Air Sampling Programmes for Managing Internal Exposures: Review of Key Practical Issues

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Overview

The purpose of this presentation is to show that a wide range of issues need to be carefully considered when planning and using air sampling programmes

- Review of sampling methods
- Issues associated with sample measurement
- Estimating intakes and comparison to bioassay
- Management issues: compliance, costs
Sampling methods
Workplace sampling
Workplace samplers: CAM

• Need to select sites where aerosol releases are reliably detected
  - CAMs often sited near to ventilation exhaust points

• US DoE study showed that these detectors often miss significant releases (up to 3 orders of magnitude)

• Smoke tests/inert aerosol releases can be used to study flow patterns and aid effective siting

• CAM detection levels might be OK for detection of acute releases, but not for chronic exposures

• Radon compensation often required: can cause false alarms
Workplace samplers: SAS

- High flow rate and therefore high sensitivity.

- Useful for monitoring stability of conditions in a workplace

- Dust loading can be an issue for long sampling periods in dusty environments

- Can give an indication of whether a more intensive monitoring regime is required

- Uncertain relation to worker intakes:
  - Non-homogenous localised air concentrations;
  - Relation between sampling periods & occupancy periods
Individual/worker sampling
Personal Air Samples (PAS)

- Mainly used for actinides (including U and NORM)
- Located as close as possible to the breathing zone
  - E.g. worn on lapel
- Low flow rates
  - continuous flow rather than ‘pulsed flow’
- Up to factor of 3 sampling uncertainty due to variations in bulk flow patterns
- Further uncertainties result from low (but radiologically significant) particle densities
## Numbers of Particles Corresponding to Various Activities

<table>
<thead>
<tr>
<th>Activity or dose</th>
<th>Density 10 gm/cm³</th>
<th>$\sigma_g=2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pu</td>
<td>Pu</td>
<td>U</td>
</tr>
<tr>
<td>1 Bq</td>
<td>211</td>
<td>1.9E7</td>
</tr>
<tr>
<td>1 DACh</td>
<td>254</td>
<td>2.8E7</td>
</tr>
<tr>
<td>1 mSv</td>
<td>25400</td>
<td>2.8E9</td>
</tr>
</tbody>
</table>
Sampling Statistics

- Birchall et al (1986) considered the statistics of particle sampling

- They calculated the probability $p(I|m)$ that the intake $= I$ Bq given that the air sampler measured $m$ Bq

- This distribution is skewed, with the mean higher than the median

- One outcome of this is that, for a single measurement, the estimated intake is more likely to be less than the true mean

- This effect decreases as the number of particles sampled increases
Sample Measurement
Calibration Issues

• No natural reference matrix available; so truly accurate calibration is not possible

• Differential source and sample geometries

• Self absorption within filter media and/or deposited particles
Measurement Issues

• **Radon (for alpha counting)**
  • On sample
  • In the lab
  • Generated from within filter material (e.g. china clay glaze on filter cards)

• **Units and quantities**
  • DAC
  • DAC-hours
  • Bq on sample
  • Bq.m\(^{-3}\) air concentration

• **Statistics for very low count rates**

• **Background subtraction**
Background subtraction

- Background counts on a non-exposed filter can show subtle variations over the year

- If some standard background subtraction is made, it is essential that this be representative of the true background at the detector

- When collected activities are very low, may find a preponderance of negative net counts (after BG subtraction)

- This effect can arise from Poisson counting statistics
Estimating intakes and comparison to bioassay
SAS used to assess intakes

• Can be used to assess intakes by worker groups if:
  • Air activity concentrations reasonably homogenous and stable
  • Relatively high concentrations of aerosol (e.g. low specific activity: U, NORM)
  • Occupancy of the area is well described and recorded

• Detection of potential acute exposures or changes to working conditions

• More generally used to demonstrate that individual estimates not routinely necessary
Other considerations

• Relationship between PAS activity and dose requires knowledge of:

• **Nuclide mix** — if total alpha activity is measured, dose will depend on relative abundance of, say, Pu, U, Ra etc. If the collected activity is large enough, consider alpha-spectrometry.

• **Particle size:** Centripeter measurements at Harwell showed AMAD around 5 um for most workplaces, but this can depend on the processes occurring in the workplace.

• **Lung solubility:** Dose per Bq of Pu239 is 3.5 times higher for soluble material compared with insoluble
Relationship between PAS & Bioassay estimates for intakes of Pu/Am
Long-term averages of PAS results

- A previous slide suggests little correlation between individual PAS results and assessed intake.

- Averages over longer periods or over groups of workers show some trends.

- A study at Harwell in the early 90s showed a clear correlation between average PAS values in a given area and the occurrence of above-LOD routine faecal results (Pu/Am activities).

- In a plant converting uranium ore into UF4 there was a correlation between workplace air sample activities and urine activities.
PAS as a trigger for investigations

- Internal dose investigations can be triggered by PAS, SAS, routine UR, routine FA, contamination surveys etc.

- A recent study of 381 investigations showed that 30 were triggered by high PAS and 11 by high SAS, compared with 89 by routine faecal sampling.

- About 50% of the investigations triggered by air sampling were confirmed as non-trivial intakes by further sampling.

- Only 30% of those triggered by a high faecal result were confirmed as non-trivial intakes.
Management Issues
Compliance monitoring

- **SAS and/or PAS can be used as confirmatory or reassurance programmes**
  - to check and validate prior risk assessments

- **Air sampling will normally need to be supported by bioassay campaigns for reliable verification**
  - unless uncertainties are well described

- **PAS can provide point estimates of dose if bioassay not able to reliably assess doses:**
  - e.g. routine bio indicates dose < 6mSv & best point estimate by PAS is 0.3 mSv
Programme costs

No definitive answer, will depend on:

• existing and available lab facilities, or need to set-up from scratch
• numbers of air sampling units required
• technical capability of techniques & facilities for the expected exposure hazards
• knowledge of air activity characteristics;
• risks of chronic and acute exposures;
• radionuclide mixes
  • air sampling is a gross measure, whereas bioassay normally nuclide-specific;
• numbers of workers
  • eg bioassay might be more cost effective for small team in specialised operations;
  • air sampling maybe better for large team in generalised operations
Conclusions

A wide range of issues need to be carefully considered when planning and using air sampling programmes:

• Costs
• Technical capability
• Objectives and QA
• Extent of knowledge and uncertainties of nature, magnitude and variability of exposure hazards
Thank you for your attention

Full paper submitted for publication on ISOE web-site

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