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ENVIRONMENTAL SCIENCE FOR THE EUROPEAN REFINING INDUSTRY

Bioaccumulation? What is it all about?

Philippe Lemaire

Bioaccumulation ?

What is it all about ?

Mineral oil in human tissues, Part I: Concentrations and molecular mass distributions

Laura Barp [a], Christoph Kornauth [b], Tanja Wuerger [b], Margaretha Rudas [b], Maurus Biedermann [c], Angelika Reiner [d], Nicole Concin [e], Koni Grob [c]

- DEFINITION
  - BCF, BMF, BAC ?
- What does bioaccumulation mean ?
- Relationship between Kow and BCF
- What has been observed in some human studies
- Why mineral oils have limited potential to bioaccumulate ?
- Why mineral oils should not be considered as bioaccumulative ?

Bioaccumulation ?

BIOCONCENTRATION ?

BIOMAGNIFICATION ?

In fact all is «Bioaccumulation»

- Bioaccumulation can be applied to all organisms including human as mammals living in the environment
- Organisms need outside compounds to maintain their life (living, growing, breeding,…)
- Bioaccumulation is the *net* result of the intake from environment and the output, minus metabolism used for living and growing

Language Misunderstanding

- **BIOCONCENTRATION = BCF**
  - Accumulation into organisms from living environment (water, air, soil,…)
    - In link with Kow, derived BCF
- **BIOMAGNIFICATION = BMF**
  - Accumulation into organisms from trophic levels (plants, herbivorous, carnivorous,…)
    - In link with Kow, derived BMF factor
- **BIOACCUMULATION**
  - Bioaccumulation is the sum of bioconcentration + Biomagnification
  - **BAC = BCF + BMF**

Generally speaking people are wrongly talking about bioaccumulation !!!

What does bioaccumulation mean

Bioaccumalation can be really characterized as being the net result of three phases:

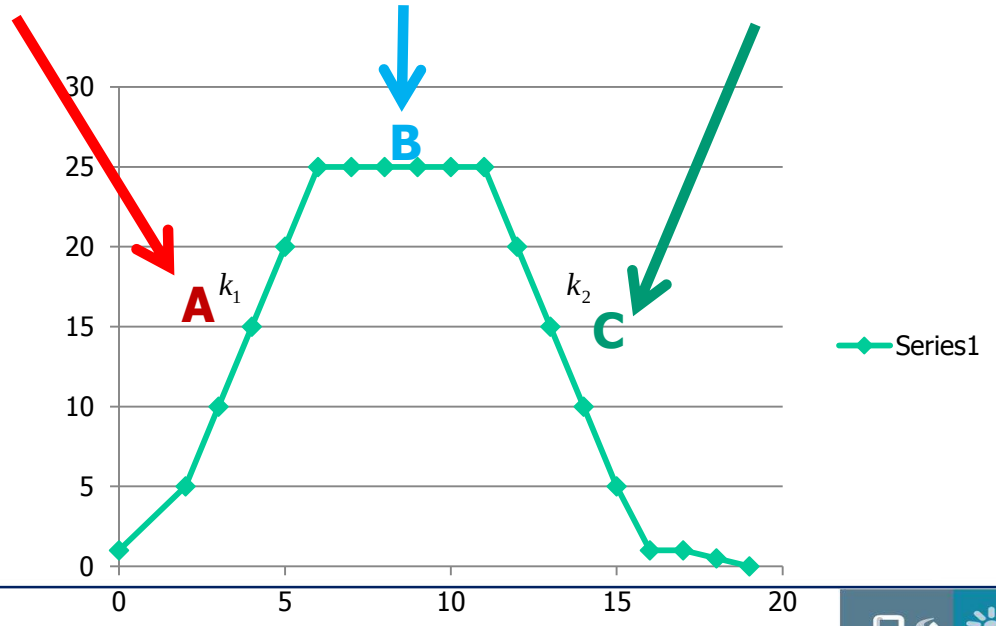
A = intake: Substances go into organisms (link with Kow and BCF) intake is higher than metabolization and elimination

B= steady state: Intake equal to «metabolization + output »

C = output: Elimination (including metabolization) is higher than intake

A simple measurement can not show if you are A,B or C

$$BCF_k = \frac{k_1}{k_2}$$

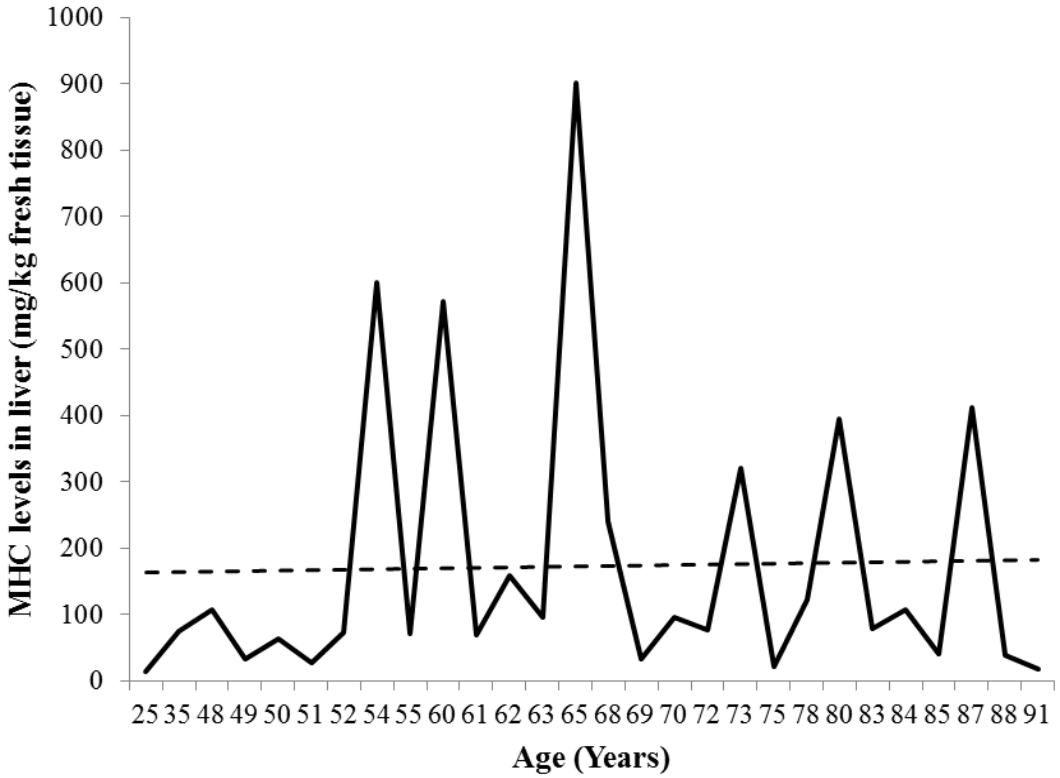


Recent human data

No relationship with age

Not indicative of becoming « higher and higher »

No adverse effects reported



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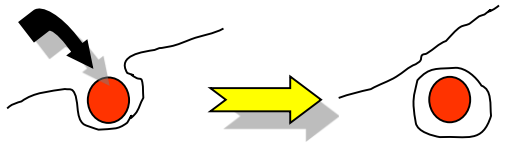
What has been observed in some human studies ?

Is that phase A of input at anytime?
Is that phase B or steady state at anytime ?
Or is that phase C or output at one time ?
Even is that endocytosis phenomena ?



The only thing that has been observed is the presence of mineral oil

Presence does not mean any toxic effect !

EFSA Position

EFSA 2017 guidance for food contact materials states:

"Bioaccumulation is a direct accumulation in mammalian tissues and not on biomagnification through the food chain.

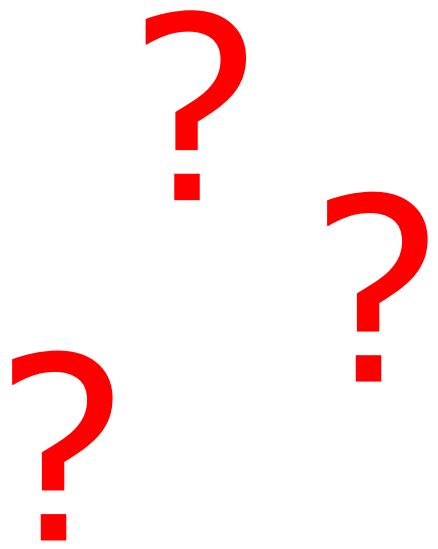
However, normally a log kow value below 3 would be considered sufficient evidence for the lack of accumulative potential in the mammalian body, unless special considerations, e.g. chemical structure, give cause for concern.

On the other hand, a log kow of 3 and higher will not by itself be proof of accumulation as a substance may not be absorbed or be metabolised to substances with no accumulation potential. In these circumstances, other evidence for the absence of accumulative potential is needed."

What does bioaccumulation mean?

- Toxicology point of view: Kow>1 and/or BCF>1
- However at regulatory point of view it is different and not that clear
- For instance: bioaccumulation is defined as being :

  67/648/CE: Kow>3 and BCF>100
  OSPAR: Kow>3 and BCF>100
  GHS/CLP: Kow >4 and BCF >500
  European PBT: Kow>5 and BCF>2000
  UK (substance of highest concern): Kow>4.5 and BCF>2000
  UK (substance of concern): Kow>4 and BCF>500
  Canada TSM: Kow>5 and BCF>5000
  vPvB: Kow>5 and BCF>5000



- These are for environment, however for mammals there is no regulatory framework and guidance to define bioaccumulation for human health
- The fact of a substance to be present in any organisms does not mean it is bioaccumulating
- Need to take into account the steady state and the output to reach the net result

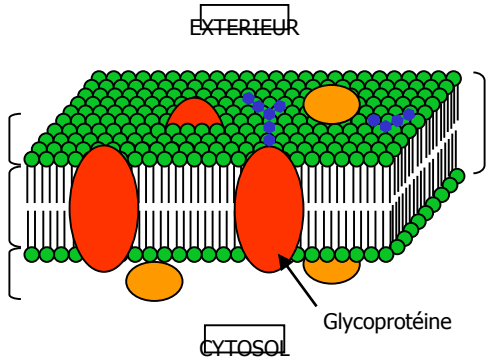
Presence is not equal to bioaccumulation:

it is A ? it is B ? it is C ?

Is Kow in direct link with BCF?

In theory yes because:

Kow is showing affinity of the substance for lipid or aqueous phases in link with the cells membran phospholipidic constitution.



Historically and theoritically speaking there is a direct link between Kow and BCF:

true for Kow between 0 and 5-6 because database has been developed with those data and given the wellknown following equations :

linear: -log BCF = 0,85 x log Kow – 0,70 for substances with Kow in the range of 2 and 6

parabolic: -log BCF = 0,20 $\log Kow^2$ + 2,74 log Kow – 4,72 for substances with Kow more than 6 but max Kow with big size molecule

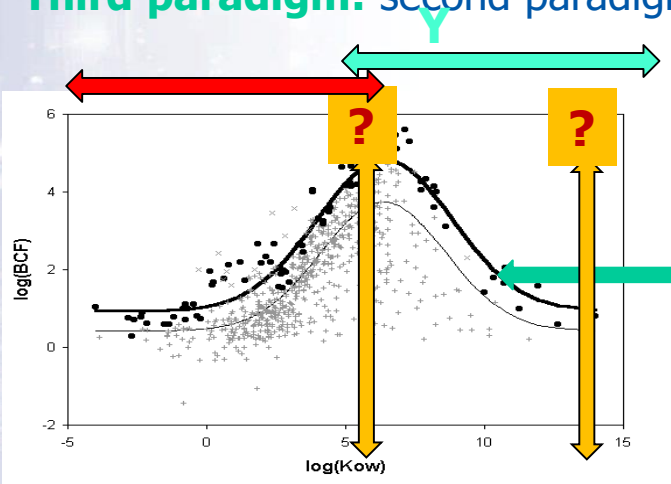
Is Kow in direct link with BCF ?

In practice yes for Kow more than **2 to 6** and less than **Y**

First paradigm: substance with high Kow have potentiality to bioaccumulate but does not mean there are bioaccumulative.

Second paradigm: Kow is in direct link with carbon chain length (higher is the chain length higher is the **probability** of the substance to bioaccumulate). Up to a certain molecular size their is link between Kow and BCF.

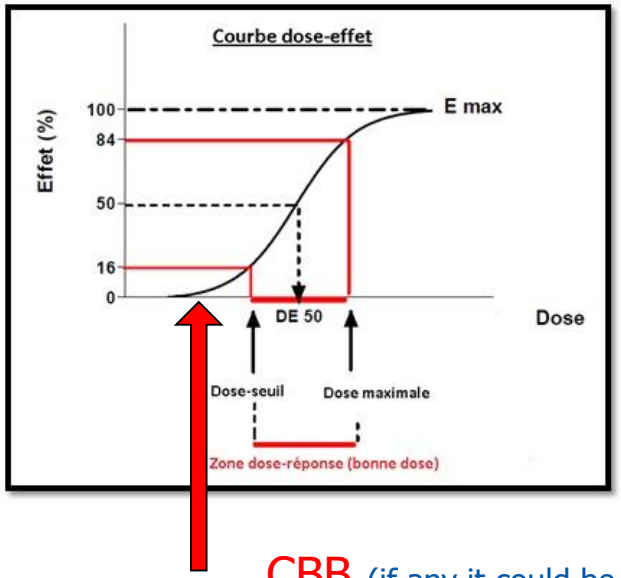
Third paradigm: second paradigm is true up to the Y value



Where does a substance starts not being anymore bioaccumulative ?

Mineral oils have limited bioaccumulative potential because of their limited gut absoprtion

What has been observed in some studies ?



CBB (if any it could be days ? weeks? years? hundred of year?)

- To reach toxic effect need to reach the Critical Body Burden = CBB
- CBB = NOAEL X BCF
- For human none of those two criteria are met because for mineral oil a « No adverse effect » has not been observed neither bioaccumulation or biomagnification.

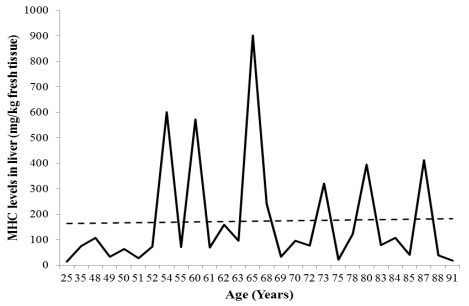
Observations made in human studies => Retention and not bioaccumulation

Why mineral oil should not be considered bioaccumulative ?

Because of numerous criteria:

- Mineral oils do not fulfil criteria for bioaccumulation
- They are too big to be bioaccumulative
- Even following available classification criteria no BCF has ever been measured in any organism
- Toxicity is required to reach CBB (NOAEL x BCF)
- Only presence and not toxicity has been observed
- No increment with age

- Retention also includes phagocytosis (lipogranuloma)



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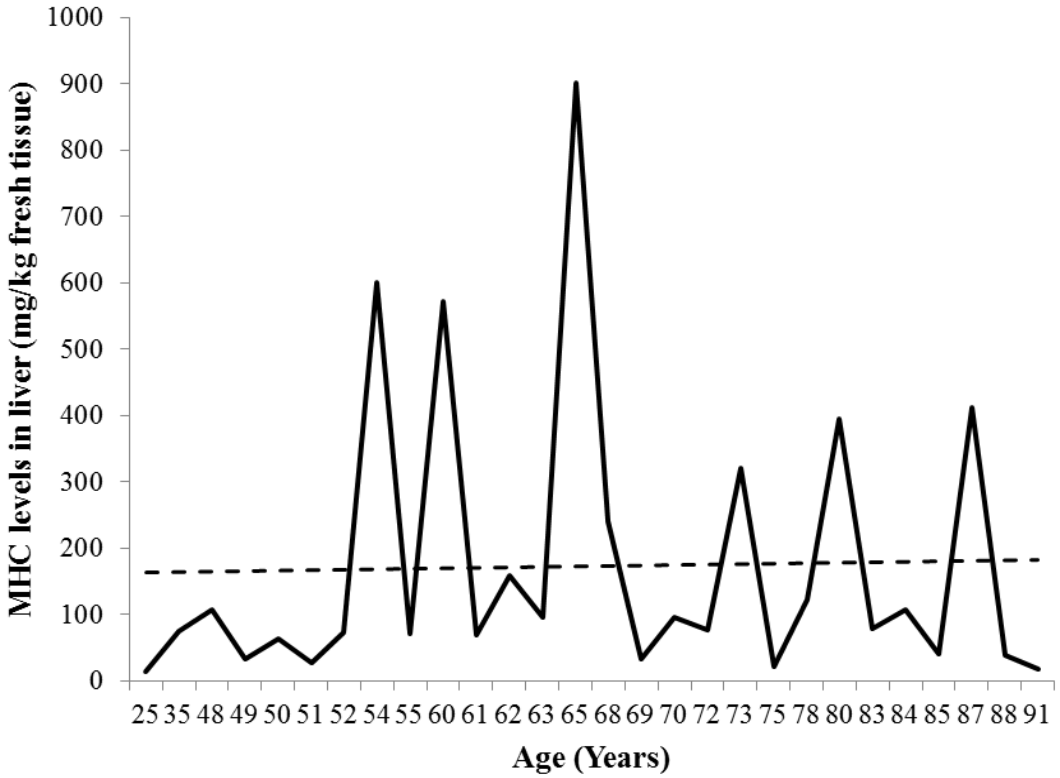

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