IAEA EMRAS, Tritium and C-14 Working Group

EMRAS: Modelling the Transfer of Tritium and C-14 to Biota and Man Notes of Working Group Meeting, Livermore, USA (19-22 April 2004)

EMRAS, Tritium and C-14 Working Group, Meeting Report 2

Notes of the IAEA EMRAS Tritium and C-14 Working Group Meeting, Livermore, USA (19-22 April 2004)

History:

The second meeting of the IAEA EMRAS Tritium and C-14 Working Group was held in Livermore, USA. The meeting was hosted by Lawrence Livermore National Laboratory.

These Meeting Notes have been prepared by: A. Venter (Technical Secretariat), P Davis (Working Group Leader) and M Balonov (Scientific Secretariat). In addition, the following people attended the meeting and contributed to the discussions and decisions documented in these Meeting Notes:

Name	Organisation	Country
F Baumgartner	Munich Technical University	Germany
I Benovich	OPG	Canada
P Guetat	CEA	France
Y Inoue	NIRS	Japan
J Koarashi	JNC	Japan
C Lee	KAERI	Korea
H Lee	KAERI	Korea
P Marks	GE Healthcare (previously Amersham plc)	UK
V Mishra	DOE	USA
R Peterson	LLNL	USA
M Saito	Safety Reassurance Academy	Japan
F Siclet	EDF	France
B Wierczinski	Munich Technical University	Germany
K Yamamoto	NIRS	Japan

Financial support of the Technical Secretariat by GE Healthcare (UK) and the Food Standards Agency (UK), and of the Working Group Leader by the CANDU Owners Group (Canada), is gratefully acknowledged.

Introduction

The second meeting of the EMRAS Tritium and C-14 Working Group was hosted by Lawrence Livermore National Laboratory in Livermore, USA, from 19-22 April 2004. The objectives of the meeting were the following:

- Discuss results for the Perch Lake and soy bean scenarios
- Discuss the draft description for scenarios involving hypothetical short-term tritium releases
- Present and discuss the draft scenario for tritium concentrations in terrestrial food chains due to continuous releases (the Pickering scenario)
- Present C-14 data sets and discuss possible C-14 scenarios
- Discuss possibilities for data sets involving tritium dynamics in large animals and fish
- Plan future work activities, including additional test scenarios

Participants were welcomed to the meeting by Albert LaMarre (LLNL). Participants introduced themselves and briefly described their background and interest in the working group. The meeting was opened by Mikhail Balonov, the IAEA Scientific Officer for this working group. Mikhail gave an update on the activities of EMRAS. Five other EMRAS Working Groups are meeting during April/May 2004. The EMRAS website has been activated.[1] General information on EMRAS, as well as the documents from the first plenary meeting have been uploaded on the website. The EMRAS Bulletin will also be posted on the website. Participants are invited to the next EMRAS Plenary Meeting in Vienna (8-11 November 2004). Further information on the Plenary Meeting will be posted on the website soon. *A new Working Group on exposure of non-human biota will be established during the Plenary Meeting.*

All the BIOMASS TECDOCs have been completed and published. A compact disc with all seven reports will be published soon.

Discussions of modelling results for Perch Lake Scenario

Phil Davis gave a short presentation of the scenario (attached). Graphic results from modellers were presented and discussed. Phil Davis presented conclusions based on observed data:

Plants

- Ratio of plant/water HTO concentrations close to one for algae, bladderwort and hornwort
- HTO concentration in the submerged part of cattails equals HTO concentration in sediment water

[1] (http://www-rasanet.iaea.org/projects/emras/emras.asp).

- In the emergent part of the cattail, half the HTO originates from air and half from the sediments.
- All OBT/HTO ratios for plants increase slightly with time. This issue needs further investigation.

Fish:

- HTO concentrations in fish and clams roughly equal the HTO concentrations in water
- OBT/HTO ratio is the same for all fish and for all parts of a given fish
- OBT/HTO ratio increases over time

Phil also presented a preliminary equation for lake sediment OBT.

The modellers each gave a short presentation of their model. Results were evaluated again for each model in view of the presentation. Predictions were generally in good agreement with the observations (see attached spreadsheet) and a second round of calculations was not required. Modellers have to send the following information to Phil Davis by 15 June:

- a short description of their model,
- an explanation of their results, and
- an indication of how water and sediment concentrations were averaged.
- confirmation that their results have been correctly plotted on the graphs

Phil will produce a draft report for discussion at the fall meeting.

Presentation and discussion of the draft scenario for tritium concentrations in terrestrial food chains due to continuous releases (the Pickering scenario)

The Pickering Scenario was presented by Phil Davis (attached). During general discussion of the scenario, further data that would be required by the modellers were identified. These include monthly temperatures, tritium concentrations in rainfall, location of rain measurement points and monthly solar radiation. Data on tritium concentration in the drinking water well may be available. The final draft of the scenario is to be distributed by end May with results submitted by end July. Five to six modellers are expected to submit results for this scenario.

Discussion of modelling results for soy bean scenario

Hansoo Lee gave a short presentation of the scenario (attached). Results from all the modellers were presented in graphic form and discussed. The modellers each gave a short presentation of their model. Hansoo Lee presented the model developed by his team at KAERI. Results were evaluated again for each model in view of the presentation. The observations showed some interesting features that not all models were able to reproduce:

- Pods that did not develop until after the exposure still showed relatively high HTO and OBT concentrations. The pods appear able to incorporate tritium present in the stems at the sites where they form.

- HTO concentrations at harvest were well above background levels, likely because of the slow breakdown of OBT in the plant.
- The leaves showed significant OBT concentrations even for those exposures that occurred when the pods were growing rapidly and most new dry matter might have been expected to be translocated to the pods.

Biomass increase/growth rate is an important factor which may explain some of the differences. Although there were significant differences between predictions and observations (see attached spreadsheet), the modellers felt that a second round of calculations was not required. Modellers have to send the following to Hansoo Lee by 15 June:

- a short description of their model
- an explanation of their results
- model prediction of growth rate and water content of plant
- confirmation that their results have been correctly plotted on the graphs

Hansoo is to submit a draft report at the next meeting.

Uncertainty

The uncertainties in the predictions for both scenarios were discussed briefly. Not all modellers estimated uncertainties, and those who did, derived them in different ways and reached different conclusions regarding their magnitude. This issue needs further elaboration in the scenario reports.

Presentation of C-14 datasets

The following C-14 datasets were presented. The purpose was to identify datasets suitable for model-data intercomparison studies.

- Francoise Siclet presented a dataset from EDF with C-14 concentrations in marine and terrestrial endpoints, as well as in river water.
- Phil Davis discussed terrestrial C-14 data from Pickering (*cf* Pickering Scenario for tritium described earlier). The data is not much above background and thus the uncertainty will be great. Some measurements also exist for Lake Huron and wetlands on CRL property, but the source terms are not well defined.
- GE Healthcare (Amersham plc) may undertake experiments with C-14, similar to the soybean scenario.
- Some C-14 data may be available from JNC, based on weekly monitoring data from the Tokai reprocessing plant stack from 1991. The chemical form of the C-14 is unknown. Monthly monitoring data for air and yearly measurements of C-14 in rice grain are available from 1985.
- Mikhail Balonov will investigate the suitability of a series of C-14 measurements undertaken at Chernobyl.

- Ansie Venter presented data collected by Scott Tucker during his PhD study at Imperial College. The experimental procedure/data collected is similar to those in the soybean scenario.
- Ansie Venter will check with Nick Beresford, UK, regarding possible C-14 data in sheep.

Data holders will provide a brief summary of data/scenario description, plus purpose of scenario by 30 June 2004. These will be circulated to participants to indicate their preference. A final decision as to the C-14 scenario(s) that will be modelled will be taken at the next meeting (September 2004).

Draft description for scenarios involving hypothetical short-term tritium releases

Philippe Guetat (CEA) presented the first draft of a hypothetical scenario involving short term releases of tritium, together with some initial calculations to help guide the discussion. The purpose of modelling such a scenario is to provide guidance to decision makers in the event of an acute tritium release to the atmosphere. The first 24 hrs would be the most crucial in terms of HTO; OBT would be of importance ~~6-8 months~~ later when foods are harvested.

Questions to be answered:

- Based on total dose without intervention, does action have to be taken within 0.3, 3 or 30 km?
- Should both children and adults be considered?
- What vegetables need to be considered?
- How long do agricultural activities have to be suspended before crops can be planted in contaminated soil again?
- How long do cows have to be removed from pasture?
- What should the reference activity value for tritium products in free trade be?[2]
- How should contaminated products be disposed of?

The study will be undertaken in two parts. The first part will be quantitative, with modellers simulating tritium transport via various pathways and calculating concentrations in various parts of the environment. This information will then be used to formulate recommendations on ways to manage the release. Practical applications should also be considered, e.g. where such a release could happen based on the locations of existing and proposed tritium handling facilities.

There are potentially three scenarios, based on different meteorological conditions (rain, night-time, daylight conditions). These should cover the worst case scenario for agricultural purposes. Defined scenarios need to be realistic, but cautious.

[2] Tritium reference level for international trade in food is 10 000 Bq/kg (to be approved)

The following suggestions were tabled:

- the working group should also consider what was done regarding meteorological conditions in similar previous studies (in Cosyma and in studies reported in IAEA publications);
- should a reference model be considered (where people can plug in their own values); and
- could the agricultural conditions and consumption rates for the reference biosphere developed in BIOMASS be used?

The following schedule was developed:

- Philippe Guetat will re-issue the scenario by 15 May 2004.
- WG members will send comments on the scenario to Philippe by 30 May 2004.
- The final scenario will be issued 15 June 2004
- Initial results are due by 15 August 2004.

Draft scenario for tritium in pine trees

Yoshi Inoue (NIRS) presented a draft pine tree scenario. Such a scenario could be useful for reconstructing historical releases of tritium. OBT in pine needles is associated with atmospheric tritium, whereas OBT in the pine tree trunk is associated with groundwater tritium.

At least 4 modellers are interested in this scenario, but, because of the very busy work programme, this scenario will only be issued at the next meeting (September 2004).

Tritium – He-3 Dating of Groundwater

Presentation by Bryant Hudson (Chemical, Biology and Nuclear Science Division, LLNL). Noble gas concentrations in groundwater record conditions at the time of recharge. Ingrowth of He-3 from H-3 decay occurs at a regular rate and is the basis of a dating technique useful over the last 40-50 years. He-3 is isolated from the atmosphere, so the relative proportion of He-3 to H-3 can be related to the age of the groundwater (and thus the H3 in historical precipitation).

Discussion on definition and measurement of OBT

(see attached discussion paper from Yves Belot)

It was decided that the working group should propose a definition of OBT to promote common usage and understanding within the tritium community. The definition will be sent to the ICRP for discussion/dialogue and (hopefully) adoption. Dosimetric data for tritium is under reconsideration at the ICRP, which will introduce dose coefficients for more tritium compounds, e.g. tritium titanide.

General discussion:

- Exchangeable tritium atoms are removed by washing but exchangeable hydrogen atoms are not. So measurements of fixed OBT do not reflect the specific activity of the non-exchangeable hydrogen.
- Should the OBT definition be based on modelling concepts (as the tritium bound to non-exchangeable hydrogen) or on experimental measurements (as the tritium concentration in dry matter or combustion water)?
- OBT occurs due to natural processes in living systems; other compounds should be referred to as tritiated organics.
- OBT is the non-exchangeable tritium in biogenic compounds
- The definition of OBT should be consistent with the dose coefficient in common use, which is based on carbon turnover time in the human body
- How does OBT in cellulose fit into this definition? OBT forms naturally in plants but is not an issue for dose because humans do not digest cellulose.

Working Definition of OBT: *non-exchangeable tritium that is originally formed through natural environmental or biological processes from HTO (or HT via HTO). OBT is an experimental number obtained from combustion, digestion, etc. and this value must be corrected if the specific activity of tritium in non-exchangeable hydrogen is required. Other types of organic tritium should be called tritiated organics, which can be in any chemical or physical form.*

Examples of tritiated organics are needed. Units of measurements should be defined (Francoise Siclet to lead).

Phil Davis will refine this definition and circulate it among WG members for comment. The WG agreed to ask Yves Belot (France) to finalise the definition and to liaise with the ICRP.

Additional tritium test scenarios, including those involving tritium dynamics in large animals and aquatic organisms

Further scenarios for tritium model-data intercomparison studies were discussed.

There is a possibility of a Loire River Scenario, as presented originally at the last plenary meeting in Vienna. But this scenario is already being modelled by the EMRAS River Group. To be discussed again at the September meeting.

The Perch Lake Scenario could be extended to let (hypothetical) tritiated organics enter the lake. However, this would then be a model-model intercomparison (for equilibrium conditions) and not a model-data intercomparison. To be discussed again at the September meeting.

It would also be possible to extend the Hypothetical Scenario, as well as the Pine Tree Scenario, to include subsurface water movement into river water.

Experiments involving animals:
Greek participants are still awaiting the outcome of their research proposal.

Scientists in Russia (Obninsk, Institute of Agricultural Ecology, Director Rudolf Alexakhin) can undertake experiments with cows, sheep and goats. They have already done experiments with HTO (ingestion and injection) where animals were fed HTO (water), contaminated feed (including OBT) and inhaled HTO for 1 hour. However, they are dependent on ISTC funding being released, i.e. an ISTC collaborator is needed. Results could be available in 3-4 years.

The Technical University of Munich also has the necessary equipment for tritium experiments with animals (e.g. a continuous growth chamber) and they have previously collaborated in ISTC Programmes.

The meeting decided that Birgit Wierczinski (Technical University, Munich) should liaise with the Institute of Agricultural Ecology, Obninsk, with the aim to undertake tritium experiments with animals under the ISTC programme and provide data for model testing to the WG.

Experiments involving aquatic organisms:

AECL (Canada) plan to undertake a study this summer involving fresh water mussels, as they are quite robust. The consequences of transplanting mussels (in terms of mussel physiology/metabolism) to Perch Lake were discussed. It might be possible to observe the mussels with an underwater camera. Modellers would also need HTO/OBT concentrations in algae, as well as dissolved OBT concentration. Mussels must be the same age. Only the edible part of the mussel will be analysed. Francoise Siclet (EDF) will check for an indicator of good health from experiments conducted at EDF. Desorption experiments will also be useful. Discussion will be continued at the September meeting and this scenario may or may not be adopted depending on how well the experiments go.

Further fish data from GE Healthcare (Amersham plc) may also be available.

Future Work Programme

ITEM	ACTION	PERSON	DATE
Hypothetical scenario	BIOMASS Reference data to P Guetat	Technical Secretariat	7 May 2004
	Submit updated scenario	P Guetat	15 May 2004
	Comment on scenario	Modellers	30 May 2004
	Issue final scenario	P Guetat	15 June 2004
	Submit results	Modellers	15 Aug 2004
Perch Lake Scenario	Submit short description of model, explanation of results and description of averaging procedures	Modellers	15 June
	Draft report	P Davis	Sept 2004
Soy bean scenario	Submit short description of model plus explanation of results, including model prediction of growth rate and water content of plant	Modellers	15 June
	Draft report	Hansoo Lee	Sept 2004
C-14 Scenarios	Submit short descriptions of the data sets	Data holders	30 June 2004
Pickering Scenario	Distribute second draft scenario	P Davis	30 May 2004
	Submit results	Modellers	30 July 2004
Pine tree scenario	Send scenario description to Secretariat	Y Inoue	30 July 2004
Definition of OBT	Refine definition and distribute for comment	P Davis	30 July 2004
	Finalise definition	Y Belot	Sept 2004
Animal experiments	Liaise with Obninsk	B Wierczinski	Sept 2004
General	Send BIOMOVS Scenario on C-14 Canadian Lake to F Siclet	Technical Secretariat	15 May 2004
	Contact N Beresford for C-14 data in sheep	Technical Secretariat	Sept 2004

For the Perch Lake and soybean scenarios, modellers are also asked to

- correct any simple mistakes in their results (arithmetic errors, problems with units and so on) and send the revised predictions to Ansie as soon as possible. Modellers should not submit new results with an improved model.
- check the spreadsheets and graphs to ensure that their results have been correctly recorded and displayed
- send descriptions of the way they calculated uncertainties to the scenario leaders.

Next Meeting

The next meeting will be held in Baden-Baden in conjunction with Tritium 2004 during the week of 12-17 September 2004. Participants must register with Tritium 2004. Participants are advised to book accommodation early. Further information as to the exact meeting dates during this week will be circulated as soon as possible.

Further Information

Information on the activities within EMRAS generally and on the Tritium and C-14 WG in particular (including the scenarios being used for model testing), can be obtained from the following people, respectively:

Mr. M Balonov
(Scientific Secretariat)
Unit Head
Dischargeable Waste Unit
Waste Safety Section
Division of Radiation and Waste Safety
Department of Nuclear Safety
International Atomic Energy Agency
Wagramerstrasse 5
P.O.Box 100, A-1400,
Vienna, Austria
Phone: (43 1) 2600-22854
Fax: (43 1) 2600-29653
E-mail: m.balonov@iaea.org

Mr. P. Davis
(Working Group Leader)
Senior Scientist, Environmental Technologies
Branch, Station 51A
Atomic Energy of Canada Limited (AECL)
Chalk River Laboratories
K0J 1J0 Chalk River, Ontario
Tel: +1 (613) 584-3311 x3294
Fax: +1 (613) 584-1221
Email: davisp@aecl.ca

ANNEX A: List of Participants at EMRAS Tritium and C-14 Working Group Meeting, Lawrence Livermore National Laboratory, Livermore, USA (19-22 April 2004).

Mr. F. Baumgärtner
Director Emeritus, Institute für Radiochemie
Technische Universität München
Grososstrasse 10d
D-82166 Gräfelfing
GERMANY
Tel: +49 (89) 851-347
Fax: +49 (89) 854-4487
Email: bgt@rad.chemie.tu-muenchen.de

Mr M Balonov
Dischargeable Waste Unit, Waste Safety Section
Division of Radiation and Waste Safety
Department of Nuclear Safety
International Atomic Energy Agency
Wagramerstrasse 5
P.O.Box 100, A-1400,
Vienna, Austria
Phone: (43 1) 2600-22854
Fax: (43 1) 2600-29653
E-mail: m.balonov@iaea.org

Mr. P. Guetat
Deputy Head of Radioanalyze Clinic Environment,
CEA/DAM/DASE/RCE
Commissariat à l'Energie Atomique (CEA)
Centre de Bruyères le Chatel
B.P. 12
F-91680 Bruyeres le Chatel
FRANCE
Tel: +33 (1) 6926-4543 (Secretary)
Fax: +33 (1) 6926-7065
Email: philippe.guetat@cea.fr

J Koarashi
Radiation Protection Division,
Tokai Works,
Japan Nuclear Cycle Development Institute
Tokai-mura, Nakagun
Ibaraki 319-1194
Japan
Fax : +81-29-282-9966
Email: koarashi.jun@jnc.go.jp

Mr I Benovich
Ontario Power Generation
Environment Support and Services
700 University Ave. (H17-E26)
Toronto, ON M5G 1X6
Canada
Tel: +1 (416) 592-7154,
Fax +1 (416)592-2466
Email: irv.benovich@opg.com

Mr. P. Davis
Senior Scientist, Environmental Research Branch,
Station 51A
Atomic Energy of Canada Limited (AECL)
Chalk River Laboratories
K0J 1J0 Chalk River, Ontario
CANADA
Tel: +1 (613) 584-3311 x3294
Fax: +1 (613) 584-1221
Email: davisp@aecl.ca

Mr. Y. Inoue
Senior Researcher, Dept. of Int. Co-operation,
Research Exchange & Training
National Institute of Radiological Sciences (NIRS)
9-1, Anagawa 4-chome
Inage-ku
263-8555 Chiba-shi
JAPAN
Tel: +81 (43) 206-3051
Fax: +81 (43) 251-7819
Email: y_inoue@nirs.go.jp /
yoshi_inoue2001@hotmail.com

Mr C W Lee
Nuclear Environment Division
Korea Atomic Energy Research Institute
150 dukjindong, Yuseong
305-353 Daejeon
Republic of Korea
Tel : +82-42-868-2296
Fax : +82-42-863-1289
Email : cwlee@kaeri.re.kr

Mr. H. Lee
Project Manager, Nuclear Environment Division
Korea Atomic Energy Research Institute (KAERI)
P.O. Box 105
150 Dukjin-dong; Yusong
305-600 Taejon
KOREA
Tel: +82 (42) 868-2395
Fax: +82 (42) 863-1289
Email: hslee5@kaeri.re.kr

Mr V Mishra
DOE
Lawrence Livermore National Laboratory (LLNL)
7000 East Avenue
P.O. Box 808
CA-94551 Livermore
USA

Mr. M. Saito
Safety Reassurance Academy
Okubo-Naka 3017-4, Kumatori-cho
Sennan-gun
590-0403 Osaka
JAPAN
Tel: +81 (72) 452-6709
Fax: +81 (72) 452-6709
Email: hmsaito@vega.ocn.ne.jp / saito@rri.kyoto-u.ac.jp

Ms. A. Venter
Enviros Consulting Limited; Telegraphic House
Waterfront Quay
Salford Quays
M50 3XW Manchester
UNITED KINGDOM
Tel: +44 (161) 874-3617
Fax: +44 (161) 848-0181
Email: ansie.venter@enviros.com

Mr K Yamamoto
4-937 Nishiya-cho Hodogaya-ku Yokohama,
Kanagawa,
Japan
240-0052
Tel +81-45-382-0639
Fax +81-45-382-0829
Email: yamamoto@yfirst.co.jp

Mr Paul Marks
Amersham plc,
The Grove Centre,
White Lion Road,
Amersham
HP7 9LL
UNITED KINGDOM
Tel:+44 (1494)545165
Email: paul.marks@amersham.com

Ms. R. Peterson
Environmental Analyst, Operations & Regulatory Affairs Division (MSL-629)
Lawrence Livermore National Laboratory (LLNL)
7000 East Avenue
P.O. Box 808
CA-94551 Livermore; USA
Tel: +1 (925) 424-6453
Fax: +1 (925) 422-8684
Email: peterson49@llnl.gov

Ms. F. Siclet
Department LNHE
Electricité de France (EDF) –
Département Environement (R&D)
6, Quai Watier; B.P. 49
F-78401 Chatou Cédex
FRANCE
Tel: +33 (1) 3087-7847
Fax: +33 (1) 3087-7336
Email: : francoise.siclet@edf.fr

Ms B Wierczinski
Technische Universität München
Institut für Radiochemie
Walther-Meissner-Strasse 3
85748 Garching
Telefon: 089 289 14342
Fax: 089 289 12204
e-mail: Birgit.Wierczinski@Radiochemie.de
homepage: www.radiochemie.de