SIMULTANEOUS MONITORING OF ALPHA AND BETA EMITTING AEROSOLS IN THE ENVIRONMENT

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ABSTRACT

Both fixed-filter and step-filter monitors can be used for the on-line surveillance of airborne fission products and transuranium elements in the environment. In this paper the specific benefits and drawbacks of these monitoring concepts are discussed. The network of the German Meteorological Service takes advantage of the complementarity of both sampling techniques. The comparability of the data received by different methods is demonstrated by some typical results of environmental measurements.

INTRODUCTION

In Europe the radiological consequences of the nuclear accident at Chernobyl have stimulated the design and the configuration of extended networks for the continuous surveillance of the environmental radioactivity. Nevertheless not all of the radiological features that have been observed in Western Europe can be taken for granted in respect to potential events in the future. But even an analysis of published data concerning the isotopical composition of the Chernobyl-fall-out clearly reveals the necessity of nuclide specific measurements at different locations:
In Germany the observed activity-ratio of Plutonium- to Cesiumisotopes had been in the order of 10^{-5} /1/. This means that the unsignificant amount of transuranium elements had been detectable by off-line radiochemical methods only. On the other hand the official russian IAEA-report /2/ states an Pu/Cs activity ratio of $1.7 \cdot 10^{-3}$ for the emitted core material. This discrepancy can be explained by the different processes of emission, transportation and deposition for non-volatile and volatile elements: A comparison of soil samples taken in distances of up to 100 km from Chernobyl and those taken in Western Europe showed a derichment of the heavier particles of the nuclear fuel material by three orders of magnitude with increasing distance to the emittent. Additionally great differences in the isotopical composition of the various contaminated clouds depending on the time of emission at Chernobyl have been found /3/. Taking into account that the inhalation dose factor of $^{239,240}Pu$ is $3 \cdot 10^4$ higher than for ^{137}Cs /4/ it can be concluded that in the area around Chernobyl α-emitters played an important role in respect to the potential inhalation risk. Since the inhalation of these radioactive particles can be reduced quite effectively by the use of masks or by staying indoors the instantaneous knowledge of the airborne presence of α-emitters can thus be quite essential for the authorities.

REQUIREMENTS FOR ENVIRONMENTAL ALPHA AND BETA MONITORING

Keeping the radiological features of the Chernobyl accident in mind, the following aspects of environmental α- and ß-monitoring have to be considered:

- The activity concentration of fission products (ß-emitters) can be expected to exceed that of transuranium elements (α-emitters) by several orders of magnitude. Thus the ß-sensitivity of the α-measurement has to be very small.

- Transuranium elements often occur as part of 'hot particles', i. e. the spatial distribution of the activity concentration can be quite inhomogeneous. Thus the volumina of the air under investigation should be sufficiently large in order to get a reliable result.

- According to the fact, that the required detection limits of artificial α-activity concentrations are typically two orders of magnitude below the natural background an effective suppression and compensation of the ^{222}Rn-daughters is very essential. Here an on-line discrimination can be performed via an energy analysis of the emitted α-particles, while the most efficient separation technique (simply waiting for the Rn-daughters to decay) yields delayed results only.

- Due to the preferential short-ranged transportation behaviour of non-volatile radionuclides the relative presence of artificial α-activity can be expected to be quite different at different locations of a network. Additionally the higher deposition rate in comparison to the volatile elements leads to a more transient time behaviour as well. Thus an on-line measurement of the α-activity concentration at selected sites of the network is desirable.

- Depending on the kind of nuclear accident the presence of artificial α-activity is related with the observation of other specific radionuclides, for example ^{144}Ce /3/, which might be identified via Γ-spectroscopy. Thus on-line Γ-spectroscopy also yields a first indication concerning the presence of small airborne α-contaminations which might remain below the detection limit of the α/ß-monitor.

- Of course the design of the monitoring techniques must fit to the specific requirements of the network. For example the desired minimum response time for an alarm or the availability of skilled crews at the individual stations have to be taken into account.

ENVIRONMENTAL MONITORING CONCEPTS

Different off-line (1,2) and on-line (3,4,5) methods can be applied for the detection of airborne α- and ß-contaminations in the environment (see table 1):

1) Using high-volume samplers combined with a subsequent radiochemical analysis detection limits in the order of several $\mu Bq/m^3$ for a sampling periode of one week can be reached. Though being the only technique for the detection of these (radiologically irrelevant) traces of radioactivity, this

method cannot supply instanteneous data which might be required in a network designed for an early warning. Depending on the distance to the laboratory and the kind of analytical method, a typical delay of at least one day between the end of the sampling periode and the final result can be assumed.

2) The off-line application of the alpha beta pseudo coincidence (ABPD) method /5/ represents a much faster evaluation technique which can be applied in the stations by unskilled personal as well. Here α- and ß-detection limits of several mBq/m³ for a sampling periode of 24 h can be reached.

3) Due to an excellent discrimination behaviour against natural radioactivity the α-energy range discrimination (AERD) method /6/ allows the on-line detection of α- and ß-emitters. The detection limit is typically 50 mBq/m³ for an integration time of two hours. According to the great volume under investigation (Φ = 40 m³/h) an instantaneous response to the presence of hot particles can thus be combined with a very low detection limit for small but persistent concentrations. The presence of personal is required for the change of the filter only.

4) Much larger service intervals (up to 6 month) can be reached by the use of step-filter monitors /7/ involving silicon detectors. Here typical detection limits for averaging times of several hours are similar to those of AERD-monitors since the much smaller flow-rate (8 m³/h) approximately balances the improved discrimination against natural radioactivity. On the other hand smaller concentrations might remain undetected since the accumulation process is restricted by the filter transportation mechanism.

5) Isotopes which are Γ-emitters as well can be identified by an on-line Γ-spectroscopical step-filter monitor.

	high volume sampler radiochem. analysis	sampler, ABPD - analysis	On-line AERD monitor	On-line α , ß step-filter-monitor	On-line γ step-filter-monitor
measured isotopes	α , ß , γ	α , ß	α , ß	α , ß	γ
nuclide specific	+ +	-	-	+(α)	+ +
discrimination vs. natural activity	+ +	+	o	+	+ +
alarm generation	-	-	+	+	+
delay between data request & final result	≥ 1 day	1 h	immediate	immediate	≤ 0.5 h
suitable for uncrewed stations	o	-	o	+ +	+
service	4h/week	0,5h/day	0,5h/week	1h/0,5 year	1h/week
typical detection limits 2h	-	-	50mBq/m³	50mBq/m³	200mBq/m³
24h	-	10 mBq/m³	10mBq/m³	-	50mBq/m³
168h	5μBq/m³	-	2mBq/m³	-	-

table 1: Application scheme of aerosol monitoring concepts (+ + excellent, + good, o moderately suited, - unsuited)

EXPERIMENTAL RESULTS

The network of the German Meteorological Service (DWD) includes methode 1, 2 or 3 and 5 (table 1). Figure 1 shows some on-line-data concerning the natural airborne activity gained by an α/β-(method 3) and Γ-measurement (methode 5) respectively.

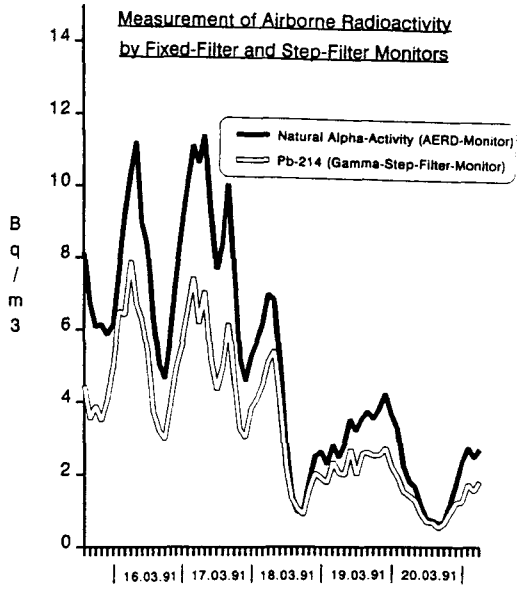

Figure 1:
Immission data measured at Offenbach, Germany

REFERENCES

/1/ ISH Institut f. Strahlenygiene München, 1986, Ergebnisse von Radioaktivitätsmessungen nach dem Reaktorunfall in Tschernobyl, ISH report 99.

/2/ USSR State Committee on the Utilization of Atomic Energy, 1986, The Accident at the Chernobyl Nuclear Power Plant and its Consequences, IAEA Post-Accident Review Meeting, Vienna.

/3/ Lindner, G., Kaminski, S., Schell, B., Schodlock, H.-J., Wahl, U., Wilhelm, Ch., 1991, Proc. 25. Jahrestagung Fachverband für Strahlenschutz, Aachen, 259-264.

/4/ ICRP, 1979, Limits for Intakes of Radionuclides by Workers, ICRP Publication 30.

/5/ Vaane, J. P., de Ros, E. M. M. , Proc. 1st Int. Conf. Rad. Prot. 1966, 997-1001

/6/ Iwatschenko-Borho, M., Frenzel, E., Kraut, N., Kreiner, H.-J., Wichmann, H.-P., 1989, Proc. 15th Reg. Conf IRPA in Visby, 487-492.

/7/ Gagel, A., Iwatschenko-Borho, M., Hofmann, B., Löw, R., Buijs, K., Servranckx, J. P., Burger, P., Wagner, G., Frenzel, E., 1991, Proc. 25. Jahrestagung Fachverband für Strahlenschutz, Aachen, 389-394.