Exercises solution

Master's degree in environmental science and engineering

Occupational and environmental health

2.2 Chemicals pollutants effects_toxicology

1) Gun's and roses

Folpet is a chemical agent used in the preventive treatment of vines (contact fungicide). The way it is used depends largely on the type of land in which it is applied. Three types of operations were observed during a visit to a farm on a treatment day.

Preparation. The product (powder) is weighed and mixed in an intermediate tank. It will then be pumped into a pipe feeding the gun (pressurized pipe).

Gun treatment (early in the day). The product is sprayed onto the vineyard by means of a high pressure watering system.

During the treatment, the worker is provided with respiratory protection and it can be estimated that the average concentration of Folpet in the inhaled aerosols is about 120μ g/m^3. The duration of the treatment is approximately one hour (one treatment per day). A hand rinse at the end of the working day shows that the surface contamination is 40μ g/cm^2.

The properties of Folpet are as follows:
N-(Trichloromethylthio)phthalimide

$C_9 H_4 Cl_3 NO_2 S$	MW = 296.55 g· mol^{-1}
Saturation vapor pressure:	Pa = 1.3· 10^{-3} (25°C)
Solubility in water:	0.8 mg/L at 25°C (considered insoluble)
LogKow	2.85

Hypothesis:
- the surface of a hand is about 450 cm^2.
- assume a respiratory flow rate of 16 L/min.

Compare inhalation and dermal doses (assuming only hands are contaminated). What type of pollutant measurement would you recommend to quantitatively assess exposure?

Dermal route

LogKow = 2.85, Kow 707

The permeation flow corresponds to $F = \frac{C_{sat}}{15}(0.038 + 0.153 \text{ Pow})e^{-0.016 \text{MW}}$

Let $F = \frac{0.8 \cdot 10^{-3}}{15}(0.038 + 0.153 \cdot 707)e^{-0.016 \cdot 296.55}$ = 5 10^{-5} $mg/cm^{2} \cdot h$

The dose received for two hands is therefore $D_{cutané}$ = $2 \cdot 450 \cdot 5 \cdot 10^{-5} \cdot 8 = 361 \mu g$
Skin exposure is considered to be 8 hours at saturation concentration because rinsing at the end of the day still shows high Folpet contamination (no hand cleaning after the gun or ineffective cleaning)

Inhaled route

It is assumed that all inhaled Folpet is absorbed
A flow rate of 16 l/min for 1 hour corresponds to a volume of 960 l
The absorbed dose by inhalation is therefore $115\ \mu g$

For the same working time, inhalation is predominant, but over the working day the **cutaneous route** is the most important. Furthermore, this is probably underestimated because the work clothes are probably contaminated, generating an absorption on a larger surface of skin.

Finally, there are risks of ingestion due to the presence of Folpet on many surfaces in contact with the hands (treated leaves, clothes...)

In such a situation, biological measures integrating all routes of entry are to be preferred. The use of surface contamination measurements (smears, rinses) can also be an effective prevention tool.

2) Loaded breath

The half-life of perchloroethylene in exhaled air is 80 hours (first order kinetics). What would be its concentration (in ppm) in the exhaled air of a person at 7 am,if he had, the day before when leaving his work at 5 pm, 15 ppm of perchloroethylene in his exhaled air?

$t_{1/2}$ = 80 h , t = 14 h
k = ln 2/ $t_{1/2}$ = 0.00866 h^{-1}
A = $A_0 \cdot e^{-kt}$
A = $15 \cdot e^{-(0.00866 \cdot 14)}$ = **13.3 ppm**

3) Biological monitoring

A hygienist wishes to monitor the exposure of a worker exposed to a solvent X using biological monitoring. He takes blood samples at regular intervals after the end of the daily work shift and obtains the following results:

[B] T_0 (Immediately after exposure) : 12.1 [μ g/l]
[B] T_4 (4 hours after exposure) : 8.5 [μ g/l]
[B] T_{12} (12 hours after exposure) : 5.9 [μ g/l]

Characterize the kinetics of this decay. What will be the potential implications of such kinetics on the follow-up strategy of the exposed person ?

This is a second order decay because the t 1/2 increases with time.
We can calculate the kinetic rate k using two points:

$1/[A] = 1/[Ao] + kt$

We find $k = 7.24\ 10^{-3}$

With $t½ = 1 / k\ [Ao]$ we find the following half-life times:

- initial half-life is 11.4 hrs
- half-life at 12 hours is 23 hours

The complete elimination of the organism is thus very slow, it is thus necessary to take samples at the end of the working week.