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MEDICAL PROBLEMS CAUSED BY VERTICAL OZONE DISTRIBUTION IN MOUNTAIN REGIONS

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Abstract

The natural increase of the ozone concentration in the troposphere with altitude up to values exceeding the standards of the World Health Organization is a problem of recreational use of the mountain regions. There is the necessity of considering of the presence of ozone-rich air at high altitudes under planning of rest, tourism and sports in the mountain regions. In fact the ozone is additional and little-known factor that bounds the recreational use of mountain regions for some population groups. Attention is drawn to the fact that symptoms of the mountain sickness are similar to symptoms of the ozone poisoning. This assumes that higher ozone concentrations promote to appearance of effects of the altitude illness or at least increases its effects. For this reason the ozone is unfavourable factor for life in the mountains.

Introduction

The ozone concentration nearly always grows with height from the ground to the upper layer of troposphere, reaching the values of 100-140 μg/m^3 at an altitudes of 1-2 km and 180-200 μg/m^3 at an altitudes of 8-9 km. It is known from the vertical ozone sounding (data of the World Ozone and Ultraviolet Radiation Data Centre – WOUDC). The ozone measurements in the mountain regions show the similar vertical distribution [4]. A schematic vertical profile of ozone mixing ratio in the troposphere is shown in Figure.

We expect strengthening ozone influence on health with altitude in the mountain regions as the ozone content in the atmosphere air increases. Why the ozone is a topical problem in the mountains?

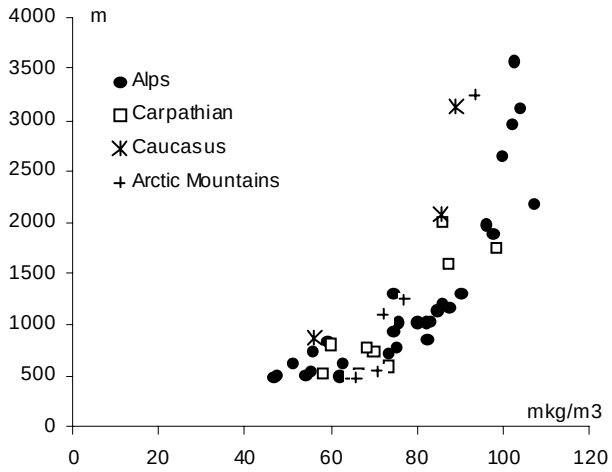

Figure. Vertical distribution of average annual ozone concentrations in some mountains regions

According to Russian hygienic regulations (GN 2.2.5.1313-03) ozone is a substance of the highest class of the danger. The ozone has the poisonous, irritant, carcinogenic, mutagenic and genotoxic action [9]. The total physiological influence of ozone on the human depends on its concentration and influence time. The irritation of eyes and nose mucous membrane, decrease of visual acuity and peripheral vision, accommodation impairment, headache, vertigo, decrease of arterial pressure, dry mouth, chest pain, insomnia, cough, bronchitis, pulmonary ventilation decrease, cardiovascular collapse, disorders of vegetative nervous system, fatigue are typical symptoms of the ozone poising [11, 16, 21]

The World Health Organization (WHO) recommends that the air quality guideline for ozone is set at the level of: ozone: 100 μg/m^3 for daily maximum 8-hour mean [23]. Based on time-series studies, the number of attributable deaths brought forward can be estimated at 1-2% on days when ozone concentration reaches this guideline level as compared with the background ozone level. It is possible that health effects will occur below this level in some sensitive individuals.

The number of additional deaths at ozone concentrations about 160 can be estimated at 3-5% in comparison with days, when concentrations are close to background values (70μg/m^3). At concentrations exceeding 240 μg/m^3 important health effects are likely. This is based on findings from a large number of clinical inhalation and field

studies. Both healthy adults and asthmatics would experience significant reductions in lung function as well as airway inflammation that would cause symptoms and alter performance. There are additional concerns about increased respiratory morbidity in children. Based on time-series evidence, the number of attributable deaths brought forward can be estimated at 5-9% for daily exposures above the estimated background [23].

Data

The data of World Data Centre for Greenhouse Gases (WDCGG) and EMEP (http://emep.int) for ozone monitoring stations located in the Alps, in the Pyreneees, in the Carpathian, in the Pennines and in the mountains in the central Spain, in the Greece, in the Scandinavian and Spitsbergen were analyzed for this study.
Finally, the results of ozone measurements at Swedish station Areskunan [Bazhanov V., Rodhe, 1997], the at the Kislovodsk mountain observatory [17], at the Terskol observatory [7] and the data of authors measurements at the Lovchorr mountain in the Khibiny were used.

Discussion

As shows the analysis of data, in the autumn and during winter time the problem of excess by ozone of specifications the WHO in mountain areas of Europe is not topical (at least to 3,5 km). The situation changes in the spring and in the summer. The ozone concentrations increase because of the photochemical ozone generation. At that the ozone concentrations can remain raised over prolonged periods as the life time of ozone in the free atmosphere is long.
The maximum of the ozone content in the Alpes and Carpathians is observed in the late spring and in the summer [4]. During this period the regular exceeding of the WHO standards in the Alpes and Carpathians takes place at altitudes about 1 km and above.
There is a high correlation (0.88) between the altitude of place (H, m asl) and the time percent for a year P_t, when an 8-hours running average of the ozone concentration exceeds 100 $\mu g/m^3$.
The equation of regression for altitudes from 500 to 3 500 m:

$$P_t = 0{,}0187 * H.$$

The mountain ozone monitoring observatories in the Russia is not enough. For this reason we have no detailed information on vertical ozone distribution the mountain regions of Russia. It is suggested that the ozone concentrations in the Caucasus are by 15–30 $\mu g/m^3$ less than in the mountain of the central and southern Europe as the intensity of the photochemical ozone generation in the region is less according to some researches [4, 17]. This fact decreases the topicality of the ozone problem in the Caucasus. However there are episodes when ozone concentration exceed the WHO standards too. As a rule this episodes are observed in the late spring and in summer. The mean monthly ozone concentrations at the Terskol peak (3120 m asl) in April-August are about 100 $\mu g/m^3$ [7]. At the same time the mean hourly ozone concentrations can reach 180 $\mu g/m^3$. The mean hourly ozone concentrations at the Kislovodsk mountain observatory (2095 m asl) reach 140 $\mu g/m^3$ [17].
It is our estimation that the exceeding of the WHO standards in the Caucasus is observed during about 10% at altitudes 1 km and up to 30% at altitudes 3 km.
The summer ozone concentrations in the North Mountain regions (the Scandinavian Mountains, the Khibiny) are less because of absent or insignificance of the processes of local photochemical ozone generate [4]. At least at altitudes up to 2-3 km there is not problem of high ozone concentrations. At the same time there are episodes of long transport when ozone-rich air mass moves in Arctic from Europe. For example, during these episodes the ozone concentrations in the Khibiny can exceed 100-120 $\mu g/m^3$ [5, 18]. However such cases are rare enough.
As a rule the ozone concentrations in the low altitude mountain regions can not cause the obvious physiological changes in the lung (they are less than 160 $\mu g/m^3$) during short residence time on the open-air. However even such concentrations of ozone represent danger for people which have problems with bodies of breath or cardiovascular system. Moreover the downward transport of ozone-rich air from the stratosphere can cause the increase of ozone concentration up to 180 $\mu g/m^3$ and more at altitudes down to 1600 m [3, 15, 19, 22].
The problem becomes more importance with altitude. For example, the ozone concentration in the base camps at the foot of Mount Everest is 160-180 $\mu g/m^3$. At the same time the ozone concentrations on its summit would be approximately 240-600 $\mu g/m^3$ [3, 15, 19, 22]. There is no question that such concentration can cause the additional respiratory distress and others physiological disorders.
It is important to note that the typical in the surface layer diurnal ozone variation with midday maximum and night minimum in the high mountains is practically absent [4]. The interdays ozone variations in the mountains are weak too [4]. For these reasons the organism in the mountains is affected by the high ozone concentrations during long period of time. It is important for considering as the period of acclimatization and passage of complex routs takes much time (up to month) [20]. At that the physical activity worsens the state of health in conditions of the ozone intoxication as the ozone under hyperventilation reaches to the lower parts of the lung which has the heightened ozone sensibility [1].

In the meantime the question on biophysical consequences of the long hypoxia or the lung hyperventilation in conjunction with the long influence of the high ozone concentrations is still an open question and it demands of the additional special medical and biologic researches.
It is necessary to recognize that the problem of the physiological action of ozone at high altitudes in the mountains is not adequately explored. For example the special researches of problems human activity in the mountains takes no notice of fact that the symptoms of the mountain sickness and the ozone poisoning are similar.
Indeed, in spite of the fact that acute mountain sickness is a syndrome of nonspecific symptoms and is therefore subjective, we pay attention to such symptoms of the mountain sickness, as breathlessness, breathlessness, irritation of upper air passages, dry cough, retrosternal pains, vertigo, ear noise, cephalalgia, palpitation, rapid pulse, cardiovascular collapse, muscle weakness, fatigue, epistaxis, nausea, decrease of visual acuity and peripheral vision, fail eyesight, stereoscopic vision, decrease of night vision, neurotic disorders. [1, 10, 13, 14]. As discussed earlier the ozone poising is accompanied by the like symptoms! This suggests that some clinical presentations of the mountain illness are caused by high ozone concentrations. At least the ozone may increase the symptoms of the mountain sickness [6].
For example, the mean altitude of incidence of acute mountain sickness in the Alps is 500 lower than in the Caucasus. The ozone concentrations in the Alps are higher than in the Caucasus. In this connection we can assume that lower height of occurrence of mountain illness in the Alps can is caused by higher ozone concentrations. At least the elevated ozone concentrations may be a contributing factor of occurrence of the mountain sickness. This question is controversial but it demands special researches.

Conclusions

The natural increase of the ozone concentration in the troposphere with altitude is a dangerous for heath because of his large toxicity. At present there are more 10 pathological states which are caused by influence of the mountain climate. Among these are the illness of heat and circulation of the blood, respiratory illness, mountain pulmonary edema, high altitude cerebral oedema and renal insufficiency [8].
The data of toxicological researches indicates that ozone has the similar influence an organism. We should pay attention to the fact that symptoms of the mountain sickness are similar to symptoms of the ozone poisoning. This assumes that higher ozone concentrations promote to appearance of effects of the altitude illness or at least increases its effects. For this reason the ozone is unfavourable factor for life in the mountains.
In fact, the ozone is the little-known factor which limits the recreational developming of the mountain regions, at least for some population groups which have problems with health.

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