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RISK ASSESSMENT OF AEROTECHNOGENIC POLLUTION GENERATED BY INDUSTRIAL ENTERPRISES IN ALGERIA AND UKRAINE

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ABSTRACT: Algeria and Ukraine are in an environmental transition phase concomitant to their economic transition. Air pollution is a real problem of public health in both countries. Similar to Algeria, air pollution is severe in Ukraine, particularly in such industrial center as Kryvyi Rih which is characterized by the existence of heavy industries. In Algeria due to the dense industrial base in such northern cities as Annaba, air pollution becomes a serious health hazard affecting populations living in this area. The aim of our research is to assess the risks of air pollution emissions with nitrogen and sulfur dioxides as a result of metallurgical enterprises activities in Annaba and Kryvyi Rih. Application of GIS mapping corresponding to monitoring networks in both cities allowing the creation of risk assessment maps with nitrogen and sulfur dioxides. Children are especially sensitive to air pollution and man-made aerosols dust. Therefore, studies have been conducted regularly issuing the effectiveness of preventive pectin tablets for two groups of children. The number of examined children was 20; whereas the duration of experiment was 3 weeks. Moreover, heavy metals content in the hair was selected to assess the effectiveness of chosen measures of rehabilitation. According to the GIS mapping data there is a constant excess of 1.5 MPC for nitrogen dioxide in the central part of Kryvyi Rih city. Furthermore, was revealed a tendency to higher content with nitrogen dioxide in the atmosphere of Annaba. On the other hand, periodic taking of pectin tablets in the areas of man-made air pollution is an effective preventive measure.

KEYWORDS: air pollution, metallurgy, monitoring, environment health, risk assessment.

INTRODUCTION:

In recent decades, Algeria and Ukraine are in an environmental transition phase concomitant to their economic transition. Air pollution is a genuine problem of public health in both countries. Algeria is ranked 42nd country in the world in terms of environmental protection, in 2011, out of 153 countries surveyed. Similar to Algeria, air pollution is severe in Ukraine which occupied 137th place out of 142 countries compared in the index of ecological stability issued by the World Economic Forum in 2002(Copsey *et al.*,2008). According to a study conducted by the program of technical assistance of the Mediterranean environment (METAP),the degradation of environment in Algeria costing $ 1.7 billion per year, or 3.6 percent of GDP. Furthermore, national report on the state of environment showed that 30% of consultations are for respiratory diseases, 40% of infant mortality (children under 1 year) is caused by respiratory diseases and 600000 asthmatics suffer permanently (Samasafia. Tech.rep, 2007).

The main sources of air pollution in Annaba are; El Hadjar steel complex and fertilizers plant (FERTIAL) (Benselhoub *et al.*, 2015a).Management and monitoring of pollution levels in this region is of paramount importance, considering the significant concentration of population in this metropolis.

Metallurgical plant in the city of Kryvyi Rih in the south-east of Ukraine was built in the middle of the last century near the iron ore quarries. This industrial center holds first place among Ukrainian cities by anthropogenic air pollution with aerosols of toxic gases and dust containing heavy metals (Babiy *et al.,* 2003).

Daily emitted into the atmosphere of these cities different gaseous substances such as: CO, NO_x, O_3, SO_2 and technogenic dust. As a result, the working population of industrialized regions is exposed to a dual man-made load, which is caused by the exposure of their organisms to industrial factors (at workplace), as well as the environment according to their place of residence (Karnaukh *et al.,* 2008).

The population in both cities is more than 600 000 inhabitants. In this regard, special importance is given to investigate health risks connected with man-made air pollution for people living in these areas. In recent years, respiratory diseases in the industrial cities in the north of Algeria have reached a maximum in Annaba region.

It is known that the iron and steel works, throws up to 1.6-1.8 tons of NO_x and SO_x aerosols for every ton

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of steel. This combination determines the high level of general morbidity of the total population in each region.

It was found that the intensity of meteorological conditions and different industrial emissions of metallurgical plants in Kryvyi Rih during a year cause the typical seasonal variations in the incidence of the city's population in the technogenic contaminated and relatively clean areas (Karnaukh *et al.*, 2008).Thus, due to the specificity of iron ore extraction and smelting of ferrous metals, both industrial region in Annaba and Kryvyi Rih are sources of artificial geochemical flow of inorganic and organic environment pollutants. It is necessary to create a database for assessing risks connected with human health and environment from various industrial activities. The specific scientific interest is also related to risk assessment of soil technogenic degradation.

The purpose of our research is to assess the risks of air pollution emissions with nitrogen and sulfur dioxides as a result of the metallurgical enterprises activities in Annaba and Kryvyi Rih.

RESEARCH METHODS:

WHO Global Strategy for workers health, adopted by the 49th General Assembly of public health protection in 1996, it includes as a priority in medical research of occupational health risk assessment.

For these reasons, it is necessary to monitor the air quality in Annaba to assess the actual degree of urban and industrial pollution and implement a protection policy for citizen's health and quality of life.

The ministry of environment has implemented a network baptized SAMASAFIA for air quality monitoring and pollution measurement (Benselhoub *et al.*, 2015b).The installation of this network was carried out in four agglomerations in Annaba namely; Annaba Center, El Bouni, Sidi Amar and Les Salines. Such networks of automatic meteorological stations were installed at the end of the last century in Dnipropetrovsk industrial region in the cities of Kryvyi Rih, Dnipropetrovsk and Dniprodzerzhynsk. As well as laboratory techniques are used for automatic control. The average daily, monthly and annual monitoring data of toxic substances in the air are compared to the maximum permissible concentration (MPC).The main targets of atmospheric pollution in Annaba (Algeria) and Kryvyi Rih (Ukraine) are mining and metallurgical plants, which are under the financial control of the company "Arcelor Mittal". To ensure the environmental audit procedure in recent years, automatic monitoring stations of air pollution have been installed at the metallurgical enterprises of Annaba and Kryvyi Rih. These measures will have a positive impact on the health of workers. The main objectives of measures:

- Determining the current state of metallurgical plant emissions;
- Obtained data are compared with the established WHO maximum permissible concentration (MPC);
- Monitoring of trends in the long term;

According to WHO the MPC of NO_2 is 0.03 mg / m^3, for SO_2 is 0.05 mg / m^3. In accordance with instructions of the Ministry of Health in Ukraine MPC for NO_2 is 0.04 mg / m^3 for $SO_2$is 0.05 mg / m^3 (Shupranova *et al.*,2014).Obviously, due to the implementation of the above objectives will be possible to identify the productive sectors that require intervention, for the introduction of environmentally friendly technologies. Posts monitoring of air pollution have been installed directly at the factory of Arcelor Mittal of El Hadjar and neighboring areas by 19 stationary posts. Measurements were carried out for all seasons 10 times per year (Abedghers *et al.*, 2002). Posts S1-S16 are connected to the main process (S2-S6, S 9- 10, S15) and auxiliary production facilities (power supply, waste water treatment). Posts S17 - S19 are the objects of residential infrastructures (school in Sidi Amar and village in El Hadjar).

Application of GIS mapping according to four stations in the city of Kryvyi Rih (Ukraine) revealed the preferential places of accumulation of toxic aerosols withNO_2 and SO_2 in the neighboring areas of enterprises. As a result of the superposition of two maps, the risk assessment map of their overall impact on the atmosphere of the city was obtained. Children are especially sensitive to air pollution and man-made aerosols dust. In this regard, studies have been conducted regularly issuing the effectiveness of preventive pectin tablets for two groups of children. The number of children in groups is 20 persons (10 in each group). The duration of the experiment was 3 weeks. The content of heavy metals in the hair was chosen to assess the effectiveness of selected measures of rehabilitation. Evaluation of heavy metals content was conducted using the method of atomic absorption spectrometry.

RESULTS AND DISCUSSION:

After pollution monitoring of atmosphere's ground layer an expert assessment of results has been made. Figure 1 and Figure 2 show the GIS maps of atmospheric pollution with nitrogen and sulfur dioxides in the industrial agglomeration of El Hadjar area.

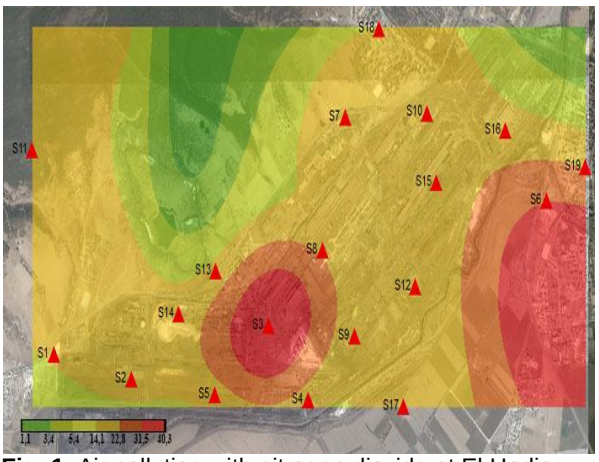


Fig. 1. Air pollution with nitrogen dioxide at El Hadjar metallurgical plant

Studia Universitatis "Vasile Goldiş", Seria Ştiinţele Vieţii
Vol. 27 issue 2, 2017, pp 99-104

Air pollution with nitrogen dioxide close to 1 MPC has been recorded according to monitoring data on several posts located near the blast furnaces and the steel shop. The second halo of NO_2 pollution was fixed over residential infrastructures (school in Sidi Amar district, village - El Hadjar).

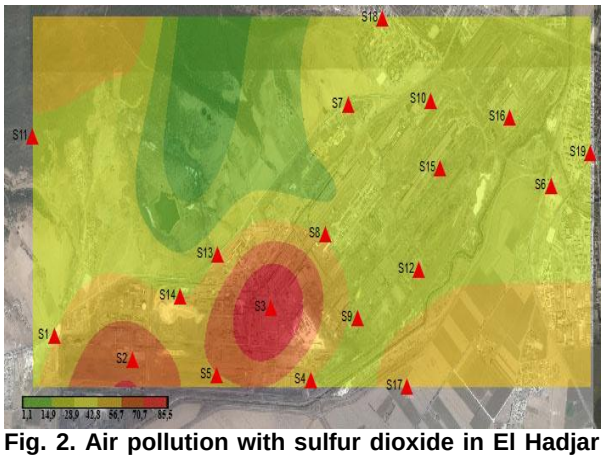


Fig. 2. Air pollution with sulfur dioxide in El Hadjar metallurgical plant

According to the majority data obtained from stationary monitoring stations, the annual average concentration of SO_2 was significantly lower than the MPC. However, a twofold excess of MPC was found in the complex hot zone (sintering and melting of iron ore in the blast furnace).These conclusions have been confirmed the presence of two zones of sulfur dioxide pollution inside El Hadjar metallurgical plant. Air pollution monitoring results with NO_2 in four zones of Annaba are shown in Fig 3

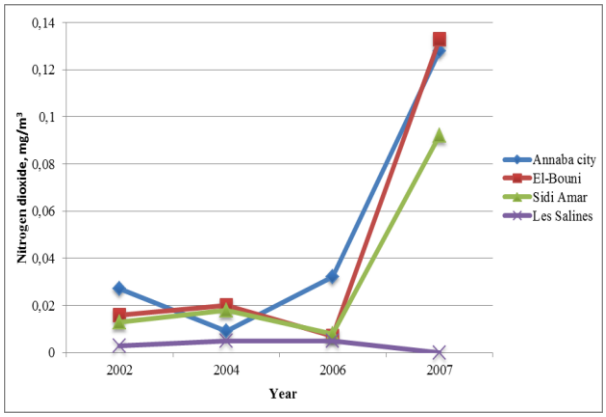


Fig. 3. Air pollution with NO_2 in four zones of Annaba

By the end of first decade of this century was a significant increase in concentrations of nitrogen dioxide in the atmosphere of the industrial areas. According to results of monthly monitoring of air pollution with SO_2, an excess of MPC was recorded in the autumn period at El Bouni (Fig 4).

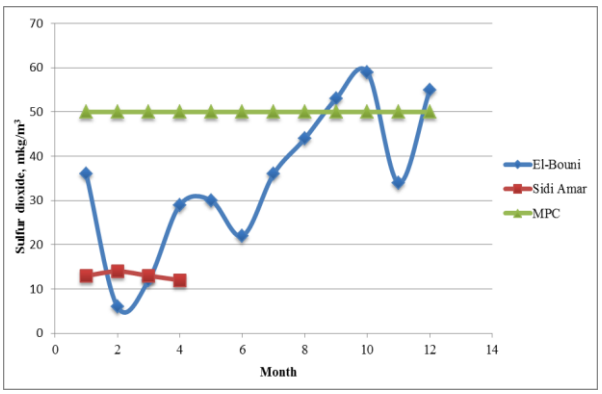


Fig. 4. Air pollution with SO_2 in industrial areas of Annaba

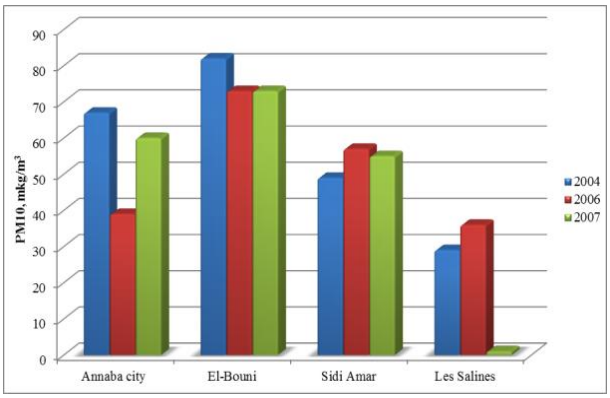


Fig 5. Air pollution with PM_{10} in four zones of Annaba

The results of air pollution monitoring by technogenic dust (PM_{10}) in four zones of Annaba are shown in Fig5.

On average during 3 years the highest content of technogenic dust was detected in the ground layer of atmosphere in El Bouni.

It was found that industrial enterprises of Kryvyi Rih (mainly mining and metallurgical complexes) are constantly released into the atmosphere more than 134 of chemical substances. Their total volume reaches 1 million tons per year (Kharytonov *et al*., 2003)

The average annual data of atmospheric pollution in Kryvyi Rih with nitrogen dioxide are shown in Fig 6.

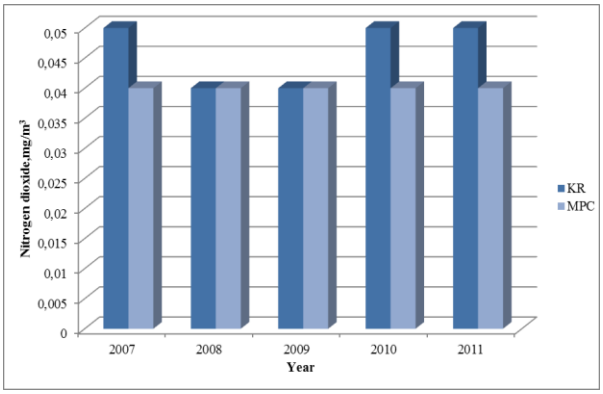


Fig. 6. Average annual air pollution with nitrogen dioxide in Kryvyi Rih

Corresponding to obtained data, there is constant air pollution in Kryvyi Rih with nitrogen dioxide. According to the WHO's recommendations exceeds the MPC in 1.2-1.7 times. Average annual Data of air pollution in Kryvyi Rih with sulfur dioxide are shown in Fig 7.

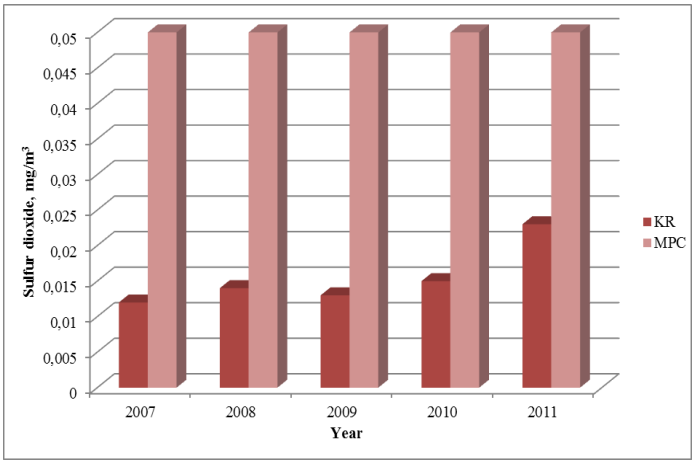
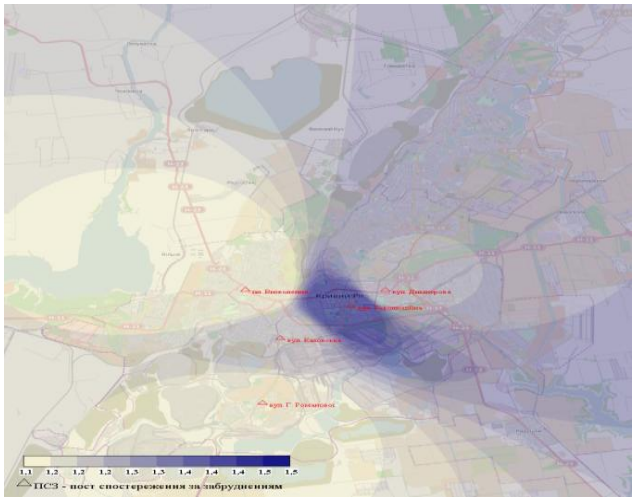


Fig. 7. Average annual air pollution with sulfur dioxide in Kryvyi Rih

In recent years, it was recorded an increase of air pollution with sulfur dioxide in Kryvyi Rih. The risk of exceeding the MPC is still lacking.

Data interpolation of three years (2009-2011) from monitoring stations in the city of Kryvyi Rih allowed the building of air pollution maps with nitrogen and sulfur dioxides (Figure 8).



a.Map of air pollution with NO_2 in Kryvyi Rih

b.Map of air pollution with SO_2 in Kryvyi Rih

Fig 8 . Maps of air pollution with NO_2 and SO_2 in Kryvyi Rih

The situation of air pollution with nitrogen dioxide in the city of Kryvyi Rih is sufficiently contrasted. Enough to note the accumulation of aerosol impurities at the maximum permissible concentration by 1.5 times in the central part of the city, where there are two factories of mining processing and one metallurgical plant.

Taking into account that in the city of Kryvyi Rih for the period 2009-2011 was dominated by north and east wind direction, it can be concluded that due to variable wind direction and the specific location of the city the sulfur dioxide is dispersed throughout the city.

It is necessary to consider that nitrogen and sulfur dioxides have the effect of summation. In the presence of a plurality of diffuse sources an overrun occur separate emissions and formed cumulative torch, actually spread over the whole industrial agglomeration.

The spatial structure of the torch is very complicated, instant impurity concentrations at various points in the city differ substantially from each other. However, the average levels of air pollution as a result of the interaction of many factors differ insignificantly.

Risk assessment map of cumulative effects of NO_2 and SO_2 in the atmosphere of the city of Kryvyi Rih is shown in figure 9.As shown in Fig9, the total torch, formed over the city of Kryvyi Rih in by the merger of emissions of numerous enterprises, under the influence of wind can spread over distances of several tens of kilometers.

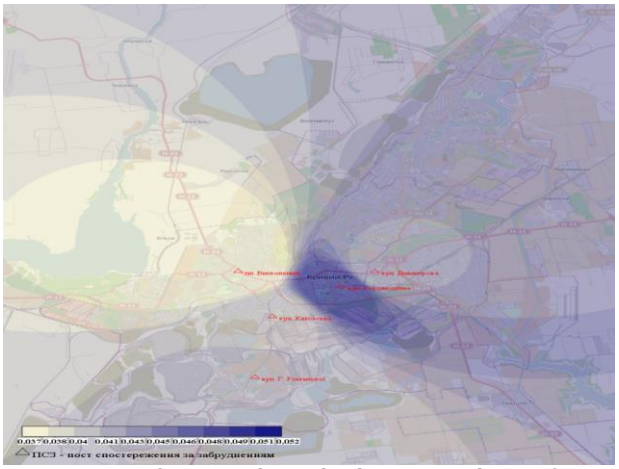


Fig. 9. Total impact risk assessment map of NO_2 and SO_2 in the atmosphere of Kryvyi Rih

It is obvious that the data of air pollution mapping in the city Kryvyi Rih with nitrogen and sulfur oxides should be used for the development of preventive measures related to the phenomenon of diseases (Nejjari *et al.*, 2003).First of all, these measures should be linked to the introduction of modern technologies of treatment of toxic aerosols and dust containing heavy metals of industrial enterprises.

As a preventive measure that can be considered is the application of "soft" sorbents for removal of heavy metals from the human organism. In this regard studies were conducted on two groups of children. One group was in a relatively clean area. Another was in kindergarten, which is located close to the metallurgical plant.

The preparation (vitamin-pectin dragee) was applied to children having the concentration of heavy metals salts in organism increased because of living in ecologically unfavorable conditions near steel plant.

The changed concentration of some metals in children's saliva and hair under influence of three-week therapy with pectin-vitamin dragee is shown in figures 10 and 11.

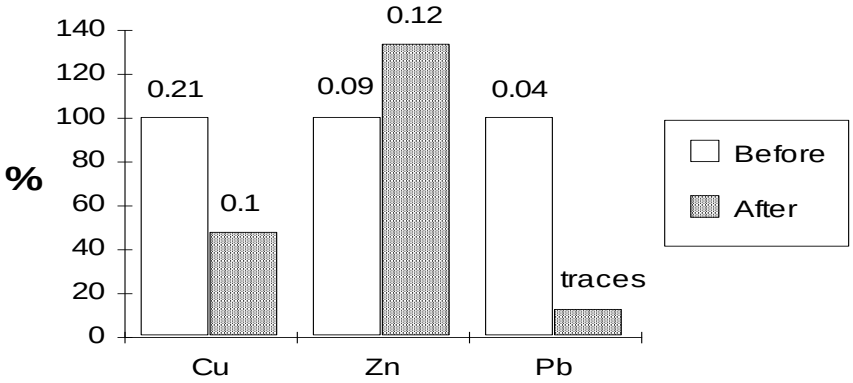


Fig. 10. The concentration of heavy metals in saliva of children before and after using pectin-vitamin tablets during 3 weeks.

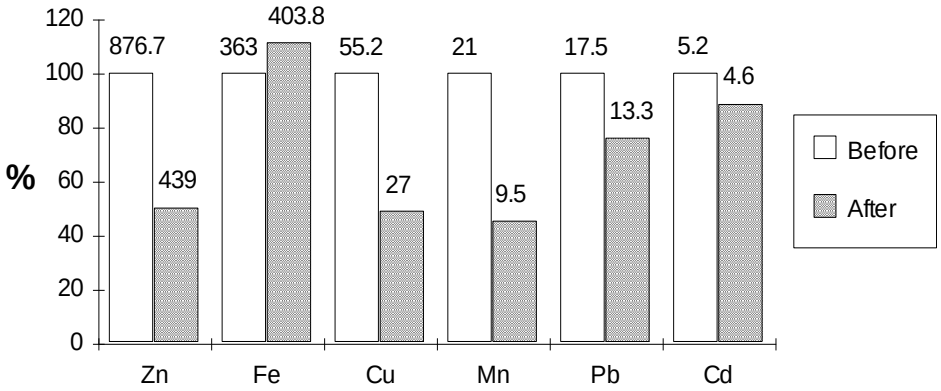


Fig 11. The concentration of heavy metals in hair of children before and after using pectin-vitamin tablets during 3 weeks

Thus, by binding heavy metals on the level of alimentary tract pectin substances decrease quantity of toxicants, passing through the organism and being fixed by tissues. After taking the preparation the content of lead in saliva decreased to tracing amounts and the number of children with lead registered in hair diminished from 53.8% to 33.3%. Accumulation of copper was reliably decreased, concentration of zinc and manganese halved, the amount of cadmium also somewhat decreased.

CONCLUSION:

According to the obtained results in this work, the following conclusions should be highlighted;

1. At the end of the first decade was a significant increase in the concentrations of nitrogen dioxide in the atmosphere of industrial zones in Annaba region.
2. Corresponding to the GIS mapping data there is a constant excess of 1.5 MPC for nitrogen dioxide in the central part of Kryvyi Rih city.
3. The revealed tendency to higher content of nitrogen dioxide in the atmosphere of megacities in the north of Algeria (Annaba) and in southern Ukraine (Kryvyi Rih) indicates the existence of risk fallout of nitric acid rain not only within cities but also in the surrounding suburban areas.
4. It is necessary to create a database accessible to Internet in order to assess risks connected with human health and environment from various industrial activities in industrial areas with high technogenic load.
5. Periodic taking of pectin tablets in the areas of man-made air pollution is an effective preventive measure.

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