Mercury Scientific information: What the public needs

Ahmad Safrudin - KPBB

The 8th Asia Pacific Mercury Monitoring Network – Workshop
Ritz Carlton Jakarta, 14 – 16 August 2019

Sarinah Building 12th Floor, Jalan MH Thamrin # 11 Jakarta Indonesia 10350
Phone: +62-21-3190 6807 Fax: +62-21-315 3401
e-mail: kpbb@kpbb.org, www.kpbb.org

Outline

1. What's public needs in relation with mercury scientific data?
2. Atmospheric mercury exposure
3. Understanding complicated mercury scientific data
4. Capacity building to transform behavior changing and policy reform
5. Resume and recommendation

What's Public Needs?

- How to interpret, understanding , and using data in relation with:
  - Mercury exposure, and pathway
  - Mercury is a naturally occurring element that is found in air, water and soil.
  - Mercury is one of the top six toxic threats, and is considered one of the top ten chemicals of major public health concern by WHO.
  - Mercury is especially devastating to children.
  - The role of artisanal gold mining.
  - Toward Mercury exposure , pathway, and its effect to human health and environment
- How to handling?

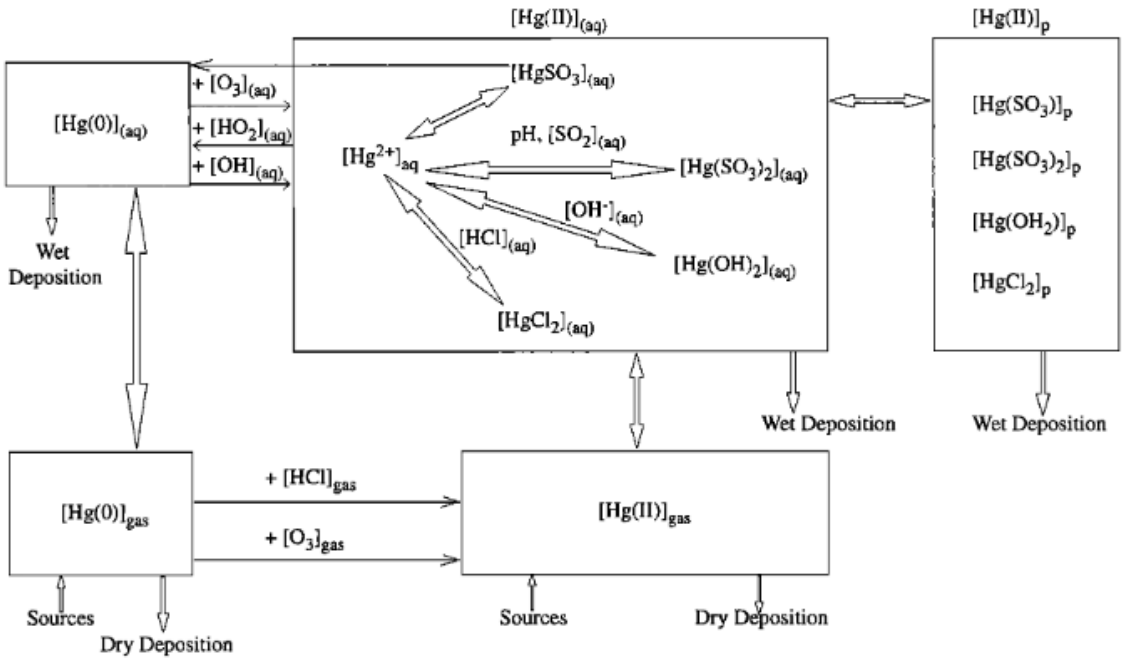
Atmospheric Mercury?

- Mercury is utilized I human life, even though its volatilization (Hg) easy to be emitted to the atmosphere.
- Today, estimates for anthropogenic interferences range from about 50 to 75% of the total annual Hg emissions to the atmosphere.
- Recent modeling suggests that the present atmospheric Hg burden has increased by a factor of 3 during the last 100 years.
- This impact, which is significant, can be examined and assessed empirically. To date, however, atmospheric Hg programs have not employed an experimental design sufficient to account for short time scale atmospheric Hg variations of natural and anthropogenic origin, and to resolve the long term temporal pattern.
- Is Hg increasing in the atmosphere?
- How we would examine temporal and spatial variations in atmospheric Hg and assess the influence of natural and anthropogenic sources on the global atmospheric Hg cycle?
- How to measure it? And how to interpret its result of measurement to the simple information that can be understanding by common people?
  - Identify between anthropogenic processes versus natural biogeochemical cycling of Hg
  - Enhanced knowledge of the behavior of Hg in the atmosphere, and
  - Interpret data base atmospheric Hg to the health effect.

It is not easy for common people include decision makers to understanding with affective awareness toward scientific data on mercury poisoning in environment.

Understanding Complicated Scientific Data

To Utilize Scientific Data



Schematic diagram of Hg atmospheric transformations, which includes gas/aqueous equilibria, ionic equilibria, solution/particle adsorption equilibrium, and gaseous and aqueous reactions.

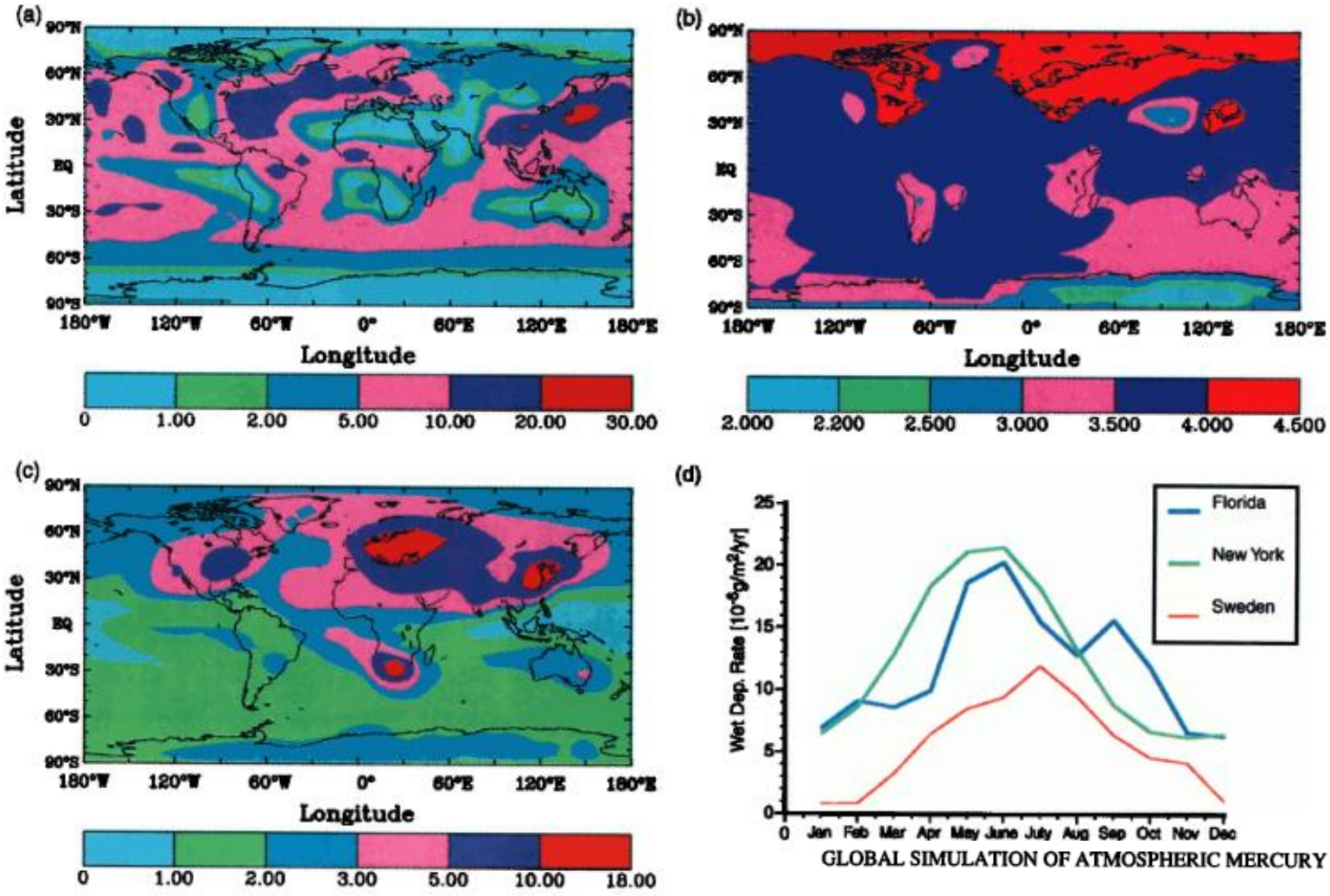
- How to serve data and its analysis to interpret the meaning of its effect to human health?
- And invite people to have affective awareness?

Table Global Hg Emission and Deposition Fluxes

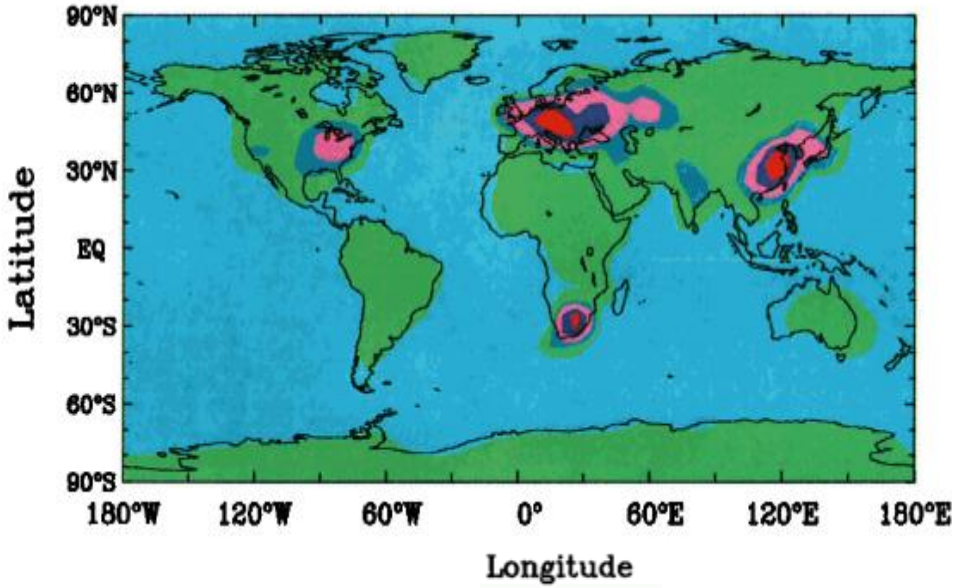
	Anthropogenic Emissions	Land Emissions	Ocean Emissions	Total Emissions	Wet Deposition	Dry Deposition	Total Deposition
Hg(0)	1070	2000	2000	5070	~ 0	1860	1860
Hg(II)	1070	0	0	1070	2860	1430	4280
Total Hg	2140	2000	2000	6140	2860	3290	6140

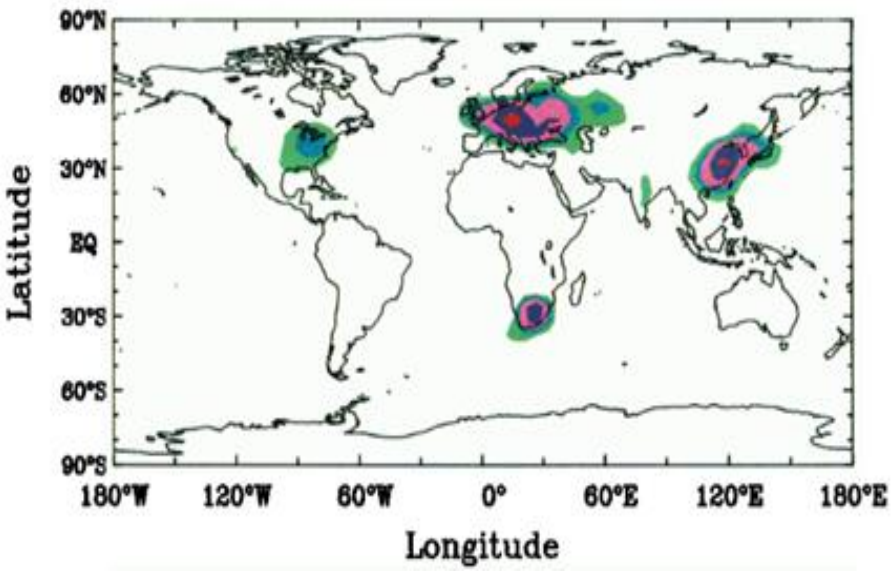
Fluxes are in Mg yr^{-1}.

GLOBAL SIMULATION OF ATMOSPHERIC MERCURY

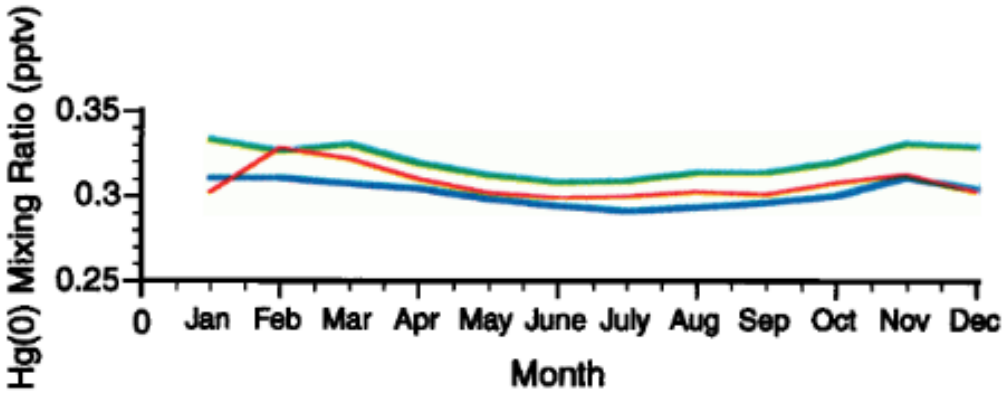


Annual average fluxes of Hg ($\mu g\ m^{-2}\ yr^{-1}$) for (a) wet deposition, (b) dry deposition of Hg(0), (c) dry deposition of Hg(II), and (d) monthly mean wet deposition flux for 12 months at three model locations, Florida, New York, and Sweden.





Surface Hg emission fluxes (10^{-6} g m^{-2} yr^{-1}) of (a) Hg(0), which consist of the natural emissions of 2000 Mg yr^{-1} (about 15 x 10^{-6} g m^{-2} yr^{-1}) from land, 2000 Mg yr^{-1} (about 6 x 10^{-6} g m^{-2} yr^{-1}) from the oceans and anthropogenic emissions of 1072 Mg yr^{-1} and (b) Hg(II), which consist only of anthropogenic emissions of 1072 Mg yr^{-1} so that the distribution of Hg(II) emissions shows the anthropogenic source distribution.



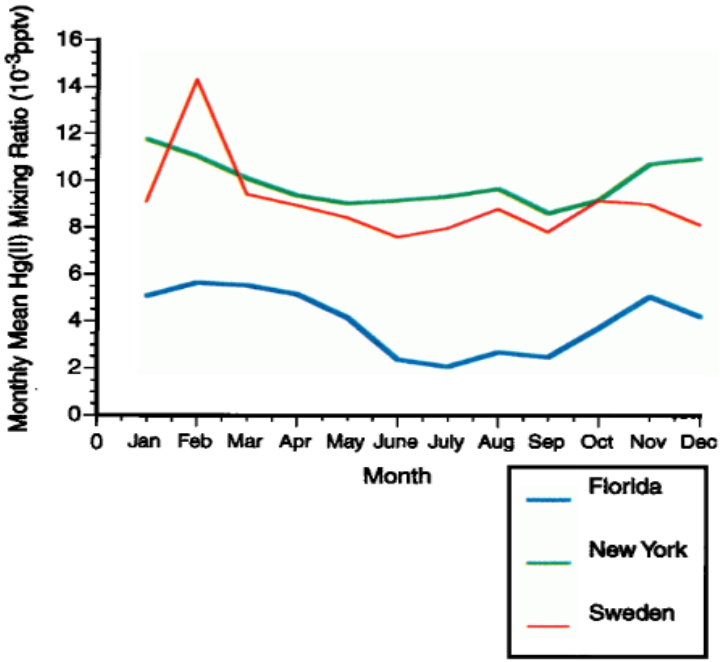


Table Equilibria and Reactions of Atmospheric Hg

Equilibrium Process or Chemical Reaction	Equilibrium or Rate Parameter[a]	Reference
$Hg(0)\ (g) \rightleftarrows Hg(0)\ (aq)$	0.11 M atm^{-1}	*Sanemasa* [1975]
$HgCl_2\ (g) \rightleftarrows HgCl_2\ (aq)$	1.4 x 10^6 M atm^{-1}	*Lindqvist and Rohde* [1985]
$Hg(OH)_2\ (g) \rightleftarrows Hg(OH)_2\ (aq)$	1.2 x 10^4 M atm^{-1}	*Lindqvist and Rohde* [1985]
$O_3\ (g) \rightleftarrows O_3(aq)$	1.2 x 10^{-2} M atm^{-1}	*Kosak-Channing and Helz* [1983]
$HCl\ (g) \rightleftarrows HCl\ (aq)$	1.1 M atm^{-1}	*Marsh and McElroy* [1985]
$SO_2\ (g) \rightleftarrows SO_2\ (aq)$	1.23 M atm^{-1}	*Smith and Martrell* [1976]
$OH\ (g) \rightleftarrows OH\ (aq)$	25 M atm^{-1}	*Klaning et al.* [1985]
$HgCl_2\ (aq) \rightleftarrows Hg^{2+} + 2\ Cl^-$	10^{-14} M^2	*Sillen and Martell* [1964]
$Hg(OH)_2\ (aq) \rightleftarrows Hg^{2+} + 2\ OH^-$	10^{-22} M^2	*Sillen and Martell* [1964]
$HCl\ (aq) \rightleftarrows H^+ + Cl^-$	1.7 x 10^6 M	*Marsh and McElroy* [1985]
$SO_2 + H_2O\ (\ell) \rightleftarrows HSO_3^- + H^+$	1.23 x 10^{-2} M	*Smith and Martell* [1976]
$HSO_3^- \rightleftarrows SO_3^{2-} + H^+$	6.6 x 10^{-8} M	*Smith and Martell* [1976
$Hg^{2+} + SO_3^{2-} \rightleftarrows HgSO_3$	5 x 10^{12} M^{-1}	*Munthe et al.* [1991]
$HgSO_3 + SO_3^{2-} \rightleftarrows Hg(SO_3)_2^{2-}$	2.5 x 10^{11} M^{-1}	*Munthe et al.* [1991]
$Hg(II)\ (aq) \rightleftarrows Hg(II)\ (p)$	34 $\ell\ g^{-1}$	*Seigneur et al.* [1998]
$Hg(0)\ (g) + O_3\ (g) \longrightarrow Hg(II)\ (g)$	3 x 10^{-20} cm^3 $molecules^{-1}$ s^{-1}	*Hall* [1995]
$Hg(0)\ (g) + HCl(g) \longrightarrow \longrightarrow HgCl_2\ (g)$	10^{-19} cm^3 $molecules^{-1}$ s^{-1}	*Hall and Bloom* [1993]
$Hg(0)\ (aq) + O_3\ (aq) \longrightarrow Hg^{2+}$	4.7 x 10^7 M^{-1} s^{-1}	*Munthe* [1992]
$Hg(0)\ (aq) + OH\ (aq) \longrightarrow Hg^{2+}$	2.0 x 10^9 M^{-1} s^{-1}	*Lin and Pehkonen* [1997]
$HgSO_3\ (aq) \longrightarrow Hg(0)\ (aq)$	0.6 s^{-1}	*Munthe et al.* [1991]
$Hg(II)\ (aq) + HO_2\ (aq) \longrightarrow Hg(0)\ (aq)$	1.7 x 10^4 M^{-1} s^{-1}	*Pehkonen and Lin* [1998]

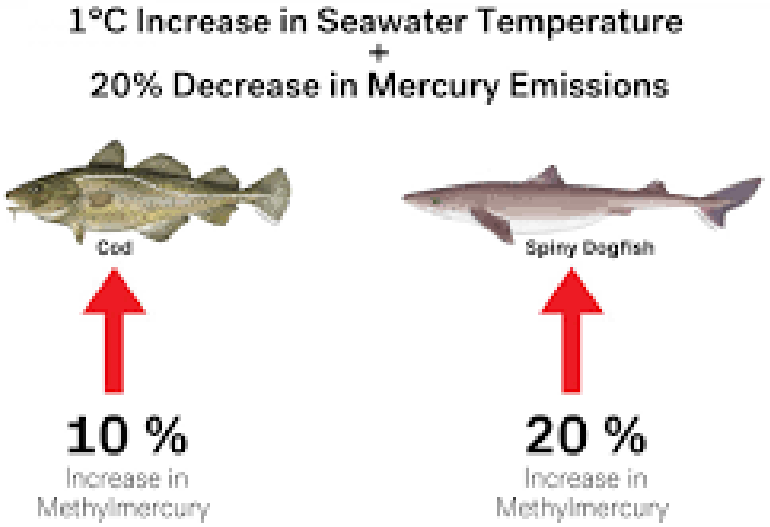


Table
Rotated component matrix for surface soil samples in Svalbard.

	f1	f2	f3	f4
SOM	−0.776			0.472
Al	0.922			
As	0.871			
Cd			0.742	
Cr	0.955			
Cu	0.887			
Fe	0.952			
Hg				0.770
Mn		0.877		
Ni	0.957			
Pb		0.804	0.417	
S	−0.453			0.666
Zn			0.840	
Variance explained (%)	46.7	13.2	13.2	11.8

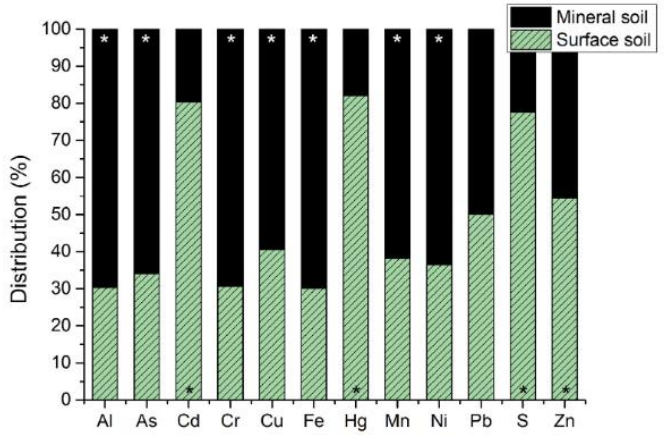
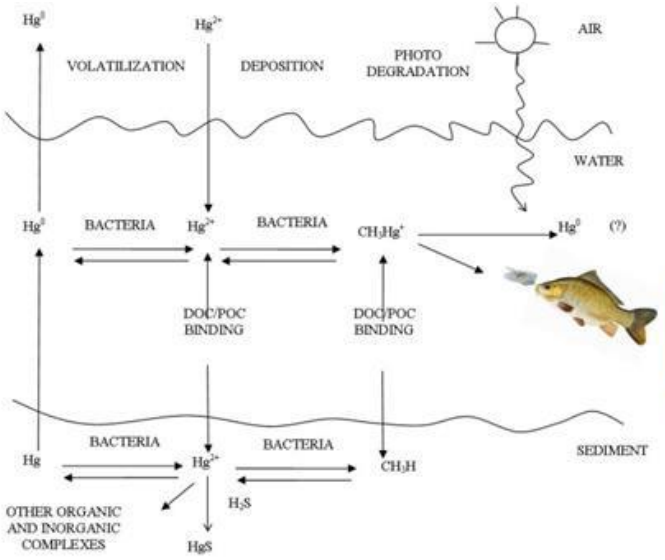


Fig. Relative distribution of 12 elements between surface soils (green shaded) and corresponding mineral soils (black) in Svalbard (n = 57). * indicates significance. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Complicated and details data toward Mercury



Mercury from earth sources (Hg°)
Inhaled mercury vapor (Hg°)
Methyl mercury (CH3Hg+)
Ethyl mercury (CH3CH3Hg+)

converts

Inorganic Divalent Mercury Hg2+ Toxic Species

Mercuric Salt
Mercurous Salt

Soluble in H2O

Diphenyl-Hg

Biomethylation

Phenyl-Hg

Elemental Hg (Hg°)

Methyl Mercury CH3Hg+

Hg2+

Fish

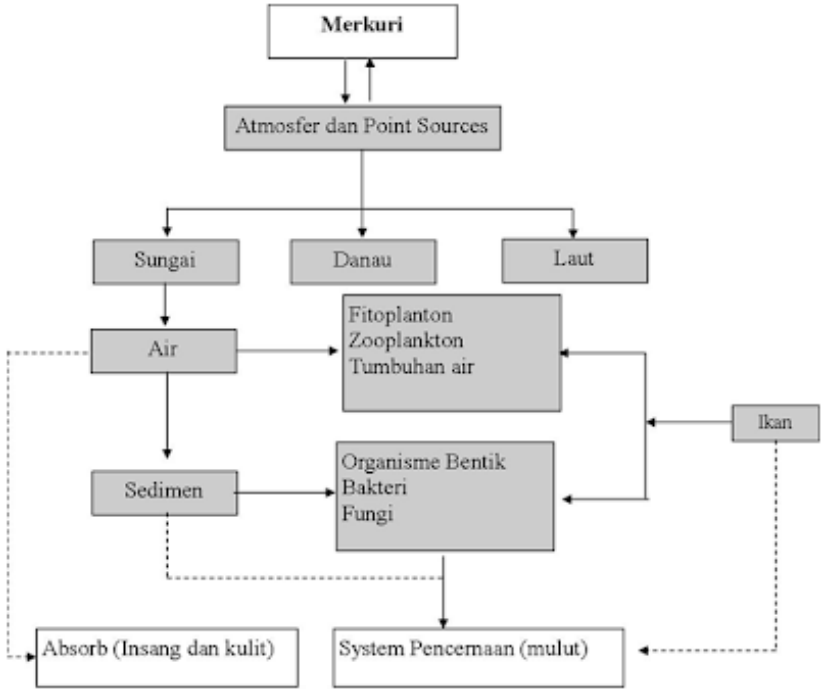
Table
Element concentrations (μg/g) in surface soils (S) and mineral soils (M) (n = 57) in Svalbard.

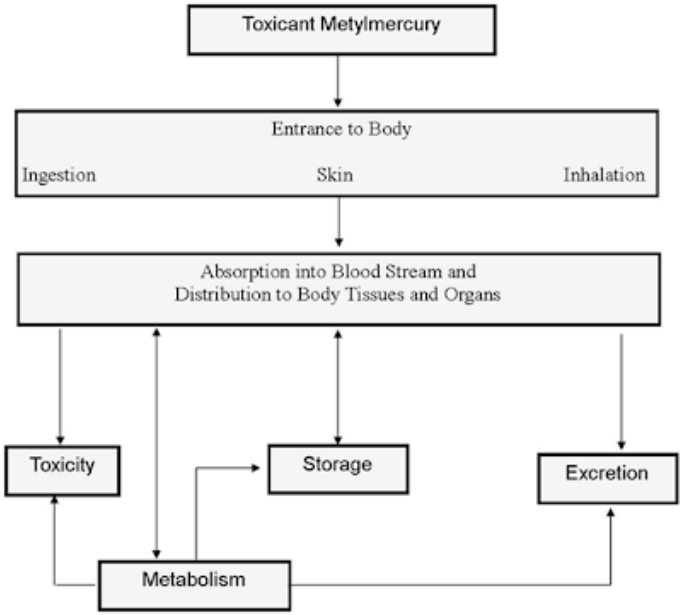
Element		Range	Median	Mean ± sd
Al	S	$1.5 \cdot 10^3$–$36.5 \cdot 10^3$	13.6	$14.4 \cdot 10^3 \pm 8.6 \cdot 10^3$
	M	$6.6 \cdot 10^3$–$56.8 \cdot 10^3$	$31.2 \cdot 10^3$	$31.9 \cdot 10^3 \pm 10.3 \cdot 10^3$
As	S	0.93–9.99	2.96	3.47 ± 2.28
	M	0.7–14.1	5.7	6.6 ± 3.1
Cd	S	0.13–1.00	0.38	0.44 ± 0.19
	M	0.04–0.50	0.094	0.12 ± 0.10
Cr	S	2.2–47.8	19.0	18.4 ± 10.7
	M	8.8–72.3	42.9	42.1 ± 12.6
Cu	S	4.0–17.8	9.8	10.2 ± 3.6
	M	3.3–28.4	14.3	15.1 ± 6.2
Fe	S	$1.3 \cdot 10^3$–$23.6 \cdot 10^3$	$10.8 \cdot 10^3$	$10.9 \cdot 10^3 \pm 6.0 \cdot 10^3$
	M	$4.9 \cdot 10^3$–$43.1 \cdot 10^3$	$25.2 \cdot 10^3$	$25.8 \cdot 10^3 \pm 7.6 \cdot 10^3$
Hg	S	0.041–0.254	0.107	0.111 ± 0.036
	M	0.004–0.060	0.023	0.025 ± 0.013
Mn	S	82–537	217	239 ± 111
	M	$0.11 \cdot 10^3$–$3.24 \cdot 10^3$	$0.35 \cdot 10^3$	$0.42 \cdot 10^3 \pm 0.41 \cdot 10^3$
Ni	S	2.0–24.9	11.9	12.0 ± 6.6
	M	4.0–36.5	20.7	21.2 ± 8.0
Pb	S	5.6–25.1	10.7	11.9 ± 4.6
	M	2.9–22.7	10.6	11.4 ± 4.35
S	S	$0.59 \cdot 10^3$–$2.54 \cdot 10^3$	$1.46 \cdot 10^3$	$1.51 \cdot 10^3 \pm 0.44 \cdot 10^3$
	M	$0.09 \cdot 10^3$–$1.42 \cdot 10^3$	$0.42 \cdot 10^3$	$0.54 \cdot 10^3 \pm 0.34 \cdot 10^3$
Zn	S	16–106	64	66 ± 17
	M	25–105	54	55 ± 18

Table
Blank detection limits (BDL) of the ICP-MS analysis (in μg/g).

	BDL Surface soil	BDL Mineral soil
Al	1	1
As	0.006	0.02
Cd	0.004	0.0008
Cr	0.08	0.02
Cu	0.035	0.009
Fe	1	3
Hg	0.003	0.006
Mn	0.01	0.009
Ni	0.06	0.04
Pb	0.02	0.002
S	25	29
Zn	0.04	0.2

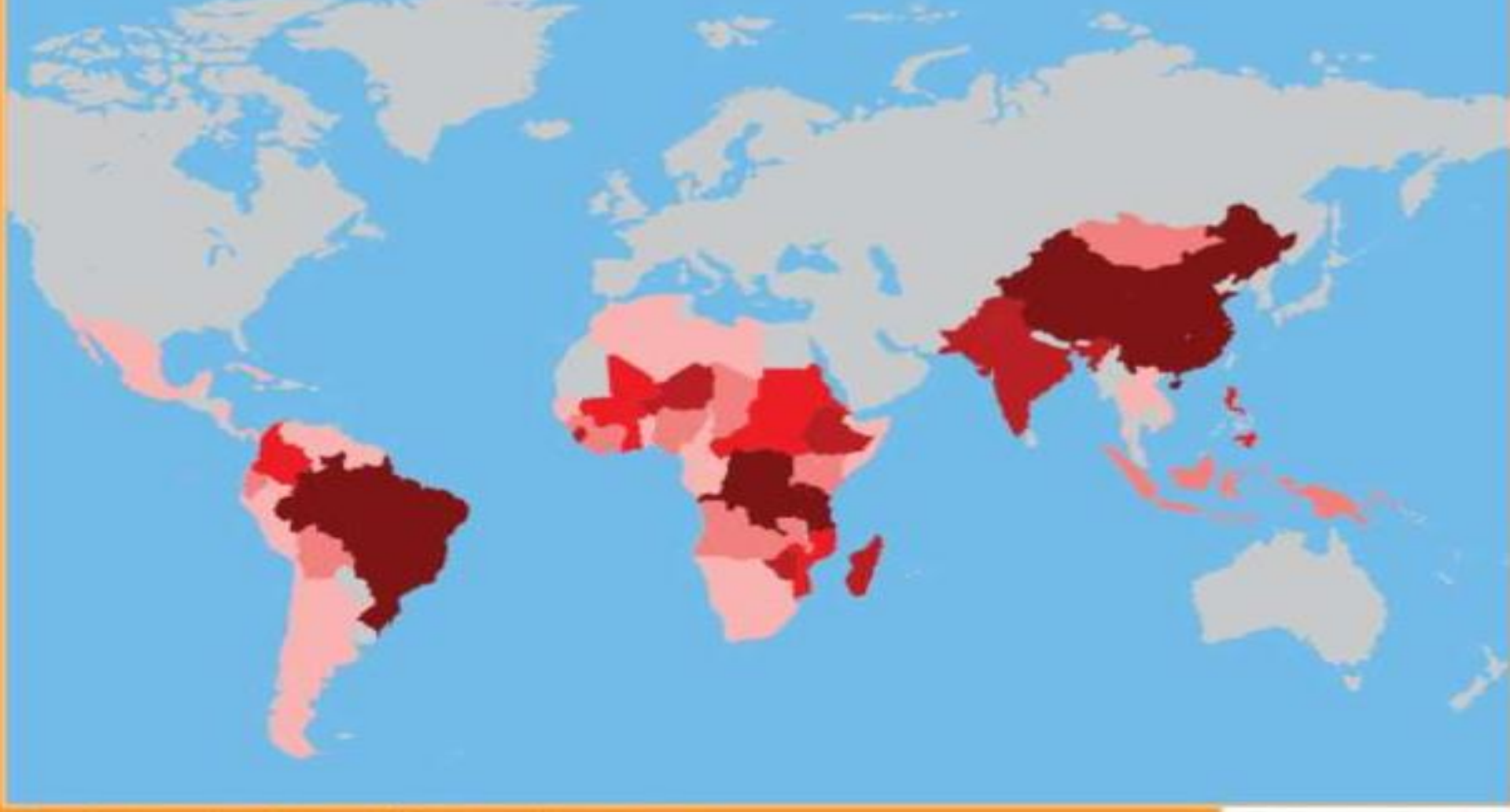
Complicated and details data toward Mercury





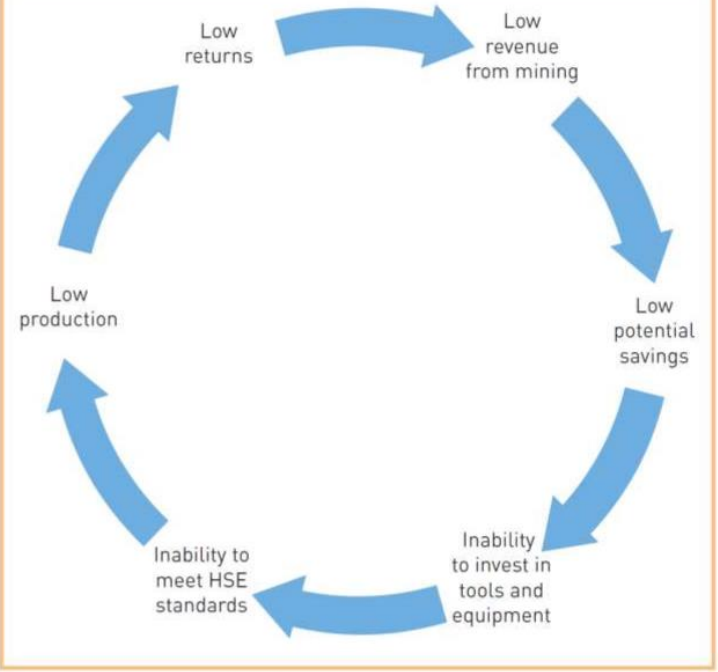
What's public needs?

- How to understanding toward complicated and details data to the simple meaning to implement and handle in their daily activities.
- Source of Mercury Exposure, the tools/equipment with content Mercury include household tools/equipment.
- Mercury as a pollutant exposure and pathway, and its characteristic (soil, water, air, atmosphere).
- Mercury effects to the human health and environment.
- How to handle toward the potential Mercury poisoning in the environment?

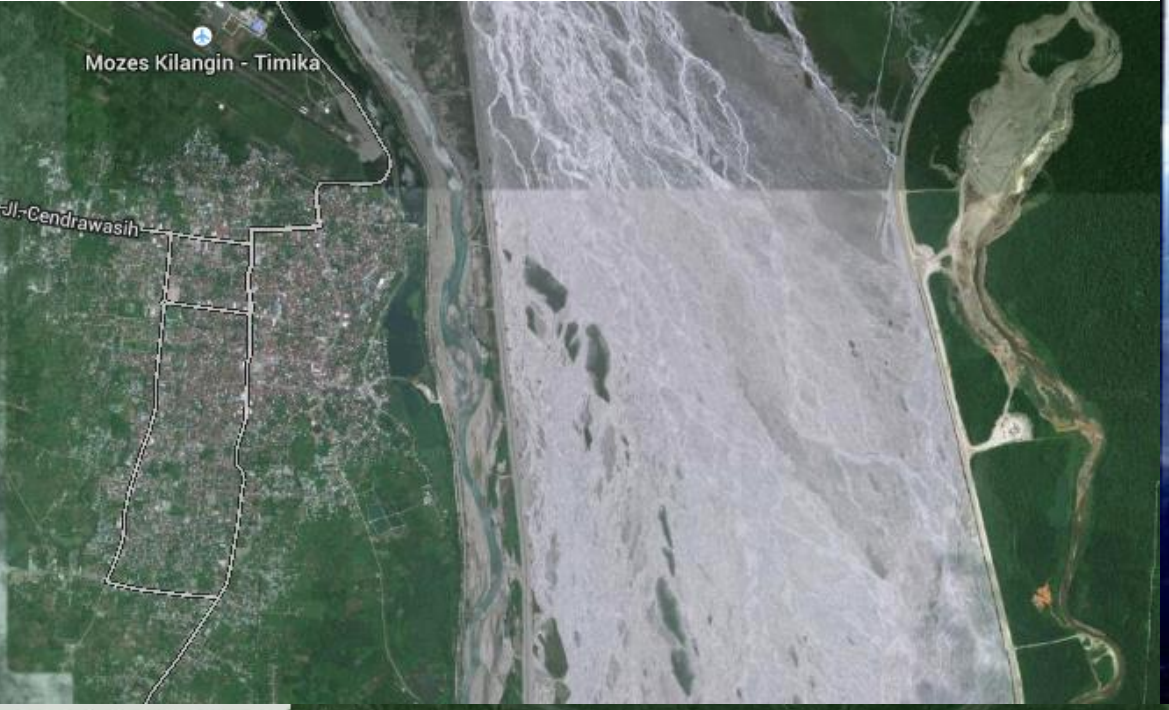


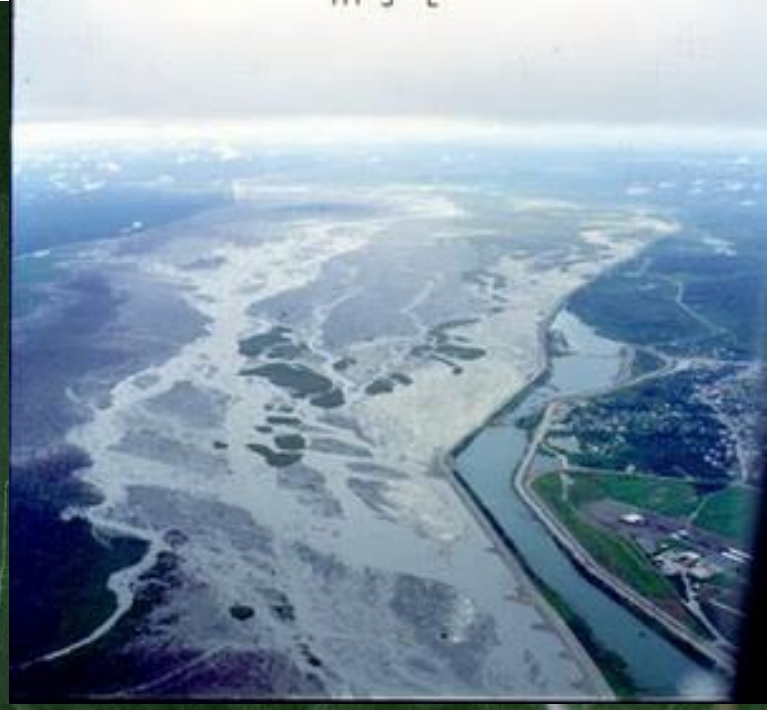
Source: Reproduced from CASM website, http://www.artisanalmining.org

Figure 2: **The "Vicious Cycle" of ASM**



Source: Adapted from ILO, 1999

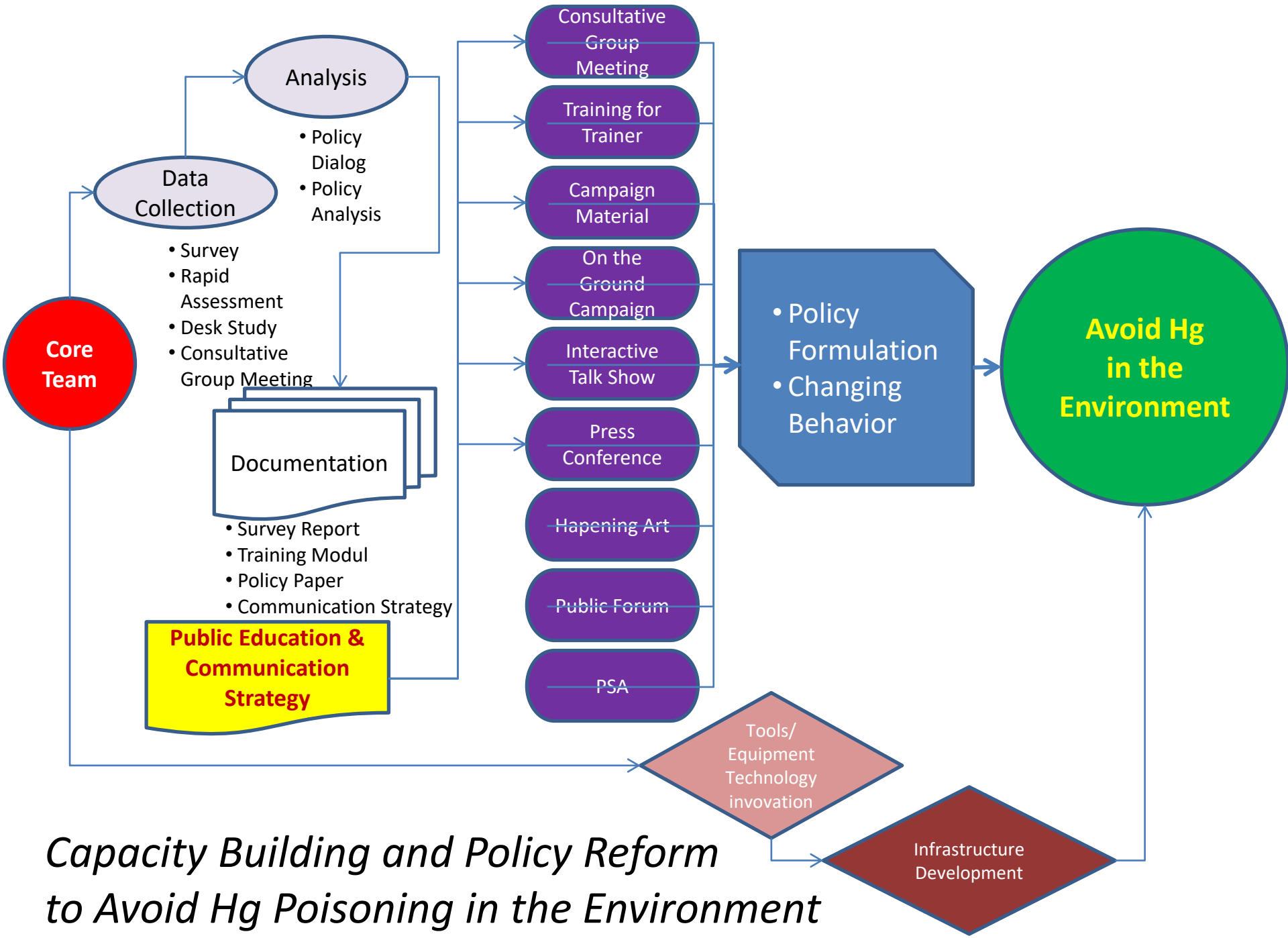

Mozes Kilangin - Timika
Jl. Cendrawasih



Capacity building to transform behavior changing and policy reform

The needs on scientific information:

- Simple monitoring
- Simple index of mercury exposure in the environment
- Simple to be interpreted without misperception
- Simple information on health effect
- How to handling.



Capacity Building and Policy Reform to Avoid Hg Poisoning in the Environment

Resume and Recommendation

- The facts show us that Mercury exposure, and its pathway in the environment include in the atmospheric layer has effected to human health and environment.
- Mercury is one of the top six toxic threats, and is considered one of the top ten chemicals of major public health concern by WHO.
- It is not easy for common people to understanding with affective awareness, include decision makers toward mercury exposure-scientific data to avoid its poisoning in the environment.
- Needs to simplification way to understanding the details and complicated scientific data for capacity building purpose ;to transform behavior changing and policy reform => simple information index.
- Needs to harmonize effort among scientist, government, private sector, int'l agencies, as well as civil society organization; to utilize mercury scientific data to emphasize change people behavior through policy reform to end mercury poisoning in the environment.

Thank you

Ahmad Safrudin - KPBB
Sarinah Building 12th Floor, Jalan MH Thamrin # 11 Jakarta Indonesia 10350
Phone: +62-21-3190 6807 Fax: +62-21-315 3401
e-mail: kpbb@kpbb.org, www.kpbb.org
puput@kpbb.org
Fb: Ahmad Safrudin; Twitter: @Mas_Puput; IG: ahmad-puput-safrudin
Phone/WA: +62 816 897959