Quantification of Labile Soil Mercury by Stable Isotope Dilution Techniques

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Introduction

Mercury is a highly toxic trace element to humans and animals. Exposure to trace levels of Hg may cause severe health effects (Fig.1.).

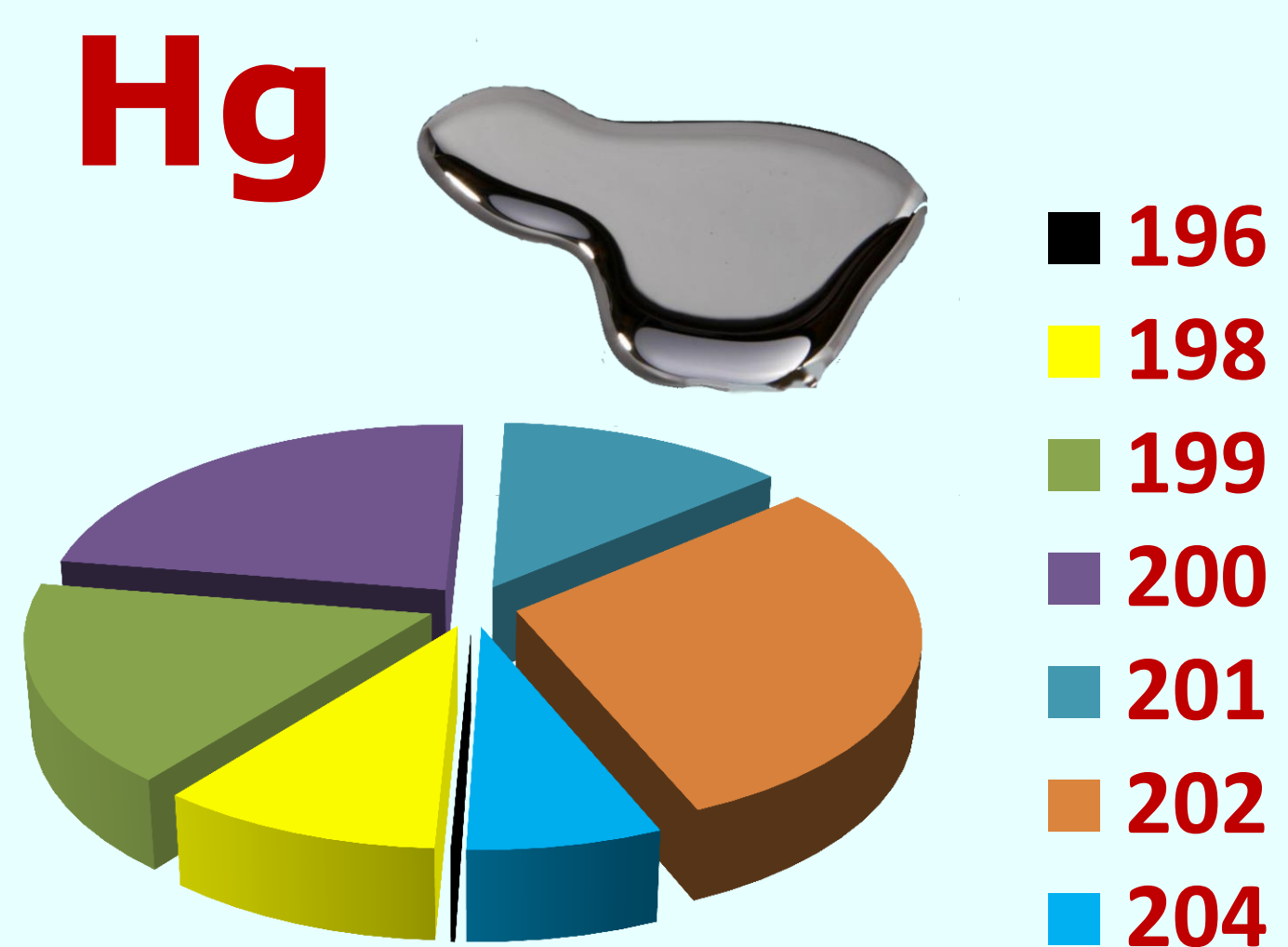Mercury is present in the environment as seven stable isotopes (Fig. 2).

Hg

- 196
- 198
- 199
- 200
- 201
- 202
- 204

Fig. 2. Mercury Stable Isotopes

Mental Confusion, Memory loss and Behavioural Disorders

Gum Inflammation

Fatigue, Joint and Muscle pain

Cardiovascular Disorders

Digestive System

Kidneys Damage

Central and Peripheral Nervous System
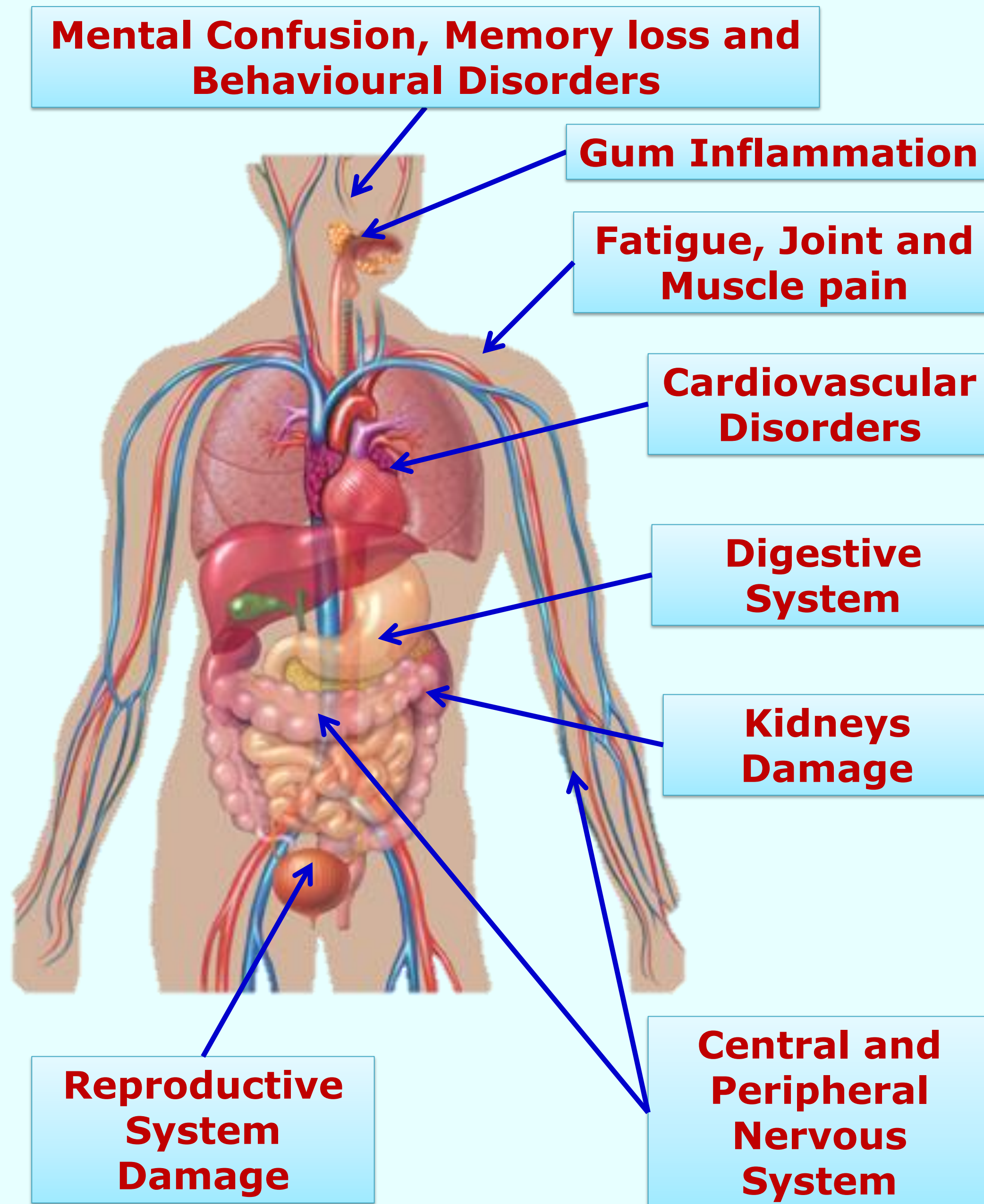
Reproductive System Damage

Fig.1. Health Effects of Mercury

Aims

I- Investigating and modelling the dynamics of inorganic mercury added to *soil (via rainfall or other inputs)* by studying the temporal change in solubility of inorganic mercury tracer ($^{196}Hg^{+2}$) spiked into soil samples.

II- Assessing the lability and bioavailability of mercury in some mercury contaminated soils by developing a stable isotope dilution procedure using enriched Hg spike (30% ^{196}Hg).

Methods

Soils with varied characteristics and Hg contamination levels were sampled from the Black Forest, Baden-Württemberg, Germany and from the Upper-Valais region, Switzerland (Fig.3). Soil samples were spiked with enriched ^{196}Hg (6 mg kg^{-1}) and equilibrated for different times before ^{196}Hg conc. and $^{196}Hg : ^{201}Hg$ ratio were assayed by ICP-MS. Labile Hg (mg kg^{-1}) was calculated from (Eq.1).

Fig.3. Sampling Locations

$$Hg_E = \left(\frac{M_{soil}}{W}\right)\left(\frac{C_{spk}V_{spk}}{M_{spk}}\right)\left(\frac{^{196}IA_{spk} - ^{201}IA_{spk}Rss}{^{201}IA_{soil}R_{ss} - ^{196}IA_{soil}}\right)$$

Eq.1.

M is the average atomic mass of Hg, W is the mass of soil (kg), C_{spk} is the conc. of Hg in the spike (mg L^{-1}), V_{spk} is the volume of spike (L), and Rss is the equilibrium ratio ($^{196}Hg:^{201}Hg$).
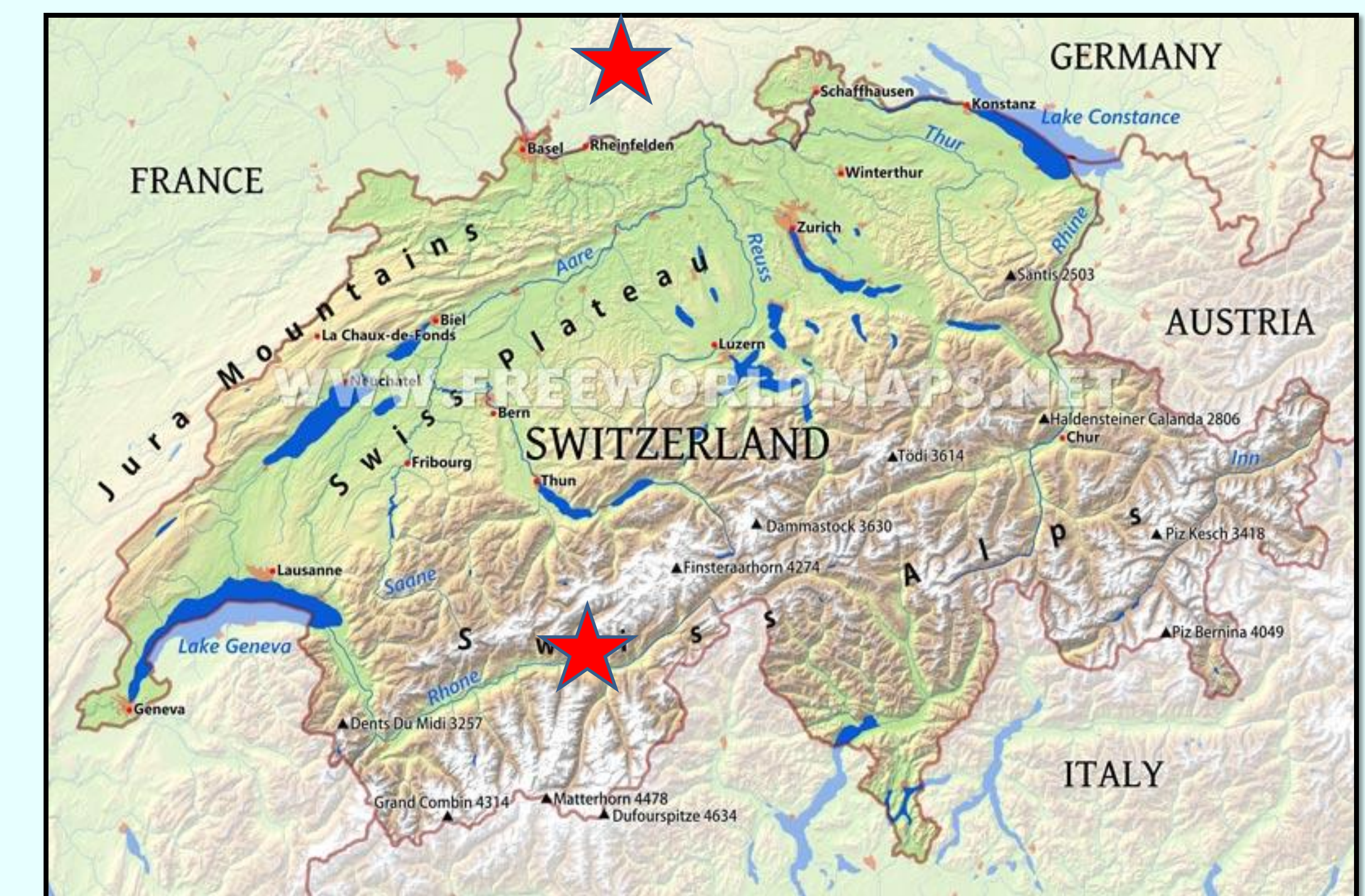
Results

I- In all soils an apparently instantaneous sorption reaction of (^{196}Hg) was followed by a slower (time-dependent) sorption (Fig 4.).

II- Progressive sorption of mercury (^{196}Hg) from solution was greatest in topsoils with higher organic contents and apparently reaching completion over hours, while substantially slower sorption rate was observed in mineral subsoils (Fig 4.).

III- Within the soil pH range investigated (3.5-7), soil organic content was found to be the sole factor that dictates the sorption rate of mercury with a direct logarithmic relationship (Fig.5.).

IV- The Hg_E values were elevated (~40% of total Hg) in contaminated locations compared to background soils indicating greater relative availability.
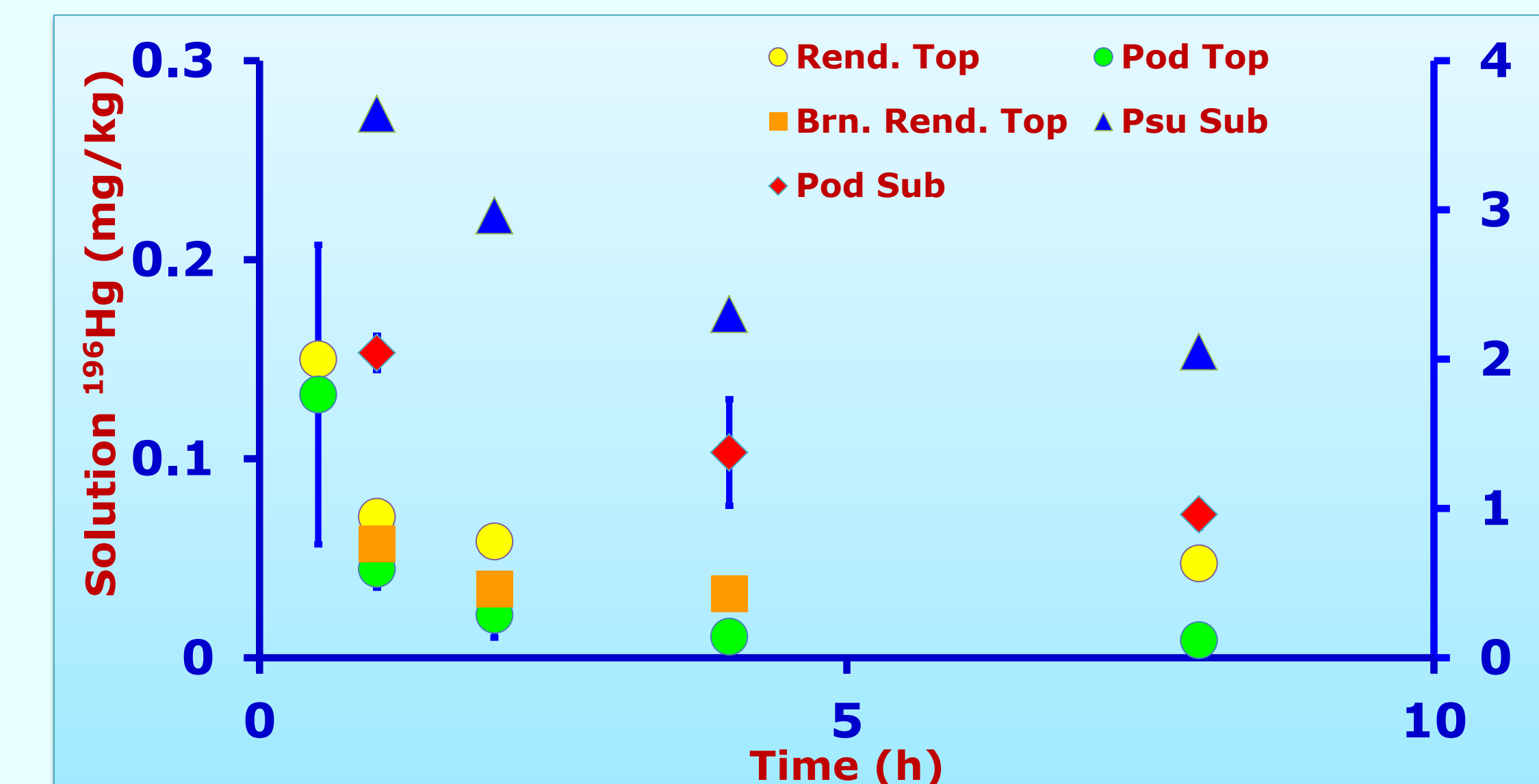

Fig.4. Temporal change in ^{196}Hg spike conc. in soil solution of soils with distinct characteristics.
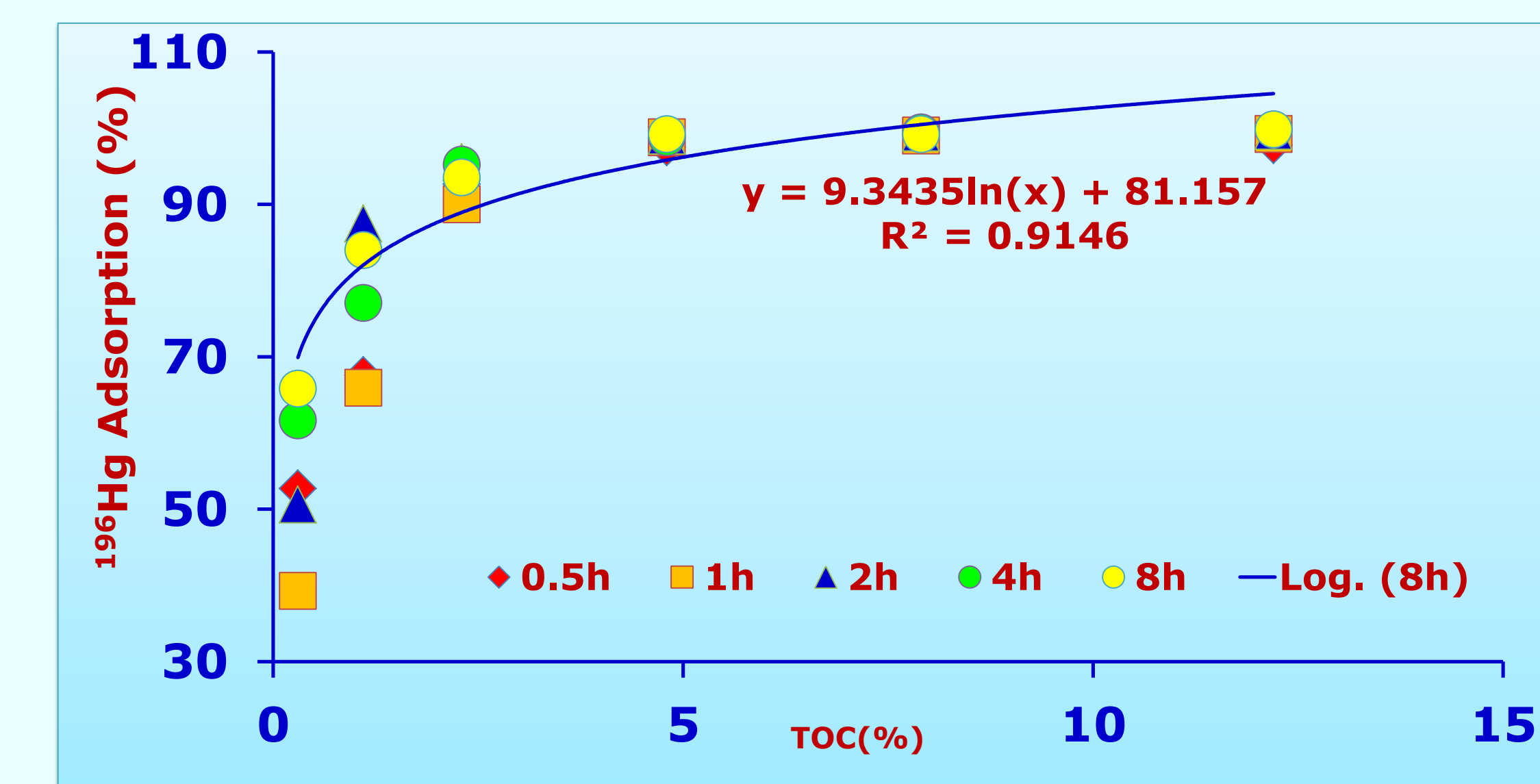

$y = 9.3435\ln(x) + 81.157$
$R^2 = 0.9146$

Fig.5. ^{196}Hg sorption (%) vs soil TOC (%) at different equilibration times