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IDENTIFICATION OF AIR POLLUTION SOURCES BY MAKING USE OF TRACERS

The possible application of two tracers – sulphur hexafluoride and fluorescent particles – for identifying selected emission sources and determining their environmental impact is discussed.

1. INTRODUCTION

It was on the turn of the 1950s that tracers began to be widely applied to investigate diffusion phenomena. In general, tracers can be divided into the following classes: dust particles (fluorescent particles, pollens), aerosols (uranine, rhodanine or oily mists), radioactive isotopes (Kr-85, Ar-41) and gases (sulphur hexafluoride). In the past few years interest has focused on a new group of gaseous tracers, on perfluorocarbons. All of the tracers have some characteristic features in common: very low or zero background concentration in the atmospheric air under study; high chemical resistance; non-hygroscopic nature; they exert no toxic influence to humans or natural environment, and they are easy to determine even when occurring at very low concentrations. Application of tracers eliminates economic considerations: the experimental and analytical systems are simple, cheap and easy to handle; the tracers are cheap and easily available.

In Poland, preference is given to sulphur hexafluoride (SF_6) and fluorescence particles (FP). The sets for sulphur hexafluoride and fluorescence particles emissions are extraordinarily simple. The emission of sulphur hexafluoride involves a standard regulator fitted to a pressure cylinder. The emission rate may be measured by a gas meter or an appropriately calibrated restrictor. The emission of fluorescence particles is carried out in a ejector system. Emission rate is determined gravimetrically by measuring weight loss. Sampling methods are reported

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by COLLINS [1] and DRIVAS [2] for sulphur hexafluoride and by LEIGHTON [3] for fluorescence particles.

2. MEASURING PROCEDURES AND MODELS

One of the major components of the measuring system is the analyzer of air samples containing the tracer of interest. In the case of fluorescence particles, the simplest method consists in visual calculation of the luminophor particles irradiating in the UV range [3]. Analyses of sulphur hexafluoride are carried out in a gas chromatograph equipped with an ECD detector [4], [5].

While sulphur hexafluoride and fluorescence particles of grain size equal to, or smaller than 5μ are used for investigating the distribution of gaseous substances, coarser fractions of fluorescence particles are made use of to examine the dispersion of dust particulates. It is possible to generate monodispersional dusts the fractions of which display different colours. The application of coloured dusts enables the distribution of concentrations for individual fractions in the vicinity of the emitter to be determined. It also allows for examining the efficiency of dust separators and precipitators.

As a rule, tracers (sulphur hexafluoride and fine fluorescence particles) are made use of to determine the distribution of concentrations for gaseous pollutants emitted at a constant rate by a single point source. Samples have to be taken on the leeward side of the emitter along two or three arcs perpendicular to the wind direction. The arcs should be sufficiently long to enable determination of transverse concentration profiles, including diffusion phenomena and fluctuations of wind direction. The distance of the arcs and the receptors located along them from the emitter depends on its height and on some meteorological factors. The spacing between the receptors should be changed with each change of conditions. It has to be calculated in terms of an appropriate mathematical model of dispersion, which includes data on both topography and meteorological situation.

When technological processes are conducted in an inadequate manner, there may occur incidental (uncontrolled) emissions of air pollutants. Incidental pollution ows its origin to leakage from technological installations, to open or broken windows, etc. In Poland, uncontrolled emissions have become increasingly frequent in the past few years, and they sometimes display very high concentrations of pollutants. They are difficult to measure (if at all), create serious hazards to the human beings exposed and to the immediate environment. The rate of uncontrolled emission may be established from the balance of the tracer which is to be introduced into the maloperated system. For this purpose it is advisable to use gaseous sulphur hexafluoride rather than solid fluorescence particles.

Owing to its high chemical stability, the tracer is never subject to transformation even in the environment of many different industrial gases. It moves towards the emitter, some part of it entering the atmosphere as a result of uncontrolled emission through leakage. The measurement of sulphur hexafluoride concentrations in the emitter and the determination of the flow rate of outlet gases enable the quantity of the tracer reaching the emitter to be established. Knowing these values, it is possible to determine the mass balance for sulphur hexafluoride and, consequently, to quantify the sulphur hexafluoride portion which has left the technological set on the pathway from the source of pollutants generation to the emitter, i.e. the incidental, uncontrolled emission. But it is also of prime importance to determine the distribution of pollutant concentrations which owes its origin to uncontrolled emission. Such determinations are relatively easy to perform, when the stack is sufficiently high, so that the point, at which the stack plume carrying the tracer reaches the ground level, lies far beyond the zone of the influence of uncontrolled emission. Thus, it suffices to measure the tracer concentrations in this zone, as they give direct information on the distribution of noxious substances leaving the object through incidental emissions. The problem is difficult to solve when the stack is insufficiently high, so that controlled and uncontrolled emissions undergo partial overlapping. When these occur, it is necessary to investigate the two types of emission separately in the initial phase. To achieve this, it is advisable to introduce the tracer direct to the flue. On measuring the tracer concentrations in the vicinity of the emitter, we obtain the distributions associated with controlled emission alone. When the tracer is introduced to the source of pollutant generation located in the technological installation, we can additionally obtain information on the uncontrolled emission of the tracing substance. The difference in the field of tracer concentrations between controlled and uncontrolled emissions indicates the contribution of the latter type.

It should be noticed that measured concentrations of tracing substances are not comparable even though they may refer to the same area. This is because they are strongly dependent on meteorological conditions and, consequently, on their fluctuation. Thus, the measured distributions of tracer concentrations should be made use of for the construction or verification of mathematical models. The number of measured data obtained by the application of tracers is of significance when constructing diffusion models for actual topographic conditions in the vicinity of a single emitter or a system of emitters. The models established from such data are reliable, and the results of calculations performed by using these models are in good agreement with the actual values, thus enabling comparisons.

The range of application for fluorescence particles is somewhat different. The only purpose for which this tracer should be used is determining the contribution of individual sources to the concentrations of pollutants at a given point. To achieve this, it is necessary to apply several types of luminophors which display similar particle fractions, but differ in the colour of light emission. The measuring procedure begins after each dust type has been introduced into the emitters of interest. When the emissions of dust particles displaying various colours are identical,the amounts of individual dusts depositing on the receptor are proportional to the contribution of individual emitters to the pollution load at the given point in a given meteorological situation.

3. CONCLUSIONS

The applications of the tracers considered in this report enable (during a long series of experiments comprising a great number of different meteorological situations) the influence of a single emitter (or a system of emitters) to be determined with an unusual accuracy. This can be achieved by using appropriate mathematical models which give an adequate description of the physiographic and meteorological conditions characterizing the immediate vicinity of the emitter or industrial plant. The models display such an accuracy because all of the empirical coefficients incorporated in them have been verified on the basis of a large set of data obtained at low cost by making use of tracers only.

Measurements involving tracers have the merit of enabling accurate estimates of pollutants dispersion from a selected source even in highly industrialized areas. Such estimates fail to be successful because of the variety of background pollution, when measurements with no tracing substance are carried out for one of the pollutants released from the same emitter.

The considerations presented in this paper substantiate the utility of tracers as applied for identifying non-conventional emission sources or for estimating their environmental impact.

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IDENTYFIKACJA ŹRÓDEŁ ZANIECZYSZCZEŃ ATMOSFERY ZA POMOCĄ SUBSTANCJI ZNACZONYCH

Przedstawiono możliwości wykorzystania dwóch substancji znaczonych, sześciofluorku siarki i pyłów fluorescencyjnych, do identyfikacji wybranych rodzajów źródeł emisji i do ustalenia stopnia ich oddziaływania na środowisko.

IDENTIFIZIERUNG DER LUFTVERSCHMUTZUNGSQUELLEN MIT HILFE VON TRACER-SUBSTANZEN

Zwei Tracer-Substanzen, SF_6 und FP, werden untersucht. Es hat sich ergeben, dass beide Substanzen zur Identifizierung der Luftverschmutzungsquellen gut geeignet sind und dass sie zusätzlich eine Quantifizierung des Einflusses dieser Quellen gestatten.

ИДЕНТИФИКАЦИЯ ИСТОЧНИКОВ ЗАГРЯЗНЕНИЙ АТМОСФЕРЫ С ПОМОЩЬЮ МАРКИРОВАННЫХ ВЕЩЕСТВ

Представлены возможности использования двух маркированных веществ - шестифтористой серы и флуоресценционных пылей - для идентификации выбранных типов источников эмиссии и для определения степени их воздействия на среду.