


NUVIA

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

Type S aerosols: AMAD 5 µm	Density 10 gm/cm3	σg=2
Activity or dose	**Pu**	**U**
1 Bq	211	1.9E7
1 DACh	254	2.8E7
1 mSv	25400	2.8E9

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

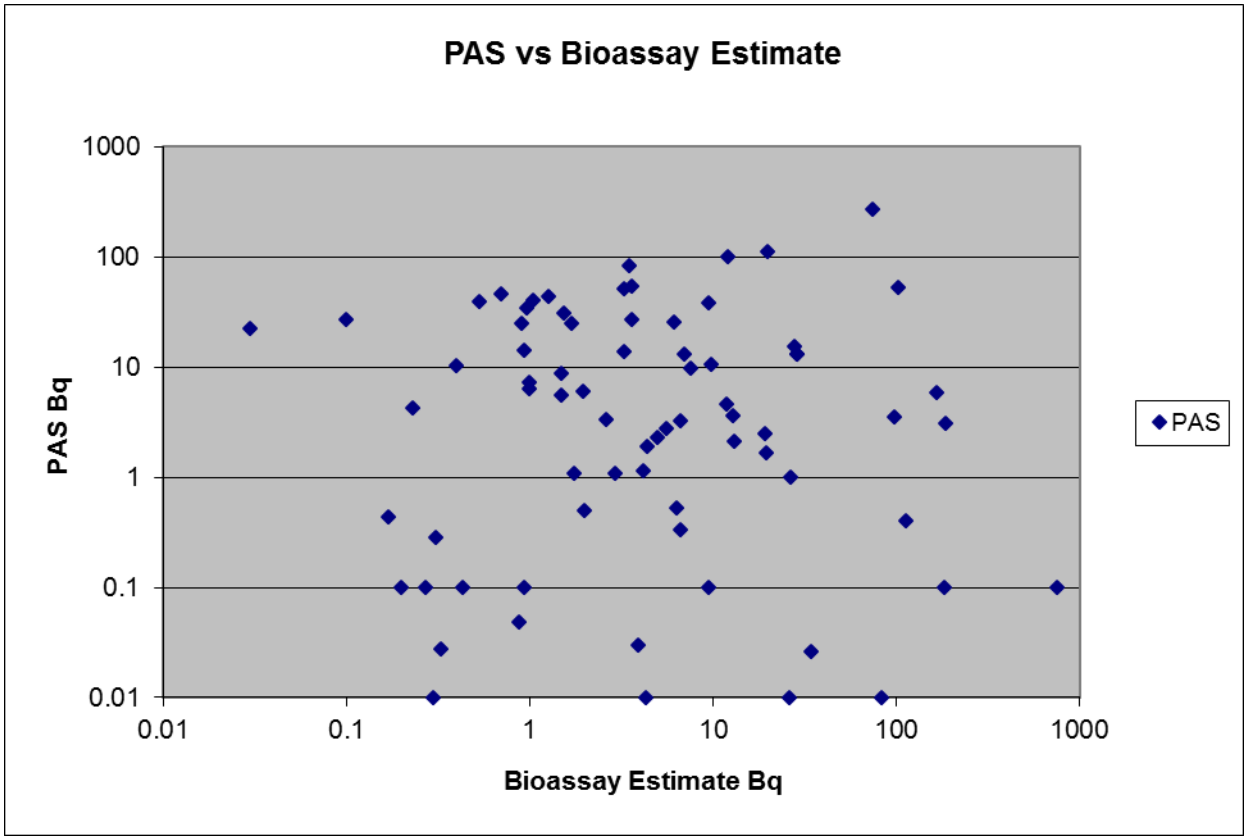
- **Relationship between PAS activity and dose requires knowledge of:**

- **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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