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Planning of ambient air quality monitoring

Planification du contrôle de la qualité de l'air ambiant

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Contents

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The main task of ISO technical committees is to prepare International Standards. In exceptional circumstances a technical committee may propose the publication of a technical report of one of the following types:

— type 1, when the necessary support within the technical committee cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development requiring wider exposure;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical reports are accepted for publication directly by ISO Council. Technical reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standard. Technical reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 4227, which is a technical report of type 2, was prepared by Technical Committee ISO/TC 146, *Air quality*.

Annexes A, B and C form an integral part of this Technical Report.

Introduction

In order to protect the environment, many different aspects of air quality have to be examined. These may include obtaining information on the existing local, regional or global air quality, forecasting the quality of air likely to be expected in the future, evaluating monitoring possibilities, or considering the complicated relationship within the context of formation and drift of airborne pollution. In each country such tasks may be formulated differently depending on its type of industry, and topographical or climatic situation. Accordingly every country has created a different type of ambient air monitoring system. The data obtained often cannot be compared directly. It is for this reason that some standardization has been undertaken (see ISO 7168) to establish a useful international exchange of ambient air quality data. In this Technical Report a classification which could be used as a basis for standardization of ambient air quality monitoring tasks is introduced.

Standardization of air quality monitoring is only reasonable and possible for those air quality monitoring systems which deal with equivalent tasks. Air quality monitoring tasks are considered to be equivalent if they fall into one class of the classification scheme which covers the task as well as the major aspect of the actual measuring scheme. Using these classifications, all likely air quality monitoring systems are arranged in the form of a matrix, where each column represents a particular task and each row a specific aspect of the measuring scheme. This representation enables detailed comparisons to be made of different aspects of air quality monitoring.

Planning of ambient air quality monitoring

1 Scope

This Technical Report establishes a classification scheme which should form a general basis for international standardization of ambient air quality monitoring and permits comparison between existing and planned ambient air quality monitoring systems. The results of such comparisons may be used as guidelines for standardization.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Technical Report. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Technical Report are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 4225 : 1980, *Air quality — General aspects — Vocabulary*.

ISO 4226 : 1980, *Air quality — General aspects — Units of measurement*.

ISO 6879 : 1983, *Air quality — Performance characteristics and related concepts for air quality measuring methods*.

ISO 7168 : 1985, *Air quality — Presentation of ambient air quality data in alphanumerical form*.

ISO 8601 : 1988, *Data elements and interchange formats — Information interchange — Representation of dates and times*.

ISO 9359 : 1989, *Air quality — Stratified sampling method for assessment of ambient air quality*.

3 General considerations

All ambient air quality monitoring tasks are designed for the assessment of environmental effects. It is therefore not sufficient merely to measure air pollutants. It is also necessary to relate the results of these measurements to observed effects. On the other hand, it is well-known that the ground-level concentration of an air pollutant can be correlated with emission rates and propagation conditions. This means that there exists a causal relationship between the source, the propagation and the effects of the air pollution.

In order to quantify any relationship, three basic concepts are introduced: emission, transmission and immission. These concepts are generally explained as follows (see also ISO 4225).

Emission is the transfer of air pollution from the source into the free atmosphere.

Immission is the transfer of air pollution from the free atmosphere to a receptor such as a human being, plant or building. The summation of immission rate over an interval of time gives the immission dose, the total air pollutant intake by the receptor.

The sites at which emission or immission take place are defined by the enveloping surface of the source or the receptor.

Transmission describes collectively phenomena affecting the air pollutants in the free atmosphere between the source and the receptor. These phenomena include all dynamic physical effects such as dilution of the pollutant with air, as well as any physical or chemical reactions that might occur.

In order to describe these concepts quantitatively, mass or other quantifiable property flux and their derivatives have to be used. Units of measurement are given in ISO 4225. An illustration of emission, transmission and immission is given in figure 1. Detailed explanations of the mathematical concepts are given in annex A.

According to these definitions, immission is a mass or other quantifiable property rate per unit interval of time, which should be measured, if possible, at the receptor. Usually, it is necessary to know the immission to a number of different receptors and not confine measurements to just one receptor. An air pollution survey should be designed to measure the immission to receptors and the possible effects. One may introduce a "virtual receptor" with unit surfaces and unit properties and study, for each such receptor, the possible immission as a function of space and time. A virtual receptor might be simulated by a special measuring system or have a defined correlation with a ground-level concentration or deposition.

4 Formulating the tasks

4.1 Establishing the objectives

Before starting measurements it is essential to establish what problem has to be solved and what constraints may have to be imposed on an "ideal" measuring system.

The following is a summary of questions to be considered.

a) Has the basic problem been defined?

1) Is there an air pollution problem or a potential problem?

2) Does a need exist for a monitoring system?

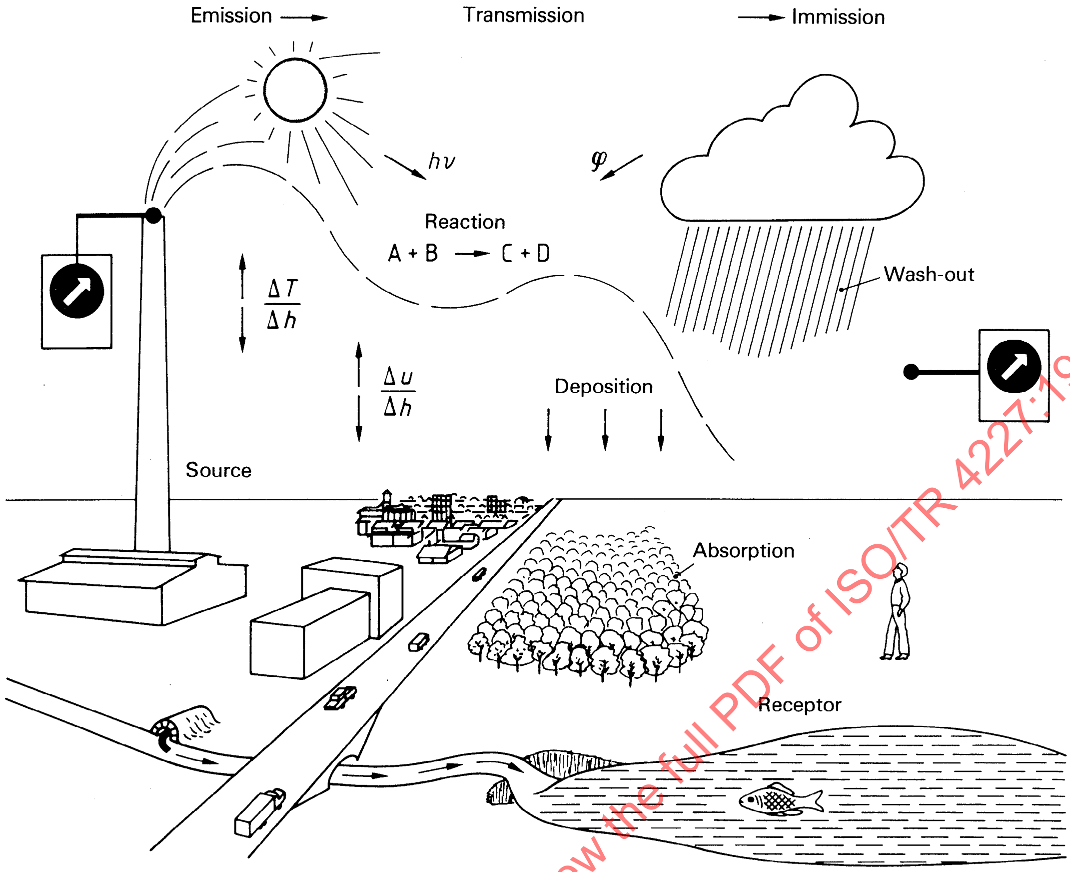


Figure 1 — Illustration explaining the concepts emission, transmission and immission

3) What should be the scope and limitations for monitoring?

b) To what extent does the basic problem relate to the following monitoring functions?

1) To quantify ambient air quality and its variation in space and time?

2) To provide a basis for air pollution control regulation?

3) To provide data for an integrated monitoring system?

4) To determine the effectiveness of control action on ambient air quality?

5) To provide real-time data for an alert and warning system?

6) To determine source-receptor relations?

7) To analyse local circulation characteristics and effects?

8) To provide trends for zoning and urban planning requirements?

9) To provide input data for operational urban models?

10) To provide data for interjurisdictional information exchange?

11) To interface with other monitoring systems?

c) What are the economic and technical constraints?

1) What funding is available and how does this relate to the confidence in the ambient air quality data to be obtained?

2) What restrictions exist on procurement?

3) What are the manpower requirements for operation, maintenance, repair, calibration and ambient air quality data evaluation?

4) What are the staff capabilities?

5) What are the training requirements for staff?

6) Is a realistic timetable achievable?

4.2 Basic classification

Once the objective of the monitoring has been established, the task has to be formulated. In order to do this, it is first of all essential to answer a number of questions concerning the objectives of the survey, the area over which air quality is to be assessed, the period of the survey and the way in which the data obtained are to be analysed and presented.

The following classification is suggested.

a) Objective

1 . . . Determination of facts

2 . . . Diagnosis

3 . . . Prediction

b) Data analysis and presentation

. 1 . . Tabulation

. 2 . . Frequency distribution

. 3 . . Characteristic values

c) Area of assessment

. . 1 . Point assessment

. . 2 . Unresolved area

. . 3 . Resolved area

d) Period of survey

. . . 1 Individual air samples

. . . 2 Unresolved time

. . . 3 Resolved time

The tasks do not have to be carried out in the order in which these classes are listed. The numbering serves as an identification of the questions and the corresponding measuring scheme. Thus each air quality monitoring task is given a four-digit identification.

Details of this classification are given in 4.3 to 4.6.

4.3 Objective

Essentially the objective may be broken down into one of the three classes: determination of facts, diagnosis, prediction. The amount of data needed to solve the problem increases with each class. For example, a diagnosis presupposes that the facts have been determined and a prediction normally means that the facts have already been stated and a diagnosis made.

In most cases, measurements have to be made to solve the problem. This means that there will be uncertainties in the data collected due to experimental error, unknown transmission parameters, etc. Consequently this leads to measurement uncertainties which can be quantified using statistical methods. Thus in defining the objective it is mandatory to define also the minimum significance level (or measurement uncertainty) allowable for the problem to be solved.

4.3.1 Determination of facts

This is to be understood as the statement and documentation of emission, transmission or immission situations. Typical examples are the establishment of ground-level concentrations at particular wind directions, etc.

4.3.2 Diagnosis

Diagnosis is finding the reason why particular immission situations exist. Examples are: particular immissions due to special conditions of emission or transmission, establishment of the precise location of a source, assessment of air pollutants to specific source or sources, establishment of the contribution of a source to a definite immission situation.

To accomplish tasks such as these, measurements of ground-level concentrations of air pollutants only may not be enough. Additional measurements may have to be made or information obtained on emission, transmission and possible effects so that correlations can be made. This will be for identification of sources following complaints, analysis of situations under stagnation conditions, and determination of the relative amount of air pollution attributable to space heating, traffic or other sources in special situations.

4.3.3 Prediction

Prediction should give information about immissions expected in the future. These could be long-term predictions based on climatic data or information on expected changes in emission or transmission, or short-term predictions for special conditions of transmission, e.g. stagnation conditions, wind direction and wind speed, chemical reactions, special emission conditions.

Typical examples are the long-term trend of immissions due to increased industrial production, effects of planned abatement measures or immissions resulting from accidental emissions.

4.4 Data analysis and presentation

Data analysis and presentation shall be closely related to the objective of the survey. It shall yield sufficient information for the solution of the problem. For example, the following information may be required:

a) daily means of the concentrations of all air pollutants;

b) diurnal variations in the concentrations of all air pollutants;

c) interval of time, each day, during which certain values have been exceeded (percentiles);

d) means of concentrations of air pollutants at certain sampling sites when the wind is blowing from certain major sources;

e) frequency distribution;

f) hourly, daily, monthly maximum values;

g) multiple regression analysis.

Care shall be taken that analysis and presentation of data for specific correlations do not lead to a loss of information that may be required at a later time. For example, the immision situation is completely described by a function of time and the three-dimensional space vector in the area of assessment.

The measured space-time function could be presented either for each sampling site as a function of time, or at a certain time as a function of the sampling sites. Usually the questions are far more complex and involve the dependence of the immission on certain emission and transmission parameters. These parameters are also space-time functions; therefore the required relationsips may be derived if these and the immision are given as a function of time and space. On the other hand, the immission can be presented as a function of the parameters themselves. Where this is done, information about time and space will be lost. For example, the dependence of immission on wind direction is derived simply from the two functions: immission as a function of time and wind direction as a function of time. However, if the data are reduced in such a way, the information on time is lost, and the time relationship of the immission cannot be recovered if additional investigations of the effect of other parameters become necessary. These aspects shall therefore be considered carefully in setting up measuring schemes and equipment.

The data presentation can be done in three different ways as described in 4.4.1 to 4.4.3.

4.4.1 Tabulation

This is the presentation of data in the form of lists, such as measured values of immission or its substitute according to location, time, or other parameters relevant to the question. Tabulation gives the largest sets of data for general evaluation at minimal expense.

Often these tables are a presentation of different dependencies, e.g. the dependence of immission on emission or transmission.

These dependencies are generally of a stochastic nature. Typical examples of this type of presentation are:

- tables of measured values according to the coordinates of different measurement points for different intervals of time or special transmission conditions;
- tables of measured values for selected measurement points in chronological order.

4.4.2 Frequency distribution

Frequency distribution describes the relationship between the values of a characteristic and their absolute or relative frequency of occurrence. This frequency may be presented as actual, relative or cumulative and can be depicted as a table, a graphic (see figure 2) or as coefficients of a function. A typical example is the relative frequencies of the occurrence of measured values within defined limits of concentration for every measurement point in an area of assessment during the specified period.

It should be noted that this method of data reduction usually brings about a loss of original information, since individual identification of each measured value is lost in the process of calculating statistical summaries.

4.4.3 Characteristic values

In many cases, the results may be depicted by a few characteristic values, e.g. the mean estimate of the indicated percentile indices. These may be derived from the frequency distribution, computed from the original list, or obtained directly during the measurement by means of automatic evaluation. Data presentation by characteristic values gives the highest degree of data reduction with a corresponding loss of original information.

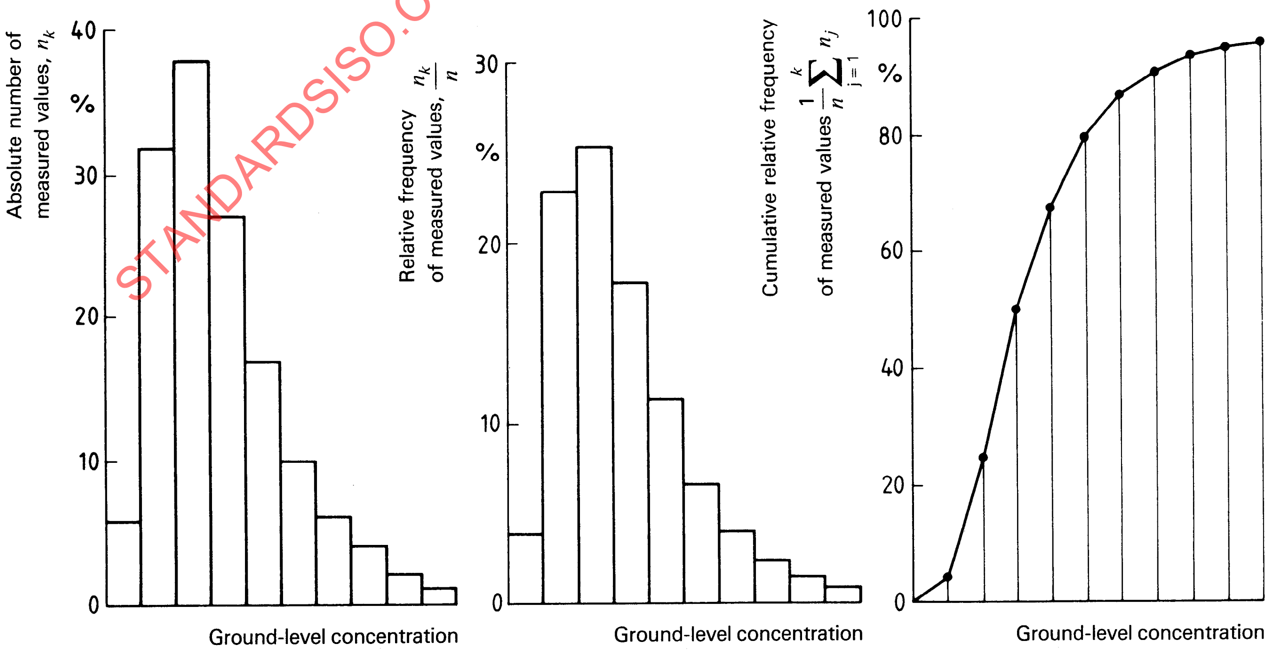


Figure 2 — Examples of graphic presentation of distribution

4.5 Area of assessment

In most cases it is necessary to assess the immission with regard to a number of different possible receptors and not for a special single receptor localized at a certain point. For this reason, the concept of virtual receptors is used. For a study of ground-level concentrations, the surface of a virtual receptor might be placed at a certain height above ground level, whereas in a study of corrosion of buildings, a surface in the form of the building might be chosen. The measuring systems should be placed to give representative values for the whole surface.

The area of assessment may be described by fixed or movable co-ordinates and it may consist of one area or a number of different sub-areas. For example, the measurement task is completely defined with regard to the area if a limitation or a definition can be fixed according to

— geographical criteria or borders between countries;

— sources or special groups of sources;

— special transmission conditions or special objects to be protected.

For practical reasons it is best to have three classes of areas of assessment, i.e. point assessment, unresolved area and resolved area (see figure 3). In all three cases sampling sites are chosen differently. If the area of assessment is composed of one or a number of fixed points, the sampling sites are directly given by the formulation of the problem. If the area of assessment is composed of one or a number of areas which have to be assessed without any spatial resolution, the measurement may be done by random sampling. Number and distribution of the sampling sites are given by the variance of the object to be measured and the required accuracy. If an area has to be assessed using the spatial dependence of the immission, the number and distribution of the sampling sites also depend on the required spatial resolution.

4.5.1 Point assessment

The area of assesment may consist of one or a number of spatially unconnected points of assessment. A point of assessment is defined as a small continuous area in which further sub-division is neither possible nor necessary for an assessment of immission. The point of assessment is represented by the measuring system used. Isolated points of assessment can be stationary or movable, e.g. a person or a point 5 km downwind of a source. An example of a number of unconnected points combined into one area of assessment is a playground (see figure 3).

4.5.2 Unresolved area

An unresolved area of assessment can be composed of one or a number of areas. Where the immission for each area as a whole is of interest and more than one sampling site for each area is required, spatial resolution is unnecessary (see figure 3) — for example, the determination of the mean of concentrations of sulfur dioxide in an industrial area where there may be more than one sampling site and where a spatial resolution regarding immission is not required between sampling sites. Another example of the assessment of a number of sub-areas is the determination of the 75 % percentiles of the concentrations of sulfur dioxide in industrial, residential and recreational areas of a city.

4.5.3 Resolved area

Within the area of assessment the immission should be assessed as a function of space. This means that a certain spatial resolution has to be established during the formulation of the problem (see figure 3). The power of the spatial resolution is given by the sampling site density, the accuracy of measurements, and possible additional information with regard to the spatial distribution of the immission. If evaluation is necessary within a limited interval of time, the spatial resolution also depends on the variance of the object to be measured and therefore on the frequency of measurements. Examples are the determination of lines of equal average concentration where a certain limiting value is exceeded within the area of assessment, or the determination of the decrease of concentrations of carbon monoxide as a function of increasing distance from a major roadway when the wind blows in a particular direction, the knowledge of the emission distribution serving as additional information.

4.6 Period of survey

The period of survey may consist of one or a number of different sections on a time axis. In each section, the immissions may be assessed as a mean with regard to time or to time lapse.

Because of variations in emission and transmission conditions during different intervals of time (year, week, day) as well as irregular cycles of emission and transmission, the period of survey has to be defined very carefully. This is especially true if different cycles occurring at the same intervals of time are to be considered, e.g. overlapping of morning cycles of space heating with daily traffic density.

Differentiation into fixed individual sampling, unresolved time or resolved time is therefore proposed for practical reasons. Fixed individual sampling means that the interval of time of sampling is established by the formulation of the task. Unresolved time implies that means are mainly to be considered. Here the number of air samples and the interval of time of sampling depend only on the variance of the object to be measured and the required accuracy. Resolved time implies that the time lapse of immission has to be measured. In this case, the number of air samples depends on the required time resolution and the reproducibility of the measuring system.

4.6.1 Individual air samples

For individual sampling, one or a number of air samples are taken over a specified period. The start time at the beginning of the period and the length of it will be defined by the formulation of the task. The period of survey covers the intervals of time of sampling (see figure 4) and these may be on a single occasion only, on cycles of occasions or at the intervals of time of special situations.

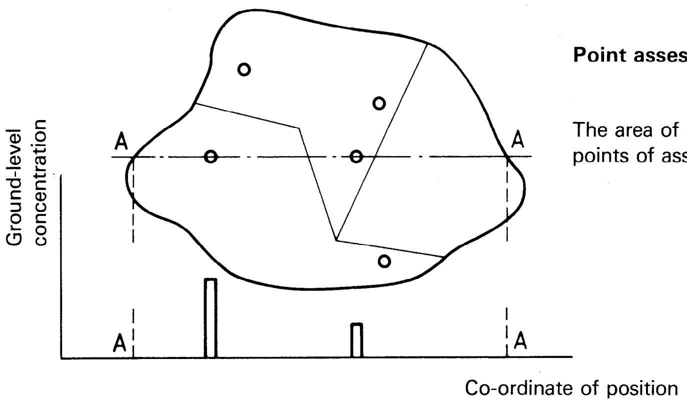
Examples are

— the concentration of carbon monoxide at 08 : 25 hours on 25 June 1973 [1973-06-25T08 : 25[1)]];

— the state of immission at sunrise each day during winter;

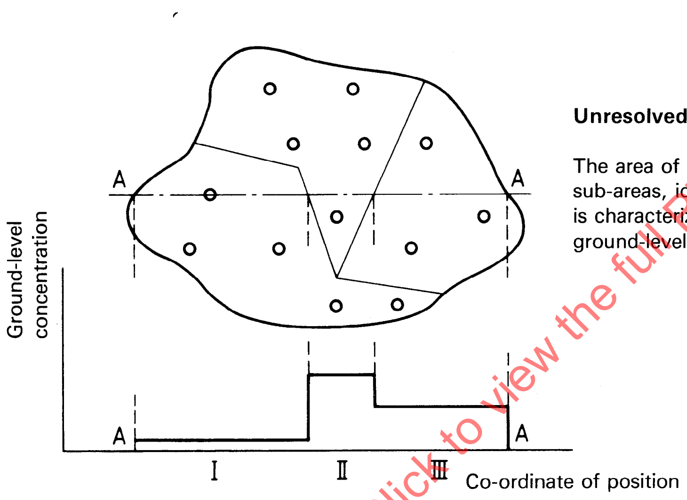
— the state of immission at the beginning of break-up of an inversion.

1) Representation according to ISO 8601.



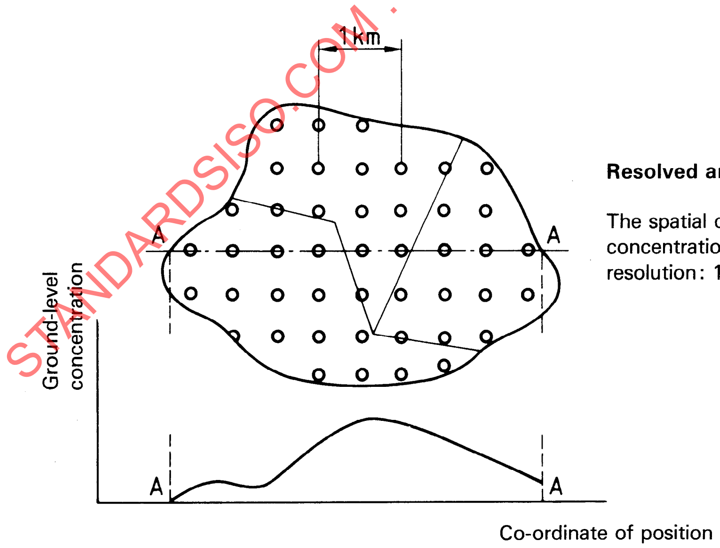
Point assessment

The area of assessment is composed of fixed points of assessment, e.g. playgrounds



Unresolved areas

The area of assessment consists of three sub-areas, identified by I, II, III, where each is characterized by an average value of the ground-level concentration



Resolved areas

The spatial dependence of the ground-level concentration is to be assessed (spatial resolution: 1 km)

Figure 3 — Area of assessment and spatial resolution

4.6.2 Unresolved time

The period of survey may consist of one or a number of intervals of time during which the immission is evaluated independently of time and where the number of air samples per interval of time depends on the variance of the object being measured. No time resolution of the quantity in the interval of time is needed. Again, there may be single occasions, cycles of occasions or special situations (see figure 4).

Examples are

- means of the immission between 0 hour on 13 June 1973 (1973-06-13T00 : 00) and 0 hour on 14 June 1973 (1973-06-14T00 : 00);
- means over one year;
- means over each of the four seasons of the year;
- 90 % value for rush-hour or heating period;
- means of immission dose during inversion.

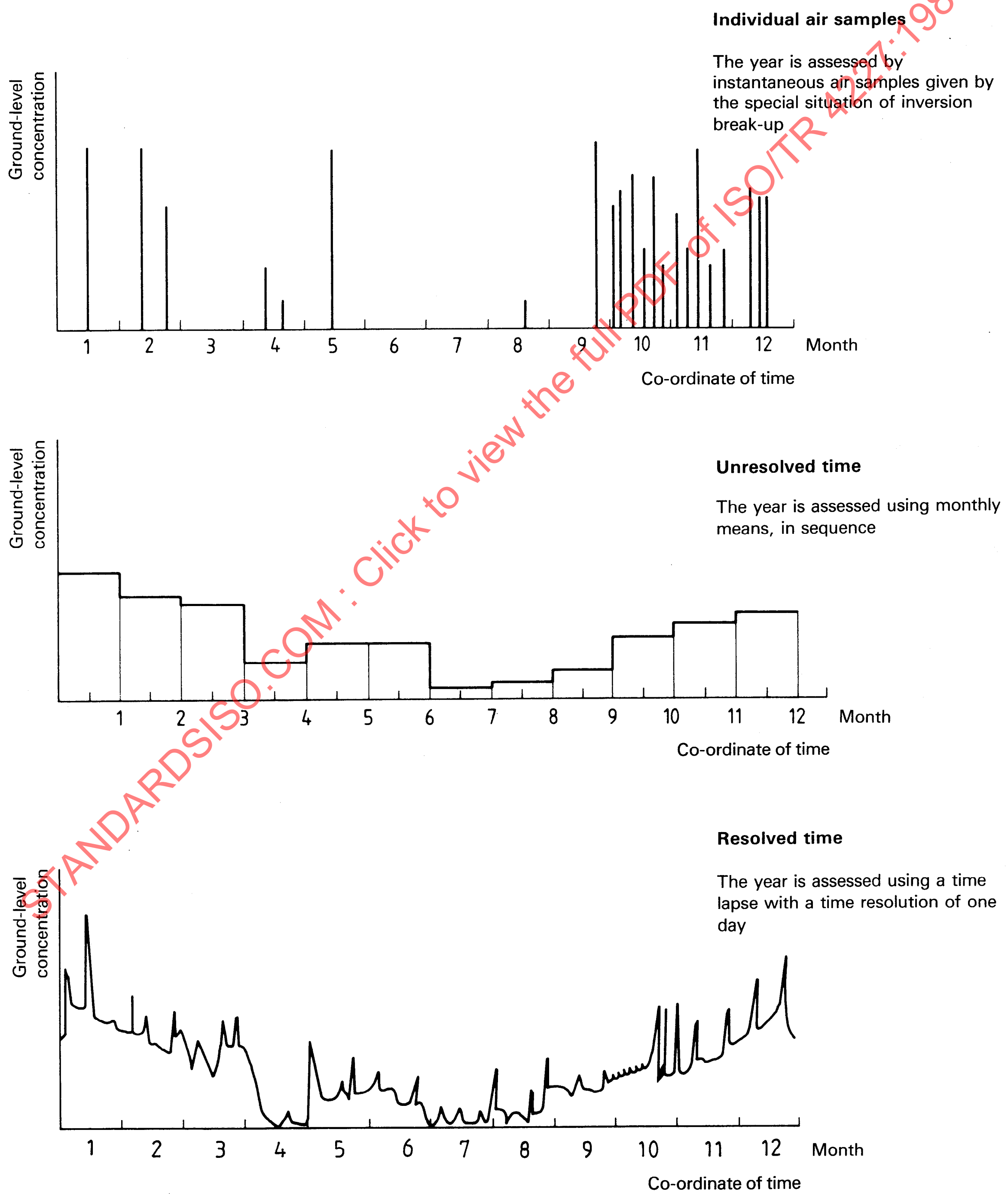


Figure 4 — Period of survey and time resolution

4.6.3 Resolved time

Here, the period of survey covers one or a number of intervals of time during which the time dependence of the immission is evaluated (see figure 4). The achievable time resolution is limited by the frequency of sampling, reproducibility and availability of data regarding time lapse of emission, transmission and immission.

If time lapses of periodic situations are examined, the time resolution is limited additionally by the number of times the situation is repeated. In this case, averaging can be carried out using data from the same relative time delay of a certain event within each interval of time. Hence the significance level of the result will also be influenced by the variability, from interval of time to interval of time, of the object under consideration. However, the significance level can be improved by increasing the number of intervals of time of measurement. Again, the period of survey can be the interval of time of a single occasion, or of cycles of occasions or of special situations.

Examples are

— time lapse of immission on 27 November 1973 (1973-11-27);

— diurnal or yearly cycles;

— smog alarms.

NOTE — During smog alarms, differentiation with regard to time can be done during the measurement.

5 Measuring system

Sensors need a finite quantity of air pollutant before they will respond and a finite interval of time before a measurement of concentration can be observed. These conditions determine the smallest spatial and time resolution of the sensor. These and other requirements for measuring instruments are given in annex B and have to be considered together with the measuring scheme for the evaluation of a measuring system (see ISO 6879).

6 Siting

The correlation of ambient air quality data in space and time should be known if one wishes to extrapolate measured values to an interval of time and a space greater than those over which the actual measurements were made.

It may be possible to estimate the number of sampling sites and the period of survey before the survey starts, using statistical methods including prior information, but often these numbers have to be determined, and perhaps revised from time to time, during the period measurements are being made. This estimation problem is completely symmetrical with respect to space and time, but, as space and time are of very different characters, it is best to treat spatial and time aspects of the measuring scheme separately.

6.1 Spatial aspects

6.1.1 Continuous

Continuous spatial measurements are possible using optical methods such as laser-related methods. These methods are utilized infrequently at present.

6.1.2 Intermittent

The number of air samples and the sampling sites need to be planned as described in 6.1.2.1 to 6.1.2.3.

6.1.2.1 Number of sampling sites and air samples

The spatial distribution of the object to be measured shall be examined using tests for variance. The quality of the information thus obtained can be estimated using Nyquist's theorem and statistical methods. The spatial resolution of the measuring scheme used shall be better than the resolution required by the task. Estimation in advance of the information likely to be obtained using a particular measurement method will be possible only if additional information is available or if a pilot survey can be carried out. Such a pilot-scale survey may be used to check the variability of air pollution levels, and mobile or stationary measuring systems may be used for the pilot survey. It may be necessary to continue a pilot survey for several months to obtain a reliable pattern.

Information regarding the number of air samples necessary is complete, if

— the absolute number of sampling sites within the area of assessment is given, or

— the relative number of sampling sites per area of assessment is given.

For "area-resolved" tasks, the minimum number of sampling sites or the minimal density of sampling sites may be estimated using Nyquist's theorem. Because of the finite reproducibility of measuring systems, the necessary number of sampling sites may be greater than that calculated using the above thorem. On the other hand, additional information regarding the spatial structure of the object to be measured may enable the number of sampling sites to be reduced.

For "area-unresolved" tasks, the absolute or relative number of sampling sites may be estimated statistically if information is available regarding the spatial distribution or variability of the object being considered. Otherwise, the number of sampling sites will have to be determined, and revised if necessary, after measurements have been started.

Information regarding the number of air samples necessary for a particular task at a certain interval of time is complete, if

— the absolute number of air samples is given, or

— the relative number of air samples per unit area is given.

For certain tasks it may be necessary to choose these numbers differently for each interval of time because of characteristic emission or transmission conditions. On the other hand, if data are available on the time dependence of the spatial variation of the object being considered, then the number of sampling sites can be calculated. However, although statistical estimation can ensure that the measuring system chosen is powerful enough for a specific task, i.e. it will provide enough information, it is prudent to consider many other practical aspects.

The number of sampling sites should not be affected by local sources, unless the survey is source-oriented. The overall number of sampling sites will depend on the purpose for which the survey is being carried out. For example, an ambient air quality monitoring system concerned with the warning of high air pollution level episodes could be achieved with two sampling sites in a flat urban area of uniform emissions. However, if the area has a complex topography or air pollution emission pattern, a larger number of sampling sites will be required. Also, if there are any major sources in the area, these shall be covered by an adequate number of sampling sites.

In relation to the air pollution emission pattern, it is important to examine existing meteorological data to determine whether the area is subject to any particular meteorological conditions which could affect the dispersion of the air pollutants.

6.1.2.2 Location of sampling sites

The locations of sampling sites may be chosen randomly, or systematically around a reference point chosen at random, or systematically. For ambient air quality monitoring tasks involving assessment of "unresolved areas", random location of sampling sites may be acceptable. With locations of sampling sites arranged systematically around a randomly located reference point, the sampling sites are chosen randomly with respect to the object being measured but ordered systematically in a certain symmetry.

Typical examples are X km by Y km grid networks which are suitable for tasks calling for the spatial dependence of the immission where no other information is available regarding the spatial distribution of the object to be measured. If, however, other information is available, the sampling site locations can be chosen systematically. For example, from a point source, the locations of sampling sites might be chosen using a symmetrical polar network with the source at the centre. Permitted deviations from systematically chosen locations shall also be defined. This is particularly important for networks or warning systems for critical spots.

In areas where there is complex topography, the locations of sampling sites will be largely determined by local dispersion conditions, and considerable care should be exercised before siting. In such an area, it is strongly advised that a pilot survey be carried out before the final selection of the sampling site locations.

6.1.2.3 Height of air intake or measurement point

The height of air intake or measurement point can also be chosen randomly or systematically with respect to a randomly selected reference height. The heights shall be given together with the locations of sampling sites when ambient air quality data are reported.

Generally, at sampling sites the measurement points should be about 3 m above ground level, but this will not necessarily apply in areas where there are high-rise buildings or where the task may specify certain other heights. For example, surveys of air pollution level from road traffic may require sampling to be carried out at normal breathing height, just under 2 m, or even lower to determine levels of air pollution to which children may be subjected.

When dealing with areas where there is a high percentage of very tall buildings, with many people living at heights where measurements of air pollution at 3 m will not give representative results, it is necessary to arrange for sampling sites to be installed at different heights. This is particularly important when such tall buildings are close to major sources.

It is also useful to examine contour maps of the area to look for potential trouble spots and, in addition, some attempt should should be made to determine the surface roughness classification as a guide to dispersion conditions.

6.2 Time aspects

6.2.1 Continuous

Instruments are available for continuous measurements and, in theory, the only limitation on their use is that their time resolution shall be better than the time resolutions required by the task. In most surveys, these resolutions vary from 3 min to 24 h at intervals of time up to one month.

6.2.2 Intermittent

The time distribution of the object being measured shall be examined using a statistical test. The quality of the information thus obtained can be estimated using Nyquist's theorem and statistical methods. The time resolution of the measuring scheme used shall be better than the time resolution required by the task. Estimation in advance of the the information likely to be obtained using a particular measurement method will be possible only if additional information or the results from pilot surveys are available.

Information regarding the number of air samples necessary is complete if

— the absolute number of air samples within the period of survey is given, or

— the relative number of air samples per unit interval of time is given.

The estimation of the minimum number of air samples or air samples per unit interval of time can be calculated in the same manner as the number of sampling sites (see 6.1.2.1), because of the complete symmetry of the method of estimation with regard to space and time. This also holds for all other quantities defining the intervals of time of measurement.

Information regarding the actual number of air samples at a particular sampling site is complete if

— the absolute number of air samples at the sampling site within the period of survey is given, or

— the relative number of air samples at the sampling site per unit interval of time is given.

The intervals of time of sampling can be chosen randomly, or systematically with respect to a randomly chosen reference interval of time, or systematically. Permitted deviations from specified intervals of time shall be defined to ensure that representative results are obtained.

Sampling should be geared, if possible, to local or specific air pollution emission patterns or other cyclic events such as the rush hour (see also ISO 9359).

7 Additional information

Additional information includes all information known before measurements start (a priori knowledge) and all measurements producing information about emission, transmission and effects. For example, this information could be emission inventories which may help to predict the distribution of ground-level concentrations. For further information on the use of a priori knowledge see ISO 9359.

7.1 Emission data

Emission data can be classified into

— measurements of emissions given either as continuous measurements or as data reduced in some way;

— calculated emissions based on plant-operating conditions or amounts of fuel burned in particular plants or areas;

— geographical information regarding size and location of sources.

There are many grades of detail of emission inventory and the amount of detail required will largely be determined by the nature of the survey. It may even be necessary to determine the pattern of emissions street by street and season by season. For less detailed emission inventories, the overall fuel consumptions for each square kilometre of the survey area may be determined. If the type of survey is comparatively simple, it may be adequate to obtain the total fuel consumptions, either annually or seasonally, of the different fuels used: coke, coal, oil or gas. Large industrial installations should be detailed individually. When dealing with industrial installations, it is important not to forget substances emitted by industrial processes which are not part of a combustion process, such as iron oxide from steelworks, fluorides from brickworks or smelters, etc. Once the overall consumptions have been determined, the next stage in emission inventory is to estimate air pollution emissions from the combustion of these fuels or from published data on emissions from certain processes. When the overall pollution emissions have been estimated, it is possible to calculate, from these values and the heights of the emissions, what ground-level concentrations are likely to be at different places. These estimates can be the basis for planning the ambient air quality monitoring system.

7.2 Transmission data

Transmission data are important for the examination of the spatial and time structure of immissions and can be classified into

— measurement of local meteorological conditions (see annex B clause B.2);

— climatic data for long-term transmission conditions;

— topographical information including information on ground contours, surface roughness of the ground, bodies of water, heat islands, etc.;

— data on secondary emissions;

— data from mathematical models.

The requirements for meteorological sensors are given in annex B.

7.3 Immission data

The available immision data include the results of measurements carried out at some earlier intervals of time at the same place, or under similar conditions, which give information about the spatial and time variation of the object to be measured. Examples of such measurements are dust deposition measurements, ambient air concentration measurements or similar measurements directly correlated to the intake of certain air pollutants.

7.4 Effects

Apart from the actual measurement of immissions, the effects of air pollutants may also be studied to evaluate immission. These effects can be classified into

— direct observation, such as damage to plants, buildings, etc.;

— other surveys which may be long-term, such as epidemiological surveys.

8 Data processing

Data processing will differ from survey to survey but three basic procedures can be classified, namely, descriptive statistics, data interpretation and data synthesis.

8.1 Data interpretation

First of all, data interpretation includes a description of a situation using statistical parameters such as mean, standard deviation, etc. (descriptive statistics). It is essential for diagnosis. The aim of data interpretation is the analysis of relations between different air quality characteristics. Sometimes requirements are simple, such as correlating the measured values of the concentration of an air pollutant with the period of operation of its source. Sometimes, interpretation problems may be more complex and may well involve the use of analytical statistical theory such as regression and correlation analysis. Statistical work is essential if mathematical models are to be validated.

8.2 Data synthesis

Mathematical models may be used to estimate immissions where measurements were not possible. Data synthesis includes trend calculations, estimation of future immission, normalization with regard to long-term climatic data and prediction of immission situations for critical meteorological conditions.

9 Classification of ambient air quality monitoring

Using the above concept all the tasks that may have to be formulated in considering ambient air quality monitoring systems can be classified. Similarly, all aspects of the actual measurements can be classified. This classification enables air quality surveys to be set up in such a way that

— the design of the survey is robust enough to ensure that all the aims of the survey can be achieved, and

— comparison with other surveys is facilitated because individual aspects are classified in a standard fashion.

Annex A
(normative)

Mathematical formulae for emission, transmission and immission

A.1 Emission

The emission rate, $E(t)$ of a source is defined by the enveloping surface integral:

$$E(t) = \int_{F_E} \varrho(\boldsymbol{v}, \boldsymbol{n}) \mathrm{d}F_E \qquad \text{(A.1)}$$

where

F_E is the smallest enveloping surface around the source;

ϱ is the density (property divided by volume) at the enveloping surface;

$\boldsymbol{v}$ is the velocity vector of the property at the enveloping surface; it contains both the mean motion and the effect of the molecular and turbulent diffusion;

$\boldsymbol{n}$ is the normal vector of enveloping surface element, $\mathrm{d}F_E$, pointing outwards;

$\varrho\boldsymbol{v}$ is the emission flux (property divided by area and time) at the enveloping surface.

ϱ and $\boldsymbol{v}$ can only be measured as a mean over a certain interval of time and surface area. The product of this mean is not necessarily equal to the mean of the emission flux within the same interval of time and surface area.

A.2 Transmission

The phenomena constituting transmission, namely transport and transformation, are completely defined when flux, $\varrho\boldsymbol{v}$ and density, ϱ, are known. The transport, $T(t)$, of a quantum of a certain property per unit interval of time across a given surface, F_T is

$$T(t) = \int_{F_T} \varrho(\boldsymbol{v}, \boldsymbol{n}) \mathrm{d}F_T \qquad \text{(A.2)}$$

with the normal vector $\boldsymbol{n}$ of the surface element, $\mathrm{d}F_T$, pointing outwards. The actual question or task defines location and shape of the surface.

The quantum, $Q(t)$, of a property transformed per unit interval of time within a certain volume, V_T, is derived from the time-space balance of this very property, i.e.

$$Q(t) = -\int_{F_T} \varrho(\boldsymbol{v}, \boldsymbol{n}) \mathrm{d}F_T - \int_{V_T} \frac{\partial \varrho}{\partial t} \mathrm{d}V_T \qquad \text{(A.3)}$$

where

F_T is the surface of volume V_T;

$\boldsymbol{n}$ is the normal vector of surface element, $\mathrm{d}F_T$, pointing outwards;

$\partial\varrho/\partial t$ is the partial, local derivative of the density,ϱ; it gives the local change per infinitesimal unit interval of time and thus describes the destruction or creation of a property within the volume, V_T.

A.3 Immission

The immission rate, $I(t)$ is defined as the enveloping surface integral:

$$I(t) = \int_{F_I} \varrho(\boldsymbol{v}, \boldsymbol{n}) \mathrm{d}F_I \qquad \text{(A.4)}$$

where

F_I is the smallest enveloping surface around the receptor;

ϱ is the density (property divided by volume) at the enveloping surface;

$\boldsymbol{v}$ is the velocity vector of the property at the enveloping surface;

$\boldsymbol{n}$ is the normal vector of enveloping surface element, $\mathrm{d}F_I$, pointing inwards;

$\varrho\boldsymbol{v}$ is the immission flux (property divided by area and time) at the enveloping surface.

NOTE — Equations (A.1) to (A.4), together with the interconnecting mass (or property) balance in space and time, sufficiently describe emission, transmission and immission. They presuppose knowledge of the density and flux fields ϱ and $\varrho\boldsymbol{v}$, correspondingly, throughout space and time, i.e. within their domains of validity including the respective boundaries.