SBORNÍK ČESKOSLOVENSKÉ SPOLEČNOSTI ZEMĚPISNÉ
Ročník 1972 • Číslo 2 • Svazek 77

JAN MUNZAR

PROBLEMS OF AIR-POLLUTION CLIMATOLOGY IN CZECHOSLOVAKIA

When Thomas Campanella was writing his Utopia on an ideal society he named the country of his dreams and invention „Civitas solis". It was not just a symbol but, at the same time, an expression of the desire that people may live in a sunny and a beautiful country, that they may respire p u r e a i r and drink clear spring water, live in the midst of parks and gardens, in peace and in healthy atmosphere. This was also determinative in the way of thinking of later Utopian socialistist. Their origin was not at all accidental; they were born as the result of contradictions which were arising between the beginning industry and a healthy environment.

Now it is obvious that air-pollution, as one of the components of the geographic environment which were affected in the negative sence by any kind of economic activity in the industrially advanced countries, is just that of the most rapid growth. Also in Czechoslovakia this phenomenon accompanying the industrial and town-building development became evident with all its negative consequences. During the first fifteen years after World War II the attention paid to the problems of air puriry was considerably lower than at present. The quantity of harmful substance polluting the air namely did not reach in those years its present size. There were also vast reserves of untouched areas capable of being employed for the localization of the energetic and other capacities — new sources of further airpollution. The aggravating tendency of the pollution growth, however, was bringing difficulties increasing in size, the solution of which could no longer be neglected.

In the thermal power station at Komořany in northwestern Bohemia, for example, an extraordinary air-pollution appeared in 1961 (lignite of low calorific value with high content of sulphur is used for burning in this power station). The SO_2 concentration values reached then up to 40 mg/m^3 (Tichý 1963). It must be taken into account that the reasons were quite different from those of the well known disasterous cases of air-pollution. While pollution of the Meuse River in Belgium, the American town of Donora and of London was caused by a „classic" meteorological situation (calm, weather without precipitations, with temperature inversion and fog), the case of Komořany broke out at downdraught conditions resulting mainly from technical imperfections. There were ten chimneys 5 m height on the roof of the power station building which had 35 m of height itself. The unsufficient super-elevations of the chimneys over the building was accompanied by a low speed of the smoke gas exit. Under a higher speed of the wind the leeward whirling behind the building originated vast concentrations in the close neighbourhood of the chimney. This is why a new spare chimney 200 m high was set to work in July 1966.

A law was passed in 1967 on the „Measures to prevent air-pollution". It established the maximum acceptable concentration of the polluting substance and the principles for computing of taxes in the case of an excessive air-pollution. According to this law, the highest acceptable SO_2 concentration is 0,15 mg/m^3 in 24 hours or 0,50 mg/m^3 in 30 minutes. The values of the dust falling as gained by sedimentation measurement must not exceed 150 t/km^2 a year. Four years of practise have given us much new information which call forth the necessity of an amendment of the law. It concerns not only the evaluation of the existing sources of air-pollution but, first of all, an evaluation of the planned sources, i. e. an improvement of the conception of the air protection. We may say that the advancement of air-pollution climatology plays a considerable role in these efforts of improving the purity of the air.

A meterorological problem of an utmost importance is how to contribute to the elucidation of the mechanisms of expansion of the harmful substance in the atmosphere in hilly terrain. The relief of Czechoslovakia is hilly enough not to allow to suppose the same air flow mechanisms and that of transfer and dispersion of the polluting substance in a certain time limit on the whole area, as it is possible in plain regions. Therefore it is quite possible to establish mathematical models which result from these mechanisms in a unique way for a certain time limit, and to establish such boundaries where transition from the one to the other takes place. In leeward sides of the mountains it is represented by a transition from a bypass of smoke plumes not affected by major whirls to a situation where these whirls deform the smoke plume which originally was a horizontal one, and transfer vast concentrations immediately to the surface of the earth. The situation is even more complicated by the difference in the height profiles of the terrain related to the individual wind directions. The knowledge of the model for all types of transfer and dispersion of the smoke plumes in an hilly terrain will not, however, prevent the differentiation of the turbulent parametres, namely in the case of a non-homogene turbulence (changes in space) and a non-stationary process (changes in time). Even with one weather situation only turns can be taken by quite a lot of various brief fields near the ground where pollution is concentrated. They are caused by different mechanisms of transfer and dispersion of the harmful substance which is complicated by various effects of sources in different heights over the terrain.

The accumulation of the sources of pollution together with unfavourable orographic and mesoclimatic conditions are the reasons for a relatively high pollution in the region of the North Bohemian Lignite Basin and the adjacent slopes of the Krušné hory (Ore Mountains) or České středohoří Highland. The nucleus of the lignite basin is situated approximately at 50° 33′ lat. N and 13° 35′ long. E. The highest frequency is that about 250 m of altitude above sea level. The oppressiveness of the questions of environment is accentuated in this region by the intensions of further development of its fuel and energetic base — 64 % of Czechoslovak power output should be set up here before 1980. This is the main reason for the preferrence of the attention paid to this part of the North Bohemian Region in the investigations of the pollution of the Czechoslovak industrial areas.

The North Bohemian Lignite Basin and its surroundings are characterized by their considerable height zoning. On rather small area (about 1200 km^2) the variance of heights above sea level within abouth 1000 m is an expressively determinative climatic factor. Thus a forming may be expected of a very stable boundary layer of atmosphere with conditions hampering aerosol dispersion (Munzar 1971 a). An important indicator of a very stable boundary layer is fog. An average number of foggy days during one year at stations of the region in question is 105, while there are 60 foggy days at stations outside the region. The highest frequency of fog appears in autumn and at the beginning of winter. In 50 % of the cases fog stays for more than 9 hours, and even more than 24 hours in 15 % of the cases. The longest continuous foggy periods within last ten years lasted for 5 days. This fact is accompanied by a decrease of the horizontal visibility even to single metres — fog represents thus a serious menace to the productive and life functions of all human activities in the area (exploitation of opencast lignite mines, traffic, etc.).

Another important characteristic of the climate in the region in question is a bad ventilation — frequent calms or very weak winds. The average speed of surface wind in one year in our region is approximately 3.3 m/sec. The relative frequency of the individual classes of wind speed in one year is as follows:

speed of the wind m/sec	00	01—03	04—06	>6
relative frequency %	21.5	41.3	21.6	15.6

According to McCormick (1968) the accumulation of admixtures in the air takes place usually under conditions of a persistence of the speeds of the surface wind lower than 7 miles an hour (= 3.1 m/sec). In the region of Most these speeds appear nearly in 63 % of the cases (Munzar 1971 b).

Owing to pollution the atmosphere of the region is less transparent and has therefore a lower reception of the solar radiation. The average duration of sunshine per year amounts here to approximately 1450 hours only. One hour of sunshine in the basin represents reception of mere 1,28 cal. cm^{-2}. This means, with regard to the results of measurements at a near Milešovka Mt. observatory (837 m above sea level), that a layer of 600 m of polluted air absorbs cca 40 % of the global radiation (Zelený 1969, Munzar 1971 b, c).

Now let us turn our attention to some most significant results of the study of relationships between meteorological factors and the air-pollution. It was discovered that the stability of the lower troposphere to the height of about 1,5 km (850 mb level) exerts an influence, which is incomparably greater than the speed of the wind, upon the occurence of SO_2 concentrations in northwestern Bohemia. The amount of immissions is not substantially influenced by the stability of the atmosphere in the lowest decametres (mast of 80 m). The influence exerted by the wind upon the SO_2 concentrations near the ground manifests itself no longer in such an explicit way. Higher concentrations occur mostly at calms or weak wind speeds, it is true, they not unfrequently appear, however, at higher speeds of the wind. The dependence of SO_2 on the wind speed has namely a local expression, e. g. by two maxima with a minimum amidst. The boundary value of the wind speed between both groups is approximately the speed of 3.0—3.5 m/sec. The highest conditioned frequency in the first group is that of speeds close to zero, in the second group that of the frequency class above 9 m/sec (Sládek 1971, Svoboda 1971).

The interpretation of the wind rose of pollution discovered maxima from three directions at one station in our area. The analysis of the location of significant sources of pollution gave an explanation just to two of them. The position of the third maximum was „illogical" — the pollution was coming from a mountain range. A more profound analysis has shown that the maximum is caused by a leeward effect, influenced by the occurence of the quasistationary rotor zone on the leeward side of the Ore Mountains. That is the reason for a special attention paid since recent time to the influence of local meteorological conditions on the regime of pollution in hilly terrain (Koldovský 1971). The subjects under discussion are first of all

1. influence of the convection. The differences in the course of the convection over a mountainous and a plain terrain during the day often exert an unfavourable evidence on the dispersion of the products of combustion. Owing to the later starting of the convection in the mountains, convection in valley positions is being suppressed so that the maximum of concentrations a day can be shifted here with 1—3 hours;
2. influence of local circulations. The anabatic wind in the early morning hours cause a transportation of impurities from the valleys up to the slopes, where significant concentrations can be measured. Catabatic winds contribute to increase the accumulations of impurities in the valleys;
3. leeward effects. Due to the variability of effects it is not possible to make conclusions of a general validity.

It can thus be seen that in a hilly terrain an imprudent interpretation of theoretical relationships and figures derived for a plain terrain should be avoided. All potential local influence of any kind must be evaluated in detail. If the case is rather complicated a meteorologist who knows local conditions of the area should be preferred in relevance to theoretical values of concentrations expected in accordance with general figures which, for their part, were based on simplifying presumptions. The dispersion of the immission values owing to meteorological influences will be probably at least some ten times higher in an hilly terrain than the dispersion of those values of emission of sources which are to be put into considerations.

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PROBLĚMY KLIMATOLOGIE ZNEČIŠTĚNÍ OVZDUŠÍ V ČSSR

Ze složek geografického prostředí, dotčených v negativním smyslu hospodářskou činností, roste znečištění ovzduší nejrychleji. Tento problém je stále palčivější i v ČSSR. Např. v roce 1961 dosáhla hodnota koncentrace SO_2 u elektrárny Komořany 40 mg/m^3. Čs. zákon „O opatřeních proti znečištění ovzduší" z r. 1967 sice přinesl první známky zlepšení, ukazuje se však nutná jeho novelizace pro zlepšení prevence čistoty ovzduší, zvláště k přihlédnutím k výsledkům klimatologie znečištění.

Hlavním problémem u nás je studium mechanismu šíření a rozptylu exhalací ve zvlněném terénu, kdy nelze využít výsledků z jiných zemí — vzorců pro rovinný terén. Je uváděn příklad ze Severočeského hnědouhelného revíru, kde velké výškové rozpětí v oblasti (kolem 1000 m) je rozhodujícím klimatickým faktorem. Jako indikátor velmi stabilní mezní vrstvy atmosféry je vzata mlha. Ve studované oblasti je průměrný počet dní s mlhou 105, v okolí jen 60. Oblast je též charakterizována malým provětráváním, nepříznivým pro rozptyl exhalací. Podíl rychlostí větru menších než 3,1 m/s dosahuje téměř 63 %. Průměrné trvání slunečního svitu za rok zde nedosahuje 1450 hodin, na 1 hodinu slunečního svitu v pánvi připadá pouze příjem 1,28 cal/cm^2. Přízemní vrstva znečištěného ovzduší do 600 m nad terénem pohlcuje přibližně 40 % globálního záření.

Pro správnou interpretaci vztahů mezi meteorologickými faktory a znečištěním je nutné studovat detailně místní meteorologické vlivy, zvláště vliv konvekce v členitém terénu, vliv místních cirkulací a závětrné efekty. V komplikovanějších případech je cennější posudek meteorologa, znalého místních podmínek, ve srovnání s výpočtem znečištění podle obecných zjednodušujících vzorců, protože lze očekávat, že vlivem meteorologických podmínek je rozptyl hodnot imisí v členitém terénu až desetkrát vyšší než rozptyl hodnot emisí uvažovaných zdrojů.