Regional Fukushima fallout in Germany – data and models

Helmut W. Fischer ✉; Daniela Pittauerová; Susanne Ulbrich; Bernd Hettwig

Institute of Environmental Physics, University of Bremen, Bremen, GERMANY

✉ *hfischer@physik.uni-bremen.de*

Introduction

Following the Fukushima NPP accident radionuclide air releases, samples of regional environmental media – rain water, river sediment, soil, grass and cow milk were taken in NW Germany and analyzed by gamma spectrometry [1]. The sampling in part contributed to the German state routine environmental radioactivity monitoring network IMIS [2], from which nationwide data could be retrieved later.

Sampling

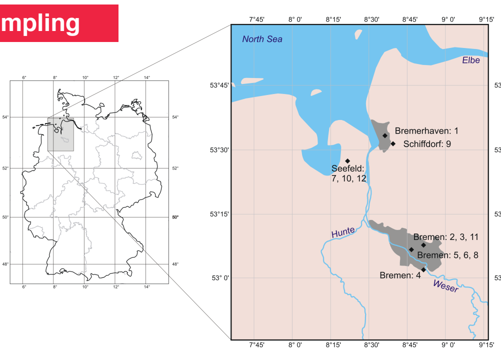

Figure 1: *Location of sampling points and corresponding sample numbers (Table 1).*

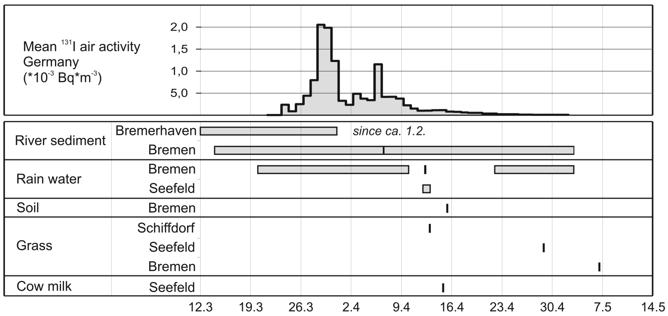

Figure 2: *Timeline of the sampling campaign. In the upper panel, averaged ^{131}I air concentrations reported by 4 German air activity monitoring stations [3-5] are plotted.*

Measured values

Table 1: *Measured values in Bq·kg^{-1} wet mass. Data are decay corrected to the end of the sampling period, unless noted otherwise.*

No.	Type of sample	Sampling period	^{131}I	^{137}Cs	^{134}Cs
1	River sediment (Bremerhaven)	ca. 1.2. – 31.3.	0.113 ± 0.046	2.67 ± 0.07	< 0.084
2¹	River sediment (Bremen)	14.3. – 6.4.	0.45 ± 0.06	1.76 ± 0.04	< 0.06
3	River sediment (Bremen)	6.4. – 3.5.	< 0.12	1.73 ± 0.05	< 0.05
4	Soil (Bremen)	15.4.	0.068 ± 0.025	3.00 ± 0.07	< 0.069
5¹	Rain water (Bremen)	20.3. – 10.4.	0.43 ± 0.03	< 0.04	< 0.04
6	Rain water (Bremen)	12.4.	0.10 ± 0.02	< 0.04	<0.04
7	Rain water (Seefeld)	11.4. – 13.4.	0.14 ± 0.02	< 0.03	< 0.03
8²	Rain water (Bremen)	22.4. – 3.5.	0.031 ± 0.008	< 0.02	< 0.02
9	Grass (Schiffdorf)	13.4.	3.58 ± 0.13	1.59 ± 0.07	0.32 ± 0.03
10	Grass (Seefeld)	28.4.	0.31 ± 0.04	0.26 ± 0.04	0.062 ± 0.014
11	Grass (Bremen)	6.5.	0.12 ± 0.03	0.18 ± 0.03	< 0.08
12	Milk (Seefeld)	14.4.	0.08 ± 0.02	< 0.02	< 0.03

¹Decay corrected to the date of the maximum rainfall (3.4.2011). ²Mixed with old rain water.

Isotope ratios

[^{131}I]/[^{137}Cs]:
In NW Germany, a residual deposition of about 2 kBq·m^{-2} ^{137}Cs remains from bomb test fallout and Chernobyl. Therefore the ratio [^{131}I]/[^{137}Cs] can differ from the atmospheric data depending on the type of sample. At the time of maximal concentration (end of March), this ratio was about 10. For the sediment samples the maximum value is 0.256, indicating a strong contribution from "old" ^{137}Cs. In fact, ^{137}Cs had been detected at these locations earlier and in similar concentrations.

[^{134}Cs]/[^{137}Cs]:
In two grass samples ^{134}Cs could be detected together with ^{137}Cs and ^{131}I. This offers the possibility to discriminate between "recent" and "old" Cs isotopes, using the [^{134}Cs]/[^{137}Cs] ratio from atmospheric measurements. This value was close to 1 in most published air concentration data [3-5]. Assuming this value, it could be concluded that the main ^{137}Cs contribution in the grass samples was "old".

Modeling

Deposition with rain
Wet deposition by rain is known to be the most effective transfer path for airborne radioisotopes to ground and water bodies. It can be estimated [6] as:

$$D = C_{air}\,\Lambda_0\,t_{rain}\,h \quad (1)$$

$$C_{rain} = D/P \quad (2)$$

D areal deposition
C_{air} isotope concentration in air
Λ_0 standard washout coefficient (=7·10^{-5} s^{-1})
T_{rain} rainfall duration
h contaminated air column height (=1000 m, assuming constant concentration within the boundary layer)
C_{rain} activity concentration in rain water
P precipitation (l·m^{-2})

Transfer of radioiodine from grass to milk
can be predicted by applying emergency models [7].

$$C_{milk} = C_{grass}\,\dot{M}_{grass}\,T_{milk} \quad (3)$$

C_{milk} activity concentration in milk
C_{grass} activity concentration in grass
$\dot{M}_{grass}$ daily grass consumption rate of cattle (=65 kg d^{-1})
T_{milk} element-specific transfer factor from grass to milk (=0.003 for iodine)

Table 2: *Comparison of modeled and measured values of Fukushima fallout in Germany. Data for whole Germany were obtained from IMIS [2]*

	Regional modeled concentrations	Regional measured data	National measured data (averages)
Deposition	2.14 Bq·m^{-2} ^{131}I 0.21 Bq·m^{-2} ^{137}Cs (Eq. 1)	1.46 Bq·m^{-2} ^{131}I (sample 2) 2.72 Bq·m^{-2} ^{131}I (sample 4) (most of ^{137}Cs "old")	7.0 Bq·m^{-2} ^{131}I (n=67) 0.20 Bq·m^{-2} ^{137}Cs (n=21)
Rain water	0.252 Bq·l^{-1} ^{131}I 0.025 Bq·l^{-1} ^{137}Cs (Eq. 2)	max. 0.43 Bq·l^{-1} ^{131}I < 0.04 Bq·l^{-1} ^{137}Cs	
Grass		max. 3.58 Bq·kg^{-1} ^{131}I max. 1.59 Bq·kg^{-1} ^{137}Cs (most of ^{137}Cs "old") max. 0.32 Bq·kg^{-1} ^{134}Cs	1.56 Bq·kg^{-1} ^{131}I (n=10)
Milk	0.20 Bq·kg^{-1} ^{131}I (Eq. 3)	0.08 Bq·kg^{-1} ^{131}I	0.008 Bq·kg^{-1} ^{131}I (n=4)

Conclusions

- Despite the large distance between source and deposition area and the usage of standard equipment, it was possible to detect traces of the emissions from Fukushima in NW Germany in various environmental media.
- Isotope ratios could be used to discriminate between "recent" and "old" deposition.
- Values were plausible when compared to reported air concentrations and predictions from simple radioecological models.
- Comparison with nationwide data shows similar values.

References

1. D. Pittauerová, B. Hettwig, H. W. Fischer: Fukushima fallout in Northwest German environmental media , Journal of Environmental Radioactivity 102, 9 (2011) 877-880
2. 2. Weiss W., Leeb H., 1993. IMIS - The German integrated radioactivity information and decision support system. Rad. Prot. Dosim. 50, 163-170.
3. BfS, 2011. Bundesamt für Strahlenschutz, Station Schauinsland, Spurenanalyse deutscher Messstellen und weiterer Spurenmessstellen weltweit (In German). 19 May 2011. http://www.bfs.de/en/ion/imis/spurenmessungen.html.
4. DWD, 2011a. Deutscher Wetterdienst (Germany's National Meteorological Service), stations Potsdam and Offenbach, Informationen zu Messergebnissen aus Spurenmessungen des DWD zum Störfall in Fukushima (In German). 19 May 2011. http://www.dwd.de.
5. PTB, 2011. Physikalisch-Technische Bundesanstalt (Germany's National Metrology Institute), station Brauschweig, Messung radioaktiver Nuklide in der Luft (In German). 19 May 2011. http://www.ptb.de/_radioaktivitaet.html.
6. SSK, 2004a. Leitfaden für den Fachberater Strahlenschutz der Katastrophenschutzleitung bei kerntechnischen Notfällen. Berichte der Strahlenschutzkommission Heft 37, Bonn (In German).
7. SSK, 2004b. Störfallberechnungsgrundlagen zu x 49 StrlSchV - Neufassung des Kapitels 4: Berechnung der Strahlenexposition; Berichte der Strahlenschutzkommission Heft 44, Bonn (In German).

Universität Bremen