The IAEA's Programme on Environmental Modelling for RAdiation Safety (EMRAS II)

EMRAS II
Approaches for Assessing Emergency Situations
Working Group 8
"Environmental Sensitivity"

M I N U T E S

of the 3rd Meeting hosted by the Institute of Agricultural & Environmental Chemistry
Università Cattolica del Sacro Cuore, Piacenza, ITALY
1–2 July 2010

IAEA Scientific Secretary	Working Group Leader
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Attending

Name / Initials* / Email	Organization / Country
Mr John E. Brittain ***(JEB)*** (j.e.brittain@nhm.uio.no)	Freshwater Ecology & Inland Fisheries Laboratory (LFI), University of Oslo, NORWAY
Ms Franca Carini ***(FC)*** (franca.carini@unicatt.it)	Università Cattolica del Sacro Cuore, ITALY
◇Mr Sohan Chouhan ***(SC)*** (chouhans@aecl.ca)	Atomic Energy of Canada Limited (AECL), CANADA
Mr Mikhail Iosjpe ***(MI)*** (mikhail.Iosjpe@nrpa.no)	Norwegian Radiation Protection Authority (NRPA), NORWAY
Mr Luigi Monte ***(LM)*** (luigi.monte@casaccia.enea.it)	ENEA, CR Casaccia, ITALY
◇Ms Catrinel O. Turcanu ***(COT)*** (cturcanu@sckcen.be)	Studiezentrum für Kernenergie (SCK/CEN), BELGIUM

ΔMr Bliss L. Tracy has retired from Health Canada since this meeting took place, please note the new email address.

*Initials used to refer to participants within minutes and actions as appropriate.

◇Unable to attend the meeting but contributed via email.

Working Group Attendance

Six participants of the EMRAS II Environmental Sensitivity Working Group (WG8) gathered for 1.5 days (1–2 July 2010) at the Università Cattolica del Sacre Cuore in Piacenza, Italy. Two other participants were unable to attend but sent results by email. The purpose of the meeting was to assess progress on modelling exercises and to discuss the next steps, in preparation for the 3rd EMRAS II Technical Meeting, being held 24–28 January 2011.

Overall Objectives and Tasks

The objective of WG8 is to explore the concept of environmental sensitivity in rural and semi-natural environments within the framework of assessments after an emergency situation. The main tasks of WG8 are to:

- formulate the concept of environmental sensitivity;
- compile a list of sensitivity factors;
- design scenarios; and
- carry out modelling exercises.

Presentations

The following presentations on individual models were given by participants at the meeting or submitted electronically by absent working group members:

- Mikhail Iosjpe (MI) – Coastal Marine Regions Preliminary Results;
- Sohan Chouhan (SC) – ♣CHERPAC results for agricultural and forest pathways;
- Luigi Monte (LM) and John Brittain (JEB) – Assessment of two lakes by ♣MOIRA-PLUS;
- Bliss Tracy (BLT) – ♣Forest and Arctic Ecosystems.
- Catrinel Turcanu (COT) – ♣Agricultural scenario.

♣ Indicates the name of the presentation given on the WG8 web page (http://www-ns.iaea.org/projects/emras/emras2/working-groups/working-group-eight.asp?s=8).

Coastal Marine Scenario

MI presented preliminary results on 6 different coastal marine regions (see the table below), chosen to represent differing sea conditions. A single deposition of 1000 Bq m^{-2} was chosen for 4 radionuclides, i.e., ^{137}Cs, ^{90}Sr, ^{131}I and ^{239}Pu. Radionuclide concentrations were calculated in sea water (unfiltered and filtered), fish, molluscs, crustaceans and seaweeds. Doses were calculated for adult, 10 and 1 year old children during the 1st, 2nd and 10th year after releases of radionuclides. Seasonality was not taken into account because this factor usually does not exert a strong influence in marine systems. It was found that Pu gave the highest doses for each category of people, and that doses to adults were always higher than doses to children.

Comments:

- Our understanding of parameterization needs to be improved.
- A factor is needed to specify the "delay" between deposition and assessment. This is important for ^{131}I.
- Wherever possible, kinetic models rather than concentration factors should be used. Distribution coefficients and concentration factors have great variability.
- It would be interesting to compare different regions, e.g., marine to freshwater systems or global to regional fallout.
- We need to be clear regarding our definition of "critical groups".

Agricultural Scenario

SC sent preliminary results by email for agricultural and forest environments. Again, instantaneous depositions of 1000 Bq m^{-2} were assumed for each of ^{137}Cs, ^{90}Sr and ^{131}I. Both dry and wet depositions were considered. Seasonal effects were considered for winter (15 February), spring (15 May), summer (15 August), and autumn (15 November). The concentrations in common food products and doses to adults, 10 year olds and 1 year olds were calculated for up to 2 years after deposition. Detailed results were presented from one selected case: ^{137}Cs, dry deposition and release occurring in summer. CHERPAC also contains a lake and fish model for Cs although the start point is not the same as for the agricultural scenario. Further clarifications were obtained through email correspondence with ***SC***.

Freshwater Aquatic Scenario

LM and JEB carried out a comparison between Lake Bracciano (a volcanic lake in Italy) and Lake Øvre Heimdalsvatn (a glacial lake in the Jotunheimen Mountains of central Norway). Lake Bracciano is very deep, with a pH ~ 8 and a low potassium content. It is never covered by ice, never reaches temperatures below 7–8°C. The mean water retention time is 137 years. Lake Øvre Heimdalsvatn is much smaller, with a mean depth of 4.7 m, a surface area of 0.78 km^2 and a catchment area of 23.6 km^2. The water residence time varies from 2 days at the peak of the spring run-off up to more than 400 days in winter (yearly average value 60–70 days).

Their first step was to calibrate the model for Cs using field data from the Chernobyl accident, then to account for:

1. environmental differences;
2. social differences;
3. population habits; and
4. consumption of animal products.

The environmental sensitivity analysis was performed assuming an instantaneous deposition of 1000 Bq m^{-2} of ^{137}Cs and ^{90}Sr occurring under different seasonal conditions (winter, spring, summer and autumn). However, due to the particular input-output structure of MOIRA-PLUS, the deposition was assumed to occur over a period of 1 month at constant rate.

The parameters chosen to indicate environmental sensitivity were the time integrated concentrations of radionuclides in water and fish as well as the dose to fish. Environmental sensitivity was calculated as the ratios of the time integrated concentrations of radionuclides in water and fish and of the dose to fish, divided by the deposition (1000 Bq m^{-2}), at 1 year, 2 years and 10 years following the contamination event. Furthermore, similar calculations were performed for the doses to critical groups of individuals due to: (a) water and fish ingestion; and (b) ingestion of water, fish and of crops and animal products contaminated following the irrigation by water from the lakes.

The most sensitive scenario was the summer deposition in Lake Øvre Heimdalsvatn, when the lake is not frozen. However, the contamination of Lake Bracciano water was more persistent, due to a longer water residence time. A distinction was made between environmental sensitivity assessment and dose assessment because in calculating doses we use not only environmental data but also data on social habits, e.g., different consumptions of fish. Critical groups eat approximately the same amount of fish. There was some discussion of the difference between dose accumulated during one year as opposed to average yearly dose. We need to refer to ICRP 108 with regard to their method of dose calculation.

Forest Scenario

BLT presented a forest scenario for an aboriginal community living at Wollaston Lake in northern Saskatchewan, Canada. Uptakes through terrestrial food chains were calculated based on the Steady State Environmental Transport Model from Standard N288.1 developed by the Canadian Standards Association. The model was designed for calculating annual Derived Release Limits from nuclear facilities under steady-state conditions, but for the purpose of this exercise, it was adapted for a single input and transient terms were added to account for radioactive decay or disappearance from the environment through ecological processes.

Depositions were considered for the 3 radionuclides, i.e., ^{137}Cs, ^{90}Sr, and ^{131}I, under both dry conditions and heavy rainfall. Radiation doses were presented for adults, 10 year olds and one year olds during the 1st, 2nd and 10th year after a summer deposition. Radionuclide concentrations were also calculated in environmental compartments (soil, water and plants or animals) either consumed directly by humans or as components of food chains leading to humans.

Summary of Results

Preliminary results from these scenarios are given in the following table. All are based on initial depositions of 1000 Bq/m^2 for each radionuclide.

	Adult doses (microsievers per year), First year after accident			
Marine *(MI)*				
Location:	**Cs-137**	**Sr-90**	**I-131**	**Pu-239**
Irish Sea	1.65	0.283	4.2	43.0
English Channel	0.95	0.132	2.9	67.5
North Sea	0.62	0.087	0.8	12.3
Skagerrak	0.88	0.128	0.6	47.6
Baltic Sea	2.58	0.422	5.1	
Kara Sea	2.86	0.509	11.0	48.3
CHERPAC *(SC)*				
Agricultural	1920	282	466	
Forest	11.2	0.403	0.04	
Forest *(BLT)*	31.80	3.05	0.09	
Aquatic *(LM and JEB)*	(summer)	(spring)		
Ovre Heimdalsvatn	2.9	420		
Lake Bracciano	0.41	150		

General Discussion

It was agreed that the end point calculations for each scenario should be doses to humans. Concentrations in essential abiotic and biotic media (soil, water, food items, etc.) should also be reported. Concentrations and doses for the different radionuclides should not be summed, but should be reported separately.

The following general scheme was proposed for comparing doses within ecosystems and across ecosystems:

	Annual radiation doses			
	Cs-137	**Sr-90**	**I-131**	**Etc.**
Within a given ecosystem				
Adult				
10-year old				
Infant				
Year One				
Year Two				
Year Ten				
Et cetera				
Spring				
Summer				
Fall				
Winter				
Across Ecosystems				
Ecosystem One	worst case	worst case	worst case	
Ecosystem Two	worst case	worst case	worst case	
Etc.	worst case	worst case	worst case	

Permafrost can show a movement of radionuclides towards the top during spring, when there is melting. Resuspension from soil or sediment should be considered a sensitivity factor.

Comparisons across ecosystems can be quite different if made per surface area, rather than per region. NRPA model ***(MI)*** has been used to make calculations on geographical regions, however data are more comparable if expressed per surface area.

There were still some differing views on exactly what we mean by “environmental sensitivity”. One suggestion was to explain or clarify what each member perceives as environmental sensitivity and come to an agreement on one or more perspectives.

Dose sensitivity is a binary concept: something is sensitive to something else. We make an assessment of the dose sensitivity to the environment. We can distinguish between sensitivity to biota and sensitivity to man.

We need to determine those environmental parameters which affect sensitivity. If we calculate Bq/kg, this is the concentration available in this environment for the consumption. We can present Bq/kg and say that they are a reflection of environmental sensitivity. We need to provide something unambiguous. We could use humans as an indicator of the environment.

Another aspect of sensitivity involves a statistical analysis of the effects of variations in the different parameters. The same parameters may exert different influences in different environments or at different times. ***MI*** has calculated a “sensitivity index” for the different radionuclides taking into account various parameters such as Kd and others. He uses the concept of local sensitivity index (Jorgensen, 1994).

It was noted that concentration factor is a model parameter, not an environmental parameter.

VB suggested that WG8 present a paper at the ICRER Conference in Hamilton, Ontario, Canada, 19–24 June 2011. An abstract was submitted in advance of the 15 September 2010 deadline.

Requirements for Further Modelling

Further work is needed particularly on the agricultural scenarios. Arctic scenarios should be run for northern Canada and Scandinavia. The MOIRA approach could be applied to a lake on the Canadian Shield. Coastal marine modelling could be extended to the Canadian Arctic and to the Mediterranean.

Progress on Goals

Task	
Review of the concept of environmental sensitivity	
Literature review	June 2009 (done)
Draft concept document	January 2010 (done)
List of environmental sensitivity factors	
Initial list	February 2010 (done)
Final list	2011
Scenario developments	
Design	January 2010 (done)
Modelling exercises	
Interim results	June 2010 (done)
Final results	June 2011
Final report	
Submission of final report	January 2012

Next Meeting

The next (fourth) Working Group 8 Meeting is scheduled to take place during the next (Third) EMRAS II Technical Meeting, being held at IAEA Headquarters in Vienna, 24–28 January 2011.