Emissions from Building Materials into the Indoor Air. Sources and Control.

The cTrap

Lennart Larsson
University of Lund, Sweden

lennart.larsson@med.lu.se

Dry air (Wikipedia)

Nitrogen	78%
Oxygen	21%
Nobel gases	<1%
Carbon dioxide	0.035%
Other (including ozone)	traces

Indoor air…

always contains numerous ”other” substances such as particles and chemicals (VOC, sVOC…)

- from the outdoor air
- from neighbors
- from items brought indoors
- from people and pets
- from the building itself

Emissions from the building itself into the indoor air

Strong links between building dampness and adverse health effects

Not harmful to be exposed to moisture – but harmful to be exposed to moisture-driven contaminants in the indoor air

Water-damaged building materials may emit several substances into the indoor air...

… chemicals already present in the materials

...degradation/hydrolysis products of materials...

...volatile organic compounds, toxins, microbial particles...



... secondary reaction products...

... water vapor...

... emissions from molds

Moisture…

drives out chemicals that are already present in the materials

Complex mechanisms:

- The water vapor evaporation rate is reduced at high RH thus facilitating vaporization of VOCs,
- Competition between VOCs and water molecules for free sorption sites of a studied material,
- The emissions rates depend upon the materials and VOCs (surface properties, polarity, volatility…)

Moisture…

reacts with building material components to form new chemicals that may be emitted into the indoor air

- 2-ethylhexanol and butanol from glue used to attach PVC flooring on a concrete slab

- chloroanisols from chlorophenols used for wood impregnation

- amines, alcohols, and aldehydes from binding agents in linoleum mats

- formaldehyde from urea-formaldehyde resins in chipboards

etc…..

Moisture…

may result in growth of molds (RH>75%) and bacteria (RH>95%) which may emit odorous and non-odorous chemicals

- VOCs (alcohols, aldehydes, sulfur compounds...)

- particle-bound toxins and other metabolites (mycotoxins, endotoxins, proteases…)

Secondary reactions

The moisture-driven VOCs (particularly VOCs with unsaturated carbon-carbon bonds) may react further, with ozone or with other emitted VOCs, forming…

- Free radicals
- New stable (often odorous) compounds

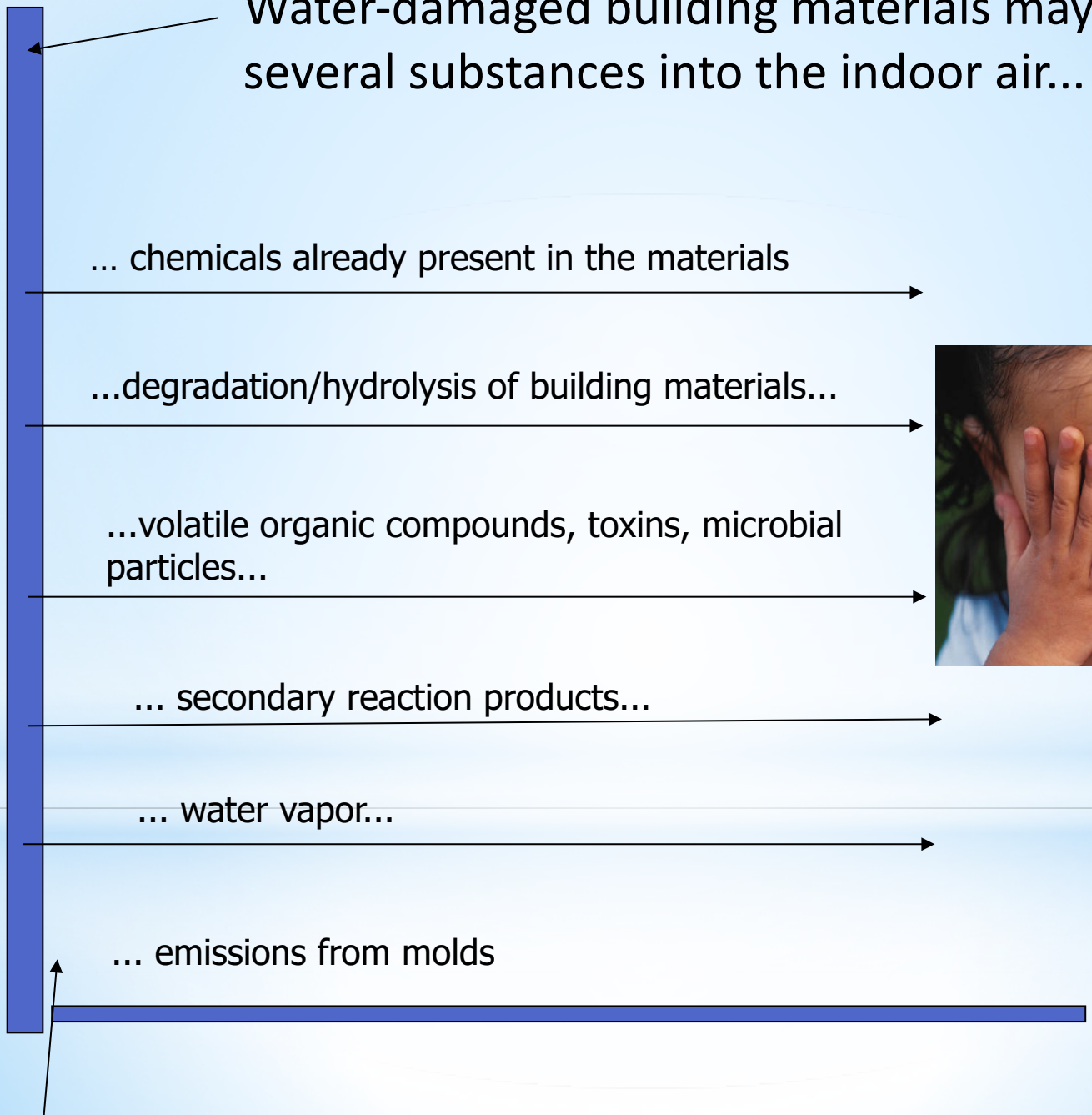
How do we ensure a healthy indoor air?

- Remove man-made chemicals from indoors – never bring them in!

- What about microbes? Bacteria may be beneficial (produce B-vitamin in our intestine, help to develop our immune system) but may also kill us (infections).

Should we remove all microbes from the indoor environment?

Water-damaged building materials may emit several substances into the indoor air...





Solving the problem

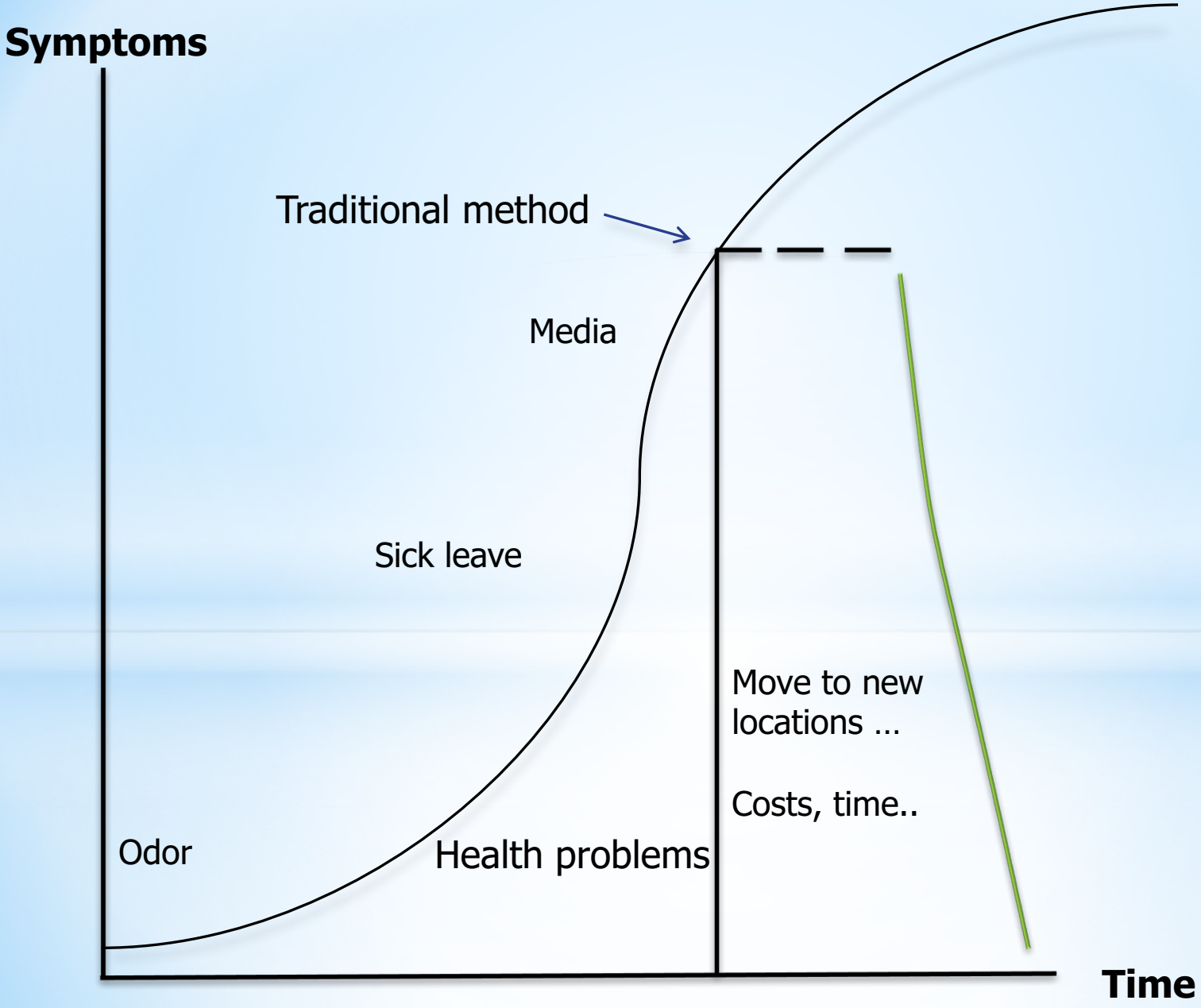
Replace affected/damaged material with new material: Often expensive and time-consuming

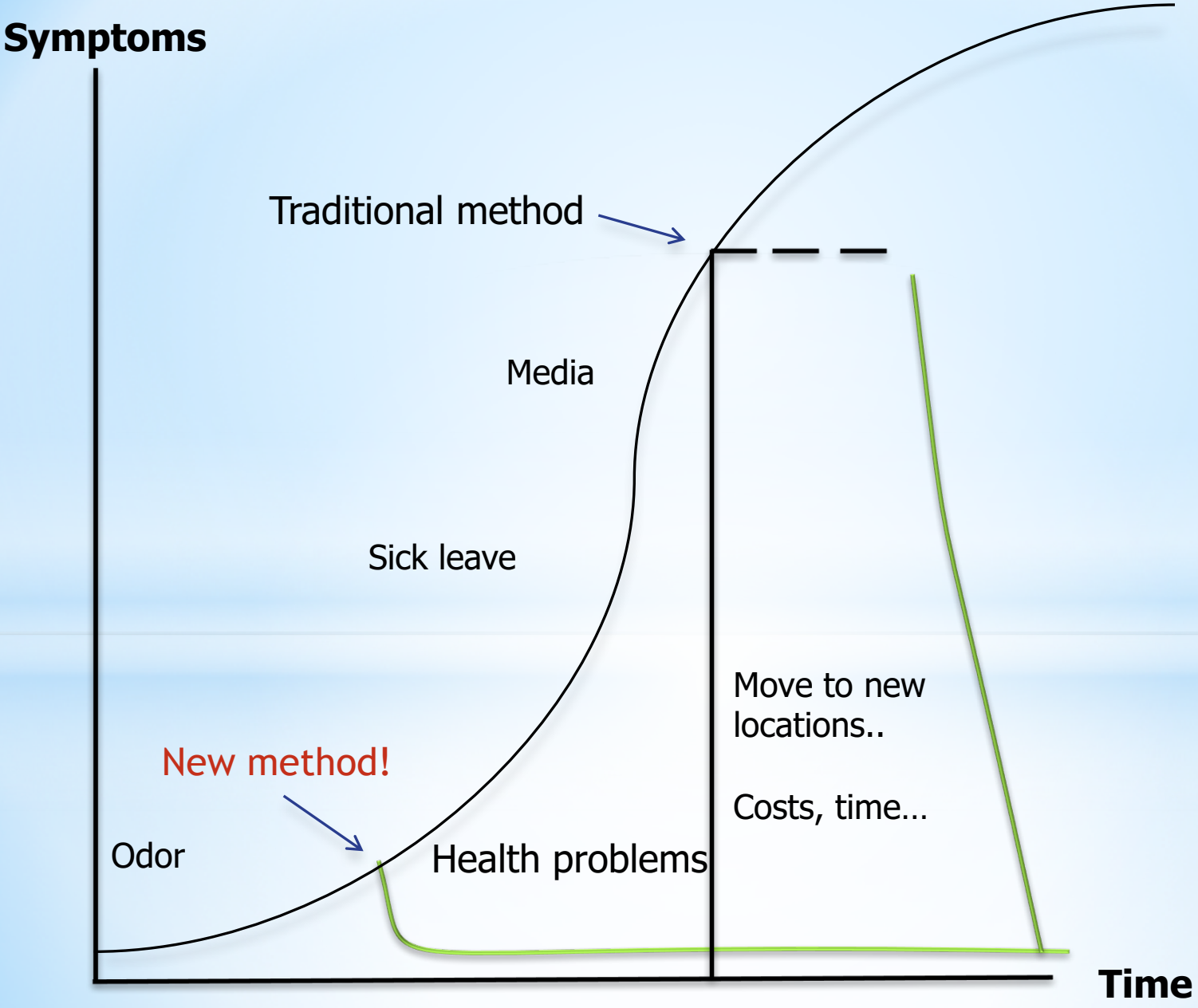
alternatively…

- portable air cleaners
- ventilation

…but they only dilute the emissions – they don´t stop them…

We have solutions – why does it take such a long time before taking action?


Symptoms
Traditional method
Media
Sick leave
Odor
Health problems
Move to new locations …
Costs, time..
Time


Symptoms
Traditional method
Media
Sick leave
Move to new locations..
Costs, time…
New method!
Odor
Health problems
Time

A new project started at Lund University in 2008 becoming a PhD project in 2010 (finished in 2014)

AIM: To develop a new product/method for efficient stop of emissions from building materials into the indoor air. The product/method should be attractive to use already at the first signs of moisture damage/mold growth/symptoms.

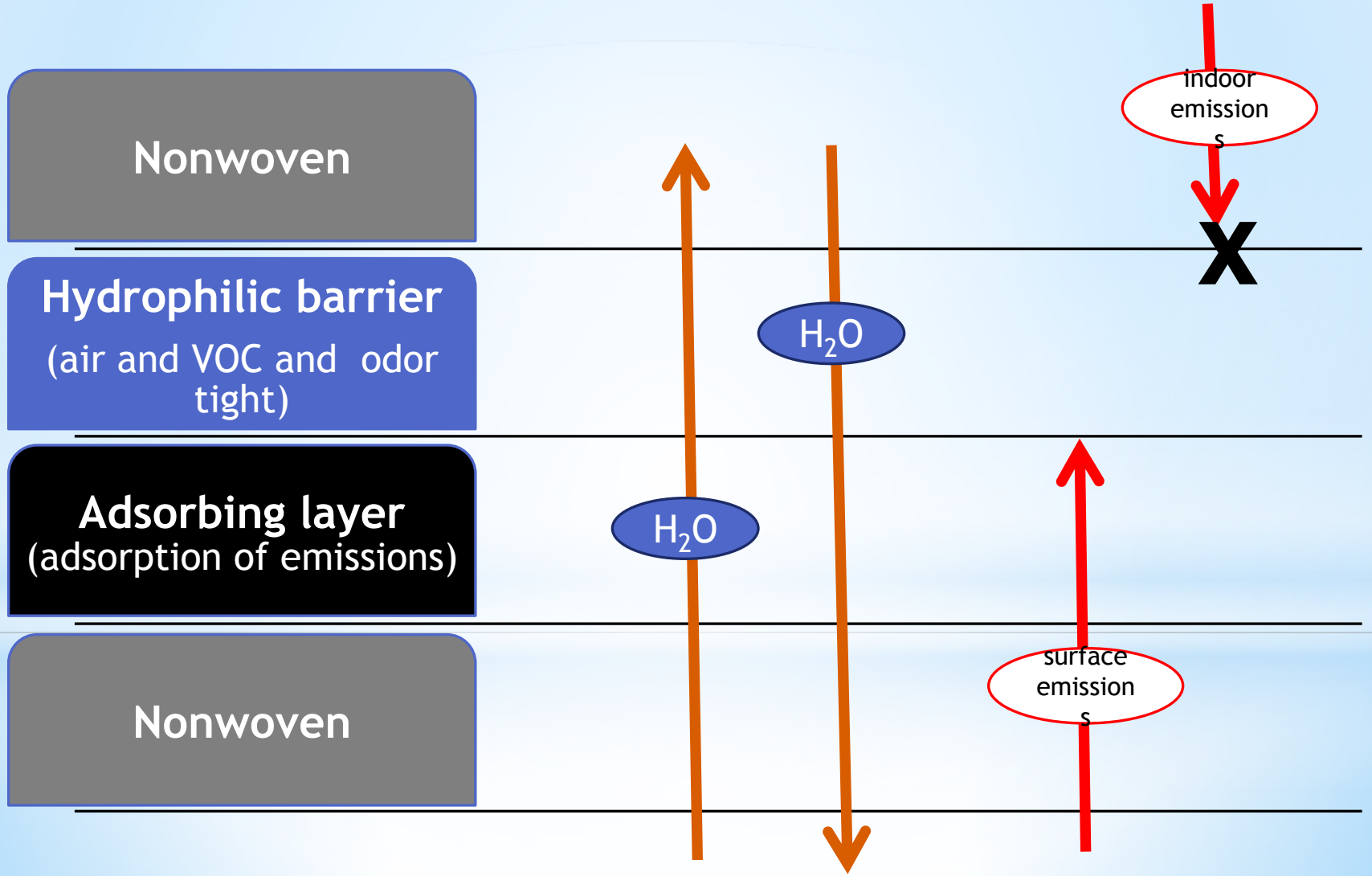
A new invention: the surface emissions trap (cTrap)

The cTrap is a flexible cloth with four layers:

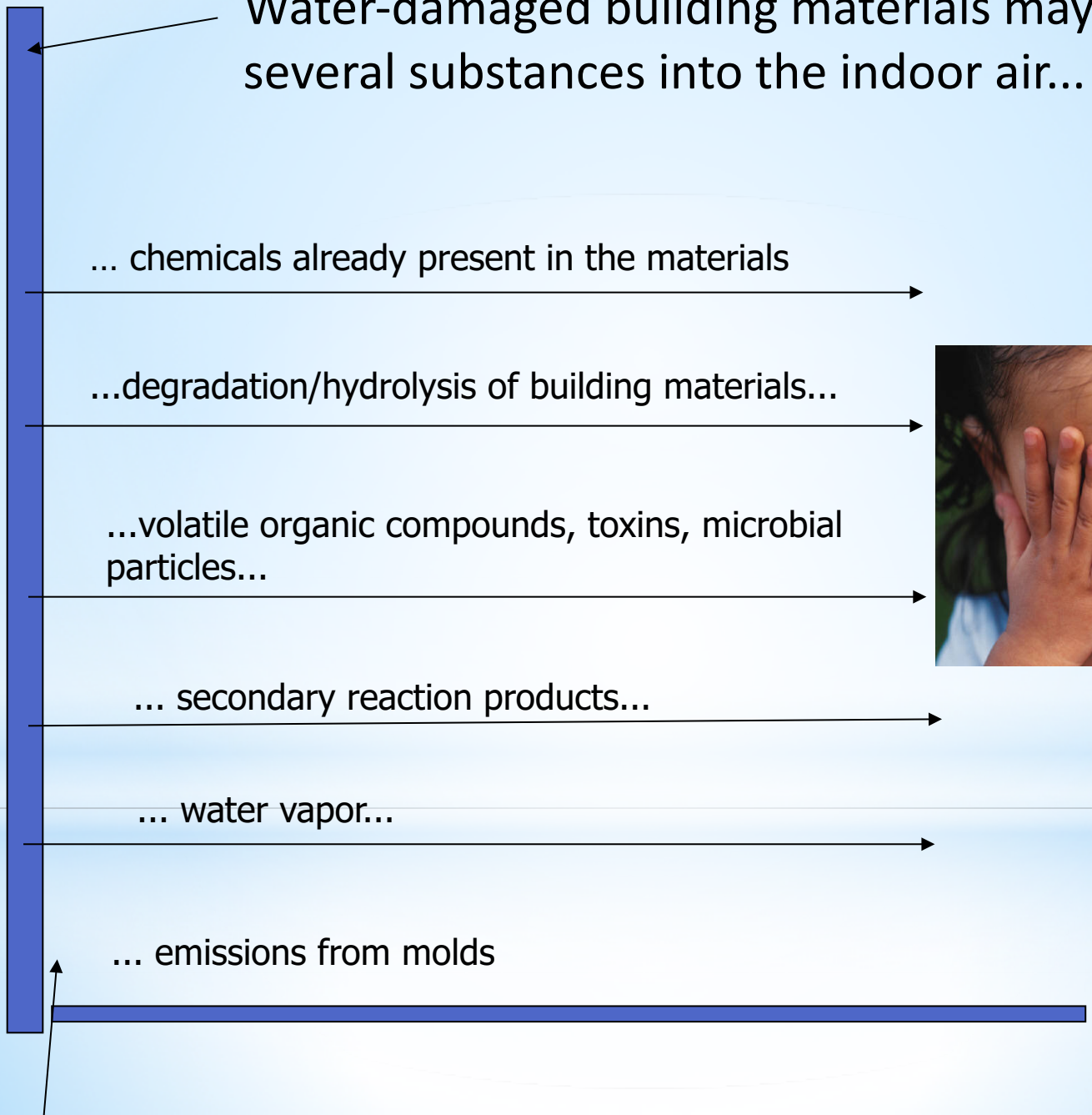
- an inner protective layer
- an adsorption layer
- a semipermeable membrane
- an outer protective layer



The surface emissions trap



Water-damaged building materials may emit several substances into the indoor air...

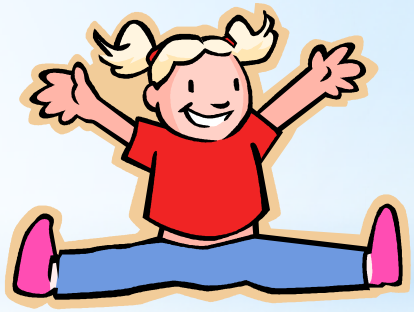




The cTrap

The cTrap blocks and binds all emissions except water vapor

The problem is solved – the emissions are stopped at the source!



... water vapor...

cTrap – a functional cloth



Thickness 1.9 mm

Length 25 m

Width 120 cm

A school in Sweden – a study 2011-2012

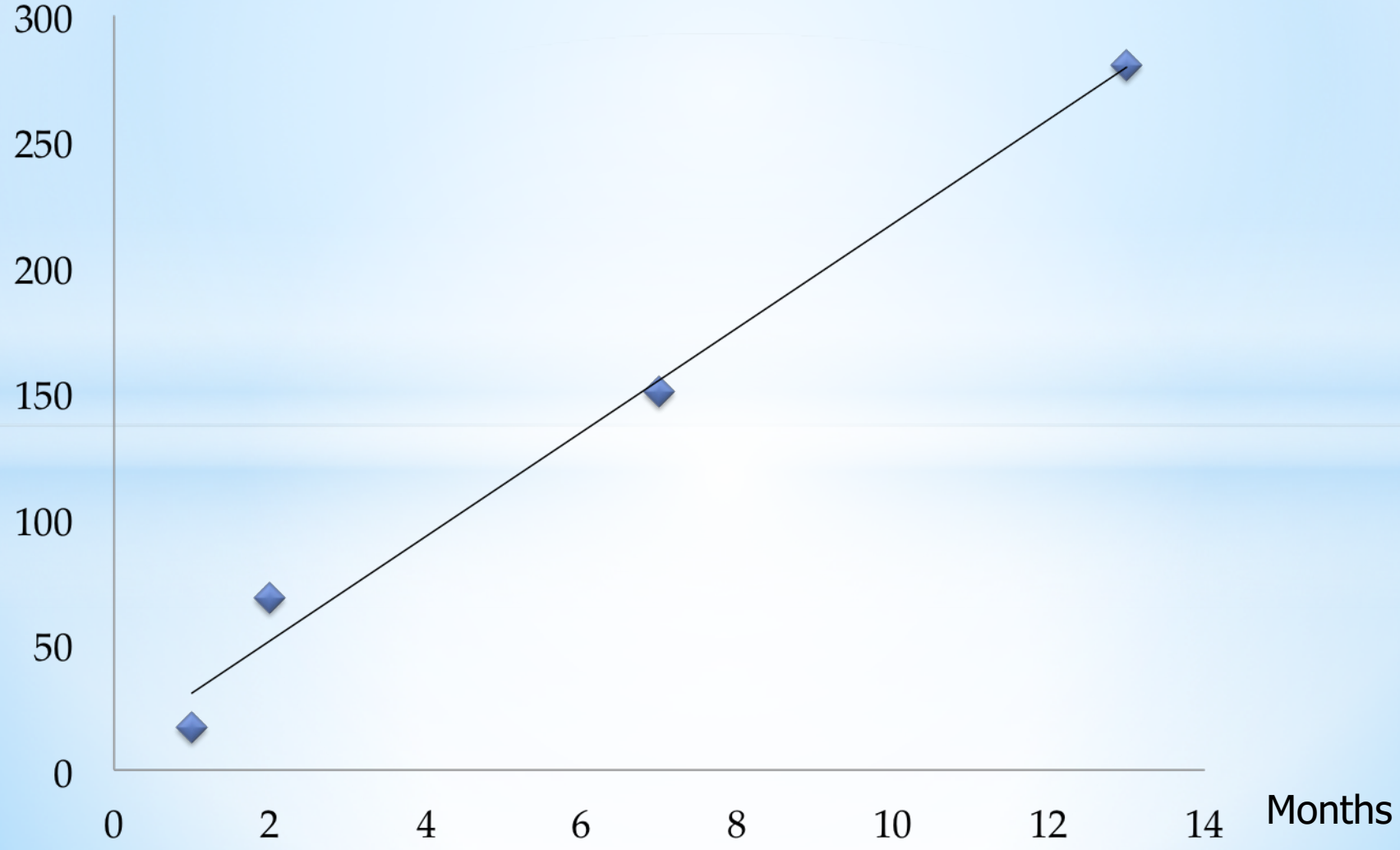
- Built in the 1970s with a PVC flooring glued on a concrete slab
- Moisture diffusion and alkaline hydrolysis of components in the glue and flooring
- Emissions e.g. (mainly) of 2-ethylhexanol into the indoor air
- Headache, stuffy air. Some classrooms unusable. Sick leave, airways irritation

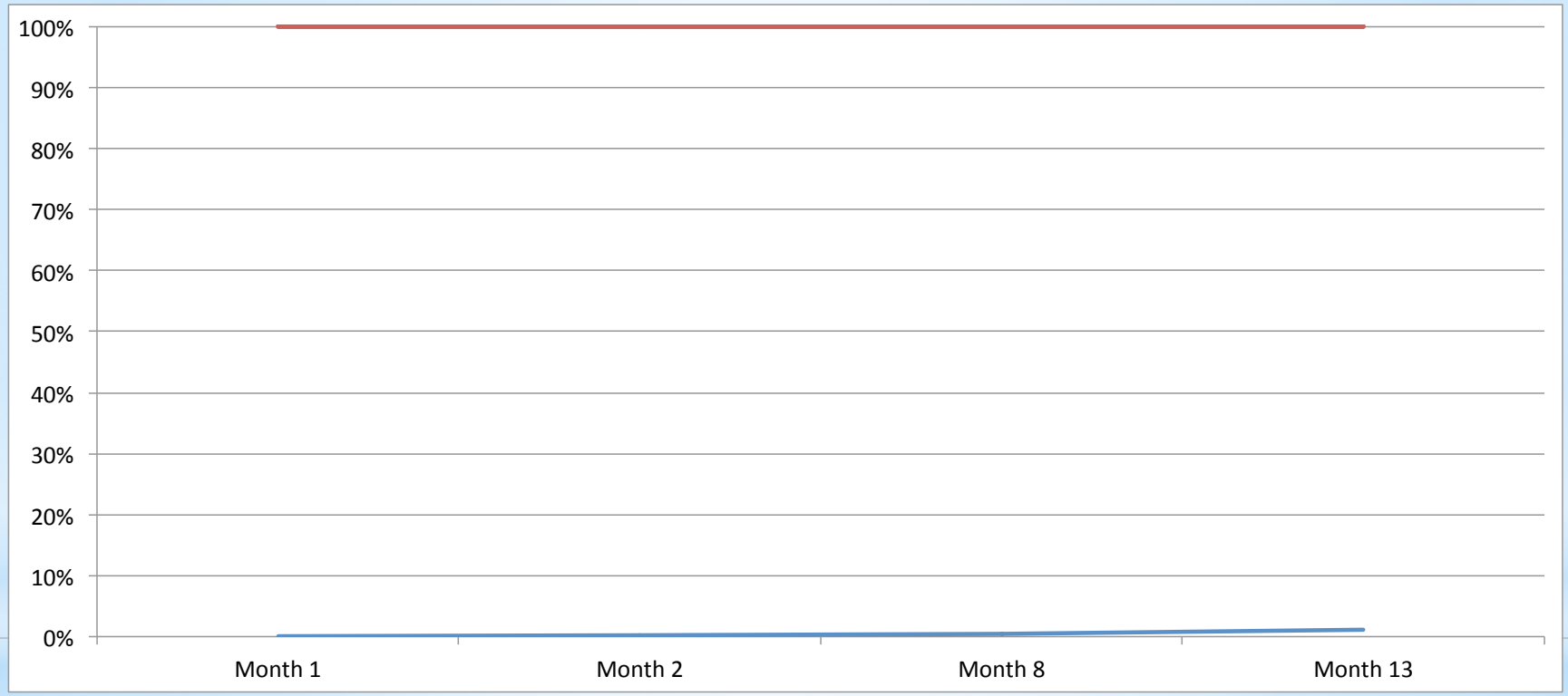
A school in Sweden, continued

- The cTrap (500 sqm) was attached directly on the PVC flooring. Over the cTrap was installed a laminate flooring.
- Air fresh!
- Decrease of air concentrations of 2-ethylhexanol.
- Increase of the amounts of 2-ethylhexanol adsorbed in the cTrap.

ug 2-Ethx/g

Consumed by the installed cTrap




100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Month 1
Month 2
Month 8
Month 13

Problem

Major water damage.
Odor, emissions from floor.



Solution

cTrap attached on the floor and
50 cm up on the wall.

Result: Fresh air!



Problem

Water leak and a disturbing odor.

Solution

cTrap attached in the ceiling and covered with a gypsum board.





Surface emissions trap performance

- Average 98% reduction of 20 tested organic air pollutants (alcohols, aldehydes, sulfides, chloroanisols, formaldehyde…) including odors and mold products

- 100 % reduction of three tested mycotoxins

- No change of the performance after (accelerated) aging up to ten years

- Very low water vapor resistance (Z= 200 s/m), thus no risk for condensation and mold growth

- Adsorbs only from one side

Performance (cont´d)

- Easy and quick to install. Can be attached directly on the existing surface material e.g. by using an adhesive tape.

- Environment friendly. Does not contain any chemicals and no chemicals are used upon installation.

- Energy saving - by reducing emissions the cTrap reduces the need for high ventilation rate.

- Robust. The cTrap is not an ordinary sealant but binds the emissions and allows the construction to ”clean itself”.

Markowicz and Larsson 2012, 2014.

Thank you for your attendance!

