State of the Art Measurement and Assessment for Marketing of Foodstuffs Produced on Contaminated Agricultural Land

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Introduction

- Context
- International aspects
- Measurement techniques
    - Gamma-ray spectrometry
    - Scintillation detectors
- Monitoring of contaminated land
    - Groundhog
    - Drone
- Individual monitoring
- Conclusions

Context

What to measure?

Emergency reference levels?

- Not now an emergency.
- Not restrictive enough.

Exemption levels?

- Not appropriate for population exposure around a nuclear plant.
- Too restrictive.

Representative person?

- Based on restricting dose to a representative person to less than 1mSv/year the ICRP limit for exposure to members of the public.
- Habits surveys etc to determine representative person.
- Who would be a representative person across many prefectures?

Local standard limits?

- Variation of representative person.
- Simple to understand.
- Set by Japanese Ministry of Health, Labour and Welfare.
- Based on restricting dose to a member of the public to less than 1mSv/year.

Local Standard Limits

Category	Limit /$Bqkg^{-1}$
Drinking water	10
Milk	50
General foods	100
Infant foods	50

These are for radioactive Caesium (^{134}Cs and ^{137}Cs)

Based on:

- Maximum permissible dose of 1 mSv per year
- Inclusion of radioactive strontium, plutonium etc.

Source: New Standard limits of Radionuclides in Foods, available at: http://www.mhlw.go.jp/english/topics/2011eq/dl/new_standard.pdf. Last accessed 11 October 2016.

Quantities measured in fiscal year* up to 22 August

Food group	Number of food samples tested
Agricultural products	11,760
Livestock products	104,519
Fishery products	8,357
Milk – infant formula	1,234
Wild animal meat	653
Water	185
Others	3,507
Total	**130,215**

*1 April 2016 – 31 March 2017

Source: Sum up of radionuclide test results reported in FY2016 (up-to-date Report as of 22 August 2016). Available at: http://www.mhlw.go.jp/english/topics/2011eq/dl/22_Aug_2016Sum_up_of_radionuclide_test_results.pdf.

Last accessed 11 October 2016.

International aspects

International Standards for food monitoring

- Codex Alimentarius FAO/WHO.
    - harmonised international food standards, which protect consumer health and promote fair practices in food trade.
    - see http://www.fao.org/fao-who-codexalimentarius/en/.

- ISO/IEC ranging from
    - General management systems
    - Good Laboratory Practice
    - Calibration
    - Specific methods for different monitoring regimes

Other programmes

Other countries monitor foodstuffs arising from:

- Radioactive releases from nuclear sites; and
- Overseas spread of contamination;
- eg Netherlands EU-mandated response plan for nationwide monitoring programmes and emergency response*.

However:

- Monitoring of small number of samples;
- No issues with throughput and counting times.

Therefore not directly comparable to the situation at Fukushima.

*Source: Brandhoff PN et al. Operation and performance of a national monitoring network for radioactivity in food, Food Control **64** (2016) 87 - 97. Available at: http://www.sciencedirect.com/science/article/pii/S0956713515303224. Last accessed 12 October 2016.

UK approach – Radioactivity in Food and the Environment (RIFE)

- Overseen by Food Standards Agency.
- Annual review of measurements carried out independently of operators.
    - Assess dose to public in vicinity of nuclear licenced sites, industrial sites and landfill sites
        - Use of Representative person
        - Doses to people living around these sites << 1mSv per year
    - Direct monitoring of areas for Chernobyl fallout ceased in 2014
    - Controls on imports of food and feed from Japan continued in 2014, but found none exceeding the maximum permissible activities.
- Four specialist Laboratories working together with a rigorous QA programme undertake the sample assessments:
    - Gamma spectrometry (cost-effective, used for most samples)
    - Radiochemical methods (α and β detection, very sensitive but only used on nuclides not detectable Gamma spectrometry)

Source: Radioactivity in Food and the Environment. Available at: https://www.food.gov.uk/sites/default/files/rife-20.pdf. Last accessed 12 October 2016.

Measurement techniques
- gamma-ray spectrometry
- scintillation detectors

Gamma-ray spectrometry

Gamma-ray spectrometry

- eg NaI(TL) detectors
- Typically 1L marinelli beakers, Metal food cans, drinks cans and plastic containers

Container (Content)	^{137}Cs MDA /Bqkg^{-1} (BqL^{-1})	Count Time /minutes
1L Marinelli Beaker (Milk or Water)	20	4
Food can (Vegetables/Meat)	50	8
350mL Drinks can (Water)	20	110
1Kg Plastic container (Meat/Fish/Eggs/Grain)	50	20

Source: Canberra Product sheet available at: http://www.canberra.com/products/radiochemistry_lab/pdf/FoodScreen-SS-C39444.pdf. Last accessed 12 October 2016

Automatic gamma-spectrometers

- For 4 L marinelli beaker:
  - Quoted MDA (^{137}Cs) is 0.3 BqL^{-1} ($Bqkg^{-1}$) in a 10,000 second count
  - Therefore to get 20BqL^{-1} ($Bqkg^{-1}$) would require ~150s
  - Gives ~ 20 samples per hour.

- For 1 L marinelli beaker:
  - Quoted MDA (^{137}Cs) is 0.5 BqL^{-1} ($Bqkg^{-1}$) in a 10,000 second count
  - Therefore to get 20BqL^{-1} ($Bqkg^{-1}$) would require ~250s
  - Gives ~ 15 samples per hour.

Source: Canberra data sheet. Available at: http://www.canberra.com/products/radiochemistry_lab/pdf/Gamma-Analyst-SS-C39995.pdf. Last accessed 12 October 2016.

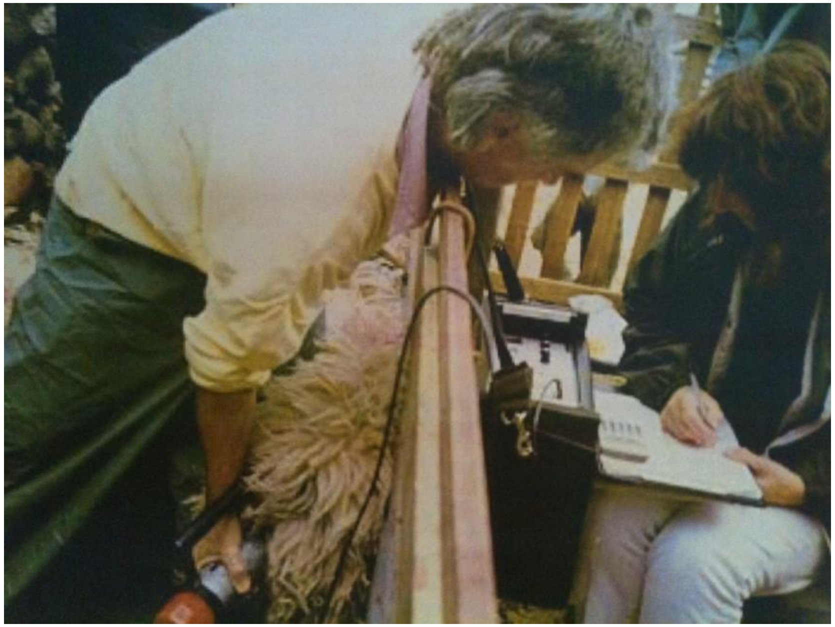
Object/tool monitors

eg Canberra Cronos-4 (Other sizes available)

- Scintillation detectors
- Features including automatic weighing, calculation of specific activity, alarms for contaminated packages, etc.
- Self shielding for low energy radiation
- Minimum Detectable Activity ~100 Bq
- Time to reach MDA (^{137}Cs) ~1 minute
- So for 80kg sack of rice at 100 $Bqkg^{-1}$ ⇨ 1 second counting times

Source: Canberra data sheet. Available at: http://www.canberra.com/products/hp_radioprotection/pdf/Cronos-4_11-SS-C40631.pdf. Last accessed 12 October 2016.

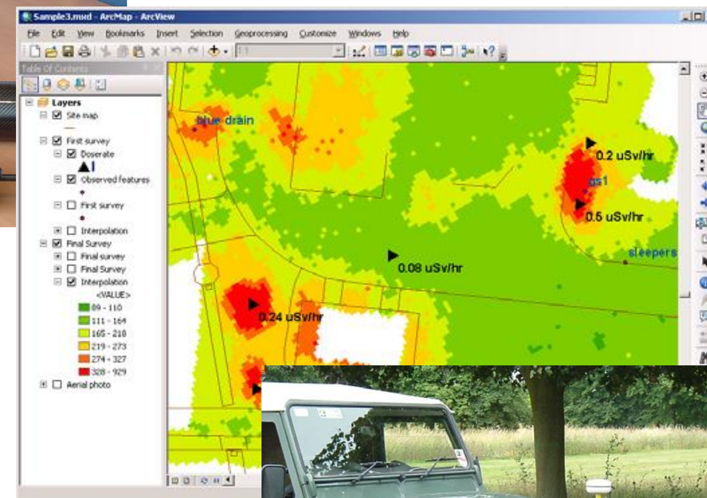
Live animal monitoring



- Developed by John Caunt Scientific Ltd for UK application (Post Chernobyl)
- Originally NaI(Tl) detectors but redeveloped with Scintillation detectors

Monitoring of contaminated land
- groundhog
-drone

In-situ monitoring of contaminated land - Groundhog

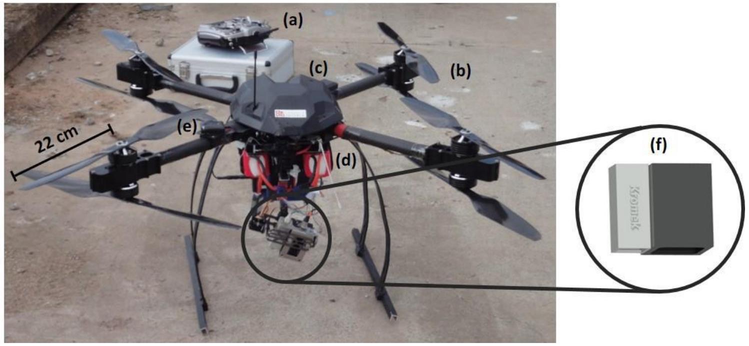


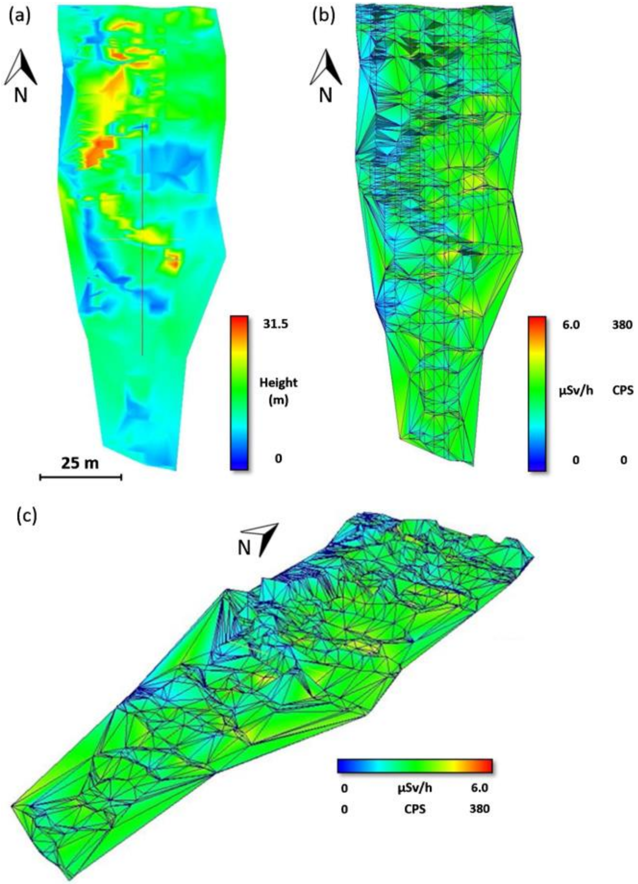
Measurement of surface and subsurface contamination:

- Typical detection in soils at 200 – 400Bqkg^{-1}
- Can be used to detect contamination in 100 – 200 mm of sand

Source: Nuvia data sheet. Available at: http://www.nuvia.co.uk/_includes/docs/Groundhog-GEM-Hiram-LandWasteCharac-Brochure.pdf. Last accessed 12 October 2016.

In-situ monitoring of contaminated land - Drones





- Rapid determination of contaminated land/crops
- 3-D mapping
- Metre scale resolution

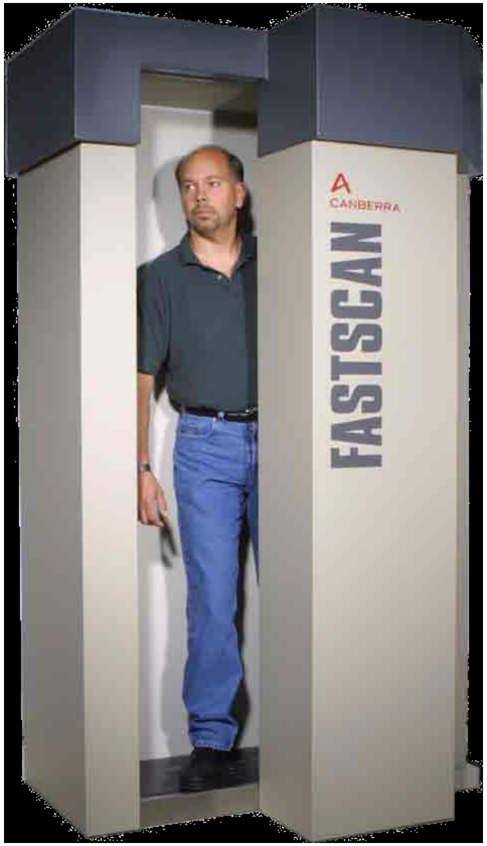
Source: P G Martin . Available at: http://research-information.bristol.ac.uk/files/74879717/Martin_et_al_2016.pdf . Last accessed 12 October 2016.

Individual monitoring

In-vivo measurement of individuals

Ultimate test of success of the programme of measurement.

- Whole body counting, typically:
    - Canberra model 2250
    - 2 x NaI(Tl) detectors
    - 2 minute scan ⇨ ~ 20 people per hour
    - Detection limit of around 200- 300 Bq for ^{134}Cs and ^{137}Cs (background dependent)
    - Using ICRP effective dose coefficients ⇨ Committed Effective Dose of ~ 40 μSv (with assumptions)



Source: Canberra data sheet. Available at: http://www.canberra.com/products/hp_radioprotection/pdf/Fastscan-C39771.pdf. Last accessed 12 October 2016.

Conclusions

Conclusions

Food monitoring
Rejection of foodstuffs
contaminated > local standard
limits

Contamination
monitoring

Individual monitoring
Reassurance