Activities of the Tritium Working Group

EMRAS II
Approaches for Assessing Emergency Situations
Working Group 7 “Tritium” Accidents

Working Group Leader Dan Galeriu IFIN-HH Romania
IAEA Scientific Secretary Mr Volodymyr Berkovskyy

Vienna 24 January 2011

Established January 2009- First EMRAS II meeting

Develop Dynamic Tritium Model

Working Group Leader: Dan Galeriu

Canada-France-Japan-Romania-Germany

The dynamics of OBT and 14C concentrations were generally poorly reproduced in scenarios involving short-term releases EMRAS I-TRITIUM &14C

END results A new document covering acute release tritium model (Jan 2012)

WG7 Aim and Objectives

- To develop a standard conceptual dynamic model for tritium dose assessment for acute releases to atmosphere and water bodies
- To focus on only starting the new model from the given air or water concentrations (HT or HTO) and the duration of the exposure
- To agree on common sub-models, based on understanding of the processes and agreed key parameters (interdisciplinary approach)
- To define the framework for an operational model
- To obtain quality assured sub-models and harmonize approaches in order to get confidence in the predictions (moderate conservatism)
- To have capability to assimilate real data from measurements

Task groups

- Task Group I covering
  - Tritium washout
  - HT/HTO deposition-reemission
  - Actual evaporation and transpiration and connected HTO concentration dynamics
  - HTO uptake and retention in plant in rain condition
  - Movement of HTO to deeper soil layers
  - Winter case (particularly deposition on snow and how to deal with snow)

  Task Group II covering
  - Use of growth models - define the minimal needs
  - OBT formation in night
  - Translocation of OBT from leaves to edible plant parts

  Task Group III
  - Modelling the transfer in aquatic food chain

  (EDF and IFIN models)

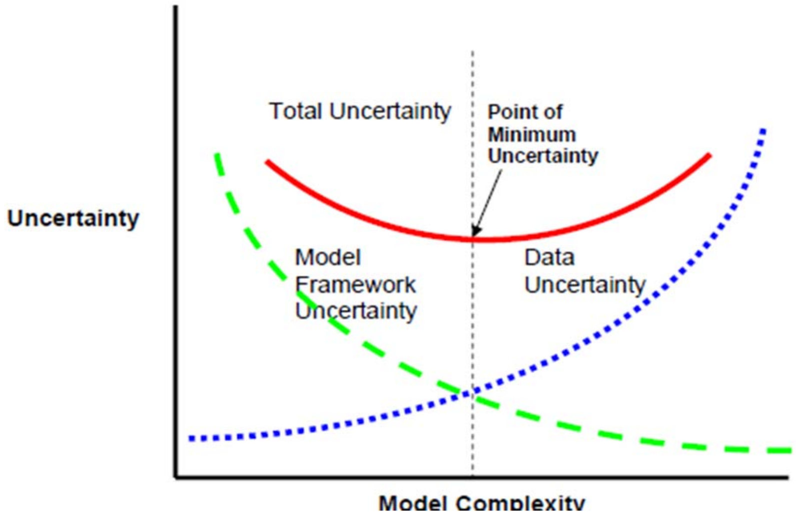
Enlarged interest (Jan. 2010)

- INDIA- start large program for experiment and models- need assistance for OBT measurement technique>> financial problems to participate
- BRAZIL- prepare for new nuclear plants- tritium in coastal water (tropical)- need cooperation. Financial problems this year
- UK (Scotland) have problems with tritium at MAGNOX- cooperation, rainy climate> we are expecting to renew contact
- Kazakhstan, SemiPalatinsk, tritium in the environment- can do experiments, will cooperate> financing?
- >22 participants, 10 active

Regulatory requirements for a model

- Relatively simple
- Transparent
- Easy to program
- Results should be conservative (but not too much)
- Deterministic calculations possible (worst case assessments)
- Probabilistic calculations possible (95% percentile as worst case)
- Is this possible for Tritium?
- Problems detected: operational models used for licensing have no provision for robustness and control of uncertainty
- Models for accident management are to complex and user non friendly

How to obtain an useful model?



Simple model - Keum et al., Health Physics, January 2006, Volume 90, p.42

Very complex model,
M. Ota &H. Nagai, EMRAS WG 7 presentation

SPECIFIC CAUSES OF UNCERTAINTY

- Missing communication;
- Experiments and OBT modelling at AECL - undisclosed;
- Cardiff case - experiments - undisclosed (but reports from Environmental Agency and FSA are available on request);
- Many reports, PhD thesis difficult to access or delayed for accessing;
- Incomplete documentation – ignoring past achievements (BIOMOVS, EMRAS I, selective uptake of DOT);
- No common knowledge data base due to copyright restriction;
- Missing appreciation – S Strack case - lost information for T in wheat;
- Limits in allocation of time and budget
- Missing dedication - only a job
- Missing peer review
- Insufficient parameter uncertainty

The forth meeting of the IAEA EMRAS II “Tritium” Accidents Working Group was held in Aix en provence, France. The meeting was hosted by IRSN [12 participants] < second in Paris !

- to discuss and harmonize the views of participants concerning the approaches for developing the conceptual model for tritium accidents (atmospheric and aquatic);
- to agree on the structure and scope of the conceptual model;
- to identify potential gaps in knowledge and expertise, which should be addressed during the model development;
- to define the structure of the technical document and share tasks according to the expertise of each participant and the interests of his/her organization or institute;
- to elaborate the work plan for developing the conceptual model;
- to distribute specific tasks to be accomplished and reported at the next EMRAS II Technical Meeting (25–29 January 2011).

Major problems in 4th meeting

- EMRAS I follow-up: dose assessment of routine tritium release, the role of reactors' cooling towers and the differences between the new Canadian Standard for derived released limits and the IAEA Handbook.
- **The development of the complete interaction matrix for terrestrial pathways of tritium transfer**
- **Wet deposition of tritium, a revision of the actual status and the proposal for an associated database was presented.**
- Presentation on the status of tritium modelling for accidental tritium releases at IRSN, AECL, CEA, and IFIN.
- **Tritium aquatic pathways, with an introduction about fish bioenergetics models and then, descriptions of different approaches for modelling purposes and the subsequent models' applications to tropical environments. The status of current fish experiments and preliminary results of fish scenario were also presented**.
- **The specific needs for tritium modelling at the ITER site at Cadarache were pointed out**.
- Tritium transfer for terrestrial pathways.

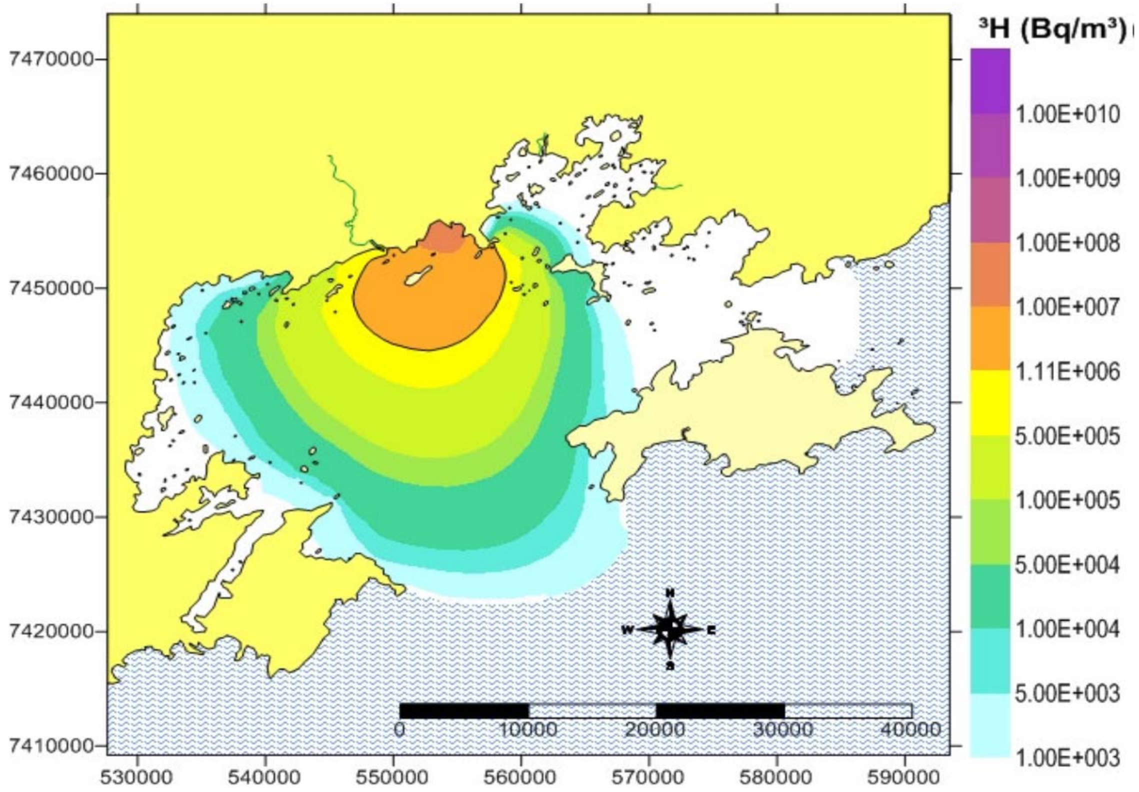
- The experimental data and the modelling hypotheses for HTO transfer and the subsequent conversion to OBT were presented based on research carried out by both CEA and AECL.
- **A complex research grade model (SOLVEG model, developed by JAEA) was presented and discussed to be further applied in order to assess the potential simplifications without significant loss of predictive power.**
- A briefing of experiments and modelling trials of OBT formation during the night time have been revised, as well as the key aspects which must be considered in models dedicated to tritium transfer from soil to plants.
- During the last day of the meeting, the WG7 members visited the Environmental Modelling Laboratory and Radioecology and Ecotoxicology Laboratory from IRSN Cadarache and the ITER site at Cadarache.

General interaction matrix for the terrestrial environment ((IRSN)

Processes of potential importance for H3 are highlighted in bold.

ATMOSPHERE	**Deposition**		**1) Deposition and interception** **2) GrossPhotosynthesis**	**Gross photosynthesis**		**Inhalation**		**1) Dry deposition** **2)Precipitation** **3) Interception**		
1)Evaporation **2)Droplet production**	WATER BODIES		**1) Root uptake** **2) Irrigation**			**Ingestion**		**1)Irrigation** **2)Recharge by surface waters**	Release from solution	Recharge by surface waters
		VEGETATION (ABOVE – BELOWGROUND)				**Ingestion**	**Ingestion**			
1)Respiration 2)**Transpiration**	Senescence and death		WATER						Root respiration	Biological weathering
1)Respiration 2) Leaf fall 3) Release of other organic compounds				DRY MATTER					Root respiration	1) Litter fall (at outcrop) 2) Senescence and death 3) Biological weathering
	1)Excretion 2) Death	Excretion			ANIMALS	1) Translocation 2) Hmetabolism?	Translocation			
Exhalation						WATER	OBT formation	Excretion	Inhalation (burrowing animals)	Excreion
							DRY MATTER			1)Excreation 2) Death and decomposition (both at outcrop)
Evaporation	Groundwater recharge		**Root uptake**		Ingestion			SOIL WATER	**Diffusive exchange**	Surface run-off
Diffusion			**Root uptake and transport in aerenchyma**					**Diffusive exchange**	SOIL ATMOSPHERE	Diffusive exchange
Resuspension (at outcrop) Diffusion	Desorption	1)External contamination 2) Irrigation			1)Ingestion 2)Bioturbation			1)**Diffusion** 2)Advection 3)Colloid transport	**Diffusive exchange**	Interface with geosphere

Hydrological model for tritium dispersion after a release of 37 PBq



Dispersion of HTO plume after 3 days following the accident in the scenario 1

F. Lamego, Institute of Nuclear Engineering, Rio de Janeiro, Brazil

In practice, an incident with tritium loss in Danube River can occur any time and it will be useful to understand the seasonal effect of the release impact on human ingestion coming from fish. Across the years, the Danube River's flow and temperature vary and for the same release of 3.7 PBq of tritium for 6 hours, the fish contamination varies also

Date of release	River flow (m^3s^{-1})	River temperature (°C)	Ingested activity of fish (Bq)[a]	% OBT[b]
February 15	3000	3	22844	3
April 15	5000	10.5	14348	7.3
May 15	3500	17	21831	13
July 15	1500	24	63377	30
September 15	1000	20	92430	28
October 15	1500	15	53790	17.5
December 15	1500	5.5	46415	4.4

[a] 0.5 kg of a mixture of carp and zander
[b] The percentage of OBT coming from the ingested fish activity

Water temperature has a large influence on the OBT content in fish and the highest impact is in late summer (September 15).

DOT- The Cardiff case

For the Cardiff case it should be noted that the tritated waste from GE Healthcare (former Amersham) includes not only the HTO and the by-product, but also the high bio available tritiated organic molecules (*i.e.* hydrocarbons, amino acids, proteins, nucleotides, fatty acids, lipids, and purine / pyrimidines).
For the model application, the input data as: the annual average of total tritium and organic tritium releases from GE Healthcare, tritium concentration in sea water and the monitoring data for mussel and flounder have been taken from literature
Using the available input data, the model successfully predicts the trend for tritium concentration in mussels and flounders

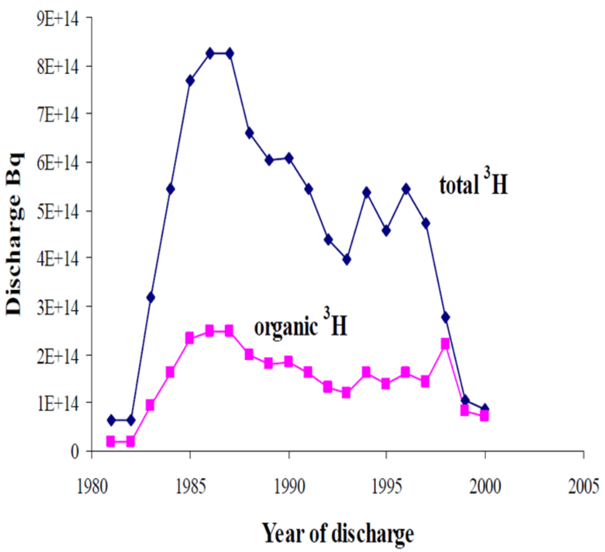
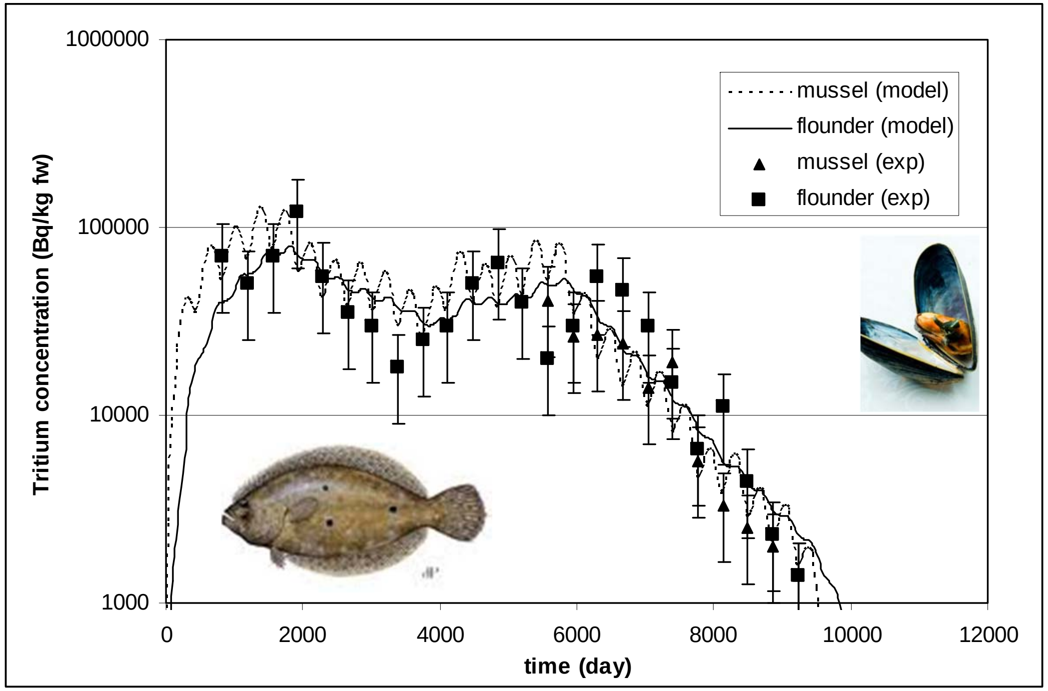
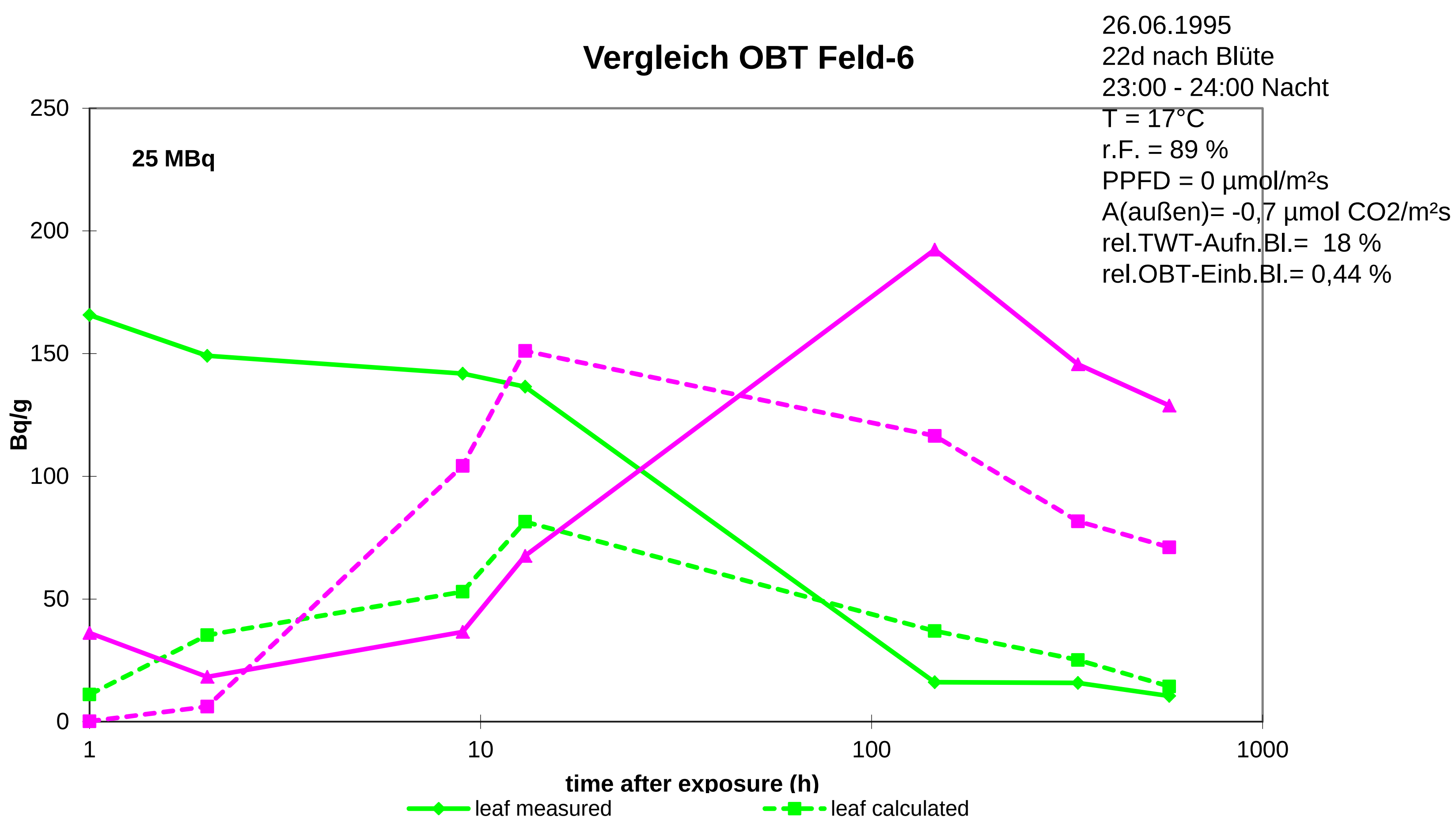


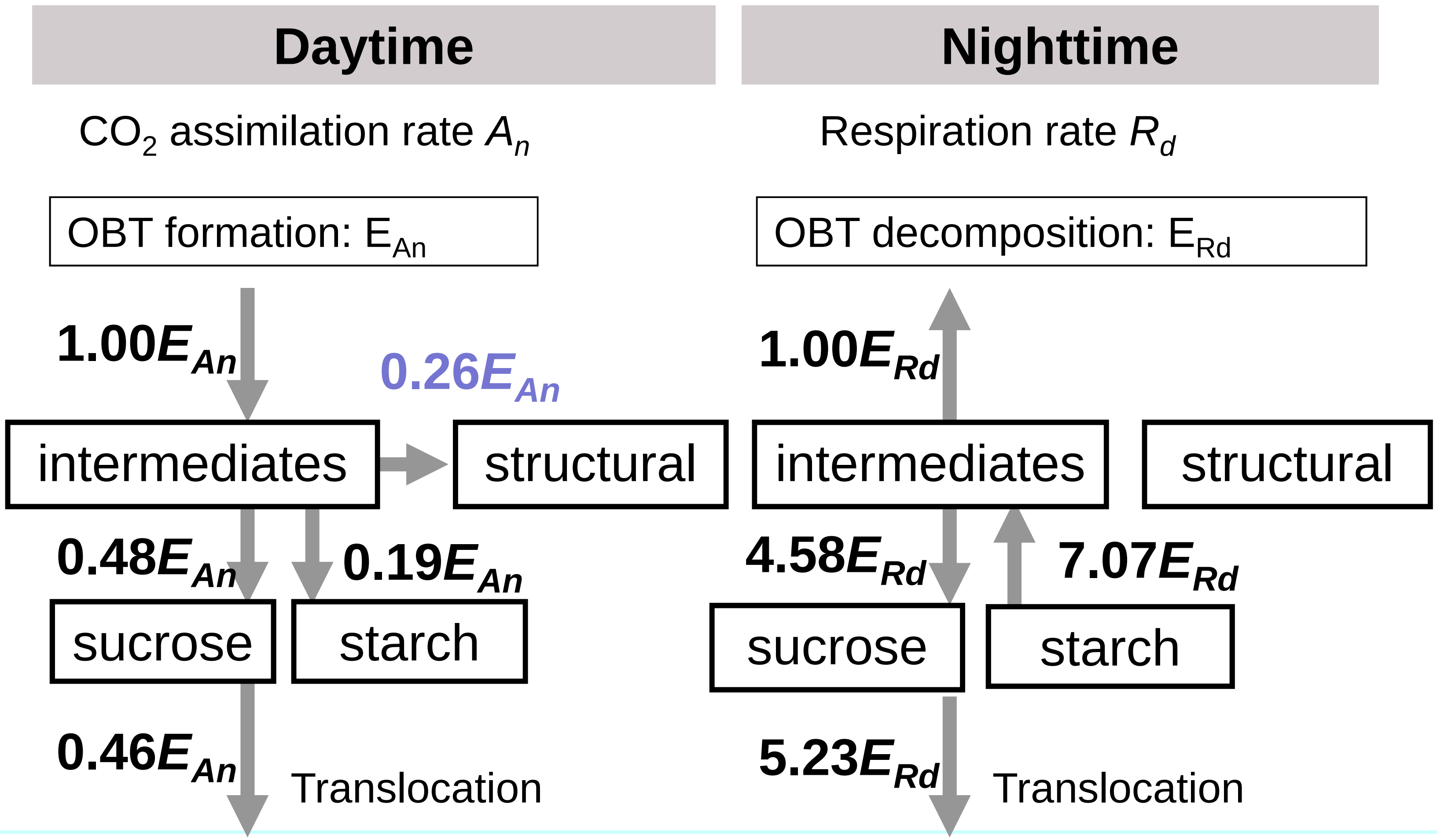
Figure 1: Record of discharges of tritiated waste from Amersham plc into the Severn Estuary



S. Strack, Experiments with Tritium in Wheat



Carbohydrate formation and translocation processes based on experimental result (Fondy & Geiger 1982)



Haruyasu Nagai, Masakazu Ota

Achievements

- Discussions and presentations on specific needs of selected sites (ITER, Rokkasho, Valduc, Cernavoda),
- Discussion and presentations on present knowledge: experiments and process level models (Japan experiments, ETMOD,UFOTRI,RODOS-FDMH, SOLVEG), sometime prior publishing
- Presentation of animal model, process, validation(IFIN)
- Presentation on aquatic models(IFIN,EDF)
- Tritium interaction matrix (IRSN)
- Major processes and briefing of actual status of modeling
- Harmonization to be expected
- Mandatory need of better OBT measurements

Activities planned and this week

Action	Person	status
Final document on tritium interaction matrix	S. Le Dizès-Maurel	Advanced draft to be discussed ; presentation ny WGL (Severine is absent)
Final document on tritium washout	L. Patryl	In term this Monday afternoon;
Accessing the Indian data on washout ratios	P. Ravi, D. Galeriu, V. Berkovskyy	No financing for Dr. Ravi, postponed
Accessing the Japanese data on washout ratios	H. Nagai	No new data
Final document on tritium transfer in aquatic environment	F. Siclet	Part one ready, part two to be inserted after acceptance for publishing (updated Aquatrit)
Experimental data about fish food, HTO in fish dynamics, and preliminary results for OBT feeding	S.B. Kim	OBT experiments not ready; final work to be presented June Canada (ECORASD 2011)
Final document on OBT formation in night time; data and modelling trials	D. Galeriu, A. Melintescu, S.B. Kim	Partially done, as OBT in night is a difficult task; many unpublished data analysed

Recovering the Japanese experimental conditions about OBT formation in night time	H. Nagai	Dr Ota will translate from Japanese
Recovering the Canadian experimental conditions about OBT formation in night time	S.B. Kim	Global solar not yet obtained, rest is OK
Description of the new Canadian OBT experiments in night time (2009)	V. Korolevych	This week
Final document on exchange velocity and OBT formation during the daytime	A. Melintescu	This week
The role of photosynthesis in canopy resistance modelling (AECL approach)	V. Korolevych	Postponed due to time budget
Final document on critical parameters of tritium transfer from atmosphere to plants	P. Guetat	This week
Final document on models uncertainty and sensitivity. Application for tritium	J. Duran	Draft this week
Numerical exercises using SOLVEG model for different soil types and in case of rain during the daytime and night time	H. Nagai	This week, presented by Dr Ota
T washout and groundwater problems	WGL and all	26 January after coffee break
Tritium in drink water-what to recommend	WGL and all	
OBT in freshwater ecosystems : long term trends in the environment of nuclear power stations".	F Siclet	

Expectations this meeting

- Agreement on further collaboration on harmonized conceptual model
- Compromise between simple and process level models
- Agreement on modeling approach and tecdoc content for wet deposition of tritium and aquatic pathway
- More insight on formation of OBT in night
- Harmonization of views on modeling tritium transfer atmosphere-plant soil
- Agreement on tritium interaction matrix
- Tecdoc content and agreement on contributors
- Firm assignment on specific task to be done until next meeting
- Proposal for next meeting guest institute and agenda

Active partners

- France
- Canada
- Romania
- Germany
- Slovakia
- Japan
- India
- Brazil
- NO RUSIA USA CHINA !!

CONCLUSIONS

“Tritium is one of the most benign of radioactive materials that I’ve worked with in my career, and I’ve worked with many of them. But on the other hand, the perception of tritium as a potential risk in the environment to the public is huge; it is absolutely huge. It is the industry’s biggest problem since the Three Mile Island accident in 1979.”

Dr. John E. Till, Author of
Risk Analysis for Radionuclides Released to the Environment - Oxford University Press 2008
(but Chernobyl?)
TODAY CHALENGES:
NIGHT FORMATION OF OBT IN CROPS
HARMONIZATION FOR CONCEPTUAL MODEL
PREGNANT WOMEN AND FOETUS
OPERATIONAL MODEL DESIGN - GENERAL CONCEPT
Welcoming China, USA, Russia
Budget!

IFIN-HH