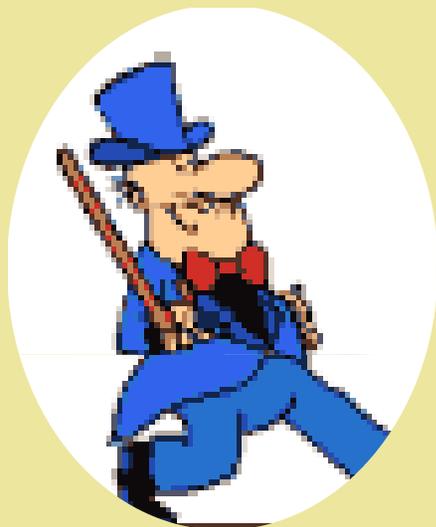


MERCURY ON THE MOVE

mercury cycling in Alaska



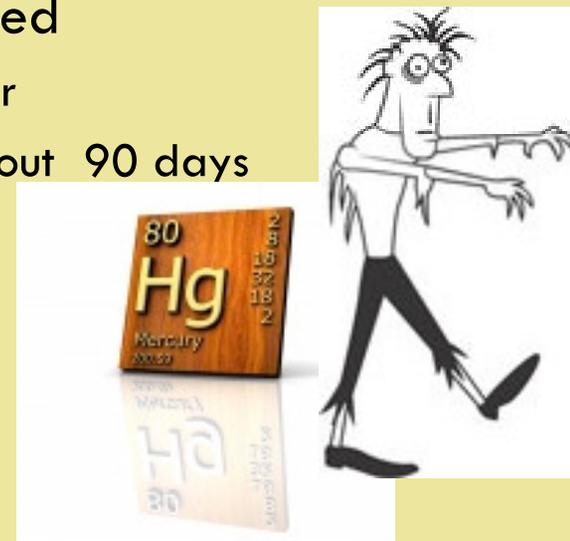
Kendra Zamzow, PhD
Center for Science in Public Participation (CSP2)

Quicksilver Conference, Girdwood, AK
October 27 2010



Mercury is a Zombie

- Like all metals, mercury cannot be destroyed, it can only change form
- When you hear the term “half life”, remember that mercury is not being eliminated, it is only being recycled
 - ▣ the half life of mercury in air is about one year
 - ▣ the half life of methylmercury in humans is about 90 days (Young 2001; IPCS 1990)
 - ▣ the half life of methylmercury in fish is about 90 days (Kramer and Neidhart 1974)



Young JF. 2001. Analysis of methylmercury disposition in humans utilizing a PBPK model and animal pharmacokinetic data. *J Tox and Env Hlth Part A* 63: 19-52

IPCS (International Programme on Chemical Safety). 1990. Environmental Health Criteria monograph 101: methylmercury. Geneva, Switzerland. Available online at <http://www.inchem.org/documents/ehc/ehc/ehc101.htm#SectionNumber:2.2>

Kramer HJ and Neidhart B.1975. The behaviour of mercury in the system water--fish. *Bull. Environ. Contam. Toxicol.* (14):699-704.



Sources

Like all metals, mercury has always been present in the rocks, oceans, and deep in the earth

It reaches the surface when volcanoes blow, when oceans meet shore, when mountains rise up and move deep rocks up to the surface, and in other natural ways

Eventually mercury cycles into some plants, trees, and soil – forest fires are one way mercury can move from soil and plants into the air



...and then came man (Burn, baby, burn)

- Burning coal
- Burning trash and medical waste
- Burning ore to get to the gold
- Burning crops and forests

All these activities release mercury into the air

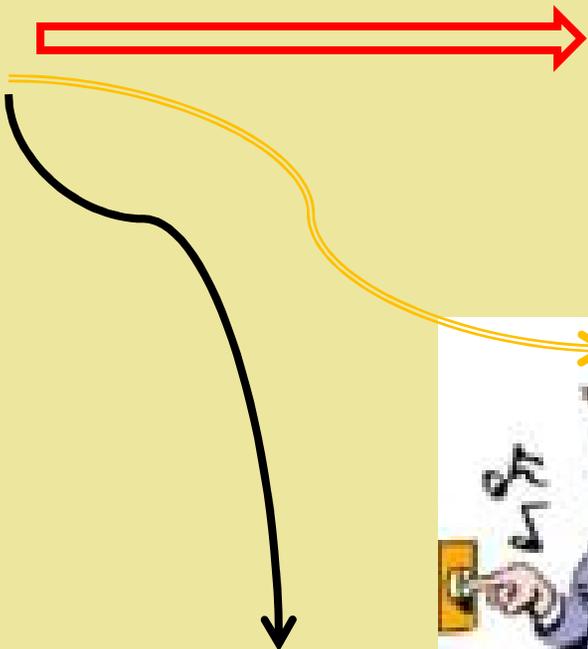


Shapeshifting physical partitioning: solid, liquid, gas

- **particulate** – e.g. on dust
- **liquid** - elemental – e.g. thermometer
- **dissolved**
 - ▣ ionic Hg^{2+} (e.g. HgCl_2 , HgBr_2 , $\text{Hg}(\text{OH})_2$)
- **gas**
 - ▣ elemental, GEM
 - ▣ ionic Hg^{2+} , RGM



Chemical species in air



GEM
elemental
(non-reactive)
gas (Hg^0)



RGM
reactive gas
(Hg^{2+})

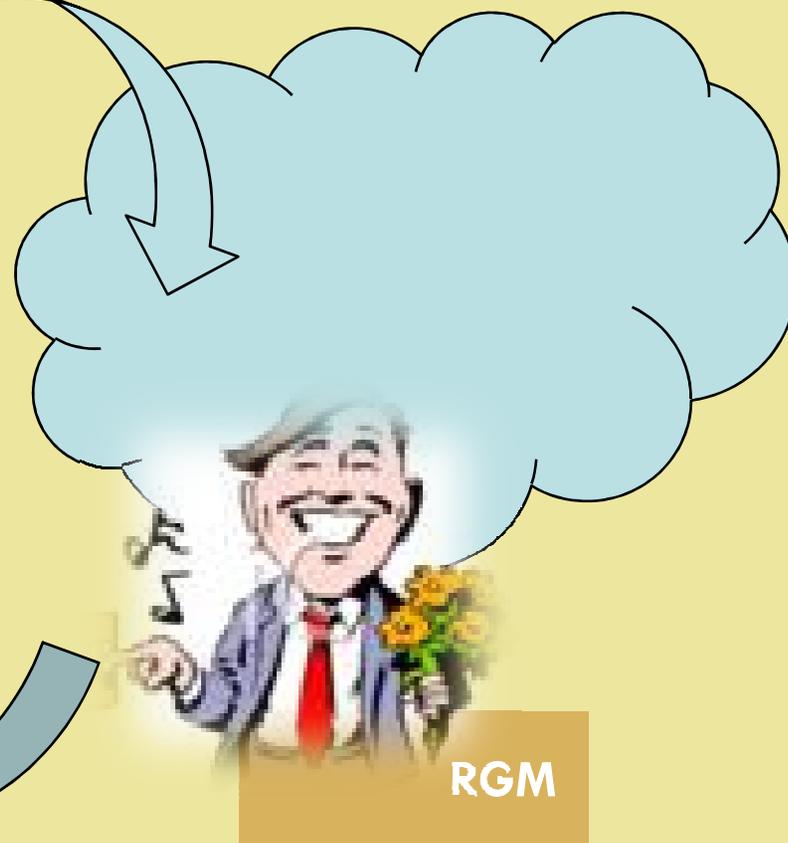
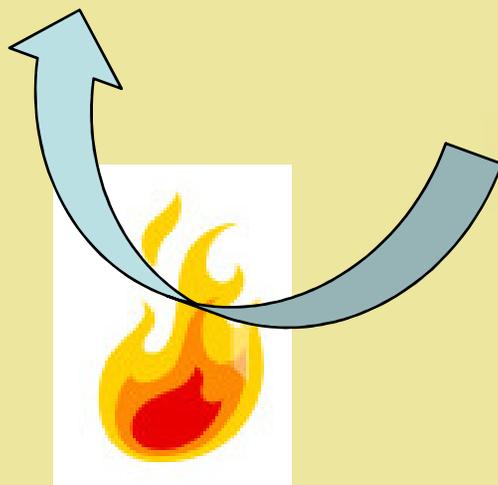
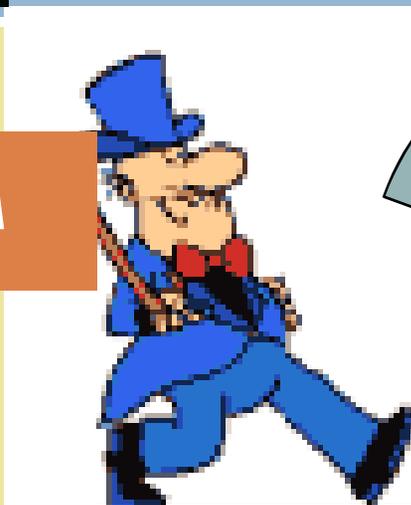


Particulate Hg



Shapeshifting, chemical species in air

GEM



RGM



RGM settles to the surface
snow, rain, dust



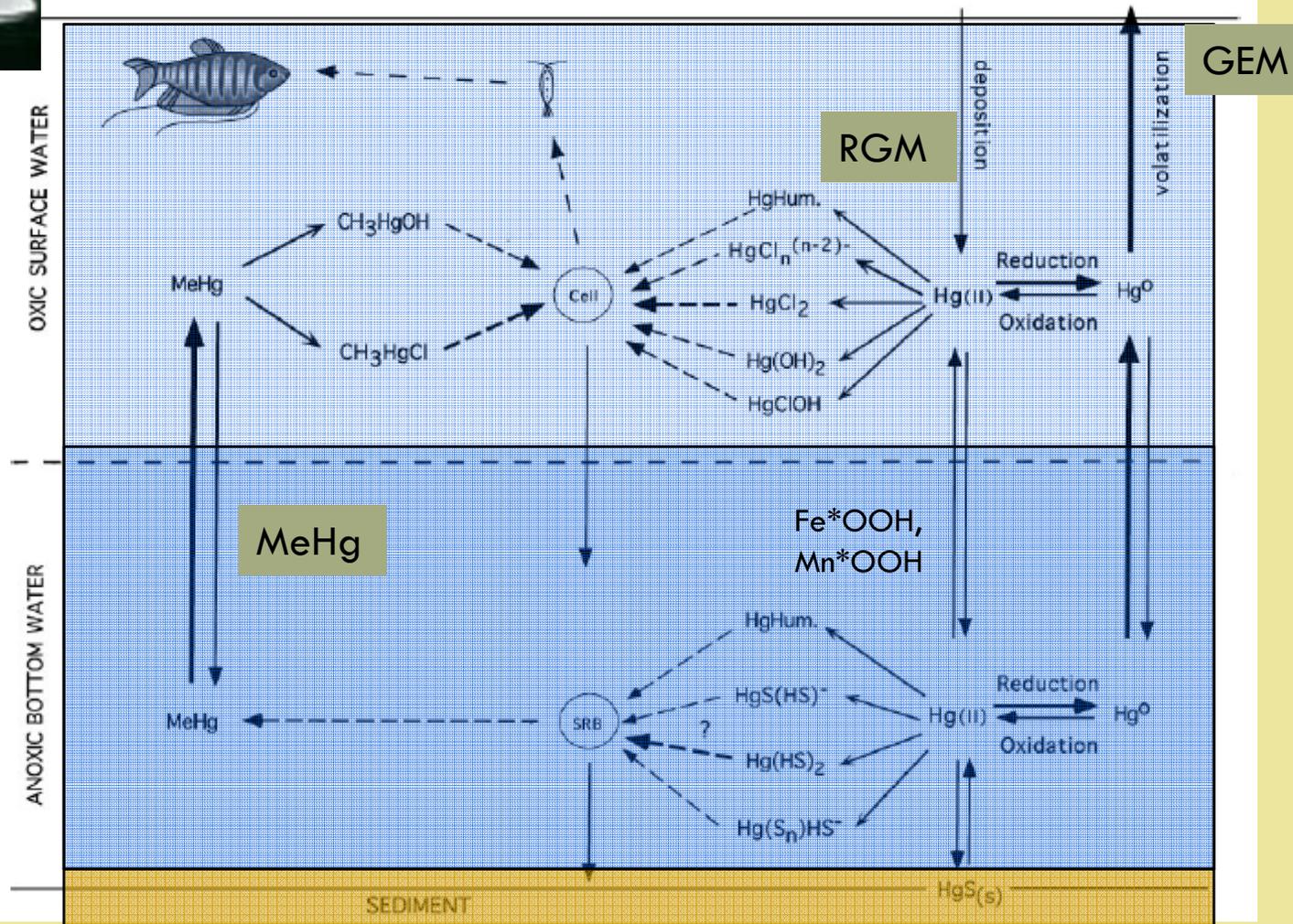


Shapeshifting inorganic to biological molecule

- bacteria live in soil and sediment – mercury is toxic to them, too
- to get rid of Hg, some bacteria add methyl groups ($-\text{CH}_3$) to it – this allows it to get out of the bacteria through the cell wall....
- but also can get IN to someone else's cell and bioaccumulate
- some fungi can also methylate mercury

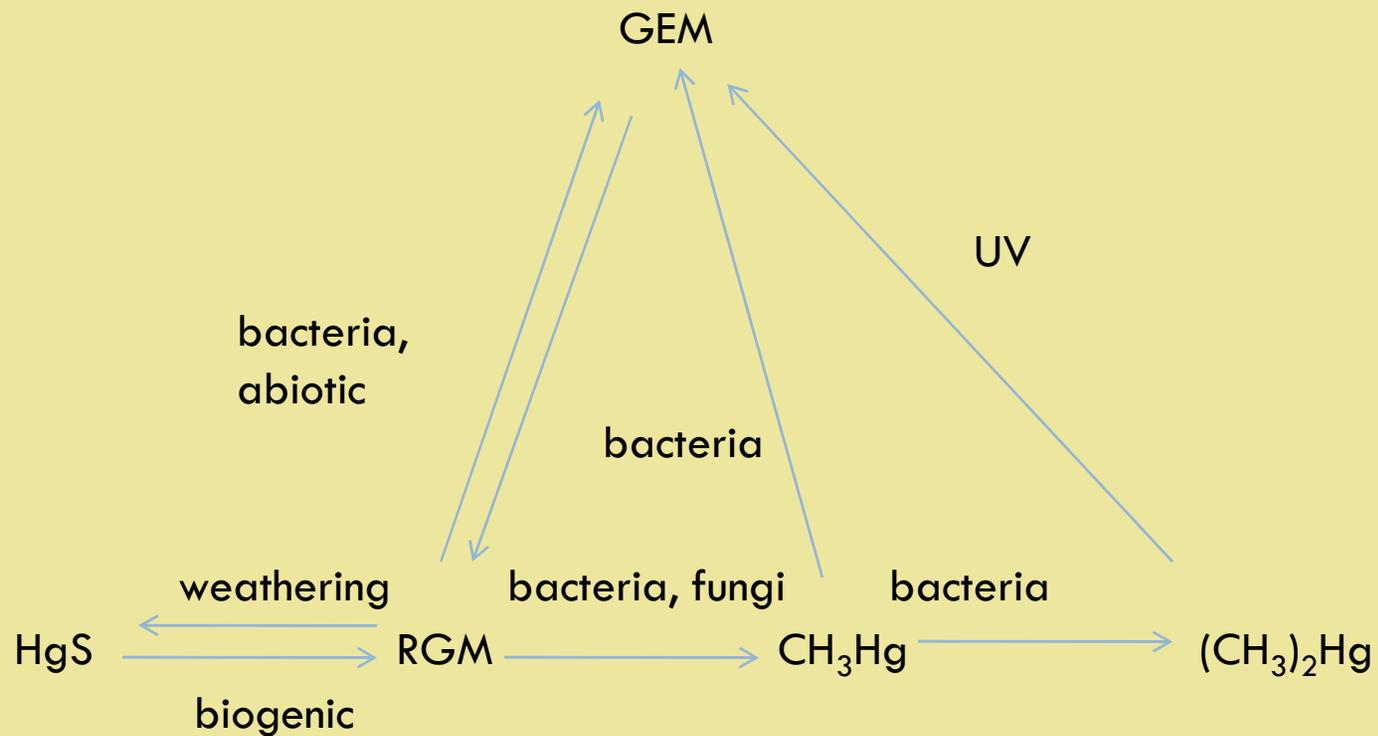


Chemistry of mercury cycling



Morel, FMM, AML Kraepiel and M Amyot. 1998. The chemical cycle and bioaccumulation of mercury. *Annu. Rev. Ecol. Syst.* 1998.29:543-566.

methylmercury cycling



adapted from *Geomicrobiology*, 2009, Ehrlich and Newman



bugs love AK

- The bacteria that methylate mercury (sulfate reducing bacteria, or SRB) love environments that are salty but not too salty, with carbon but only small chains, and with very little oxygen
 - swampy areas (e.g. wet tundra), estuaries and oceans
 - forest soil, stream sediment
- Hg in AK may settle on environments that SRB love to live in
- Limitations on bug growth include: high sulfide and chloride, high oxygen, low temperatures



Putting it all together

- Mercury (GEM) travels
 - ▣ from around the northern hemisphere vaporizes to gas and circulates in the arctic
 - ▣ arrives directly from Asia on air currents
 - ▣ and may come along ocean currents
- Enters rain, fog, snow, and dust, settling to earth (RGM).
- When settling on the right environment, may be methylated (MeHg).



Recycling

- Mercury constantly changes form
 - GEM in air and seawater oxidizes to RGM (UV light, free radicals)
 - RGM reduces to GEM through UV light and biological reactions
 - but DOC in the water can “compete” for UV and limit photoreduction
 - and bacteria may not reduce Hg until it reaches a certain concentration
 - SRB transform inorganic Hg to organic methyl mercury
 - UV may demethylate mercury
 - fish/people eliminate it slowly (half life about 90 days)
- Because mercury won't sit still, it is difficult to track and to know how much is in air, water, soil/sediment at any one time
 - Is the mercury in the air in the afternoon the same as was in the soil in the morning? will it go back into the soil at night?
 - Does mercury move in and out of leaves freely?
 - Will the mercury measured in a lake photo-reduce and vaporize into the air?
 - Will UV light in shallow Alaskan lakes demethylate MeHg to ionic RGM?

Local and global

- Because most mercury comes from out of state, it is impossible to reduce it through state regulation (*except by limiting new industrial sources in AK)
 - potential new sources in-state include coal-fired power plants and thermal gold processing mills
- Understanding mercury cycling is one key element to understanding risk.

Tsin'aen

Questions?

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