

ODOUR MEASUREMENT AND ODOUR POLICY IN GERMANY

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ABSTRACT

Odour emissions can cause serious annoyance in the neighbourhood of the emissions source. Thus, especially in densely populated areas, odour is a topic since several decades in Germany. Development of measurement possibilities and development of odour policy are connected, because formulation of standards as well as control of compliance with these standards need appropriate measurement methods. This paper gives a glimpse of the development of both parts and thereafter explains the actual state of them inside Germany. Also, the actual state of practice with this respect as can be found in some other European countries will be presented in short. Then some special notes will be presented concerning some special cases as for example waste technology, wastewater treatment technology and application at agriculture.

KEYWORDS

Odour measurement; odour policy; olfactometry; odour sampling techniques; dispersion calculation; odour standards; waste treatment; landfills; wastewater treatment, measures against odours

1 INTRODUCTION

Ten to fifteen years after world war II, Germany experienced a massive economical improvement, usually called the "Wirtschaftswunder". During that time, at the end of the fifties and the beginning of the sixties, industrialization grew massively. In general, during that time nobody cared too much about environmental issues.

In 1955, Germany's first mechanical composting plant, which composted wastewater sludge together with municipal waste, went into operation immediately beneath a working-class district of the city of Duisburg in the Rhine-Ruhr-area, a highly industrialized part of Germany. During summer of the following four years, odour emissions, and thus degree of annoyance caused by these emissions, was such that the city government discussed to tear down the newly built plant. It must be kept in mind that at that time no legislation concerning odour annoyance existed. Regarding that, someone may guess how critical the situation was. Even the term of "environmental protection" in Germany did not exist at that time. It first was used in public and political discussion at the turnover from the sixties to the seventies.

The two most important compartments of the environment - water and atmosphere - were covered by federal legislation in 1976 and 1974, respectively. These dates may be recognized as the beginnings of increasing efforts by the government in order to protect the environment against pollution.

But as the example given above makes clear, in special cases odour was an issue even before those dates. This is true for odour policy as well as for common interest on possibilities for odour measurement methods. The VDI-Commission on Air Pollution Prevention started to draw its attention to odours in the seventies already.

In addition, some persons from the practical or the scientific side, who were concerned with odour problems, also contributed to the field during that time. For example, at the Nurnberg wastewater treatment plant, serving an amount of more than 300,000 population equivalents and located in the city, surrounded by large housing complexes, problems arose very early. Thus, the chief engineer of that plant, Dr. Hartmann, was forced to do a lot of research in this field, and, consequently, he wrote some publications at the beginning of the seventies that

are still recognized as the most important and innovative of that time.

Also, the people of the city of Duisburg mentioned already had to do work on this, as it was decided to operate the composting plant instead of tearing it down. Thus, a lot of odour abatement technologies were tested here, and finally the use of biofiltration, using the compost from the plant itself as the biofilter material, was successful, making the biofiltration popular throughout Germany.

However, if talking about Germany in this paper, it must always be kept in mind that in the future the membership in the European Union will have more and more influence on policy as well as measurement.

2 ODOUR MEASUREMENT IN GERMANY

2.1 Introduction

Already during the sixties measurement of odours became an issue at farms, especially where large numbers of animals were groomed. Thus, the research institutes concerned with farming were interested very early in measuring odours and odour emissions.

In addition, in densely populated, highly industrialized areas such as the Rhine-Ruhr-Area inside the state of Northrhine-Westfalia, it soon became obvious that a measurement method for odours was needed, as the examples mentioned above make clear.

The first approach was the dilution method, as this method also was known from the measurement of odours in water, prescribed in the German Standard Testing Methods for Water.

During that time, several research institutes built their own "olfactometer" in order to determine the dilution which is necessary to reach the odour threshold, recognized as the dilution at which 50% of the responses of the test person(s) were negative ("no odour") and the other 50% of the responses of the test person(s) were positive ("yes, odour"). The most famous ones were made by Mannebeck, called "TO", which stands for "Tragbares Olfaktometer" ("Portable Olfactometer"). As the first types in fact were portable and were used in the field for quick measurement, today the newest model TO7 can only be carried by at least 2 persons, but it is, however, a very good olfactometer where 4 test persons can work on simultaneously.

Progress was made and progress, of course, was also demanded by legislation in order to be able to set standards. Thus, methods of measuring emissions as well as methods of assessment of the odour impact were needed, and standardization of these methods was urgent, as the results differed by factors of 100 or even more in the beginning of the measurement activities. Special attention had also to be drawn to the emissions of area sources without a defined outward airflow.

In general, the measurements as shown in figure 1 are used in Germany today.

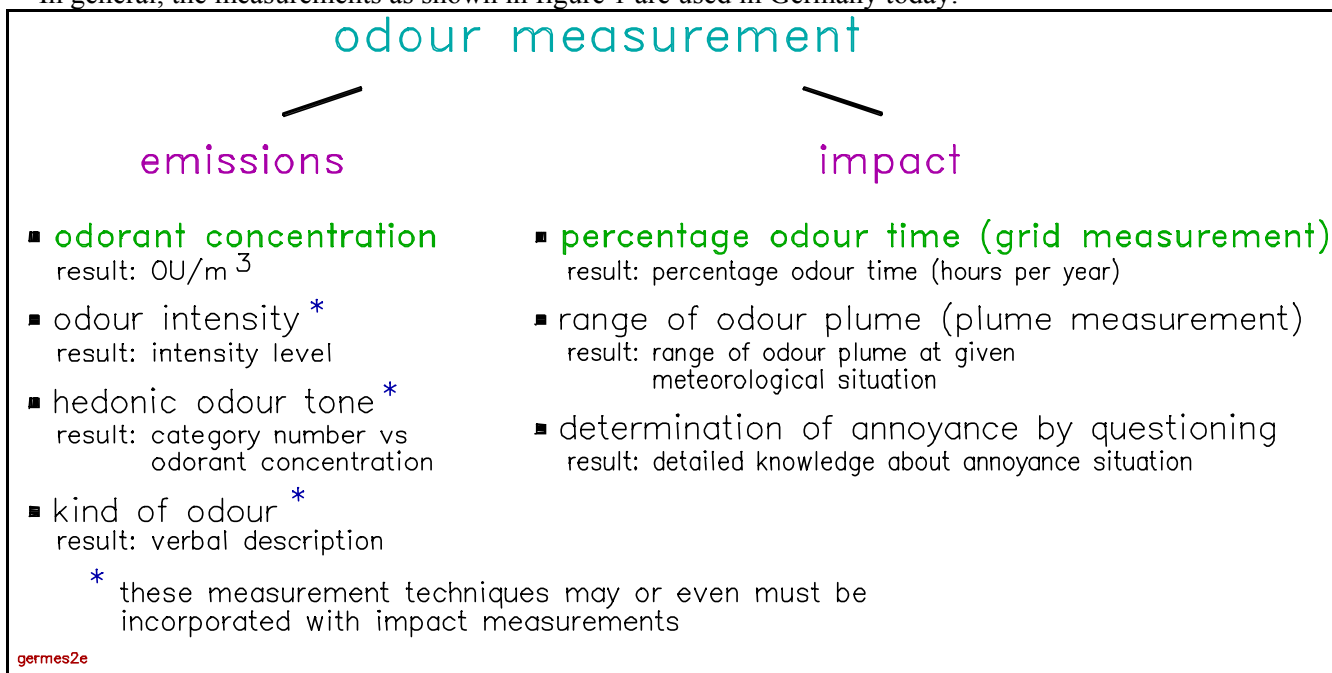


Fig. 1: Possibilities of odour measurement

They will be explained in the following text.

2.2 Possibilities of emissions measurement

As mentioned, the Commission on Air Pollution Prevention started early to work on odours. The members of the workgroups of the Commission consist of volunteer experts.

The most important measurement is the determination of the **odorant concentration**. The respective workgroup created the VDI-guideline 3881 "Olfactometry - Odour threshold Determination", finally released in 1986. This is the basic guideline in Germany from 1986 for the last more than ten years until today. But in contrary to the usual systematic of the VDI guidelines, which prescribe to use just one possible method for testing, VDI 3881 allowed several variants. Two questioning methods were allowed at that time, namely the yes/no-method and the forced-choice-method. In addition, two methods for presentation of the dilutions were allowed, namely the method of limits as well as the constant method.

However, in Germany usually the combination of yes/no-method and method of limits is applied. Thus, presentation of the dilution series, where two adjacent dilutions differ by a factor of 2, started at the highest dilution number. Questioning ends after two positive answers in sequence. The dilution number necessary to reach the odour threshold is calculated for each dilution series by calculating the geometric mean of the dilution number with the last negative answer and the dilution number with the first positive answer. The dilution number of the threshold of one measurement is the geometric mean of the dilution numbers calculated in the first step for single series, as mentioned before. The result is the dilution number necessary to reach the odour threshold, which is then associated with the odorant concentration of the sample c_{OD} , expressed in OU/m^3 . Thus, a sample which is at the threshold without being diluted, has the odorant concentration of $c_{OD} = 1 OU/m^3$ by definition, also called the threshold concentration.

It must be kept in mind that the odour threshold, upon which the determination of the odorant concentration is based, is associated with the detection threshold, not with the recognition threshold. In fact, the dilution number necessary to reach the recognition threshold will be lower than the odorants concentration measured according to VDI 3881.

Several surrounding conditions are prescribed in VDI 3881, but they will not be discussed in this paper, as in the future the expected CEN guideline, which is presented in detail by Monika Paduch during the workshop, will replace the national VDI guideline. It was also due to this reason that the workgroup which intended to renew the 3881 guideline, starting work in 1993, finished its work in 1996 without issuing a draft of the new version of the guideline.

The method for determination of **odour intensity I** is prescribed in VDI-guideline 3882 part 1, released in October 1992. The result of the measurement, which usually is carried out using an olfactometer, is the intensity level. Panelists have to assess the intensity of the sample in accordance with the following category-scaled numbers:

Odour	Intensity level I
Extremely strong	6
Very strong	5
Strong	4
Distinct	3
Weak	2
Very weak	1
Not perceptible	0

Odour intensity and odorant concentration are connected by the Weber-Fechner-law, which may be written as:

$$I = k_W * \log(c_{OD})$$

with: I = Intensity level
 k_W = Weber-Fechner coefficient
 c_{OD} = odorant concentration

In cases where not only the detection threshold, associated with the value of $1 OU/m^3$, is the criterion, it is

necessary to know the Weber-Fechner coefficient k_w . Frechen made systematic measurements on wastewater plants (1995a) and waste treatment facilities and landfills (Frechen and Ketter, 1995) and was able to demonstrate by means of some hundred olfactometric intensity measurements on both types of facilities that the intensity level of 3 ("distinct odour") is associated with an odorant concentration of approximately 4 OU/m^3 .

Nevertheless, the actual perceived intensity also can be assessed without olfactometer, for example during field inspection.

The method for determination of **hedonic odour tone** is prescribed in VDI-guideline 3882 part 2, released in september 1994. Dilutions are presented via an olfactometer to the panelists. If the panelist detects an odour, the hedonic odour tone of the perceived concentration must be evaluated according to a category scale ranging from -4 ("extremely unpleasant") over Zero ("neither pleasant nor unpleasant") to +4 ("extremely pleasant").

Similar to the intensity, the hedonic odour tone is coupled with the odorants concentration (or with the intensity, as these two are coupled with k_w), and in general it can be stated that the degree of unpleasantness rises with rising odorants concentration in the sample presented to the panelist.

For the determination of the **kind of odour** no guidelines exist. This is a free description of the perceived odour, which will usually result in sentences like "smells like ...". Although no guideline exists, the kind of odour is a very important feature today, as will be explained later. Additionally, the kind of odour can also be a valuable information when it is necessary to identify and locate specific emission sources.

2.3 Sampling

Quite often, the results of olfactometric measurement are needed with dispersion modelling. This means that it is not sufficient to present odorant concentrations. What we really need are emission mass flows from the respective emission sources, given in terms of OU/h or OU/s . As the following table shows, there are different types of odour sources.

Table 1. Characterization of emission sources

		defined airflow	
		Present	not present
size of	point	active point source	passive point source
source	area	active area source	passive area source

In case of **point sources**, usually a total covering during sampling is possible. However, the maximum size of a "point" source depends upon the circumstances, and "point" sources can be considerably large. Examples for typical "point" sources may also be the doors of a storage building or the ventilation of such a building. In both cases airflow and concentration can be measured.

With **area sources** it is not possible to cover the whole surface during sampling. Thus, partial covering is necessary, and the percentage of coverage of the total area depends upon different influences (degree of exactness required, total size of area, financial resources for the measurement program, relevance of the results etc.). In Germany, percentages between 5% and 1% of the total area are under discussion nowadays, depending upon size of source.

Where **airflow** is present (active area sources), samples can be taken from the off-gas and can be analyzed by means of determination of the odour concentration in OU/m^3 . Simultaneously, the offgoing airstream has to be measured. Thus, the total emitted odorant flow rate in OU/h can be determined.

Most problems arise where **no airflow** can be measured (passive area sources), as is the case with lots of large areas at waste management facilities, such as landfill surface, slopes, compost heaps etc.. In these cases it is necessary to use a special sampling principle shown in Figure 2.

The principle of this sampling is well known here in New South Wales, and there was a lot of work done on this principle at the University, see Jiang et al. (1995) and Bliss et al. (1995). A certain amount of area is covered by a box (or similar) and an airstream goes through this box, consisting only of odourless, preferably synthetic air. We usually operate the box at a wind speed of 0.02 m/s . On the side of the box opposite to the

inlet the same amount of air must be taken out by means of exhausting to assure even pressure. At this point an air sample can be taken for determining the odorants concentration. Since the air throughput of the sampling box in m^3/h is known as well as the size of the area that is covered by the box, the specific airflow in $\text{m}^3/(\text{m}^2 \cdot \text{h})$ related to the covered area can be calculated. As, in addition, the odour concentration OU/m^3 will be measured, it is possible to calculate the specific emitted odorant flow rate in $\text{OU}/(\text{m}^2 \cdot \text{h})$ and also calculate the total emitted odorant flow rate q_{od} in OU/h , regarding the total size of the area.

Whatever types of sources are present at a plant, it is always necessary to finally obtain the odorant mass flow of each source in order to do atmospheric dispersion calculations. Thus, for each source of odours, the appropriate sampling method has to be chosen. Final results for the emission of each part of the plant have to be given in terms of the odorant flow rate q_{od} , thus in OU/h . When comparing different plants, specific odorant flow rates are necessary as for example given in $\text{OU}/(\text{m}^2 \cdot \text{h})$ for area-related sources, or in OU/Mg for throughput-related sources, as can be found at waste treatment facilities, see Frechen (1995b).

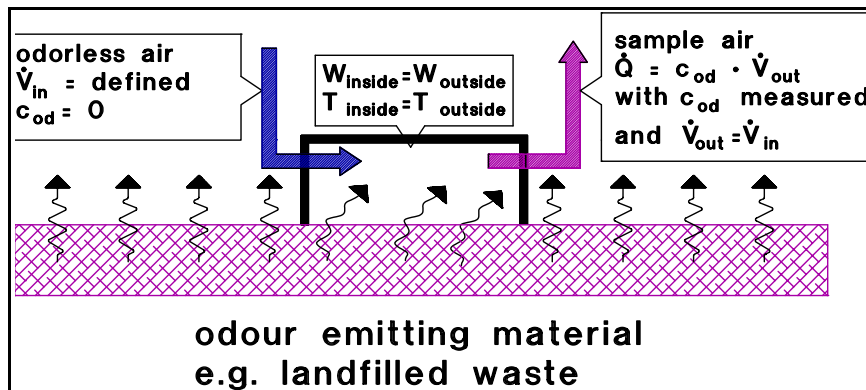


Figure 2: Principle of sampling on area sources without airflow

2.4 Methods for assessment of impact

The assessment of environmental impact caused by odours is done according to VDI-guideline 3940, "Determination of Odorants in Ambient Air by Field inspection", issued in final version in October 1993. Two types of field inspection are described which have different tasks of the determination.

If it is asked how high the actual impact in a given situation is, the **grid measurement** has to be carried out. A grid of equidistantly spaced points is drawn over the assessment area. The squares defined by measurement points at each corner are the assessment squares. The distance between measurement points (grid spacing) usually is 250 m, although this may vary from 1,000 m to 100 m depending upon the specific situation. During an assessment period of one year or half a year, single measurements are made at the measurement points. 26 single measurements are prescribed per measurement point, thus, per area 104 single measurement results are relevant. A single measurement is performed by one assessor, who has to assess the odour impression at the measurement point during 10 minutes. Usually, the assessor has to assess the ambient air every 10 seconds, giving 60 samples in 10 minutes. The assessors are given a code of odour qualities, against which they can check the odour. This code is to be chosen depending on the objective of the test, and may be expanded by the assessors if new odour qualities are observed. This procedure implements, that the assessor must at least recognize the odour kind (quality). Thus, obviously the measurement does not use the odour detection threshold as it is used by olfactometry.

The odour frequency is the number of positive responses divided by the total number of samples, and is equal to the percentage odour time (absolute time of odour impact during measurement). Then, depending upon the the odour percentage, it is decided by a switching function whether the single measurement is associated with a positive or negative result. This is called the odour hour concept. A single measurement is scored as positive (one odour hour) if the percentage of time during which an odour is **clearly recognizable** exceeds a previous defined percentage. More concerning the odour hour concept can be found later.

The final results of the grid measurement are the grid square values, which are the mean values of the odour hour measured at the four corner points. These values then can be compared with set standards for the area, see explanation later on.

If the extent of an odour plume is to be determined, then **plume measurement** has to be done. The single measurement methodology as well as the odour hour concept are the same as described with the grid measurement. The difference is that no grid is formed. Instead, the assessors will be positioned downwind of an odour emitting source in at least three different distances. For each distance, at least five measurement points are

necessary. The objective of this measurement is to determine the extent of the odour plume at a given meteorological situation. Thus, parallel meteorological measurements are necessary.

From the results of such measurement, one can re-calculate the emission level which had to be relevant during the plume measurement by doing an atmospheric dispersion calculation for the respective meteorological situation backwards in order to determine the total emission mass flow. In fact, by iteration of the dispersion calculation the total emission mass flow is varied, until the results of the calculation equal the results of the plume measurement.

The methodology of **questionnaires** is used to determine the actual annoyance in the neighborhood. It is described in the VDI-guideline 3883, part 2, issued March 1993. Professional interviewers visit the homes selected at random from the total number of homes, and do a questionnaire by means of a questionnaire form. At least 40 homes in the relevant area and 40 homes in a control area of the same characteristic, but without odour impact, should be used.

One of the cornerstones of the questionnaire is the question using a thermometer scale, graphically prepared in the questionnaire form, which has a scale from 0 - no annoyance over 1 - very little annoyance through 10 - extremely high annoyance. The mean of these answers for the area which had to be examined is the most important resulting value.

When discussing the regulations in other European countries, this type of determination will gain more attention.

Although this method is rarely used in Germany until today, we have had very positive experiences with it, especially in a case where we had to give an expert opinion in a court trial.

3 ODOUR POLICY IN GERMANY

3.1 Introduction

Before 1972, the states of the Federal Republic of Germany were responsible for the policy concerning air pollution. During that time, only some of the states did have regulations concerning air pollution. Of course, as the problems are more important in densely populated, industrial areas, the state of Northrhine-Westfalia was the state with the most regulations with this respect. However, the problem of annoyance due to malodours was not covered explicitly.

In 1974, the "Federal act on protection against detrimental effects on the environment caused by air pollution, noise and vibration", hereafter called "BImSchG", which is the German abbreviation, was issued by the federal government, thus valid for all (at that time) eleven states of the Federal Republic of West-Germany. Before, every state had (or had not) its own regulations. Since then, odorous substances are an issue of environmental protection if they cause "serious annoyance" of the neighbourhood or the general public due to "their kind, their extent and their duration". These definitions will be discussed later more in detail.

Starting with the BImSchG, the federal government was responsible for regulations in the field of air pollution in general. Nevertheless, the states themselves were still able to add their own, statewide regulations in order to specify the general regulations given by the federal government, here especially the BImSchG. Again, it was noted that the state of Northrhine-Westfalia was the only one to issue regulations. Usually, during the seventies and eighties, the other states did not issue similar regulations, but used the ones issued by Northrhine-Westfalia where necessary.

3.2 Minimum distances between industry and residential areas

Since 1974, re-issued in 1982 and 1990, Northrhine-Westfalia has a "Minimum Distance Regulation" which establishes minimum distances between industrial or commercial areas and residential areas. The distances were established with respect to air pollution as well as to noise, with the aim of avoiding "serious annoyance" according to the BImSchG-definition. The regulation is to be used by the governmental authorities only when deciding over area development plans. It is in no case a regulation which is relevant when planning an emitting facility. When planning an emitting facility, the BImSchG and the subsequent, supplemental regulations are relevant.

According to the Minimum Distance Regulation, when planning areas with industrial and residential areas,

the area development plans have to maintain the distances given in the regulation, which depend upon the type of industry which will in future be allowed to settle in the respective area. Prescribed minimum distances range from 1,500 m to 100 m. Some examples for the minimum distances demanded are:

Minimum distance 1,500 m between residential areas and

- Chemical industries with more than 10 production units
- Furnaces for pig-iron production
- Power plants with a heat power of more than 900 MW

Minimum distance 1,000 m between residential areas and

- Furnaces for steel production
- Wharfs (if outside of buildings)
- Facilities for the removal of animal cadavers

Minimum distance 700 m between residential areas and

- Facilities for production of sauerkraut (if more than 10 tons per day)
- Facilities for production of sugar
- Car industries

Minimum distance 500 m between residential areas and

- Facilities for raising more than
51.000 hens or
102,000 young hens or
102,000 fattened poultry or
1,900 fattened pigs or
640 sows
- Slaughterhouses with a throughput of more than
500 kg poultry per week or
4,000 kg other animals per week
- Landfills
- Drive-in-cinemas

Minimum distance 300 m between residential areas and

- Composting plants
- Wastewater treatment plants

In most cases, one can clearly distinct between the issues of odour and noise from these examples.

3.3 Regulations concerning odour impact in ambient air

The BImSchG is the federal legislative framework for air pollution, noise and vibration. The objectives of this law are to protect man and environment from detrimental effects and to take precautions against such effects. Regarding odours, the law defines that it is illegal to cause "serious annoyance" due to "kind, extent or duration" resulting from odours. The impact caused by odours can be described by the kind of odour (or the hedonic tone, see explanations above), the intensity of the odour impression and the duration of the odour impression. This theoretical approach results in a set of standards to be met which can be described in a three-dimensional way. At a given hedonic odour tone, the extent of odour impact (percentage of time) must be low if intensity is high and vice versa. At lower hedonic tone values, this relation must be moved to shorter percentages of time and vice versa. This is a very simple explanation, as in fact intensity and hedonic tone are coupled, as explained above. So, in fact there should be a nonlinear area in the three-dimensional space made up by hedonic tone, intensity and percentage of time.

As in practice it is very difficult to assess or measure all three components, usually the hedonic tone is left unrecognized. Then, the problem is reduced to a two-dimensional one, regarding the connection between odour intensity (coupled to odorant concentration by the Weber-fechner law) and percentage of time during which this

odour intensity (or odorant concentration) is exceeded.

In Northrhine-Westfalia, as here problems were most relevant even decades ago, there existed a regulation concerning refineries since 1974. This regulation contained some parts that were related to odour impact. Also, it contains a procedure to do atmospheric dispersion calculations.

The "TA Luft", which is a federal regulation coupled to the BImSchG, issued in 1974 and re-issued in 1983 and 1986, contains a procedure to do atmospheric dispersion calculations. This procedure of carrying out calculations according to a simplified Gaussian distribution model is prescribed in whole Germany since the existence of the TA Luft. The basic formula is shown in figure 3.

Formel I:

$$C(x,y,z) = \frac{10^6}{3600 \cdot 2 \pi u_h \sigma_y \sigma_z} Q \exp \left[-\frac{y^2}{2 \sigma_y^2} \right] \left[\exp \left[-\frac{(z-h)^2}{2 \sigma_z^2} \right] + \exp \left[-\frac{(z+h)^2}{2 \sigma_z^2} \right] \right]$$

Fig. 3: Formula for the dispersion modelling of gases

In Northrhine-Westfalia, in 1984 (renewed in 1986) a regulation was issued statewide that contained hints on how to use the TA Luft. Included were the essential points of the refinery regulation (with minor changes). These hints were valid until beginning of 1995. The main standards were as follows: An odour impact is legal, if the odour threshold (determined by dispersion modelling according to TA Luft) did not exceed 1 OU/m³ during more than 3% of the year. An odour is recognized as an illegal impact if distinct odour is perceived during more than 5% of the year.

Two things are remarkable with this. First, the regulation did not stipulate just one standard, but gave a lower limit and an upper limit. Areas falling in between these two limits had to be assessed individually. Second, the odour concentration/odour intensity was recognized with the limits (threshold and distinct odour, to be associated with 4 OU/m³ at waste and wastewater facility emissions, see above). Atmospheric dispersion modelling produces lines of the same percentage of time at a given limit concentration (e.g. 12 OU/m³ or 4 OU/m³). But, however, it was recognized that the hourly mean values of the odour concentrations calculated by the dispersion model were not suited to describe the annoyance correctly, as is depicted in figure 4. The problem with this atmospheric dispersion calculation is that it produces hourly means of immission concentration, whereas people smell odours within much shorter periods than one hour. Thus, depending upon the variation of concentrations it may often occur that the hourly mean is below the odour threshold (or any other given limit value) and there are several time periods within the hour where the concentration is above the limit value. This was first pointed out by Högström (1972) and is explained in figure 4. In order to assess the extent of odorous impact to people more correctly it is stipulated that an hour may be recognized as exceeding the limit value if the limit value is exceeded during 10% of one hour, thus during 6 minutes. In practice, it is assumed to be sufficient to multiply the hourly mean by a factor of 10. This is the so-called "Factor-10-model", which is equal to the TA Luft model except of the modification mentioned. The factor of 10 is assumed to be equal to the "odour hour concept" mentioned already.

Since 1995 until today, in Northrhine-Westfalia (and most of the other states of Germany as well) a new regulation is relevant, called the "Geruchsimmissions-Richtlinie" and abbreviated with "GIRL". Here some major changes have been made

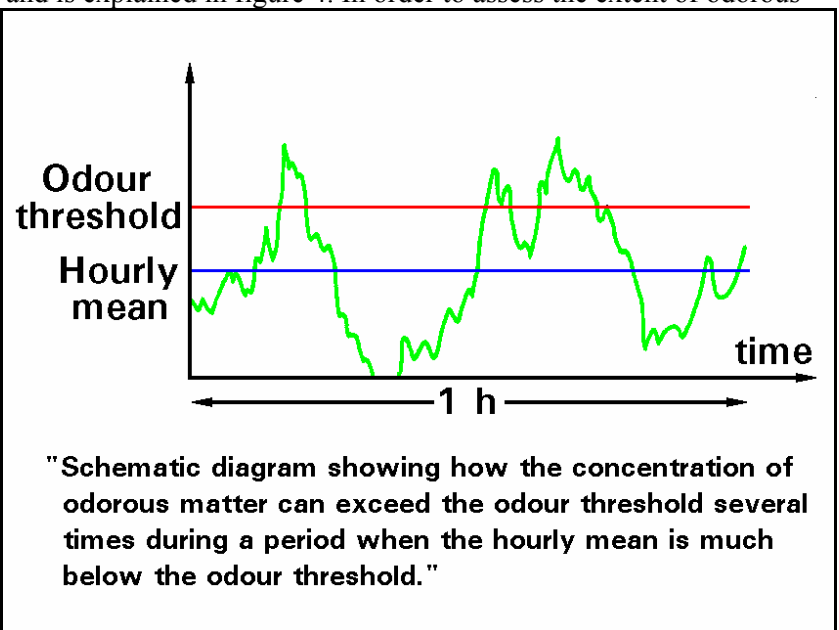


Fig. 4: Comparison between long-term and short-term odour concentration, from HÖGSTRÖM 1972

compared to the regulation mentioned before. The GIRL drops the "distinct odour" and only uses the threshold value of 1 OU/m³ for dispersion calculations. It prescribes the use of the Factor-10-model for dispersion calculations, thus multiplying the resulting impact odour concentrations by 10 before comparing them to the standard of 1 OU/m³, which in fact leads to a limit of 0.1 OU/m³ as an hourly mean..

In the GIRL, standards are set for measurement squares. By doing so, both the grid measurement method (for existing impact, detected by field inspection) as well as the atmospheric dispersion (where the measurement square values have to be calculated as the mean from 9 point values of the respective area) can be combined. This was important, as one of the basics of the BImSchG is that legalness of a plant to be newly built depends upon the actual impact plus the new impact to be expected from the plant under design. Thus, both methods are needed, and the results (Actual Impact AI and the new, additional impact NI) are to be added and then compared with the maximum allowed impact MI. Thus, it must be: $AI + NI \leq MI$. For field inspections, to be carried out according to VDI 3940, see above, it is stipulated in the GIRL that a single measurement is positive (odour hour detected) if 10% of the 60 samples of the single measurement are positive.

Maximum impacts concerning odours are now, based on these concepts, defined as follows:

- for residential areas: not exceeding 0.10, which is 10 percent of the time of a year,
- for industrial areas: not exceeding 0.15, which is 15 percent of the time of a year.

When looking at this values, the allowable impact may seem to be very high. Thus, it has to be kept in mind that some conventions are included:

- The impact concentrations calculated by the dispersion calculation are multiplied by a factor of 10.
- The "odour hour concept" is used, and the limit value for field inspections to determine the AI is stipulated to be set by 10% for a single measurement. An example may show the consequences of this concept: let us assume two single measurements have been made, each with 60 samples, this gives a total number of 120 samples. Let us assume 12 samples were positive. This indicates an odour percentage of (real) time of 10%. If 6 of the positive samples were detected in each single measurement, then for both of the two single measurements the limit percentage of 10% was reached, leading to the fact that two positive results (two odour hours) were detected by the assessors, which is a percentage of 100% of all (two) single measurements. Any other distribution of the positive responses would at least have produced one odour hour, resulting in a percentage of 50% of the single measurements. So, in this case, 10% of real-time-odour detection will be assigned 50% or even 100% of odour hours for assessment purposes. As can be seen from this example, due to the two-step odour hour concept, percentages seem to be quite high as usually (except in special cases) the real time percentage is significantly lower.

A comparison between the various regulations will be shown during the presentation.

4 ODOUR POLICY IN OTHER EUROPEAN COUNTRIES

4.1 Switzerland

It is stated that "too high impacts" are not allowed. Impact is "too high" if a "relevant portion of the population" is "significantly annoyed". The determination of the annoyance uses the method of questioning. Most important response is the thermometer value of annoyance given in a thermometer scale from 0 to 10, see above.

The following scheme applies:

Annoyance	thermometer value	Percentage of strongly annoyed (≥ 3)	Measures
strong	> 5	>25%	immediate measures
medium	3-5	10%-25%	long term measures
reasonable	< 3	< 10%	no special measures

Emission standards concerning odour concentration are not stipulated, although emission standards are set for about 150 substances which can cause odour, anticipating that no serious annoyance will occur if these standards are met.

4.2 The Netherlands

Policy has the objective as to keep the population free from annoyance as far as possible. It is planned that in the year 2000 not more than 12% of the population are annoyed by industrial odours (annoyed here stands for "perceive sometimes or even often annoying odour"). The percentage of people strongly annoyed by industrial odours should then drop below 3%.

The percentage results are renewed every year by questioning. Supplemental to the yearly questioning a telephone questionnaire was developed.

4.3 Comparison

As can be seen, the way of handling the problem is different in Germany from that to be found in other countries. In fact, the method of questioning is used very rarely, although after the author's opinion this should be a cornerstone of the whole policy. Of course, in order to give similar conditions to all participants, for example industrial branches which want to expand, some general valid standards are necessary.

Maybe a mixture between the annoyance-orientated strategy of the Netherlands and Switzerland and the impact-level-strategy of the German government could serve the purpose best.

5 MEASURES AGAINST ODOURS

It is always necessary to look after the basic mechanisms of odorants formation and odorants emission, as can be seen from the scheme listed in figure 5. As can be seen at the example of a waste facility, several processes such as degradation, formation, transport and emission can be isolated at every single part of a facility. This general scheme is valid for most facilities and processes.

When designing measures against odours, different strategies can be followed, as listed in figure 6.

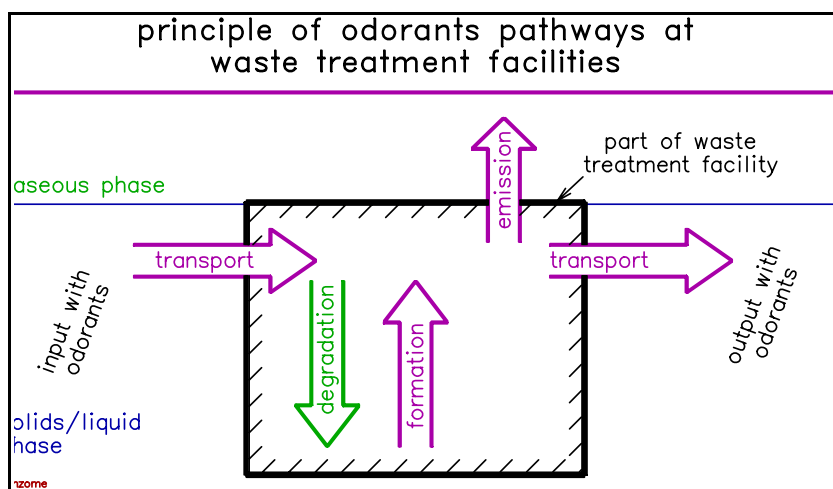


Fig. 5: Pathways of odorants - example waste facility

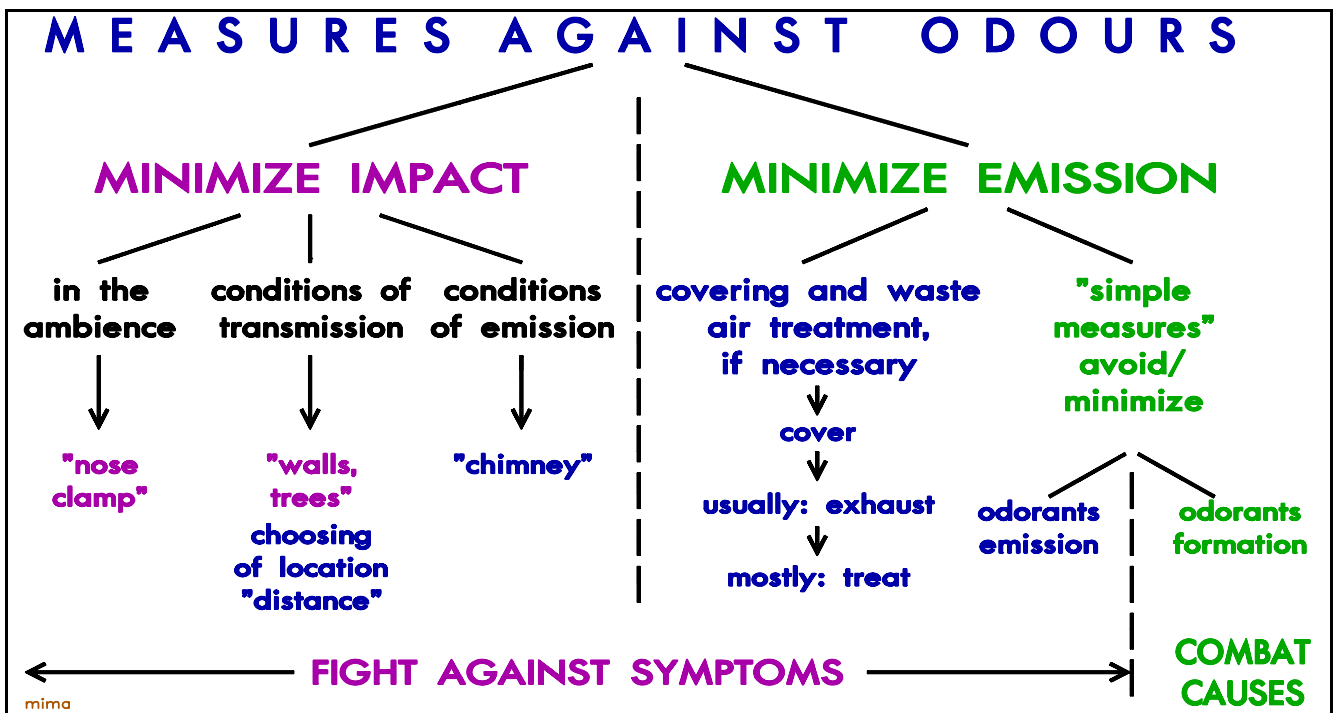


Fig. 6: Possible strategies for measures against odours

During the presentation, the possible measures and applications are discussed with respect to different cases such as wastewater treatment plants, waste facilities and farming.

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