Emerging needs for physicochemical analyses in connection with radiological terror preparedness

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Some comments on the needs for updated decision support instruments

Existing decision support systems and the host of underlying data have focused almost exclusively on accident scenarios at nuclear installations

The world of today is facing a series of ’new’ threats, notably radiological terrorism, for which we are not adequately prepared, and which can have special measurement and analysis requirements.

A recent report from the US Commission on the Prevention of Weapons of Mass Destruction Proliferation and Terrorism considers it very likely that a large attack using weapons of mass destruction (could be a nuclear bomb) will occur in a city somewhere in the world within the next 4 years.

Due to the significantly lesser difficulties in acquiring the components and knowledge needed to construct a potent radiological dispersion device (e.g., a ’dirty bomb’), a well-staged radiological terror attack might well be more likely to occur.

Possible sources

IAEA

Example of 'orphaned' sources:
Two containers, each with 1300 TBq ^{90}Sr, found in a forest in Georgia in 2002.

For comparison, the total ^{90}Sr release from Chernobyl was estimated to ca. 8000 TBq (Sohier, 2002).

Key factors: availability, sufficient source strength, transportability, physical half-life, types of radiation/energies, suitability for aerosolisation and dispersion

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Some important radionuclides of concern in connection with ‘dirty bombs’

Radionuclide	Typical physicochemical form of large existing sources	Existing strong sources and their strengths
^{60}Co	Metal (can be dissolved in acid - liquid)	Sterilisation irradiator (up to 400,000 TBq). Teletherapy source (up to 1000 TBq)
^{90}Sr	Ceramic ($SrTiO_3$) - insoluble, brittle, soft (Mohs hardness: 5.5), can be powdered	Radioisotope thermoelectric generator (1000-10.000 TBq)
^{137}Cs	Salt (CsCl) (can be dissolved - liquid)	Sterilisation irradiator (up to 400,000 TBq). Teletherapy source (up to 1000 TBq)
^{192}Ir	Metal – soft - Mohs hardness 6.5 (can be powdered), insoluble in water	Industrial radiography source (up to 50 TBq)
^{226}Ra	Salt ($RaSO_4$) (can be powdered), very low solubility	Old therapy source (up to 5 TBq)
^{238}Pu	Ceramic (PuO_2) - insoluble, can be powdered	Radioisotope thermoelectric generator (up to 5,000 TBq)
^{241}Am	Pressed ceramic powder (AmO_2)	Well logging source (up to 1 TBq).
^{252}Cf	Ceramic (Cf_2O_3) - insoluble	Well logging source (up to 0.1 TBq).

(see, e.g., Harper et al., 2007; Ferguson et al., 2003; Argonne, 2005)

Suitability for aerosolisation and dispersion

Harper et al. (Sandia Natl. Lab.), 2007

Powders: Depends on, e.g., original powder size and porosity
Phase transition possible at high pressure
Typically 20-80 % aerosolised

Ceramics: Typically 2-40 % aerosolised

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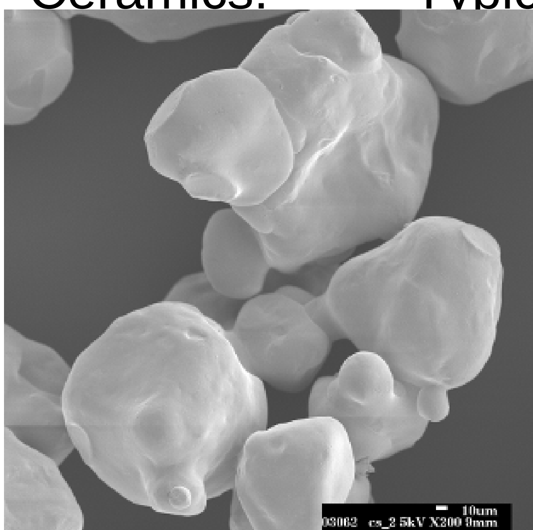
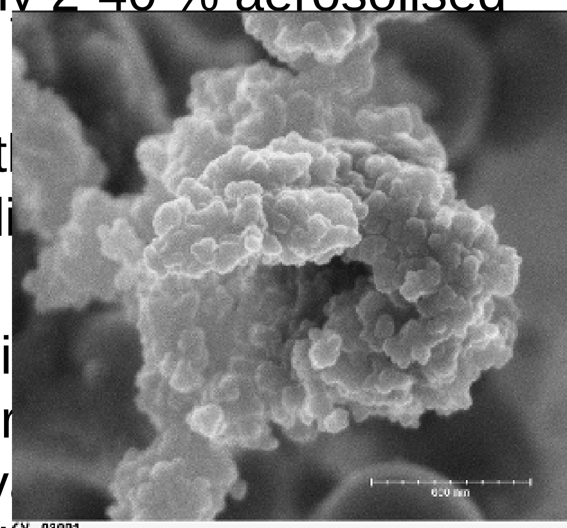
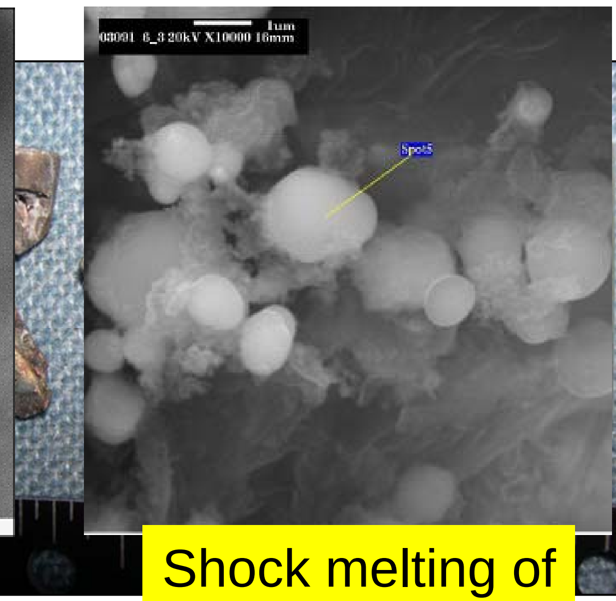


Initial salt grains (large)



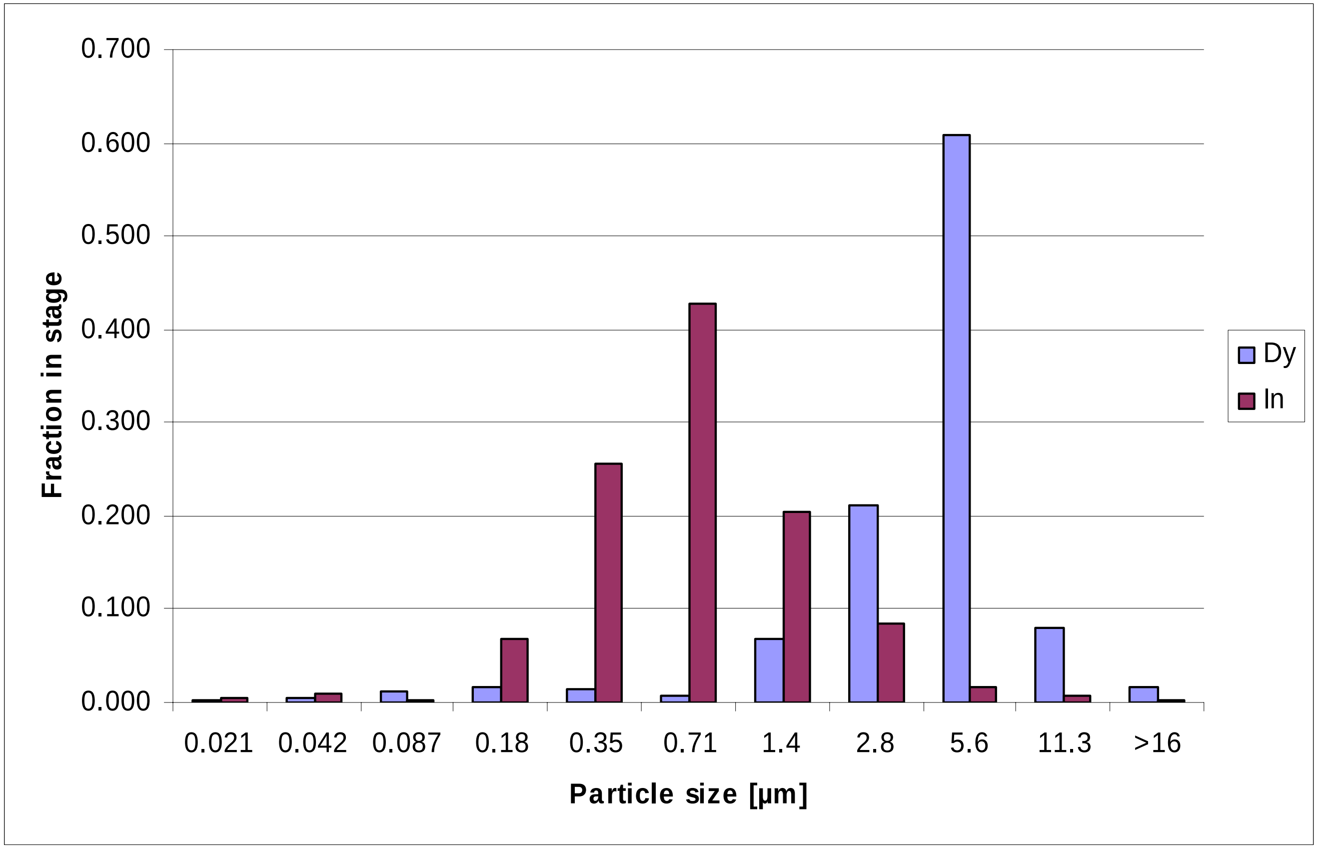
Shock sublimation of salts (< 1 µm)



Shock melting of salts (< 10 µm)

Debris of … on

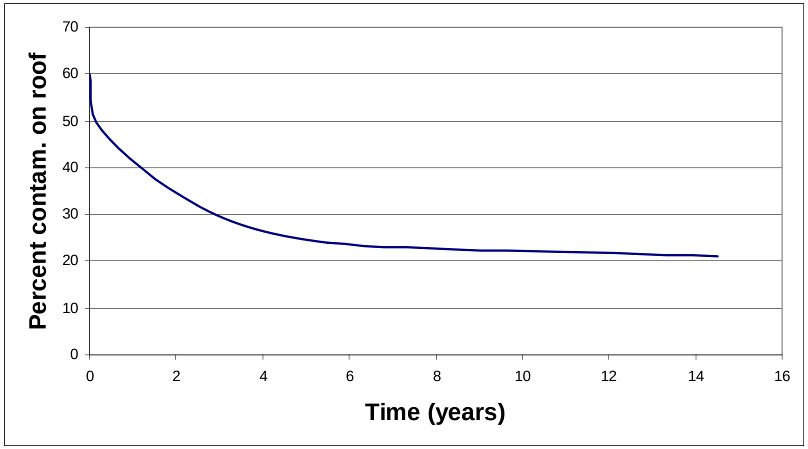
Aerosol size distribution – In nebulisation



Medical nebuliser

Natural and forced removal from 'urban' surfaces

Chernobyl-experience for roofs



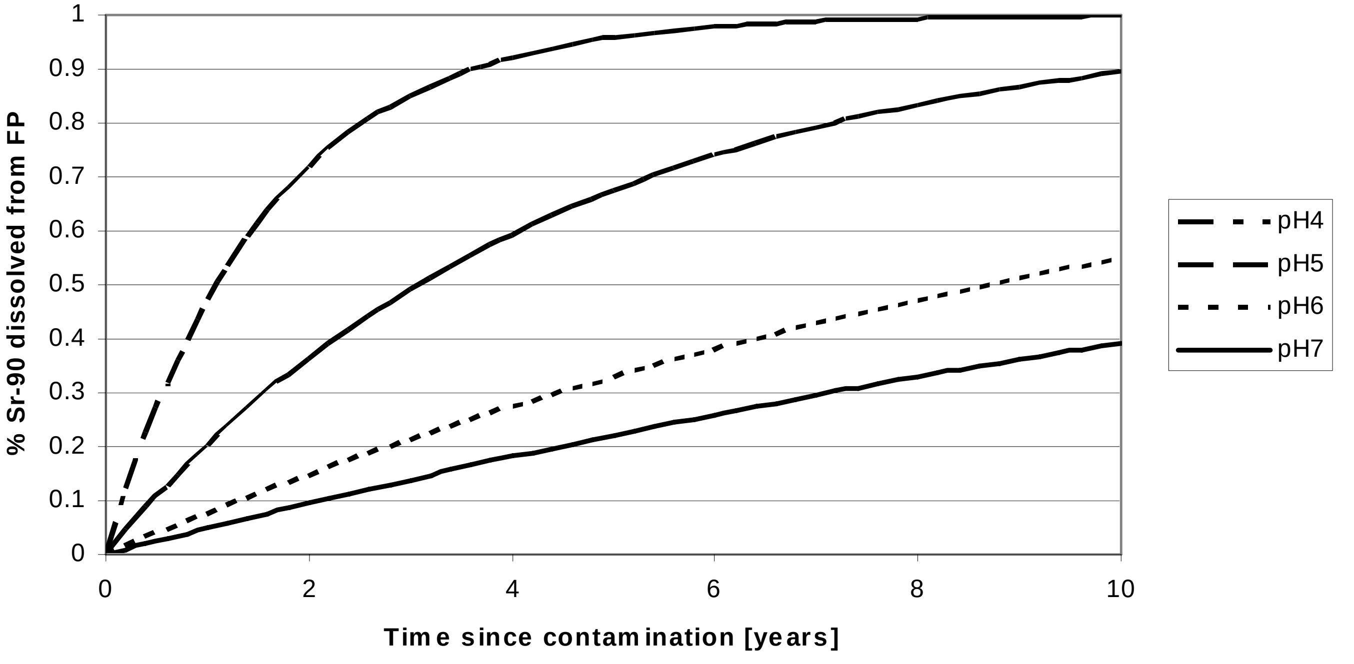
Different particle characteristics lead to different post-deposition behaviour.

Spraying of inert water solutions on similar limestone walls removed two-thirds of the caesium contamination in Pripyat, but only about one-fifth of the caesium contamination in Vladimirovka (Roed & Andersson, 1996).

IAEA studies modelling concluded that standard weathering parameters were inapplicable to describe contaminant migration in the Pripyat area (model output far from measured contamination/ dose rate).

Clark and Cobbin (1964) recorded a DF of 50 when hosing a street contaminated by 44-100 µm particles.

Migration in soil of low-solubility contaminants



Time-dependence of the fraction of ^{90}Sr dissolved from fuel particles in the areas contaminated by the Chernobyl accident, according to an empirical model. Model curves are shown for different soil pH values.

Implications and conclusions

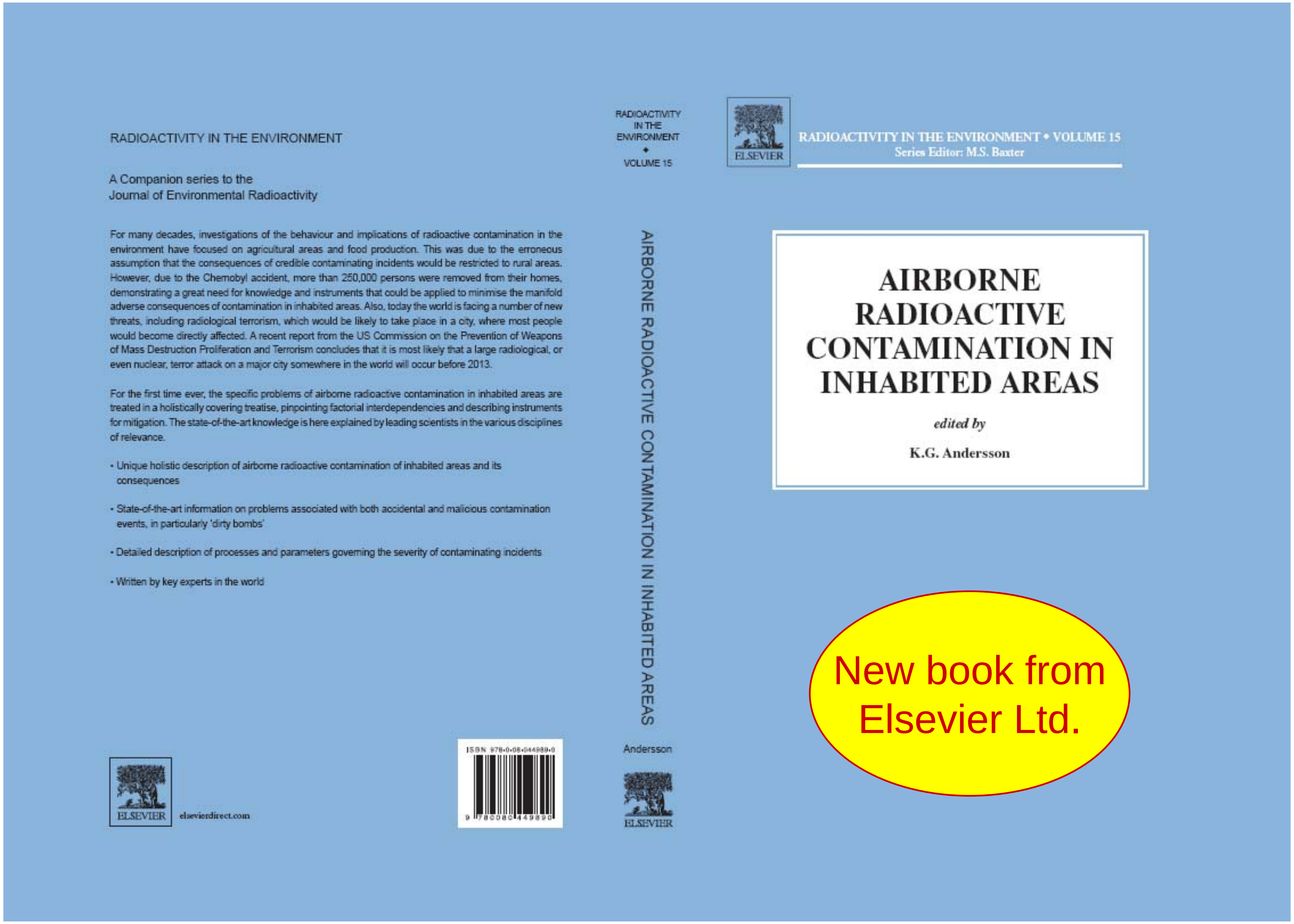
Targeted techniques for examination of fixation of 'untraditional' contaminants in soil and other materials in inhabited areas are needed (e.g., targeted sequential extraction procedures).

Contaminant could be a single pure alpha or beta emitter, which would set new requirements to laboratories' measurement techniques. Rapid analysis is here a key issue.

Estimation of environmental behaviour of different contaminants on different physicochemical forms is needed PRIOR to an emergency, to allow parameterisation of DSS to facilitate reliable consequence prognoses for justification and optimisation of intervention.

Investigations (e.g., solubility, leachability, morphology, surface composition, size) of bomb-produced particles of radionuclide surrogates can give important information, allowing contaminant classification with respect to environmental migration.

Airborne Radioactive Contamination in Inhabited Areas



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