L I S - B e r i c h t e

Nr. 46

Air quality surveillance in the Federal Republic of Germany

Publisher:

Landesanstalt für Immissionsschutz
des Landes Nordrhein-Westfalen
Wallneyer Str. 6
D-4300 Essen 1

1984

ISSN 0720-8499

Air quality surveillance in the Federal Republic of Germany

Dr. M. Buck and Dr. P. Bruckmann

AIR QUALITY SURVEILLANCE IN THE FEDERAL REPUBLIC OF GERMANY

Dr. M. Buck and Dr. P. Bruckmann

S u m m a r y

The report gives a description of the monitoring programs for ambient air pollutants of the State Institute for Air Pollution Control (LIS) in Essen. These programs include facility-related measurements for licensing procedures for new industrial installations as well as general air quality monitoring. Experimental designs and methods are described. An outline of the smog-alert system in Northrhine Westphalia and a discussion of quality control in pollutant monitoring are included.

Z u s a m m e n f a s s u n g

Der Bericht beschreibt die Programme zur Luftqualitätsüberwachung der Landesanstalt für Immissionsschutz in Essen. Meßvorschriften und -methoden für anlagenbezogene Messungen in Genehmigungsverfahren sowie Systeme zur Überwachung der allgemeinen Luftqualität innerhalb und außerhalb von Ballungsgebieten werden erläutert. Weiterhin werden der Smogwarndienst in Nordrhein-Westfalen sowie die Qualitätskontrolle bei der Immissionsmessung kurz diskutiert.

1. Introduction

In 1974, the Federal Air Quality Protection Law (BImSchG) [1] and the Technical Instructions for Air Pollution Control (TA-Luft [2]) provided the legal basis for surveillance of air pollution in the F.R.G. Two main tasks were formulated for control networks: measurements of the impact of pollutants at sites of planned or existing industrial plants (plant-related measurements), and general monitoring of air quality in polluted regions. Plant-related measurements play a crucial role in licensing procedures for new industrial facilities, as will be explained later in more detail.

The purpose of surveillance in regions with existing or potential high pollution levels is to present an actual and quick overview of pollution loading and to provide information on trends and causes of air pollution. If monitoring is continuous, it can serve as smog-alert system at the same time.

Although the legal framework was given by the Federal government, the execution and implementation of regulations are within the responsibility of the states (Länder), as Northrhine-Westphalia, Bavaria, etc.

In this paper, we will concentrate on the monitoring networks in Northrhine-Westphalia, which, in the Rhine-Ruhr region still has the most urban-industrialized part of the F.R.G. to supervise. This surveillance is carried out by the State Institute for Air Pollution Control (LIS) at Essen, and will be described in the following sections. As the monitoring networks of the other states differ only in size and in some minor details, this can be also taken as example for the other states in the F.R.G. and, therefore, for Germany itself.

2. Facility-related measurements

One of the prerequisites for the licensing of a new industrial facility with environmental impact is that the air quality standards, defined in the TA Luft [2], must not be exceeded in the surrounding area. In order to guarantee this aim, ambient air measurements are taken in the area, which will later be charged to the planned factory. These measurements are performed in such a way as to describe the general pollution load, which is representative for the particular site. Then, emissions of the new plant are estimated, and their additional impact is calculated by standardized diffusion modelling (Gaussian plume modell). The calculated, additional impact of the new plant is added to the measured values of the ambient pollution already existing. The result is compared with the air quality standards of the TA Luft (Table 1). Generally, construction of the new plant will not be allowed if the sum of the measured and calculated values exceed the air quality standards (there are some exceptions).

Table 1. Air quality standards of the TA-Luft [2].

Components	Annual average (IW1)	98-(95)-percentile [a)] (IW2)
SO_2	0,14 $mg.m^{-3}$	0,40 $mg.m^{-3}$
NO_2	0,08 $mg.m^{-3}$	0,30 $mg.m^{-3}$
CO	10 $mg.m^{-3}$	30 $mg.m^{-3}$
Cl_2	0,10 $mg.m^{-3}$	0,30 $mg.m^{-3}$
Suspended particulate matter (TSP)	0,15 $mg.m^{-3}$	0,30 $mg.m^{-3}$
HCl	0,10 $mg.m^{-3}$	0,20 $mg.m^{-3}$
Cd in TSP	0,04 $\mu g.m^{-3}$	---- $\mu g.m^{-3}$
Pb in TSP	2,0 $\mu g.m^{-3}$	---- $\mu g.m^{-3}$
dust	0,35 $g.m^{-2}.d^{-1}$	0,65 $g.m^{-2}.d^{-1}$
HF	1,0 $\mu g.m^{-3}$	3,0 $\mu g.m^{-3}$

a) The 98-percentile is taken, if results of continuous measurements or spot check measurements from a period of at least three years are available, the 95-percentile otherwise.

Because of the importance of the plant-related measurements for the licensing procedure, details of the measurements and their design are regulated by the Federal Government in the TA Luft [2].

First, the area which will be impacted by the new factory is defined. Generally, this area is a circle, with the factory at the centre, and a radius which is 30 times the minimal stack height (which is also prescribed by the TA-Luft). As an example, a plant with a stack height of 150 m would have an impacted area with a radius of 4,5 km. Within this circle, smaller areas of 1 square km (1 km x 1 km) are defined (Figure 1). Measurements have to be performed in such a manner as to give representative values for each square kilometer which is fully included within the circle. The time period for the measurements is generally one year, as the air quality standards are defined on an annual basis.

Principally, there are two possibilities to obtain representative values for each square kilometer: discontinuous random sampling or continuous measurements. The procedure most often employed is random sampling at the 4 corner points of each square kilometer. Prescribed sampling times are 0,5 h for gaseous air pollutants, 24 h for T.S.P. and one month for dustfall. In order to obtain results with high accuracy and precision, the number of the grab samples should be high. This conflicts with economic considerations intended to minimize costs of the measurements. Therefore, the legislator had to find a compromise between these oppositing principles.

This is done by providing for different sample sizes, depending on the pollution load. The idea behind this is that at pollution levels near the air quality standards, less uncertainty can be accepted than at low pollution loads. The details are given in Table 2.

Table 2. Frequency of spot check measurements in relation of the pollution load

Number of discontinuous measurements yr^{-1} km^{-2}	pollution load in % of the air quality standards IW1 [a]
104 (gaseous compounds)	> 80 %
480 (T.S.P., incl. Pb, Cd)	> 80 %
52 (gaseous compounds)	60 - 80 %
240 (T.S.P., incl. Pb, Cd)	60 - 80 %
no measurements necessary	< 60 %

[a] estimated, calculated or measured

Discontinuous grab sampling at the corner points of each square kilometer may be substituted by continuous measurements with a grid width of four kilometers, if the pollution load is estimated to be below 70 % of the air quality standard IW1. In this case, greater uncertainties in regard to the spatial variability of air pollution impact can be tolerated, because there is still a safety margin of about 30 % to the air quality standards. Likewise, measurements of suspended particulate matter may be performed with distances of 4 km between the stations. Above 70 %, continuous measurements also have to be carried out with a grid width of one kilometer, so that there are no economic advantages compared with discontinuous measurements.

From the frequency distribution of the measurements, either discontinuous or continuous, the sample mean (I1V) and the 98 percentile (I2V) (or the 95 percentile) are calculated. I1V represents the average pollution load, whereas I2V indicates peak values. If only results from discontinuous measurements are available, which were performed over a period of less than three years, the 95 percentile is used instead of the 98 percentile. In polluted regions of Northrhine-Westphalia, this case will normally not occur, as general air pollution monitoring is done year by year in a 1 km^2 grid width (compare chapter 3).

In either case, the calculated additional pollution loads of the new plant under consideration, I1Z and I2Z, are added to the measured values, and the sums are then compared with the air quality standards (compare Table 1) for each square kilometer. If the air quality standards are exceeded at one or more squares, the licence for the new plant can not be given, if I1Z and I2Z are significant (1 % of I1V).

The air quality standards of the TA Luft are of course closely connected with the prescribed measurements procedure. They already include a certain safety margin to allow for the confidence limits of the measurements, and are therefore only valid if the measurements are performed as prescribed in the TA Luft.

The same measurement design as described above is also applied in those cases, where the air quality criteria are not met in the neighbourhood of existing plants, or where complaints from the public give rise to this presumption. Diffusion modelling of emissions is then used to calculate the emissions reduction, which is necessary to meet the air quality standards in the future.

Only measurement methods, which are checked and approved by expert groups of the VDI (Association of German Engineers) may be used. The VDI issues a collection of checked procedures [3].

We will now proceed to the second main complex, the general monitoring of air pollution in densely populated urban-industrialized regions.

3. General monitoring of air pollution

According to the Federal Air Quality Protection Law (BImSchG) [1], the states have to define regions with existing or potential high pollution levels, and to monitor the air quality in this area. In Northrhine-Westphalia, for example, an area of 4000 square kilometers, the Rhine-Ruhr region with about 6 million inhabitants, is such a polluted district (Figure 2). The aim is to describe the general level of air quality and trends and, if possible, sources of widespread pollution, rather than to yield high spatial resolution, as in the facility-related measurements. In addition, it should allow a quick overview of the air quality, if possible, in real time, for example as a basis for a smog-alert system. The results of these measurements are used to check the effectiveness of pollution control measures, and to compare the air quality of different regions in the F.R.G. and in the European Community.

Especially the requirement of real time monitoring can only be fulfilled by continuous measurements. Therefore the components which can be continuously measured by automated instruments, as SO_2, NO_x, CO, O_3 and T.S.P., are measured in small monitoring stations. These stations are arranged in a more or less regular network and connected via telephone lines with a central computer, which allows real time data processing.

In Northrhine-Westphalia, the grid width of the network is about 8 km. This gives a total of 42 fully automated stations in the Rhine-Ruhr district. Figure 3 shows the exterior and the interior of such an automated station.

The central computer is situated at the LIS at Essen. The measured values are transmitted every minute and on this basis, half-hourly averages or daily means can be calculated. Meteorological variables as wind speed and direction, sunshine, total rainfall etc. are also measured [4]. In the F.R.G., about 250 such automated stations are operating, with total of about 1200 instruments.

Because of the ability to monitor in real time, these systems are ideally suited for a smog-alert system. They show immediately, if the air pollution level exceeds smog-alert criteria. In combination with a weather forecast which predicts stagnant meteorological conditions to prevail for at least the next 24 hours, the different stages of the smog-alert are announced.

In the F.R.G., smog-alert systems are principally designed for the classical London type winter smog. Therefore, the decisive compounds are SO_2, NO_2, CO and suspended particulate matter (T.S.P.). Photochemical episodes of the Los Angeles smog type are also indicated by the ozone monitors of the networks, but as O_3 concentrations in the F.R.G. fortunately do not reach such high levels that human health is endangered, no smog alert exists for this kind of air pollution.

In the following, a brief outline will be given of the smog-alert procedure in Northrhine-Westphalia, which does not differ much from those of the other states. In the Rhine-Ruhr region, two smog-alert districts have been defined and each district is supervised by 6 smog-alert stations. Smog-alert will be announced if

a) the weather forecast does not exclude the occurrence of an inversion situation for 24 hours or more, and if
b) the following smog-alert criteria are exceeded for at least one component at more than half of the stations in the smog-alert district (Table 3):

Table 3. Smog-alert criteria (mg/m³, three-hour mean)

Component	Smog-alert-stage		
	1	2	3
SO_2	0,8	1,6	2,4
Total Suspended Particulate	0,8	1,6	2,4
CO	30	60	90
NO_2	0,6	1,2	1,8
Index value (combination of the 4 components)	4	8	12

The measures taken are briefly outlined in Table 4.

Table 4. Measures taken during a smog-alert

Stage: 1	2	3
Inform the public, hospitals, industries, etc. via newspaper, radio, TV. Appeal to everybody to reduce emissions as far as possible.	Traffic is prohibited from 6-10 am and from 3-8 pm, with the exception of vehicles for medical care, fire brigade, etc. Only low sulphur fuels (< 1 %) are allowed.	General prohibition of traffic; low sulphur fuels as in stage 2; reduction of production and even total shut down of industries, as arranged by the control authorities.

Since the inauguration of the smog-alert system in 1974, the smog-alert has had to be announced only once (1979, stage 1). There were, however, several episodes which approached stage 1. More details can be found elsewhere [5].

There is still the problem of the spatial variability of air pollution. 8 km is quite a large distance, and there may be smaller regions where the air quality criteria are exceeded that are not shown by the automatic stations. Therefore, monitoring of air quality in the Rhine-Ruhr region is completed by mobile spot check measurements with a grid width of 1 kilometer.

The mobile measurements are performed in the same manner as the plant-related measurements discussed in chapter 2 (52 measurements per square kilometer and year for each of the 4000 square kilometers). This has several advantages:
a) as the measurements are in accordance with the "TA Luft", the results can be used in the licensing procedure of new plants. No additional measurements are necessary, if the pollution load is below 80 % of the air quality standards (compare chapter 2).
b) The continuous system with perfect time resolution, but coarse spatial resolution is complemented by the discontinuous system with good spatial resolution.

This system was started in 1962 and is older than continuous surveillance. The components SO_2, NO, NO_2, Fluorine and total hydrocarbons were measured. Details can be found in [6].

So far, only measurement of the classical air pollutants has been discussed. There are a lot of other important components of air pollution, such as polycyclic aromatic hydrocarbons (PAH), other organics, like the phytotoxic ethene or the carcinogenic benzene, or heavy metals. Today, and presumably in the near future, these compounds cannot be measured automatically with sufficient accuracy in the field. Therefore, the monitoring networks have to be supplemented by additional measurement programs. To give some examples, total suspended particulate is collected at about 50 stations (collection time of 24 h) and is analyzed for heavy metals like Pb, Zn, Cd, Co, Cr, Ni, Hg and As. The organic fraction of the particulates is analyzed to determine 6 polycyclic aromatic hydrocarbons, like the benzopyrenes. 16 single hydrocarbons as ethene, benzene and toluene are sampled manually at the sites of the 42 automatic stations and analyzed in the laboratory on a yearly basis [7]. In the near future, it is planned to include additional carcinogenic organics, as acrylonitrile, vinyl-chloride and other halogenated hydrocarbons.

Finally, spot check measurements are performed in emergencies, around special sources (for example, asbestos fibres near asbestos processing industries), in cities, outside the polluted Rhine-Ruhr region and in forests, where especially sulphure acid and nitric acid are of interest.

4. Quality assurance

Because the consequences of wrong measurements can be very severe (for example the costly delay of the construction of a power plant), great efforts have to be taken to assure the quality of the measurements. To begin with, the methods are thoroughly examined by expert groups and published as VDI guidelines, as already mentioned. More than 50 guidelines exist today. Instruments and devices are checked by institutes and federal or state agencies, which are independent from the producers. Only approved instruments, announced by the Federal Ministry of the Interior, are used in air pollution control. In addition, round robin tests of several laboratories with reference standards are performed at regular intervalls. For example, such a test was run at the LIS measuring SO_2 and NO_x by all control agencies of the states in the F.R.G. All laboratories measured simultaneously from a sample line containing the same calibration mixture. Automatic as well as manual methods were used. The comparison of the laboratories was very good, the deviations of the single laboratories from the mean value being in the 10 % range (Figure 4).

Within the framework of cooperation between the F.R.G., the Netherlands, Belgium and Luxembourg, several international round robin tests have already been performed at the LIS in Essen.

L i t e r a t u r e   c i t e d

[1] Gesetz zum Schutz vor schädlichen Umwelteinwirkungen durch Luftverunreinigungen, Geräusche, Erschütterungen und ähnliche Vorgänge (Bundesimmissionsschutzgesetz - BImSchG) vom 15.03.1974. Bundesgesetzblatt, Teil 1, Nr. 27 (1974), pp. 721-1193.

[2] Erste Allgemeine Verwaltungsvorschrift zum Bundes-Immissionsschutzgesetz.
Technische Anleitung zur Reinhaltung der Luft - TA Luft - vom 28.08.1974 (GMBl., p. 426), in der Fassung vom 23.02.1983 (GMBl., p. 94).

[3] VDI-Handbuch Reinhaltung der Luft,
Verein Deutscher Ingenieure (Ed.),
Beuth: Berlin, Köln, Vol. 1-7.

[4] PFEFFER, H.U.: Das Telemetrische Echtzeit-Mehrkomponenten-Erfassungssystem TEMES zur Immissionsüberwachung in Nordrhein-Westfalen.
LIS-Report 19, LIS (Ed.), Essen 1982.

[5] KÜLSKE, S.: Analyse der Periode sehr hoher lokaler Schadstoffbelastungen im Ruhrgebiet vom 15.01.1982 bis 20.01.1982.
LIS-Report 24, LIS (Ed.), Essen 1982.

[6] IXFELD, H., K. ELLERMANN and M. BUCK: Bericht über die Ergebnisse der diskontinuierlichen Schwefeldioxid- und Mehrkomponentenmessungen im Rhein-Ruhr-Gebiet für die Zeit vom 01. Januar 1981 bis zum 31. Dezember 1981.
Schriftenreihe der Landesanstalt für Immissionsschutz des Landes NW, 56, pp. 49-79, W. Girardet, Essen 1982.

[7] BRUCKMANN, P., R. BEIER und S. KRAUTSCHEID: Immissionsmessungen von Kohlenwasserstoffen in den Belastungsgebieten Rhein-Ruhr.
Staub - Reinhaltung Luft, 43 (1983), S. 404-410.

A p p e n d i x

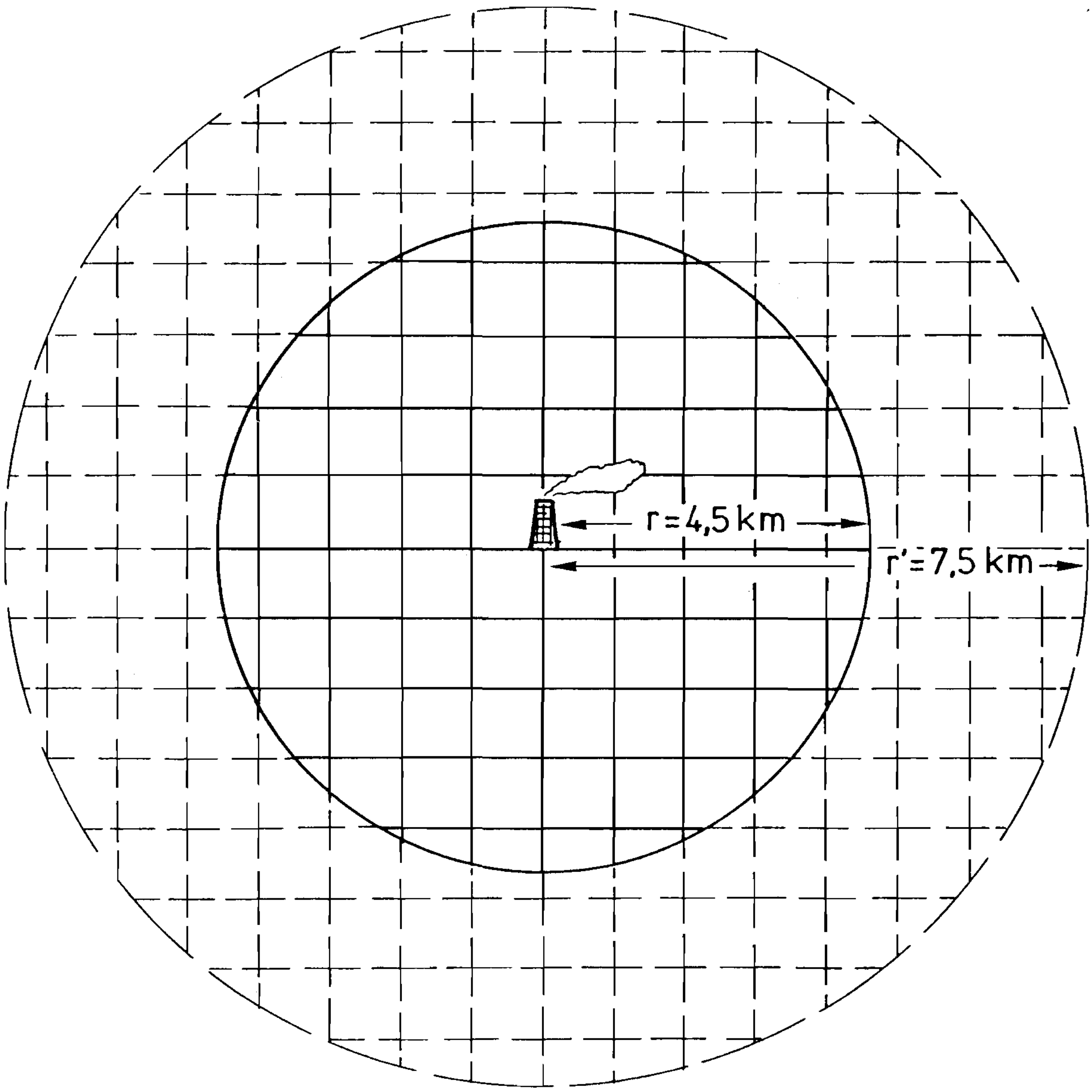


Fig. 1.:

Impacted area of a new plant in the licensing procedure according to the TA-Luft.
Inner circle (30 times the prescribed stack height): measurements for each square kilometer fully included are imperative.
Outer circle (50 times the prescribed stack height, dashed lines): measurements only for those square kilometers where the calculated additional burden IZ1 is greater than 1 % of the air quality standard IW1 (compare Table 1).

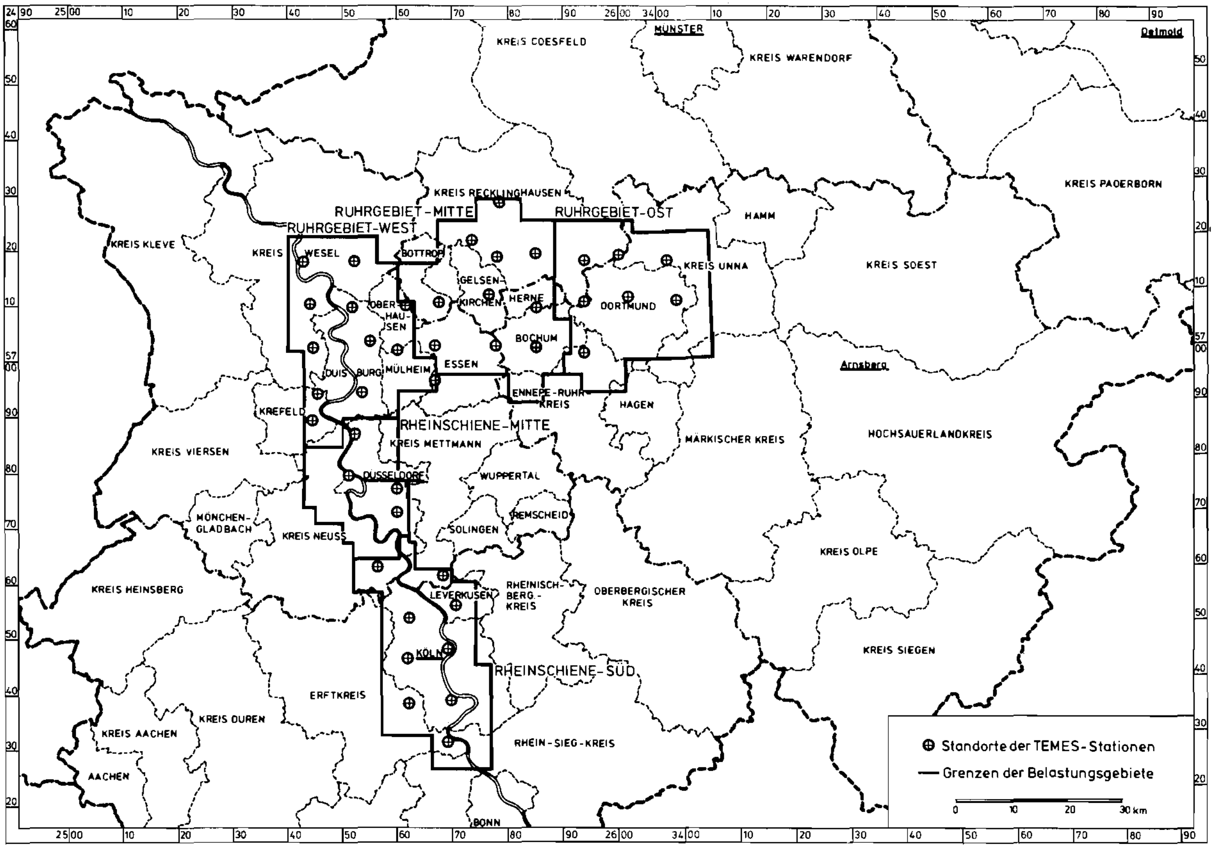


Fig. 2.:
Regions with existing or suspected high pollution levels in Northrhine-Westphalia and sites of the continuous monitoring stations (grid width: 8 km).

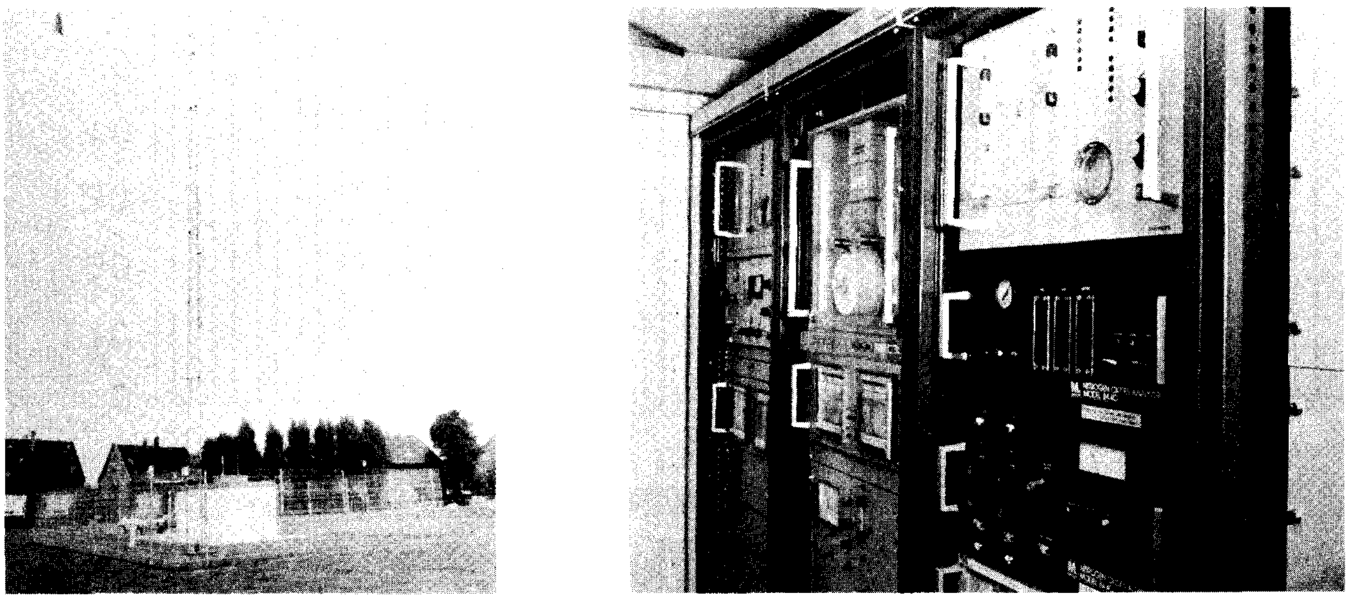
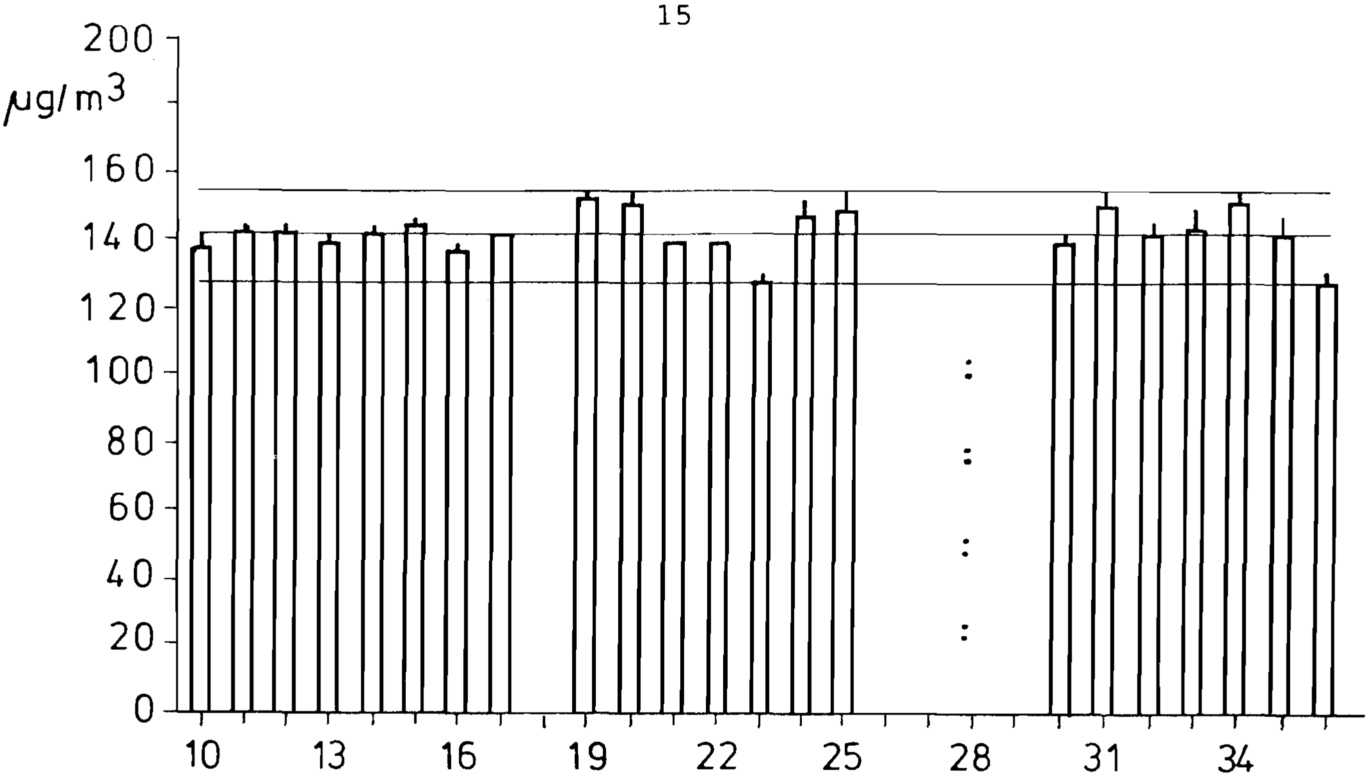
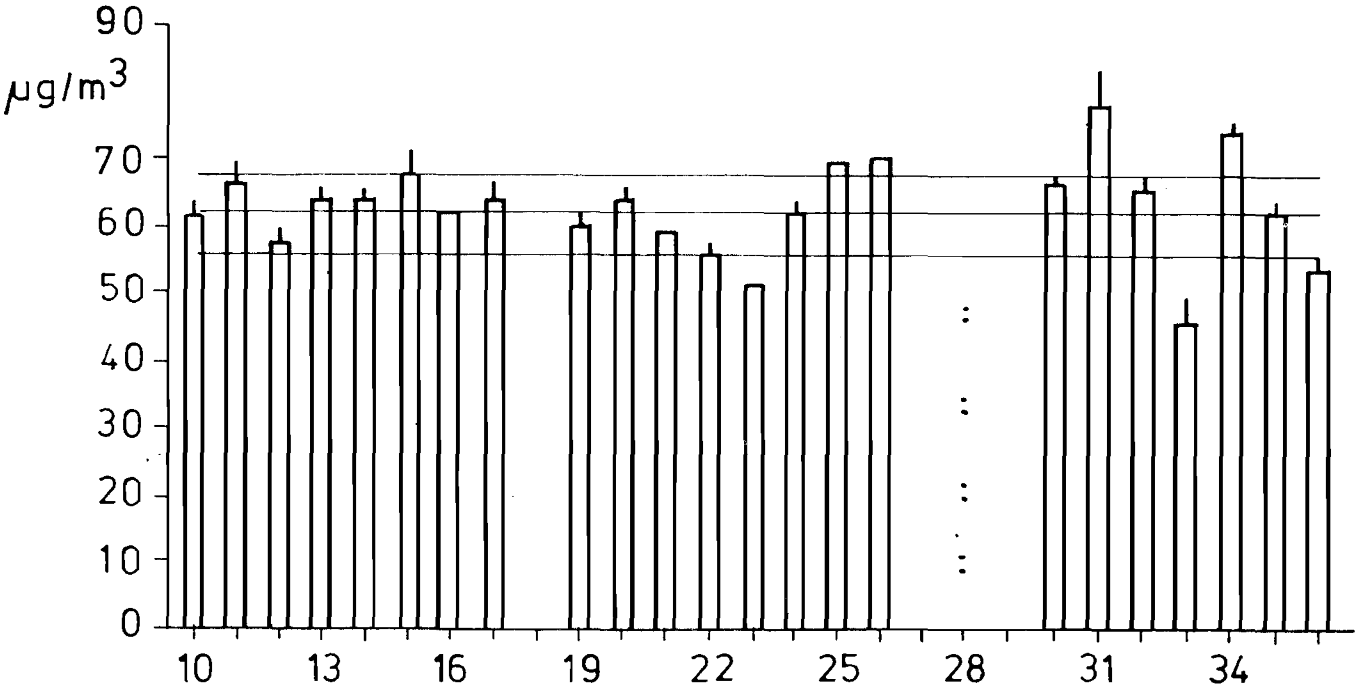


Fig. 3.: Exterior and interior of a continuous monitoring station with a pylon for meteorological instruments.



calibration mixture 2, sample mean: 140 µg/m³ SO_2



calibration mixture 5, sample mean: 60 µg/m³ SO_2

Fig. 4.: Results of round robin tests for SO_2, performed by the State Agency for Air Pollution Control (LIS) at Essen.

y-axis: measured concentration.
x-axis: number of participant.

Berichte der

LANDESANSTALT FÜR IMMISSIONSSCHUTZ DES LANDES NORDRHEIN-WESTFALEN, ESSEN

- LIS-Berichte -

Die LIS-Berichte haben spezielle Themen aus den wissenschaftlichen Untersuchungen der LIS zum Gegenstand. Die in der Regel umfangreichen Texte sind nur in begrenzter Auflage vorrätig. Einzelexemplare werden Interessenten auf Anforderung kostenlos zur Verfügung gestellt.

Anforderungen sind zu richten an die

Landesanstalt für Immissionsschutz
des Landes Nordrhein-Westfalen
Wallneyer Str. 6
4300 Essen 1

Berichte-Nr. 1: (vergriffen)	KRAUTSCHEID, S. und P. NEUTZ: LIDAR zur Fernüberwachung von Staubemissionen. - Nachweis der Kalibrierfähigkeit eines LIDAR-Systems - (1978).
Berichte-Nr. 2: (vergriffen)	BUCK, M.: Die Bedeutung unterschiedlicher Randbedingungen bei der Messung und Beurteilung der Luftqualität (1978).
Berichte-Nr. 3: (vergriffen)	SCHEICH, G.: Entwicklung und Anwendung von Ausbreitungsmodellen und Luftüberwachungsprogramme in den USA (1979).
Berichte-Nr. 4: (vergriffen)	SPLITTGERBER, H. und K.H. WIETLAKE: Ermittlung der Luftschalldämmung von Bauelementen für Industriebauten am Bau (1979).
Berichte-Nr. 5:	SPLITTGERBER, H.: Zur Problematik der Meßgrößen und Meßwerte bei Erschütterungsimmissionen (1979).
Berichte-Nr. 6: (vergriffen)	STRAUCH, H. und K.H. GOLDBERG: Ermittlung der Dämmwirkung von Dachentlüftern für Werkshallen im Einbauzustand unter Berücksichtigung der baulichen Nebenwege (1979).
Berichte-Nr. 7: (vergriffen)	KRAUSE, G.M.H., B. PRINZ UND K. ADAMEK: Untersuchungen zur Anwendbarkeit der Falschfarbenfotografie für die Aufdeckung und Dokumentation von Immissionswirkungen auf Pflanzen (1980).
Berichte-Nr. 8:	WIETLAKE, K.H.: Erschütterungsminderung durch "Direktabfederung" von Schabotte-Schmiedehämmern (1980).
Berichte-Nr. 9: (vergriffen)	STRAUCH, H.: Methoden zur Aufstellung von Lärmminderungsplänen (1980).
Berichte-Nr. 10:	HILLEN, R.: Untersuchung zur flächenbezogenen Geräuschbelastungs-Kennzeichnung -Ziele, Methodik, Ergebnisse- (1980).
Berichte-Nr. 11: (vergriffen)	MANNS, H., H. GIES und W. STRAMPLAT: Erprobung des Staub-Immissionsmeßgerätes FH62I für die kontinuierliche Bestimmung der Schwebstoffkonzentration in Luft (1980).
Berichte-Nr. 12: (vergriffen)	GIEBEL, J.: Verhalten und Eigenschaften atmosphärischer Sperrschichten (1981).
Berichte-Nr. 13:	BRÖKER, G., H. GLIWA und E. MEURISCH: Abscheidegrade von biologisch- und chemisch-aktiven Aggregaten zur Desodorierung osmogener Abluft von Tierkörperbeseitigungsanlagen (1981).

Berichte-Nr. 14: (vergriffen)
BRANDT, C.J.:
Untersuchungen über Wirkungen von Fluorwasserstoff auf Lolium Multiflorum und andere Nutzpflanzen (1981).

Berichte-Nr. 15: (vergriffen)
WELZEL, K. und H.D. WINKLER:
Emission und interner Kreislauf von Thallium bei einem Drehrohrofen mit Schwebegaswärmeaustauscher zur Herstellung von Portlandzementklinker unter Einsatz von Purpurerz als Eisenträger. - 1. Bericht - (1981).

Berichte-Nr. 16:
PRINZ, B. und E. KOCH:
Umweltpolitik und technologische Entwicklung in der VR China (1984).

Berichte-Nr. 17:
BRÖKER, G. und H. GLIWA:
Untersuchungen zu den Dioxin-Emissionen aus den kommunalen Hausmüllverbrennungsanlagen in Nordrhein-Westfalen (1982).

Berichte-Nr. 18:
BUCK, M., H. IXFELD und K. ELLERMANN:
Die Entwicklung der Immissionsbelastung in den letzten 15 Jahren in der Rhein-Ruhr-Region (1982).

Berichte-Nr. 19:
PFEFFER, H.U.:
Das Telemetrische Echtzeit-Mehrkomponenten-Erfassungssystem TEMES zur Immissionsüberwachung in Nordrhein-Westfalen (1982).

Berichte-Nr. 20:
BACH, R.W.:
Über Schätzfunktionen zur Bestimmung hoher Quantile der Grundgesamtheit luftverunreinigender Schadstoffkonzentrationen aus Stichproben (1982).

Berichte-Nr. 21:
STRAUCH, H.:
Hinweise zur Anwendung flächenbezogener Schalleistungspegel (1982).

Berichte-Nr. 22:
SPLITTGERBER, H.:
Verfahren zur Auswertung von Erschütterungsmessungen und zur Beurteilung von Erschütterungsimmissionen (1982).

Berichte-Nr. 23: (vergriffen)
KRAUSE, G.M.H.:
Immissionswirkungen auf Pflanzen - Forschungsschwerpunkte in den Vereinigten Staaten von Amerika. Bericht über eine Reise in die USA und die Teilnahme am 13. Air Pollution Workshop in Ithaca, N. Y., in der Zeit vom 02.05.-24.05.1981 (1982).

Berichte-Nr. 24: (vergriffen)
KÜLSKE, S.:
Analyse der Periode sehr hoher lokaler Schadstoffbelastungen im Ruhrgebiet vom 15.01.1982 bis 20.01.1982 (1982).

Berichte-Nr. 25: (vergriffen)
VAN HAUT, H. und G.H.M. KRAUSE:
Wirkungen von Fluorwasserstoff-Immissionen auf die Vegetation (1982).

Berichte-Nr. 26:
KOCH, E., V. THIELE, J. GIEBEL, H. STRAUCH und P. ALTENBECK:
Empfehlungen für die problemgerechte Erstellung von Immissionsschutzgutachten in Bauleitplanverfahren (1982).

Berichte-Nr. 27: (vergriffen)
MANNS, H., H. GIES und G. NITZ:
Verbesserung der Zuverlässigkeit und Vergleichbarkeit von Messungen zur Ermittlung aromatischer Kohlenwasserstoffe in der Außenluft (1982).

Berichte-Nr. 28:
PRINZ, B., G.M.H. KRAUSE und H. STRATMANN:
Vorläufiger Bericht der Landesanstalt für Immissionsschutz über Untersuchungen zur Aufklärung der Waldschäden in der Bundesrepublik Deutschland (1982).

Berichte-Nr. 29:
GIEBEL, J.:
Untersuchungen über Zusammenhänge zwischen Sperrschichthöhen und Immissionsbelastung (1983).

Berichte-Nr. 30:
MANNS, H. und H. GIES:
Ergebnisse der Laborprüfung und Optimierung des meßtechnischen Teiles der Ozon-Meßplätze im Meßnetz LIMES-TEMES (1983).

Berichte-Nr. 31: BEINE, H., R. SCHMIDT UND M. BUCK:
Ein Meßverfahren zur Bestimmung des Schwefelsäure- und Sulfatgehaltes in Luft (1983).

Berichte-Nr. 32: BEIER, R. und P. BRUCKMANN:
Messung und Analyse von Kohlenwasserstoff-Profilen im Rhein-Ruhrgebiet (1983).

Berichte-Nr. 33: FRONZ, W.:
Ermittlung von Verkehrsgeräusch-Immissionen
- zum tageszeitlichen Verlauf des Geräuschpegels und des Verkehrsaufkommens an Bundes- und Sammelstraßen (1983).

Berichte-Nr. 34: BRÖKER, G.:
Zusammenfassende Darstellung der Emissionssituation in Nordrhein-Westfalen und der Bundesrepublik Deutschland für Stickstoffoxide (1983).

Berichte-Nr. 35: PIORR, D. und R. HILLEN:
Veränderung akustischer Kenngrößen infolge der nächtlichen Abschaltung von Lichtsignalanlagen (1983).

Berichte-Nr. 36: BUCK, M., H. IXFELD und K. ELLERMANN:
Benzol-Immissionsmessungen im Lande Nordrhein-Westfalen (1983).

Berichte-Nr. 37: BACH, R.-W. und H. STRATMANN:
Untersuchungen zur Bestimmung der Aufnahmerate des IRMA-Gerätes bei verschiedenen Anströmverhältnissen (1983).

Berichte-Nr. 38: (vergriffen) WIETLAKE, K.H.:
Beurteilung und Minderung tieffrequenter Geräusche (1983).

Berichte-Nr. 39: STRAUCH, H. und K. SCHWENGER:
Geräusche und Erschütterungen, verursacht durch elektrisch angetriebene Wärmepumpen (1983).

Berichte-Nr. 40: BRÖKER, G. und B. SCHILLING:
Schwermetallemissionen bei der Verbrennung kommunaler Klärschlämme (1983).

Berichte-Nr. 41: HILLEN, R.:
Über Möglichkeiten zur Verbesserung der Qualität von Schießgeräuschmessungen im Immissionsbereich (1983).

Berichte-Nr. 42: KLEIN, M.:
Untersuchung zur Schallausbreitung im Freien - Ziele, Physik der Schallausbreitung, Vorgehensweise, Ergebnisse - (1983).

Berichte-Nr. 43: PFEFFER, H.-U., S. KÜLSKE und R. BEIER:
Jahresbericht 1981 über die Luftqualität an Rhein und Ruhr.
Ergebnisse aus dem telemetrischen Immissionsmeßnetz TEMES in Nordrhein-Westfalen. (1984)

Berichte-Nr. 44: BUCK, M., H. IXFELD und R. BEIER:
Immissionsbelastung durch Fluor-Verbindungen in der Nachbarschaft der Aluminiumhütte LMG in Essen. (1984).

Berichte-Nr. 45: STRAUCH, H. und R. HILLEN:
Geräuschimmissionen in Großstädten; Flächenbezogene Kennzeichnung dieser Geräuschimmissionen (1984).

Anmerkung:
Die LIS-Berichte - auch die vergriffenen - stehen Interessenten in zahlreichen Universitäts- und Hochschulbibliotheken zur Ausleihe bzw. Einsichtnahme zur Verfügung.