Dynamic transfer in the aquatic and terrestrial environment of tritium liquid releases

Françoise Siclet –EDF R&D

National hydraulics and environment laboratory

EMRAS II – WG 7 – 24-28 January 2011

Dynamic model of tritium transfer in the case of discharges in surface waters

- Dispersion/transport in river or sea
- Transfer to aquatic organisms
- Transfer through irrigation to agricultural products

Dispersion/transport in river

- River transport models tested on the Loire scenario (EMRAS)

  •Simulation of the dispersion of Tritium discharges in the whole Loire river system (~ 350 km)

  •Comparison between calculated tritium concentration and measurements at Angers (last station downstream)

▪ CASTEAUR	*IRSN, France*	*box model*
▪ MASCARET – TRACER module	*EDF, France*	*1D dodel*
▪ MOIRA+ – MARTE module	*ENEA, Italy*	*box mode*
▪ RIVTOX	*IMMSP, Ukraine*	*1D model*

Conclusions :

•Good agreement between model and measurements for average concentrations

•Performance of models controlled by appropriate estimates of water velocities and water fluxes : 1D hydrological models better adapted to acute releases or high hydraulic variability

See **GOUTAL et al., 2008, Journal of Environmental Radioactivity**

Dispersion/transport in coastal waters

•not tested within the EMRAS program

•but hydrodynamic models have been developed and implemented for the dispersion of pollutants

• recommandation to use 2D – depth averaged model (if there is no vertical stratification) otherwise 3D model

Dispersion/transport in river or sea

- Loss of tritium due to exchange at the water-air interface
  - Model developed and calibrated on the Loire river
  - Secondary pathway

See **MARANG et al., 2010, Journal of Environmental Radioactivity**

Transfer of tritium in the food chain

- General approach
  - HTO
    - Rapid equilibrium between HTO in the organism and HTO in the surrounding media
    - Turn-over rate controlled by ratio between water intake and body water content (biological half-life lower than one day for aquatic organisms)
  - OBT
    - Photosynthesis : main pathway from HTO to OBT. Isotopic discrimination against HTO during photosynthesis due to chlorophyll system binding more easily to HHO than HTO . No isotopic discrimination for biological processes involving larger tritiated molecules.
    - OBT turn-over follows the same pathways as organic carbon=>same general model for OBT and carbon 14 in phytoplancton, fish, terrestrial plants and animals: dynamics based on carbon assimilation rate (photosynthesis for plants and food intake rate for animals)

      See **Sheppard et al., 2006, Journal of Environmental Radioactivity**
    - Model tested on the mussel contamination and depuration scenarios and on the pig scenarionin the EMRAS programme

Transfer of tritium in the food chain- equations and parameters

- Equations for HTO and OBT in living organisms expressed in specific activities (Bq/g H)
  - conversion to mass concentrations: water content (TRS 472) and water equivalent factors

- Tritium in phytoplankton and plants (HTO and OBT)
  - Value of relative photosynthetic rate, and discrimination factor

- Tritium in aquatic animals (HTO and OBT)
  - Value of relative ingestion rate, and H/C content

Transfer of tritium in the food chain - Case of dissolved organic tritium releases

- Approach
  - dissolved bio-available organic molecules enters the pool of dissolved organic matter in river or sea water
  - At equilibrium the specific activity of OBT in the aquatic biota is equal to the specific activity in the dissolved organic matter.
  - turn-over rates depend on the relative carbon assimilation rate (same kinetic parameters as for OBT from HTO releases)
- Parameters
  - Values of DOC in different water bodies and values of H/C in dissolved organic matter

Transfer to irrigated soil, crops and farm animals

See Ciffroy , 2006, *Journal of Environmental Radioactivity*

- HTO concentration in plants grown on irrigated soils
  - contamination is due to root uptake of soil water
  - HTO concentration in soil water
    - Function of precipitation, evapotranspiration (calculated from meteorological data), and irrigation rate (can be fixed or calculated for optimal crop growth)
    - Soil divided in 3 layers : ploughing zone, cultivable zone, deep soil
  - Plant TFWT(t) = $HTO_{ploughing\ zone}(t)$

or depending on crop type

Plant TFWT(t) = $(HTO_{ploughing\ zone}(t) + HTO_{cultivable\ zone}(t))/2$

Transfer to irrigated soil, crops and farm animals

- Model description
  - Once the HTO concentration in plant is calculated, the OBT concentration in plants and the HTO and OBT concentrations in terrestrial animal products are calculated using the models and parameter values for release to air.
- Suggested equations based on the carbon assimilation model
  - OBT in vegetative part of irrigated crops
  - OBT in animal feeding on irrigated crops or drinking contaminated water