G.J. Heij and J.W. Erisman (Editors). Acid Rain Research: Do we have enough answers?

Deposition Network of the Federal Environmental Agency (UBA) - Results and Trends

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Abstract

The UBA network is based on longterm standardised meteorological immision and deposition measurements at national level. Deposition data of Eastern (EG) and Western (WG) Germany were compared for 1986-1993, especially at times characterised by a dramatic decrease in air pollution. Important results so far have been the strong decrease of base cations, but the decrease in SO_4 deposition has not reached such a high level in EG. The current slow increase in N-deposition (nitrate, ammonia) is accompanied by a slow increase in acidification in EG. Generally, the deposition level in EG and WG both slowly reached the same level.

Introduction

A Commission of Experts on Environmental Matters and the German Union of Water Management and Natural Resources (DVWK) found the deposition measurement operations too diverse to reach uniform findings on deposition for Germany. These findings are based on the fact that too many factors are involved in this process: for example, different deposition collectors, sampling frequencies and chemical analytical methods. The distribution of sampling sites is irregular and regionally confined. This leads to minimising the comparison of data.
Using this as an argument, the UBA network has been extended to include the wet-only deposition measurement. The special quality of this network is the combined standardised meteorological immission and deposition long-term measurements at national level using automatically operated container stations and manned stations.

Background, Sampling Sites and Methods

Since the beginning of the 1980s, daily-bulk measurements have been carried out at UBA-manned stations. These measurements are indicated in Table 1.
With the unification of Germany, 10 stations from a total of 30 belonging to the wet-only deposition network of the Meteorological Service of the GDR were joined up to the network of the UBA. From the end of 1991, this has led to the gradual development of a national wet-only measuring programme as stated above (Figure 1).

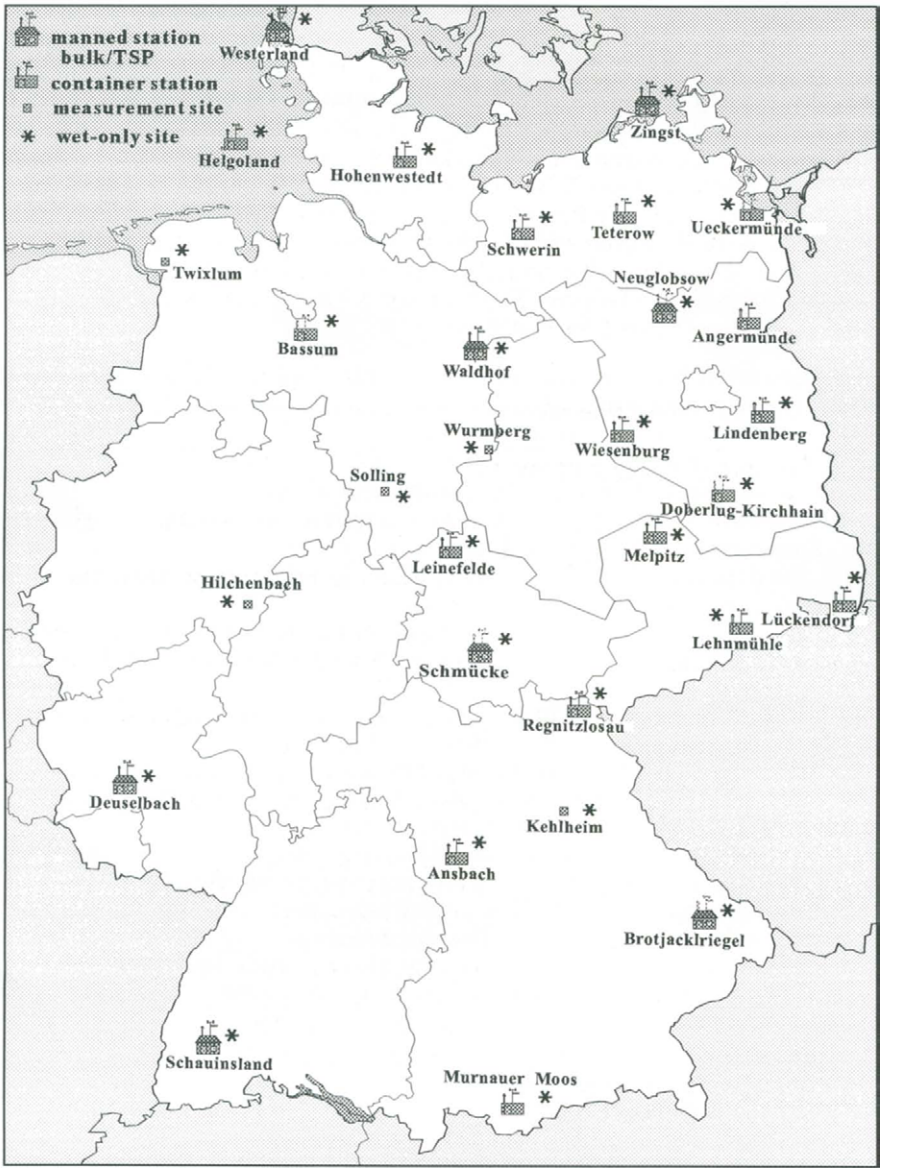


Figure 1. Immission and deposition sites within the UBA Monitoring Network

At the moment, measurements are being carried out at 26 stations; the entire network will be completed by the end of this year. The measuring programme is intended to estimate the quantity of rain, pH, conductivity, main ions and selected heavy metals. First, the precipitation sampling was achieved by means of an ANTAS wet-only collector produced by the Meteorological Service.
After a favourable comparison of deposition collectors of the former GDR and the FRG (mean deviation < ca. 5 %) the collector was replaced by NSA 181 KD produced by the Eigenbrodt firm. This wet-only collector contains a permanent cooling and sample-changing system, allowing samples to be changed every two weeks instead of weekly. The samples are analysed in the laboratory of the Institute of Energetics in Leipzig. The bulk samples are analysed at the UBA site in Schauinsland (see Table 1 for methods).

Table 1
UBA programme of deposition measurements and analytical methods

programme type *wet-only programme*:	
number of stations: 30	8 manned stations 16 automatically operated container stations 6 stations in cooperation with the federal states
sampler:	wet-only NSA 181 KD Fa. Eigenbrodt
frequency of sampling:	weekly (Tuesday-Tuesday), 8:00 a.m. (7:00 UTC)
	precipitation volume, conductivity, pH
	SO_4^{2-}, NO_3^-, NH_4^+, Cl^-
	Na^+, Mg^{2+}, Ca^{2+}, K^+
	heavy metals: Pb, Cd, Cu, Zn, Mn
bulk programme:	
number of stations: 8	8 manned stations
sampler:	bulk ARS 721 Fa. Eigenbrodt
frequency of sampling:	daily, 9:00 a.m. (8:00 UTC)
	precipitation volume, conductivity, pH
	SO_4^{2-}, NO_3^-, NH_4^+, Cl^-
	Na^+, Mg^{2+}, Ca^{2+}, K^+
	heavy metals: Pb, Cd, Cu, Zn, Mn, Fe

analytical methods *wet-only / bulk programme*::

parameter	**method**	**detection limit**
SO_4^{2-}	ion chromatography	10 µg 0,21µeq/l
NO_3^-	on chromatography	10 µg 0,16 µeq/l
NH_4^+	ion chromatography	10 µg 0,55 µeq/l
NH_4^+	flow injection	10 µg 0,55 µeq/l
Cl^-	ion chromatography	10 µg 0,28 µeq/l
Na^+	ion chromatography	10 µg 0,43 µeq/l
Mg^{2+}	ion chromatography	10 µg 0,25 µeq/l
Ca^{2+}	ion chromatography	10 µg 0,50 µeq/l
K^+	ion chromatography	10 µg 0,80 µeq/l

wet-only deposition: laboratory of the Institute of Energetics, Leipzig bulk deposition: laboratory at Schauinsland/UBA site

The wet deposition measurements are inspected at regular intervals to improve quality (QA/QC). For instance, spotchecks are carried out at the sites. We participate in national and international intercomparisons of collectors and analytical methods.
The conditions for choosing the deposition measurement site must represent:
- the background level of air pollution and deposition. They must include as many types of ecosystems as possible. The sites not owned by the UBA must be suitable for long-term measurement/observation. Another aspect was to measure on sites where scientific research installations and institutions of the various Länder (federal states) already existed. The intent was for them to complement each other.

In addition, at UBA automatic stations the following measurements were combined:
- wet-only/weekly - UBA;
- wet-only/daily or four-hourly sampling - Institute of Tropospheric Research, Leipzig;
- micrometeorological/inferential measurements - Fraunhofer Institute of Environmental Research, Garmisch Partenkirchen;
- measurements of TSP total and component amounts - UBA.

This cooperation is presently being conducted through the SANA Research Project (re-development of Eastern Germany). The aim of this cooperation is to develop, if possible, a method to estimate the entire deposition input for Germany using measurements and modelling and also considering the chemical processes in the atmosphere.

Results and discussion

For the initial evaluation, data is available from eight stations in Eastern Germany (EG) and five manned stations in the Western Sector of the Federal Republic of Germany (WG) for the period 1986-1993.
The deposition data of the bulk deposition UBA network (WG) was compared with the wet-only deposition data from the Meteorological Service (since 1988 wet-only) up to 1991, when UBA data (EG) was used. In fact, the bulk samples on sites with a low pollution level are analysed only after a rainfall, so that they are more comparable to wet-only samples (see Table 2). The change in emission, and in its wake the immission matrix, was carried out at short notice in the quickest possible time, especially in EG, (i.e. in the period between 1986-1993). This was accelerated by the collapse of industry and agriculture in the former GDR, which is now experiencing an upward swing.

Table 2
Mean values for wet deposition for 1986-1993

	year	RR	SO_4^{2-}	NO_3^-	NH_4^+	Cl^-	Na^+	Mg^{2++}	Ca^{2+}	K^+	H^+
		mm	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha
WG	86	1.018	30.59	22.20	7.52	20.39	11.32	1.59	3.38	1.49	0.32
	87	1.082	31.09	26.22	8.04	15.92	8.37	1.28	3.84	1.30	0.35
	88	1.052	31.65	25.61	8.43	27.21	14.56	2.11	3.80	1.56	0.31
	89	751	24.54	20.70	6.79	16.26	8.16	1.41	3.57	1.20	0.24
	90	862	25.94	19.27	6.51	42.00	22.21	2.70	3.75	1.75	0.22
	91	736	21.16	17.49	5.61	26.65	13.60	1.94	3.16	3.38	0.21
	92	920	21.10	19.54	6.07	24.62	13.58	1.75	3.86	1.22	0.20
	93	906	21.11	19.21	6.08	20.80	10.86	1.41	3.69	1.03	0.20

	year	RR	SO_4^{2-}	NO_3^-	NH_4^+	Cl^-	Na^+	MG^{2++}	Ca^{2+}	K^+	H^+
		mm	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha	kg/ha
EG	86	542	63.13	19.53	7.68	8.95	4.89	1.83	12.26	2.29	0.20
	87	576	66.24	19.57	8.82	10.17	4.82	2.13	14.65	2.02	0.22
	88	515	64.24	20.28	8.14	13.52	6.74	2.15	14.21	2.46	0.21
	89	396	41.44	14.95	6.43	8.77	4.18	1.11	7.21	1.09	0.16
	90	520	37.44	15.44	6.81	8.99	4.06	1.10	5.73	0.86	0.16
	91										
	92	437	17.67	13.12	3.84	7.55	4.21	0.82	0.82	1.28	0.28
	93	549	22.31	16.49	5.92	6.73	3.51	0.74	0.74	1.27	0.20

WG - mean values for the deposition sites of Westerland, Waldhof, Deuselbach, Schauinsland, Brotjacklriegel
EG - mean values for the deposition sites of Schwerin, Teterow, Neuglobsow, Lindenberg, Leipzig, Leinefelde, Schmücke

The decrease in SO_2 emission (see Figure 2) is accompanied by a simultaneous decrease of particulated matter emission (flying ash with Ca and Mg) and is in accordance with the mean value of SO_2 immission (see Figure 3) in rural areas (ca. 35 % lower) during 1985-1988. For the same period, in urban areas this value rose to 40 to 65 %. Nevertheless, the SO_2 immission in EG is three times higher than in WG and leads to exceedances of permitted annual values (140 $\mu g/m^3$ SO_2) of the Technical Instruction on Air Quality/TA-Luft) in Germany. The particulated matter immission dropped by 30 % on average.

The annual wet deposition (see Table 2) depict a slower decrease in comparison to the immission. This is reflected especially in the case of WG, where a marked fall in immission took place between 1987-1988. But the SO_4 deposition showed a decline only from the beginning of 1989. The same can be said of EG, although the decline began here in 1989/1990. This could be related to the delayed (1990) decrease of particulated matter immission.

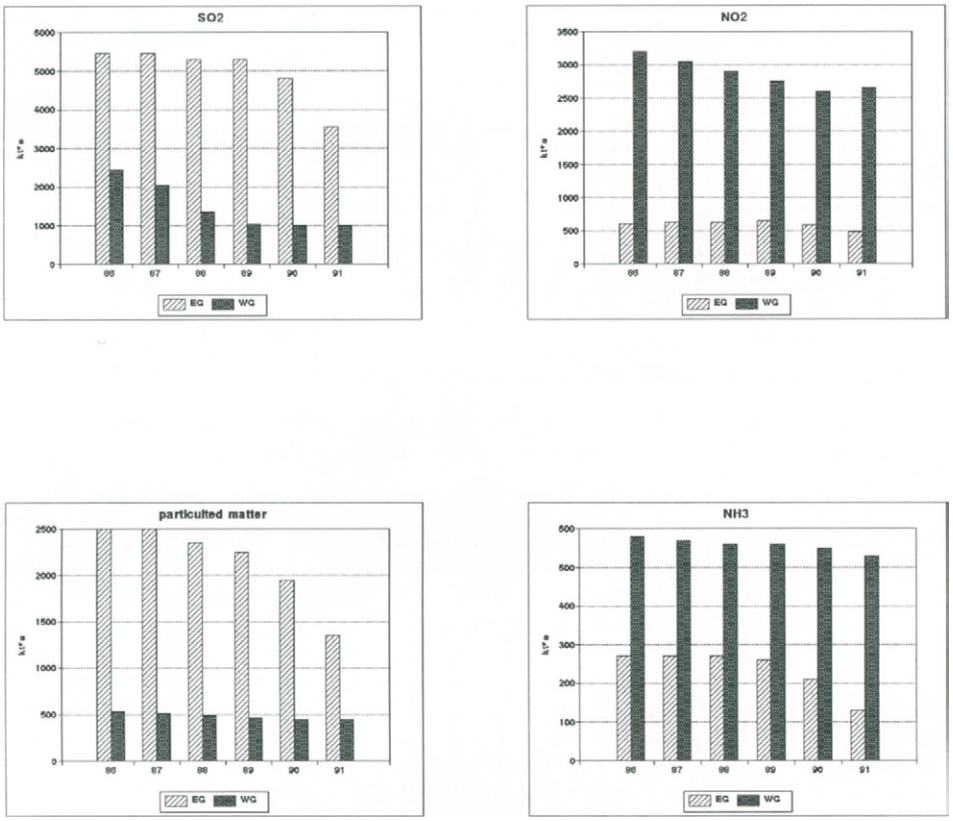


Figure 2 Trend of SO_2, NO_2, NH_3 and particulated matter emission in Germany 1986-1991 (Data from UBA)

At the beginning of the period in question, the SO_4 deposition decreased twofold in comparison to WG (see Figure 4). In EG the base Ca cations achieved a fourfold decrease and Mg also decreased somewhat more than in WG (see Figure 5). At the end of 1993 the situation was different. The SO_4 deposition in EG decreased by two-or threefold, the Ca deposition likewise. Within this same period the SO_4 deposition decreased by a third and the Ca deposition in WG remained unchanged. The SO_4Ca-ratio for EG is characterised by strong deviations caused by irregular decreases in SO_2 and Ca emissions.

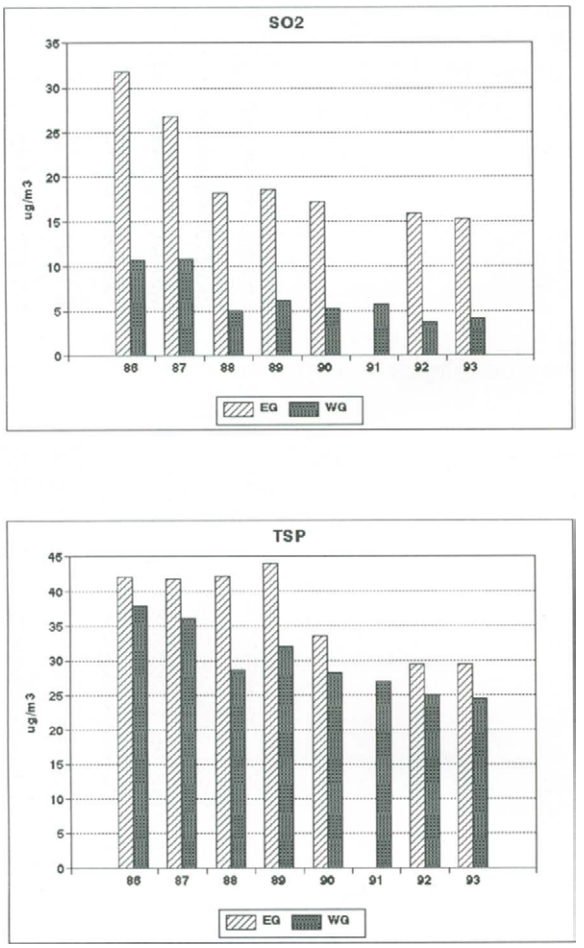


Figure 3 Trend in SO_2 and TSP immission in Germany
(yearly mean concentration based on daily means)

The following developments have been recorded for the nitrogen compounds. The NO_3 deposition decreased slightly in WG between 1988-1991 and has since either remained constant or shown a minor increase. In EG this tendency has increased only since 1993. The NH_4 deposition shown a downward trend in WG. In EG the values were the same at the beginning of this period. In 1992 these deposition values were reduced by 50% and with the revitalisation of agriculture there has been a further increase.
It can be noted that the acidifying capacity is in principle characterised by a slow increase in acidifying species (SO_4^{2-}, NO_3^-, Cl^-, $NH4^+$, H^+) and the more decreasing input of base cations. This development indicates a slow increase in acidification (see Figure 7) and represents a danger for the ecosystems.
The ration of the main parameters of wet-deposition in EG and WG is increasing to the same level (see Figure 8). This development is a result of the active environmental policy and application of measures for air purification of national level.

Conclusions

- Acidification is increasing, especially in Eastern Germany. With the long-term and standardised wet-only network demonstrated we are able to follow the trend more accurately.

- In order to estimate the total input by deposition and its effects we need measurements on fog and cloud deposition, also on dry deposition over low vegetation and forests.

- It will be necessary to combine the measurement activities of several institutes to get information on deposition in Germany, including application using model calculations.

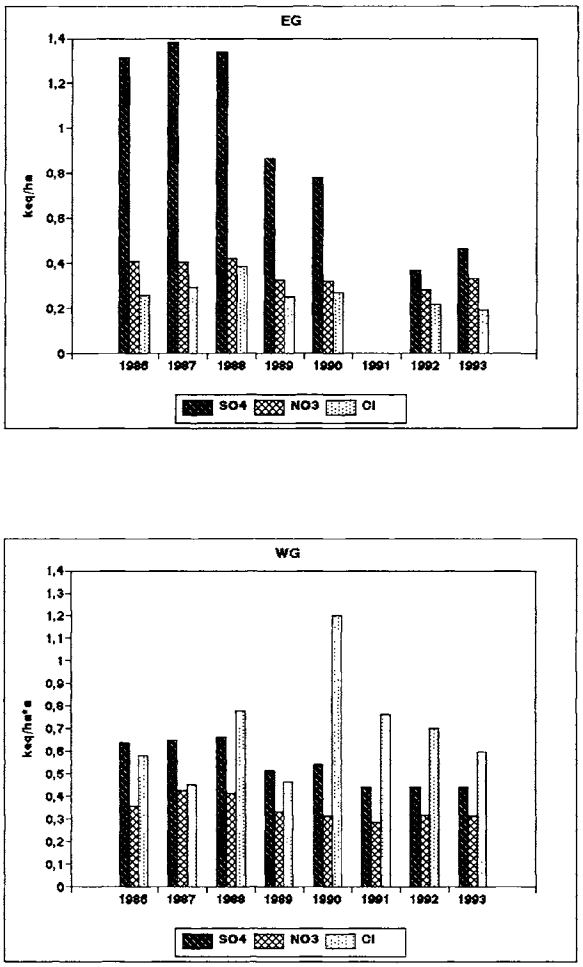
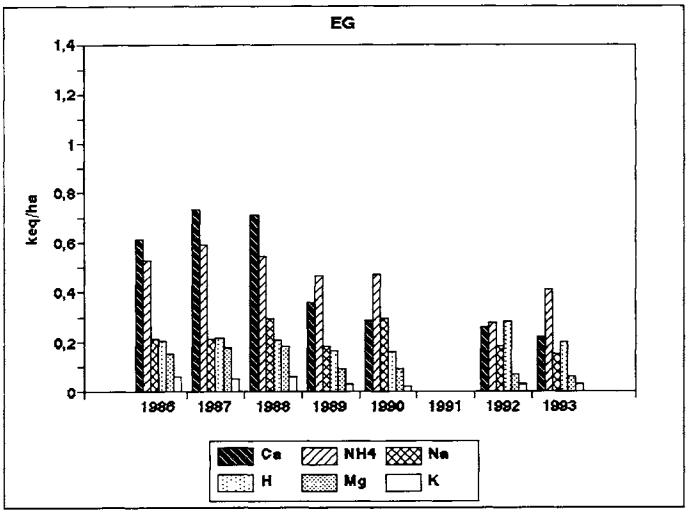


Figure 4 Yearly development of the mean deposition values (anions) in EG and WG. There is no sea-salt correction for Westerland, so the mean value of Cl is influenced by this factor



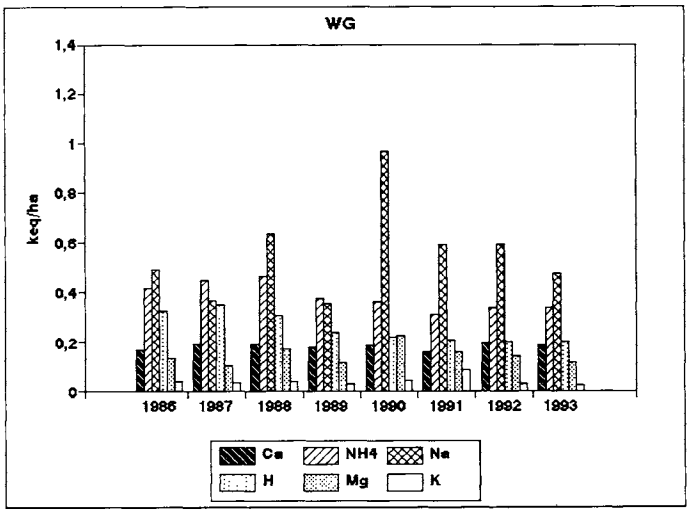


Figure 5 Annual development of mean deposition value cations in EG and WG

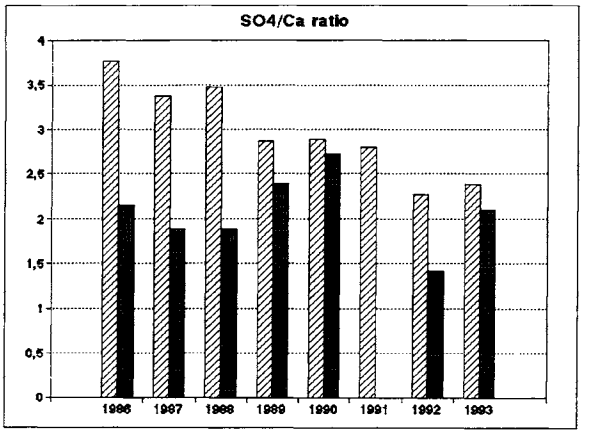


Figure 6 Yearly development of SO_4Ca deposition

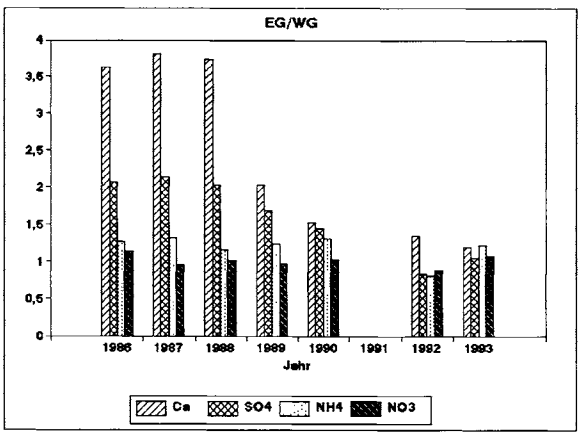
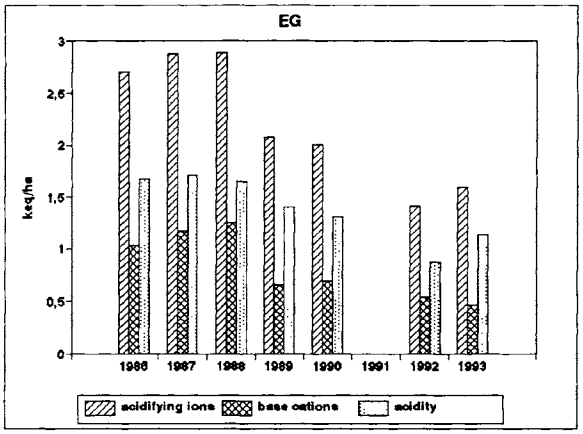


Figure 8 Yearly development of ratio of main ions in deposition EG/WG



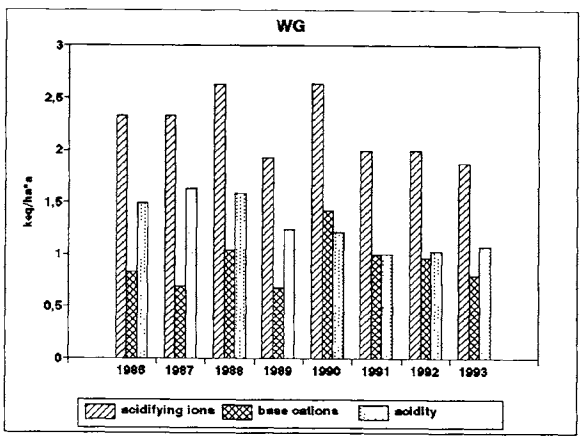


Figure 7 Yearly development of acidity
(A-acidifying ions (SO_4^{2-}, NO_3^-, NH_4^+, Cl^-, H^+), B-base cations (Na^+, K^+, Mg^{2+}, Ca^{2+}) acidity = A-B)