)} \times 100$$

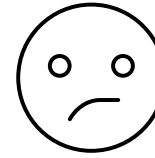
Relative bioaccessibility (RBAc)

$$RBAc (\%) = \frac{BAc \text{ soil}}{BAc \text{ reference form}}$$



Bioaccessibility
(BAc) mg/kg

Bioaccessibility measure



France reference method : UBM test

- ✓ Validated / *in vivo* (As, Cd et Pb)
- ✓ Standardized (ISO 17924)
- ✓ Recommended in the national methodology for managing polluted sites and soils (MTES, 2017)

Little or no use by polluted soil managers :

- × Lack of test awareness
- × Test validated only for As, Cd and Pb
- × Time-consuming, costly and requires real know-how
- × Operational difficulties



Feedback on the contribution and consideration of the oral bioaccessibility of lead in a pilot area

Intersol

March 27, 2024

Madeleine Biltmann

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Aurélie Petfrène (Junia, ISA) – Benjamin Pauget (Tesora) – Corinne Hulot (Ineris) – Arnaud Papin (Ineris)

Previous feedback presented at Intersol 2024



InVS-Ineris (2012) method

As et Cd :

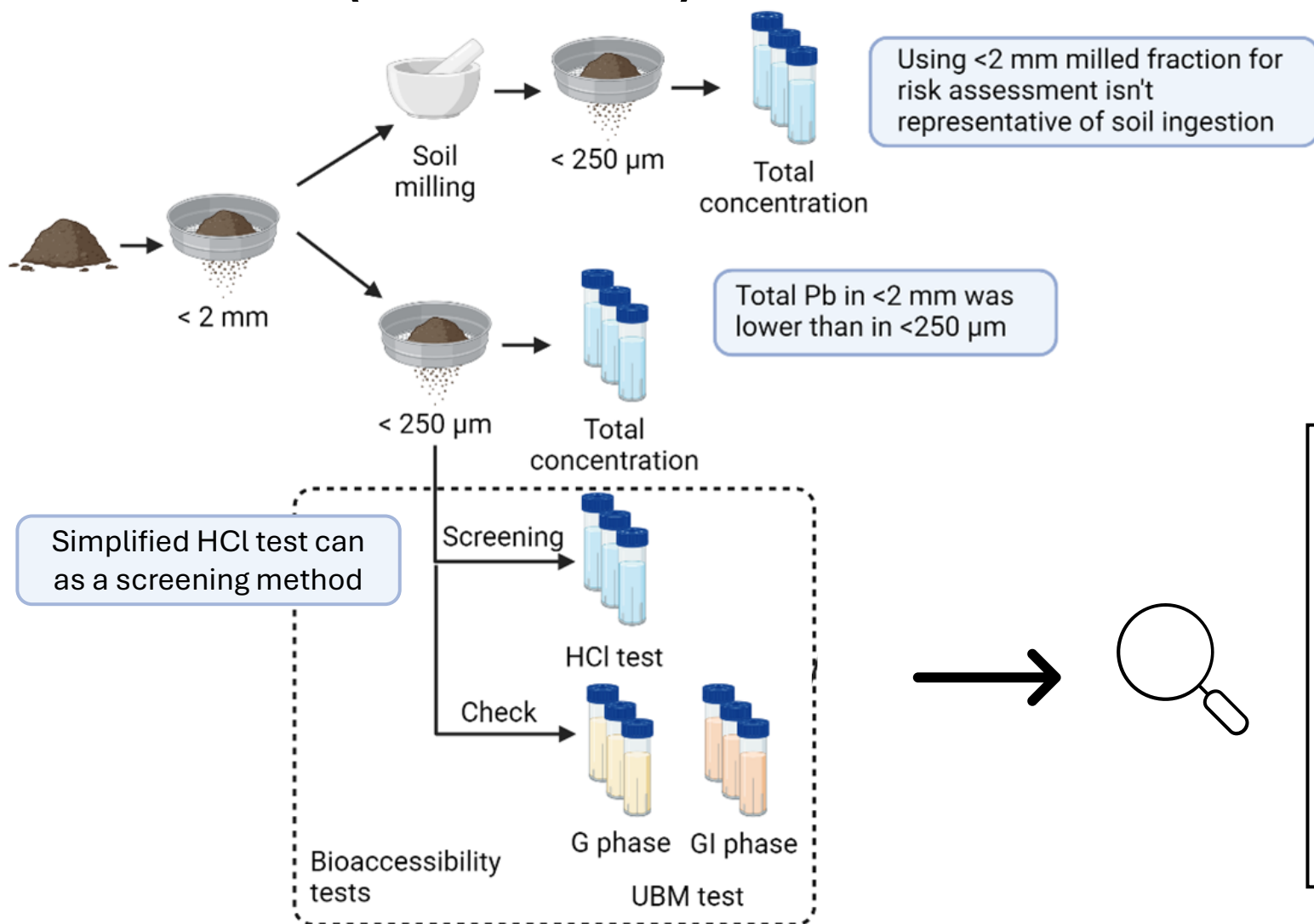
$$CDI_{adjusted} = CDI \times BAC_{soil}$$

Pb :

$$CDI_{adjusted} = CDI \times 2 \times BAC_{sol}$$

Factor 2 : limits the use of Pb oral bioaccessibility if > 50%

Conclusion and perspectives of previous feedback (Intersol 2024)



Human health risk assessment of lead exposure from soil ingestion in a French pilot study: insights from the application of a new bioaccessibility approach

Madeleine Billmann · Aurélie Pelfrène · Arnaud Papin · Benjamin Pauget · Rabia Badreddine · Corinne Hulot

To be investigated:

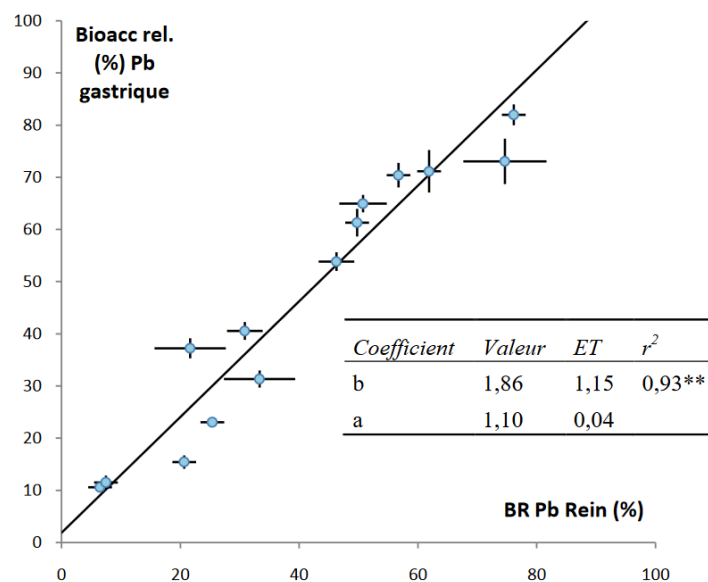
- Choice of phase



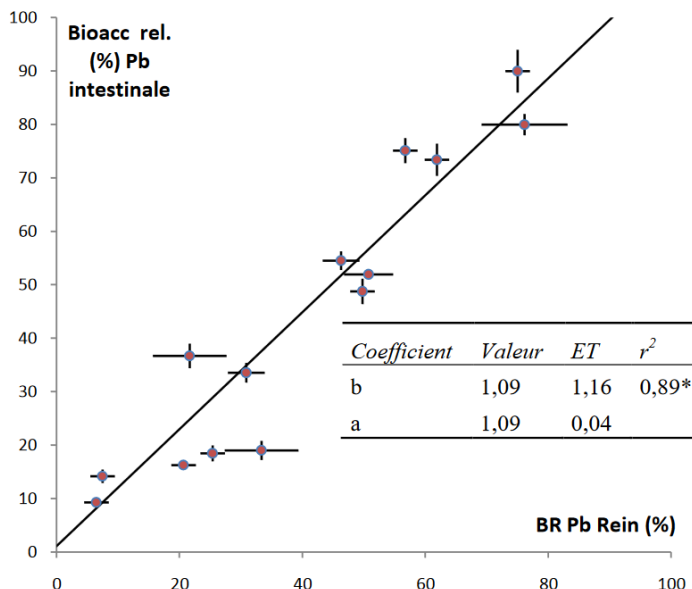
- Method for integrating bioaccessibility into risk calculations



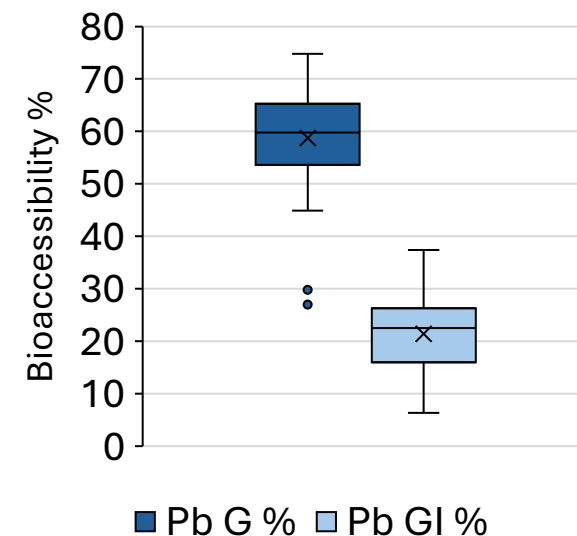
In vitro/in vivo correlations



Caboche (2009)



Previous feedback soils (n = 45)



InVS-Ineris (2012) guidelines :

- Highest bioaccessibility
- or
- best *in vitro/in vivo* correlations

For Cd and Pb: use of bioaccessibility in the G phase

For As: use the bioaccessibility of the highest phase



Integrating bioaccessibility

- 1 *In vitro/in vivo* equation to determine the relative bioavailability (RBA) of Pb from the relative bioaccessibility (RBAc) in the gastric phase :

$$RBA = 0,91 \times RBAc - 1,69$$

- 2 $RBA_c = \frac{BAc\ Pb\ G\ soil}{BAc\ Pb\ G\ reference\ matrix}$

- 3 Pb reference matrix : Pb acetate
BAc Pb G = 99 %



New equation proposal

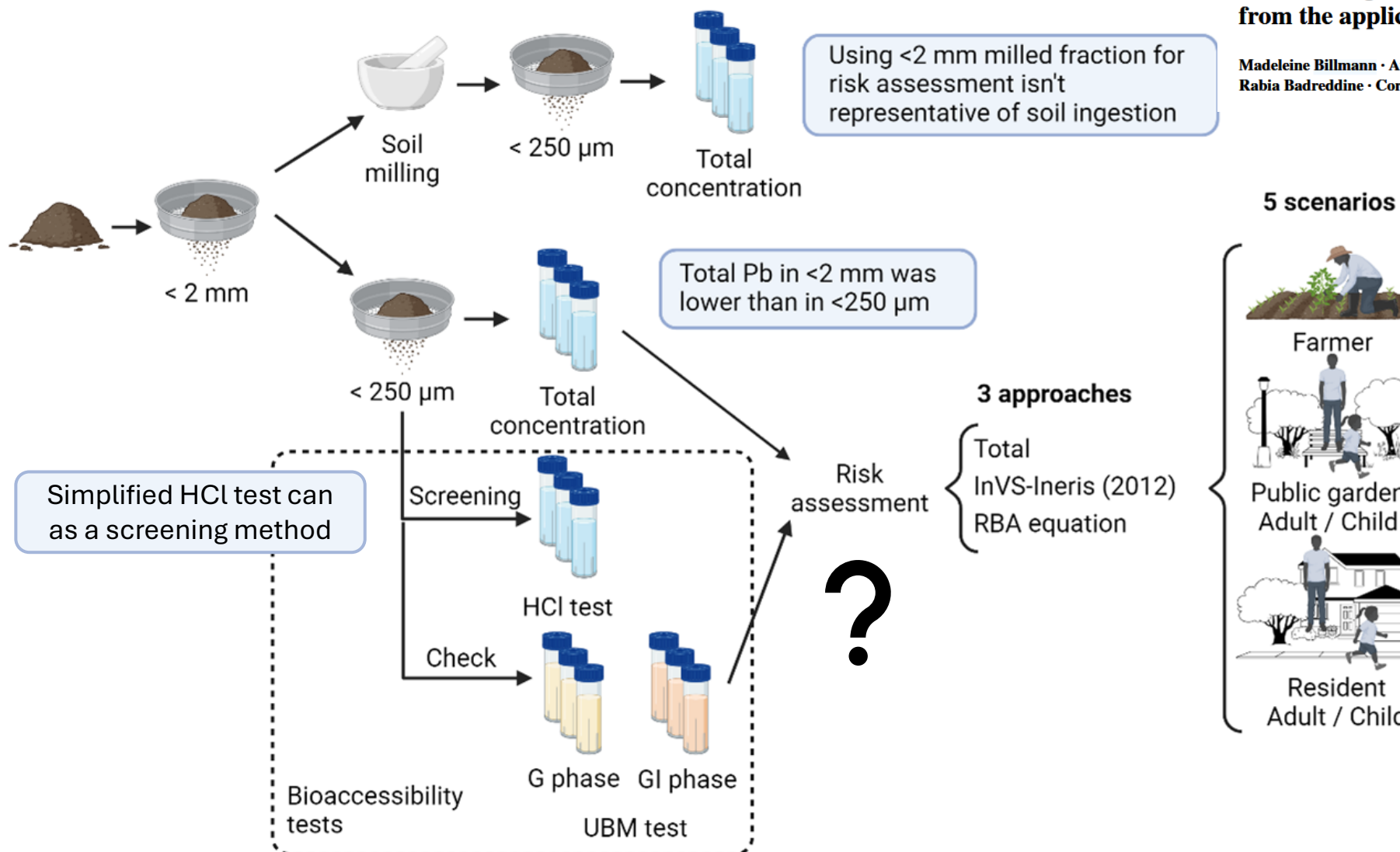
$$RBA\ As\ G = 1,00 \times \frac{BAc\ As\ G}{0,95} + 0,01$$

$$RBA\ As\ GI = 0,99 \times \frac{BAc\ As\ GI}{0,92} - 0,04$$

$$RBA\ Cd\ G = 1,04 \times \frac{BAc\ Cd\ G}{0,98} - 2,77$$

$$RBA\ Pb\ G = 0,91 \times \frac{BAc\ Pb\ G}{0,99} - 1,69$$

Contribution of the use of a new approach



Environ Geochem Health (2025) 47:109
<https://doi.org/10.1007/s10653-025-02418-8>

ORIGINAL PAPER



Human health risk assessment of lead exposure from soil ingestion in a French pilot study: insights from the application of a new bioaccessibility approach

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5 scenarios



Farmer



Public garden
Adult / Child



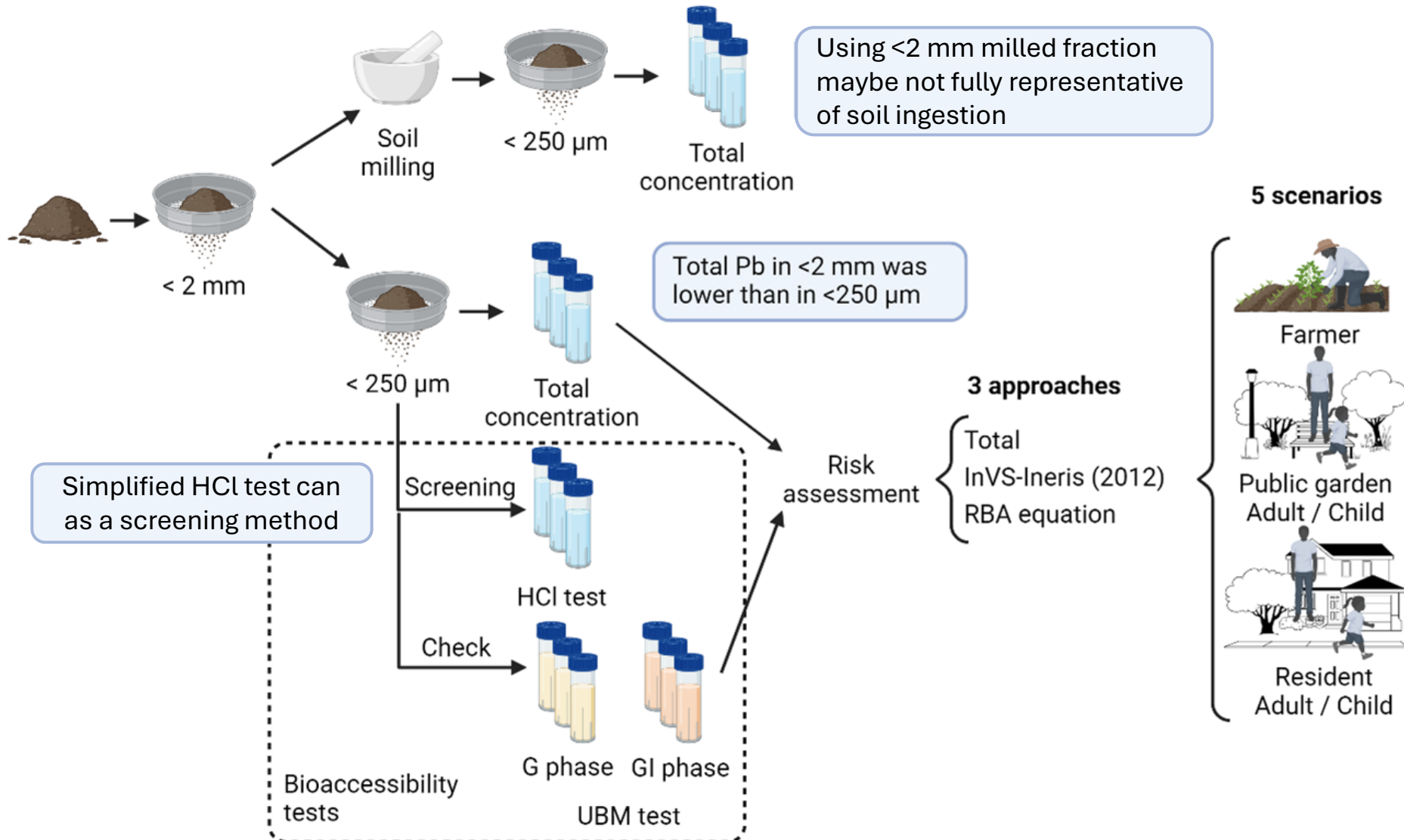
Resident
Adult / Child

Contribution of the use of a new approach

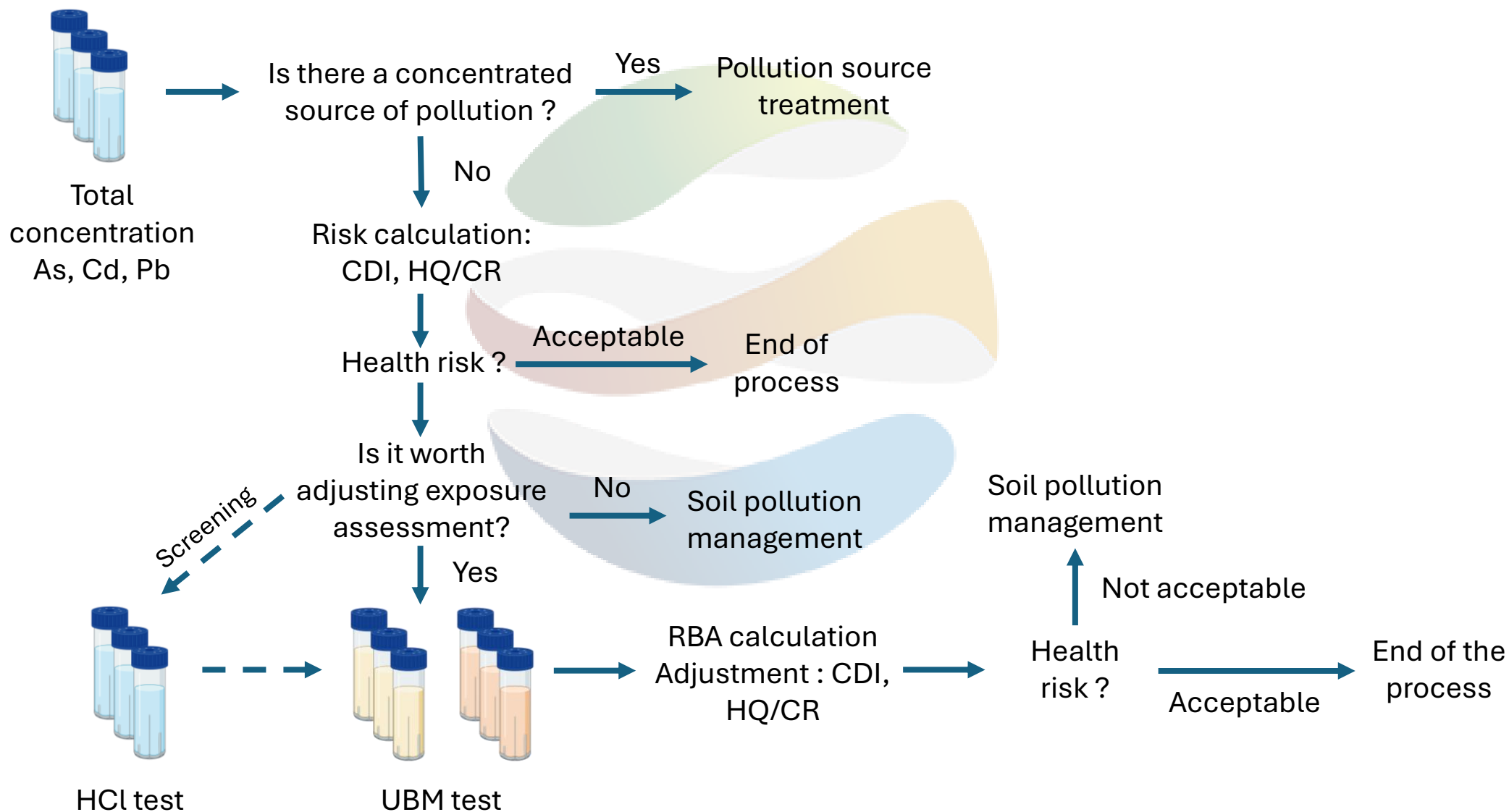
A1 : Total concentration
 A2 : New method (RBA equation)
 A3 : *InVS-Ineris (2012) method*

Site	Pb pseudo- total (mg kg ⁻¹) milled	BAc G (%)	RBD G (%)	HQ					
				Child public garden			Resident child		
				A1	A2	A3	A1	A2	A3
SSD2	106	27	23	0,4	0,1	0,2	1,0	0,2	0,6
PAR37	106	67	60	0,4	0,3	0,6	1,0	0,6	1,4
PAR2	159	55	49	0,7	0,3	0,7	1,5	0,8	1,7
PAR4	138	56	50	0,6	0,3	0,6	1,3	0,7	1,5
PAR5	135	57	51	0,6	0,3	0,6	1,3	0,7	1,5
PAR6	232	54	48	1,0	0,5	1,0	2,2	1,1	2,4
PAR7	396	56	50	1,6	0,8	1,8	3,8	1,9	4,3
PAR11	274	66	59	1,1	0,7	1,5	2,6	1,6	3,5
PAR14	211	59	52	0,9	0,5	1,0	2,0	1,1	2,4
PAR18	273	69	62	1,1	0,7	1,6	2,6	1,6	3,6

Conclusion of the feedback



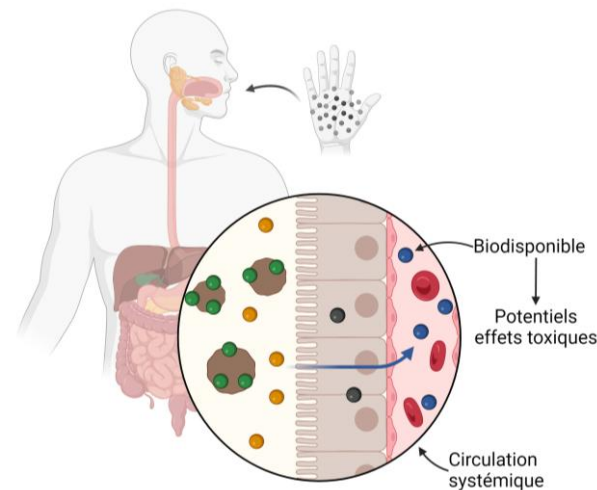
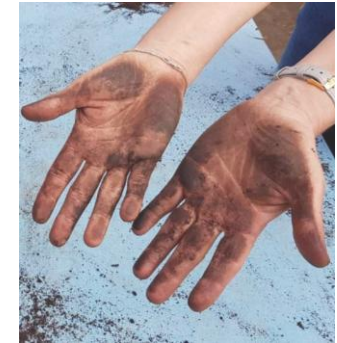
When to use bioaccessibility in HHRA



Thank for your attention



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UBM test