IUR Web Based Questionnaire Results for Multipollution

Research, Facilities and Scientific Priorities

Executive Summary

The IUR Taskgroup for Protection in a Multipollution Context

The IUR Taskgroup for protection in a multipollution context main emphasis is to bring together experts involved in experimental research and model development in closely related areas of environmental chemistry and toxicology. It has the following primary objectives:

- To bridge the gap between radioecology and other areas of environmental contamination and toxicology through identification of synergies;
- To identify interested researchers and facilities where multipollution research is or may be conducted
- Review literature on behaviour and effects of radionuclides in a multipollution context and compare approaches in study of environmental behaviour, environmental risk assessment and effects analysis in the study of conventional contaminants and radiocontaminants;
- Identify knowledge gaps and most important research needs
- Establish common research programme e.g. on study of combined effects and model formulation for combined effects; effect of multipollution context on the effects induced by a single pollutant and study of occurrence of synergistic/additive effects; study and validation of bioassays in a multipollution context

To help establish these objectives, an interactive website containing a research expertise questionnaire was set up to collate information on the following:

1. To identify knowledge gaps and to prioritise research requirements to address them;
2. To identify research groups working on the issue of multipollution, their interest in this study and/or capacity to conduct multipollutant studies.

This report represents the findings of this questionnaire. In total, nineteen respondents provided the information that is summarized below. Researchers were asked their opinions of multipollution research deficiencies and priority areas for future R&D multipollution programmes. These can be summarized, in order of priority, as follows:

1. We need to better understand how the multipollution context affects the behaviour of a single pollutant (e.g. migration, bioavailability of U where there are other chemical contaminants present
2. We need to investigate additive and synergistic effects
3. We need to consider the ecological response of biota to both radioactive and non-radioactive chemical stressors
4. We rely too much on single stressors exposure experiments
5. We rely too much on single pollutant scenarios in contaminant behaviour studies
6. We need to investigate how environmental parameters affect the behaviour of multiple stressors in order to propose the most adequate remediation strategies
7. We need to better understand and estimate uncertainties in a multipollution context

Four other knowledge gaps were offered for consideration:

- We need to better understand internal interactions (i.e. beyond environmental influences, to consider internal biokinetics/toxic response, including homeostasis & adaptive response, as well as multiple effect thresholds; this includes considering if/how physiologically based pharmacokinetic/pharmacodynamic models might help guide the evaluation.
- We need to better understand/define appropriate approaches for (a) extrapolation (including across species, routes, timing, and to environmentally relevant doses, also considering compositional differences (e.g., relative proportion of mixtures components), and (b) selecting and evaluating appropriate indicators or surrogates, ranging from indicator organisms for certain conditions to biomarkers of exposure and effect.

- We need to better understand the biological relevance of the indicated effect, and how to appropriately account for differential sensitivity/susceptibility.
- We need to provide input to "-omics" studies (genomics, proteomics, metabolomics/metabonomics) and related informatics, so these studies can provide meaningful information at the whole-organism level that can be incorporated into risk assessments to guide decisions for overall protection.

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Introduction

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Time Frame

The process to generate the questionnaire and prepare this report was conducted on the following timescale:

- Initial discussions on the requirements for the interactive website (June - August 2004)
- A core group discussed and prepared the questions to appear on the website. An invitation was made to identify interested parties and IUR members who can participate in the review of the information received. (September 2004)
- Interactive website and data collection to start (December 2004) for both the available facilities and researchers within the IUR membership and information on knowledge gaps
- Nine to ten month live period while the website was running for IUR members and other interested parties to provide ideas and list knowledge gaps (December 2004 to September 2005)
- Review of information received and summary prepared for discussion at task group meeting (April 2005 to September 2005)
- Dissemination of final summary report (October 2005)

Report Structure

This report represents the findings of this questionnaire. The report is split into two sections. The first section is concerned with multipollution knowledge gaps and provides priorities for future R&D programmes. The second section lists the research interests and facilities of all the questionnaire respondents

Report Contributors

This report has been prepared by the Multipollution Taskgroup members.

- Carmel Mothersill
- Christelle Adams
- David Copplestone
- Hildegarde Vandenhove (Chair)
- José Godoy
- Masahiro Doi
- Satoshi Yoshida
- Stanislav Geraskin

The Taskgroup members would like to thank the input of David Wilson in data collation and evaluation and report writing.

Knowledge Gaps and Issues – statement summaries to derive future R&D needs and priority areas.

Multipollution research is concerned with the interactions (whether synergistic, additive, antagonistic) between radionuclides and other environmental contaminants, such as dioxins, heavy metals, PAHs, PCBs and pesticides.

IUR members and other interested parties where asked, via a research expertise questionnaire, their opinions on a series of seven statements relating to multipollution research knowledge gaps and issues. The statements where rated 1-5, based on whether the respondent strongly agreed (1), agreed (2), neither agreed nor disagreed (3), disagreed (4) or strongly disagreed (5) with the statement. The questions were generated by agreement with the IUR multipollution taskgroup members.

The summary of the statements and responses are found in Figure 1. Nineteen responses were received in total. In order to assist with the direction of future research programmes, these responses where ranked in order of priority. Priority rankings for each statement were calculated by attaching a score to each rating, and adding these scores up. The scores were: strongly agree = 2; agree = 1; neither agree nor disagree =0; disagree = -1; and strongly disagree = -2. Therefore, the total score for each statement could range between -38 (all strongly disagrees) to 38 (all strongly agrees).

Full details of the breakdown of response to each statement are given in Appendix 1.

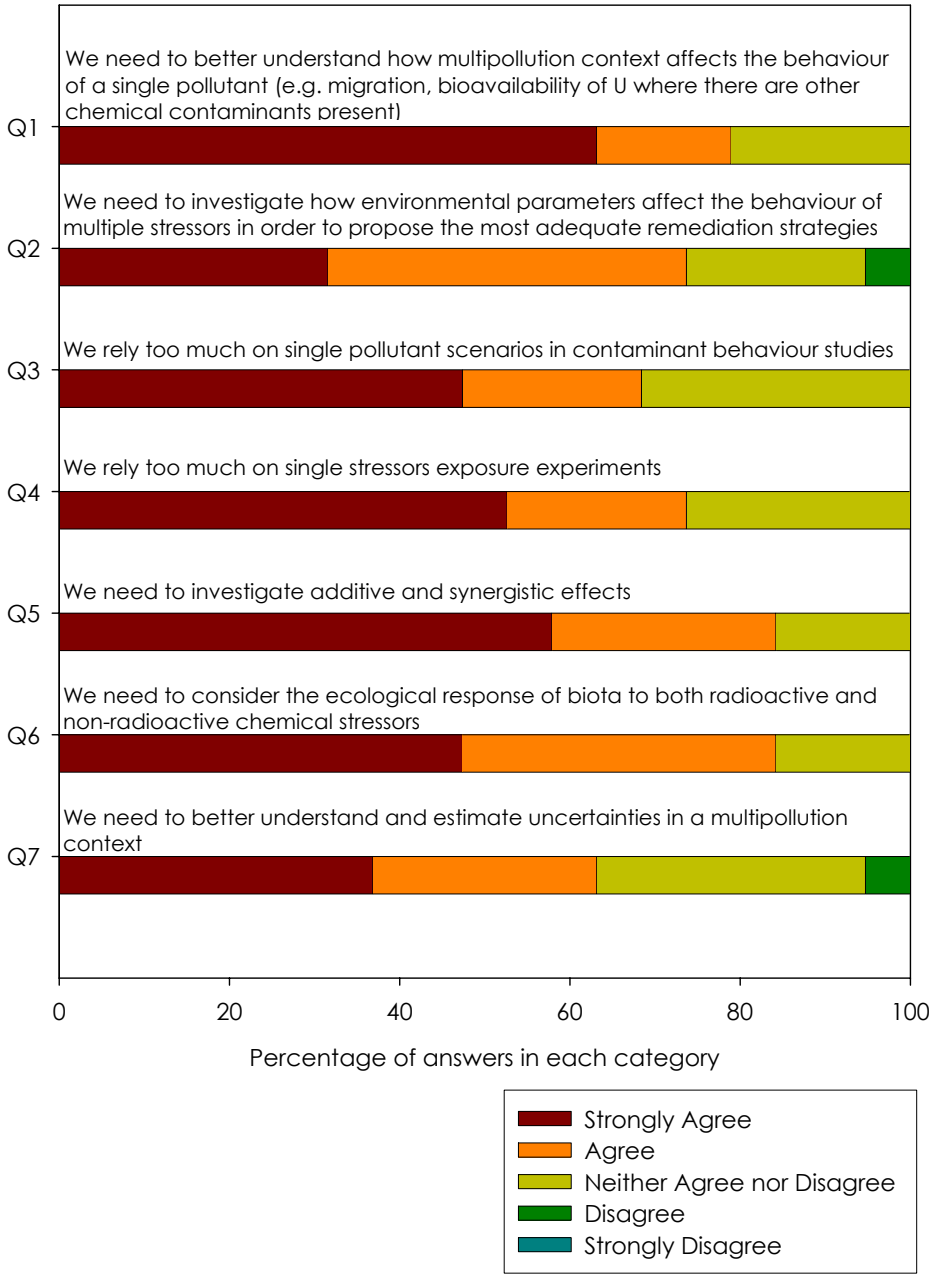

Figure 1. Summary of responses to proposed multipollution research knowledge gaps.

The majority of responses to all questions were positive (either strongly agree or agree). At least 63% (statement 7) of respondents agreed with all statements. To further highlight this fact, only statements 2 and 7 received any negative responses (both by the same respondent). A number of comments were received to qualify these responses.

- Statements 1(how multipollution affects single pollutants), 5 (investigating interactions)& 6 (response of biota to radioactive and non-radioactive chemical stressors) were all considered important because 'there are very few, if any sites where a single pollutant acts on its own'.
- A suggestion was made to alter statement 5 to read ' We need to investigate interactions' (or at least antagonistic and synergistic effects), as additivity is the common default.
- A suggestion was made to alter statement 6 to read 'We need to consider the ecological response of biota, and the health response of humans, to both radioactive and non-radioactive chemical stressors
- Whilst agreeing with statement 2 (investigating how environmental parameters affect multiple stressor behaviour), a respondent suggested that remediation strategies should be targeted at the most important stressors at any particular site, requiring an understanding of how environmental conditions affect different stressors. Furthermore, the data on single species (of bacteria and fungi at least) differ greatly. A more molecular orientation of studies would likely result in a better understanding than measuring just caesium contents in fruitbodies. This is essential to understand uptake mechanisms and thus remediation.
- A caveat was suggested for statement 3 (relying on single pollutant scenarios studying contaminant behaviour); that it was probably true in the laboratory, but not in the field, where a wider range of contaminants is usually studied.
- Support for statement 4 (relying on single stressor exposure experiments) was received, but it was stated that the experimental data for multiple stressor exposures does not exist as yet.
- In supporting statement 7 (understanding and estimating multipollution uncertainties), it was suggested that achieving this goal would be difficult until methodologies encompass uncertainty assessments.

Finally, it was suggested that these knowledge gaps were more important and relevant for ecotoxicologists: radioecologists already appreciate the sensitivity of ecosystems.

In order to assist with the direction of future multipollution research programmes, the findings show that knowledge gaps should be addressed in the following order:

Rank	Score	Statement
1	27	We need to better understand how multipollution context affects the behaviour of a single pollutant (e.g. migration, bioavailability of U where there are other chemical contaminants present.
1	27	We need to investigate additive and synergistic effects.
3	25	We need to consider the ecological response of biota to both radioactive and non-radioactive chemical stressors.
4	24	We rely too much on single stressors exposure experiments.
5	22	We rely too much on single pollutant scenarios in contaminant behaviour studies.
6	19	We need to investigate how environmental parameters affect the behaviour of multiple stressors in order to propose the most adequate remediation strategies.
7	18	We need to better understand and estimate uncertainties in a multipollution context.

In addition to these deficiencies, a further four knowledge gaps were proposed for consideration:

- We need to better understand internal interactions (i.e., beyond environmental influences, to consider internal biokinetics/toxic response, including homeostasis & adaptive response, as well as multiple effect thresholds; this includes considering if/how physiologically based pharmacokinetic/pharmacodynamic models might help guide the evaluation.
- We need to better understand/define appropriate approaches for (a) extrapolation (including across species, routes, timing, and to environmentally relevant doses, also considering compositional differences (e.g., relative proportion of mixtures components), and (b) selecting and evaluating appropriate indicators or surrogates, ranging from indicator organisms for certain conditions to biomarkers of exposure and effect.

- We need to better understand the biological relevance of the indicated effect, and how to appropriately account for differential sensitivity/susceptibility.
- We need to provide input to "-omics" studies (genomics, proteomics, metabolomics/metabonomics) and related informatics, so these studies can provide meaningful information at the whole-organism level that can be incorporated into risk assessments to guide decisions for overall protection.

Additional Comments

There were some general comments on the questionnaire procedure. Apart from the fact that people considered it time consuming the main comment was as follows:

'I particularly appreciate one of the aims of this questionnaire that is to evaluate the numbers of laboratories able to work on the multipollution context. It should perhaps be emphasized that it must include the radionuclides (because all the ecotoxicology laboratories are able to work on multipollution in general). Such a questionnaire could raise interesting collaborations. I spent quite a lot of time to fill in the different forms (expertise on transfer and effects could be on the same page, since usually, they relate to the same studies (ecosystems & contaminants)). As regards knowledge gaps, it is difficult to rank them, because they are numerous and not particularly related to radioecology. I think the form on organisation details should be at the end (because you have to fill in "private" details, before knowing the questions you'll have to answer to). The same problem with giving the names of two persons of our staff (I don't see the aim of that point). A little problem is not being able to read again the forms once they are fell in. As regards the process of providing the questionnaire outside the UIR Taskgroups, how will this be done?'

Details were also given on a Master's programme offered by the University of Helsinki.

Research Interests, Capabilities and Facilities

To facilitate joint working and collaboration amongst researchers in environmental multipollution, respondents were asked a series of questions about their research interests, capabilities and facilities. Research interest and capability questions were in two separate areas: the transfer, and the effects of radionuclides and other contaminants. The questions asked where as follow:

Transfer of Radionuclides
Do you conduct studies on transfer processes in the environment in a multipolution context?
Provide details of main experience/strengths, ecosystem studied, and type of experiment.

Do you conduct studies of the effects of multipollution on the environmental behaviour of radionuclides?
Provide details of main experience/strengths, contaminants worked or are interested in working with, ecosystems studied and type of experiments.

Effects of Radionuclides
Do you conduct studies on radionuclide transfer to organisms in a multipollution context?
Provide details of main experience/strengths.

Do you conduct studies of the effects of multipollution on biota?
Provide details of main experience/strengths.

Do you have the capability to conduct studies of the effect of multipollutants on biota, if you do not already conduct them?
Provide details of main experience/strengths.

Provide details of organisms worked with and ecosystem worked in, contaminants worked or are interested in working with, and the biological effects studied.

Have you performed Environmental Risk Assessments for radioactive and non-radioactive pollutants and/or have interest in it and/or would like to contribute in a comparison of approaches in ERA for conventional contaminants and radionuclides?
Provide details.

In total, there were nineteen respondents. A summary of responses concerning the transfer and effects of radionuclides are in Tables 1 and 2 respectively. Full details of all responses on the transfer of radionuclides, the effects of radionuclides, and the organisations research facilities can be found in Appendix 2.

Generally it may be concluded that at the institutes of the nineteen respondents, very limited studies are conducted dealing explicitly with the effects of multipollution, including radionculides, on contaminant behaviour and induced effects. Sometimes investigations or assessments are performed in a multipollution environment, however, without really considering the implications of the multipollution context.
Eleven of the nineteen respondents perform studies including radionuclides. Overall there are more studies performed in the freshwater and marine environment than in the terrestrial environment.
Research topics and interests are very diverse.

In order to find areas of common interest and facilitate collaboration between organisations, respondents were asked if they had interest in participating in common experiments in the context of multipollution.
Considering the priority areas identified and the research areas and interests indicated it can be primarily suggested that collaborations can be sought in (1) small well-defined experimental set ups to study (1) the effect of the multiple pollution context on (single) pollutant availability and transfer either in the freshwater/marine environment or terrestrial environment; (2) small well-defined experimental set ups to study the effects induced by multiple stressors in the freshwater/marine environment or terrestrial environment; (3) performing ERA at multipolluted sites.
Preliminary grouping of respondents interested to study multipollutant (including RADs) transfer and/or effects) or ERA is given in Tables 3-6.

Respondents were also asked if they are have access to data on multistressor studies including radionuclides? Seven respondents replied they had access to this information and would like to share this information.

The organisations that took part in this questionnaire are as follows:

1. Argonne National Laboratory, USA
2. Belgian Nuclear Research Centre, Belgium
3. Centre for Ecology and Hydrology, UK
4. CIEMAT, Spain,
5. Democritus University of Thrace, Greece
6. ECOMatters Inc., Canada
7. Environment Agency, UK
8. Enviros Consulting Ltd, UK
9. Fisheries and Oceans Canada, Canada
10. Friedrich -Schiller –Universität, Germany
11. IRSN, France
12. iThemba Laboratory for Accelerator Based Sciences, South Africa
13. McMaster University, Canada
14. Norwegian University of Life Sciences, Norway
15. Riso National Laboratory, Denmark
16. SENES Oak Ridge, Inc., Center for Risk Analysis, USA
17. SPA "Typhoon", Russia
18. Università Cattolica del Sacro Cuore, Italy
19. University of Helsinki, Finland

Table 1.Summary of research interests and capabilities of respondents in transfer of radionuclides and other contaminants. T-Terrestrial, M-Marine, Fr-Freshwater, CE-Controlled Environment, Fi-Field, Dio-Dioxins, HM-Heavy Metals, Pest-Pesticides, Rad-Radionuclides, O-Other (See Appendix 2 for details).

	Transfer Processess in the Environment in a Multipollution Context						Effects of Multipollution on the Environmental Behaviour of Radionuclides												
Organisation	Conduct Studies?	Ecosystem Type				Experiment Type		Conduct Studies?	Contaminants							Ecosystem Types			Experiment Type	
		✓T	M	Fr	CE	Fi		Dio	HM	PAH	PCB	Pest	Rad	O	T	M	Fr	CE	Fi
Argonne National Laboratory	✓	✓		✓			✓		✓	✓	✓	✓	✓	✓	✓		✓		
Belgian Nuclear Research Centre	✓	✓			✓	✓	✓		✓				✓		✓			✓	
CEH	✓	✓		✓	✓	✓	✓	✓	✓			✓	✓		✓		✓	✓	
CIEMAT									✓							✓	✓		✓
Democritus U. of Thrace												✓			✓		✓	✓	✓
ECOMatters Inc.	✓	✓			✓	✓	✓		✓		✓		✓		✓			✓	
Environment Agency	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Enviros Consulting Ltd	✓	✓	✓	✓		✓			✓	✓	✓		✓		✓	✓	✓		✓
Fisheries and Oceans Canada									✓	✓	✓	✓	✓	✓		✓		✓	
Friedrich -Schiller –Universität	✓	✓			✓	✓	✓		✓				✓		✓			✓	✓
IRSN	✓			✓	✓				✓	✓	✓	✓	✓				✓	✓	
iThemba Laboratory	✓	✓		✓		✓			✓			✓			✓		✓		✓
McMaster U.																			
Norwegian U. of Life Sciences	✓	✓	✓	✓	✓	✓			✓		✓	✓	✓		✓	✓	✓	✓	✓
Riso National Laboratory	✓	✓	✓			✓						✓			✓	✓			✓
SENES Oak Ridge Inc.																			
SPA 'Typhoon'							✓	✓				✓			✓	✓	✓	✓	✓
U. Cattolica del Sacro Cuore																			
U. of Helsinki	✓	✓		✓		✓	✓		✓				✓		✓		✓		✓

Table 2. .Summary of research interests and capabilities of respondents in effects of radionuclides and other contaminants. T-Terrestrial, M-Marine, F-Freshwater (See Appendix 2 for details).

Organisation	Studies on radionuclide transfer to organisms?	Studies on the effects of multipollution on biota?	Capability to conduct effect studies?	Organism Types													Contaminants							Perform Environmental Risk Assessments?
				Amphibians	Bacteria	Birds	Crustaceans	Fish	Insects	Invertebrates	Mammals	Molluscs	Plants	Reptiles	Soil Fauna		Dioxins	Heavy Metals	PAHs	PCBs	Pesticides	Radionuclides	Other	
Argonne National Laboratory	✓	✓									T							✓	✓	✓	✓	✓		✓
Belgian Nuclear Research Centre	✓	✓	✓										T					✓				✓		✓
CEH				T		T					T		T		T		✓	✓			✓	✓		
CIEMAT																	✓	✓						
Democritus U. of Thrace			✓					F					T								✓			
ECOMatters Inc.	✓												T					✓		✓		✓		✓
Environment Agency		✓	✓				TMF	MF		TMF		MF					✓	✓	✓	✓	✓	✓		✓
Enviros Consulting Ltd																								✓
Fisheries and Oceans Canada			✓				M	M		M		M						✓	✓	✓	✓	✓	✓	✓
Friedrich -Schiller –Universität	✓	✓			T													✓				✓		
IRSN	✓	✓					F	F				F	F					✓	✓	✓	✓	✓		
iThemba Laboratory	✓		✓					F					T					✓			✓			✓
McMaster U.	✓	✓						F			T							✓			✓			✓
Norwegian U. of Life Sciences	✓	✓	✓		TMF		TMF	MF	TMF	TMF	TMF		TMF		T			✓		✓	✓	✓		
Riso National Laboratory	✓						M	MF		M	TM	M	TMF								✓			✓
SENES Oak Ridge Inc.																								✓
SPA 'Typhoon'								F			F	F					✓				✓			✓
U. Cattolica del Sacro Cuore																								
U. of Helsinki	✓																	✓				✓		

Table 3: Preliminary grouping of institutes interested and having potential to study multipollutant (including RADs) transfer (and effects) in marine or freshwater environment under controlled conditions

Institute	Main topic	Contaminants	Media	ERA*	Interest for collaboration
CEH	Transfer studies	RAD, HM, dioxines, pesticides (not clear if in MP context)	T: Animals, plants, fauna FW	N	Yes. Not explicit
EA	Transfer (E, F, M)	Virtually all	T, M, F; Crustaceans, invertebrates, Fish, Molluscs	Y	Yes: Any areas of mutual interest
Fisheries and Oceans Canada	No transfer or effects studies: mostly exp. work on Organnometallic compounds	RAD, HM, PAH, PCB, Pesticides	M	Y	Bioaccumulation and tissue distribution
IRSN	Transfer and effects	RAD, HM, PAH, PCB, Pesticides	F: Algae, invertebrates and fish	N	Ideally yes but depends on time and extent of exp
McMaster University	Effects	HM and radiation	T: mammals; F: fish	Y	Fish exposure in heavy metal background
Norwegian University of Life Sciences	Transfer and effects	HM, PCB, Pesticides	T, M, F; Bact, crust, fish, insects, invertebrates, mammals plants		RAD, HM
SPA Typhoon	Transfer	RAD, Pesticides, Dioxins	T, M, F	Y	Yes. Not explicit
iTemba Laboratory of Accelerator Based Sciences	Transfer of tracers (Na-22 and Zn-65)		T: plants; F: fish	Y	NORM and other heavy metals

Table 4: Preliminary grouping of institutes interested to study multipollutant (including RADs) transfer (and effects) in terrestrial environment under controlled conditions

Institute	Main topic	Contaminants	Media	ERA*	Interest for collaboration
Belgian nuclear research centre	Transfer studies and effects	RAD, HM	T: Plants	Y	Effects induced on plants exposed to multiple pollution
CEH	Transfer studies	RAD, HM, dioxines, pesticides	T: Animals, plants, fauna) FW	N	Yes. Not explicit
ECOMATTERS	Transfer in terrestrial Reproduction endpoint	RAD, HM	T: Plant	Y	Yes. Not explicit
EA	Transfer (E, F, M)	Virtually all	T, M, F; Crustaceans, invertebrates, Fish, Molluscs	Y	Yes: Any areas of mutual interest
Friedrich Schiller Univ.	Transfer and effects	HM and RAD	T: plants, rhizosphere org.	N	Mycorrhizal biofiltration effects
Norwegian University of Life Sciences	Transfer and effects	HM, PCB, Pesticides	T, M, F Bact, crust, fish, insects, invertebrates, mammals plants		RAD, HM
SPA Typhoon	Transfer	RAD, Pesticides, Dioxins	T, M, F	Y	Yes. Not explicit

Table 5: Preliminary grouping of institutes interested to study multipollutant (including RADs) transfer (and effects) in terrestrial environment under field conditions

Institute	Main topic	Contaminants	Media	ERA*	Interest for collaboration
Belgian nuclear research centre	Transfer studies and effects	RAD, HM	T: Plants	Y	Effects induced on plants exposed to multiple pollution
CEH	Transfer studies	RAD, HM, dioxines, pesticides	T: Animals, plants, fauna) FW	N	Yes. Not explicit
ECOMATTERS	Transfer in terrestrial Reproduction endpoint	RAD, HM	T: Plant	Y	Yes. Not explicit
EA	Transfer (E, F, M)	Virtually all	T, M, F; Crustaceans, invertebrates, Fish, Molluscs	Y	Yes: Any areas of mutual interest
Enviros	Transfer. Site monitoring and ERA	RAD, HM, PCB, PAHs	T M F	Y	Field experiments
Friedrich Schiller Univ.	Transfer and effects	HM and RAD	T: plants, rhizosphere org.	N	Mycorrhizal biofiltration effects
Norwegian University of Life Sciences	Transfer and effects	HM, PCB, Pesticides	T, M, F; Bact, crust, fish, insects, invertebrates, mammals plants		RAD, HM
SPA Typhoon	Transfer	RAD, Pesticides, Dioxins	T, M, F	Y	Yes. Not explicit
iTemba Laboratory of Accelerator Based Sciences	Transfer of tracers (Na-22 and Zn-65)		T: plants; F: fish	Y	NORM and other heavy metals

Table 6: Preliminary grouping of institutes interested in performing ERA at multipolluted sites or in comparison of approaches to ERA in a multipollution context

Institute	Main topic	Contaminants	Media	ERA*	Interest for collaboration
Argonne National Laboratory	Desk work ERA	Virtually all	Human health	Y	ERA for multiple radioactive and non-radioactive contaminants, exposure and effects
Belgian nuclear research centre	Transfer studies and effects	RAD, HM	T: Plants	Y	Effects induced on plants exposed to multiple pollution
ECOMATTERS	Transfer in terrestrial Reproduction endpoint	RAD, HM	T: Plant	Y	Yes. Not explicit
EA	Transfer (E, F, M)	Virtually all	T, M, F; Crustaceans, invertebrates, Fish, Molluscs	Y	Yes: Any areas of mutual interest
Enviros	Transfer. Site monitoring and ERA	RAD, HM, PCB, PAHs	T M F	Y	Field experiments
Fisheries and Oceans Canada	No Transfer or effects studies: mostly exp. work on Organnometallic compounds	RAD, HM, PAH, PCB, Pesticides	M	Y	Bioaccumulation and tissue distribution
iTemba Laboratory of Accelerator Based Sciences	Transfer of tracers (Na-22 and Zn-65)		T: plants; F: fish	Y	NORM and other heavy metals
McMaster University	Effects	HM and radiation	T: mammals; F: fish	Y	Fish exposure in heavy metal background
SPA Typhoon	Transfer	RAD, Pesticides, Dioxins	T, M, F	Y	Yes. Not explicit