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THE IMPACT OF NITROGEN OXIDES ON THE ENVIRONMENT AND HUMAN HEALTH IN CHINA

ВОЗДЕЙСТВИЕ ОКСИДОВ АЗОТА НА ОКРУЖАЮЩУЮ СРЕДУ И ЗДОРОВЬЕ ЧЕЛОВЕКА В КИТАЕ

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The article is devoted to the study of the atmospheric nitrogen oxides influence on the population health and the environment state in China. Since 2011, emissions have decreased by 2.4 times. However, the concentration of nitrogen dioxide in the ambient air is still almost 4 times higher than the values recommended by the World Health Organization. It has been proved that high concentrations of nitrogen dioxide in Ningbo's air was the main cause of low precipitation acidity, high acid rain frequency, high lung cancer incidence and death from lung cancer from 2006 to 2011.

Статья посвящена изучению влияния оксидов азота атмосферного воздуха на здоровье населения и состояние окружающей среды в Китае. С 2011 года выбросы уменьшились в 2,4 раза. Однако концентрация двуокиси азота в окружающем воздухе по-прежнему почти в 4 раза превышает значения, рекомендованные Всемирной организацией здравоохранения. Доказано, что высокие концентрации диоксида азота в воздухе Нинбо являются причиной низкой кислотности осадков, высокой повторяемости кислотных дождей и являлись основной причиной заболеваемости раком легких и смерти от рака легких с 2006 по 2011 год.

Ключевые слова: выбросы оксидов азота, атмосферный воздух, окружающая среда, здоровье населения, Нинбо, Китай.

Keywords: nitrogen oxides emissions, ambient air, environment, human health, Ningbo, China.

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The rapid development of China's cities and economy has caused a series of problems. For example, according to the World Health Organization, at the beginning of the 21st century, the highest deaths from urban air pollution were experienced in China. At present, as before, the biggest challenge facing China's environment is to reduce air pollution. And the control of nitrogen oxides pollution is undoubtedly one of the most important and difficult issues. Because when nitrogen oxides enter the environment, they have chemical transformations and reactions to sunlight. So, they participate in the destruction of the ozone layer, climate change, the formation of smog, reduce the acidity of precipitation, affect air, soil, water, biological diversity, and human health [1].

The central government has put forward nitrogen oxides emission reduction targets in the «12th and 13th Five-Year Plans». Therefore, the purpose of our work was to evaluate the impact of nitrogen oxides on the environment and health in China. To achieve this goal, the following tasks were solved:

1.To identify areas with the highest nitrogen oxides emissions in China.

2. Taking the city Ningbo as an example, analyze the situation of ambient air nitrogen oxides pollution and the effectiveness of the measures taken by China to reduce the concentrations.

3. To assess the state of the environment and human health in the region with elevated concentrations of nitrogen oxides in the air (using the example of Ningbo).

The objects of the study were nitrogen oxides concentrations and emissions in China, environmental and human health impacts of nitrogen oxides, and measures taken to ambient air nitrogen oxides reduced in China. Theoretical and statistical research methods were used during investigation. Statistical materials were taken from open internet sources [2-5].

The NO_x emission standards for some countries (table 1) is presented below. Comparing the data in Table 1, we can conclude that the Daily average value of the Nitrogen dioxide emission concentration limit in China is 1.25-3.75 times higher than in neighboring countries (Russia and Kazahstan) and 2-4 times higher than the values recommended by the World Health Organization.

Table 1

Ambient nitrogen oxides emission concentration limit of settlements and places of recreation for the population, mg/m³

Country and Region		Nitrogen dioxide emission concentration limit (NO_2)		
		Maximum one-time	Daily average	Average annual
Republic of Belarus		0,250	0,100	0,040
China	*	0,10	0,05	-
	**	0,15	0,10	-
	***	0,30	0,15	-
Kazakhstan		0,200	0,04	
Russia		0,085	0,04	
The European Union		0,200	-	0,040
Recommendation of WHO		0,200	0,025	0,010

*Notes. 1. * – the environmental standards of nitrogen oxides (converted to NO_2) for nature reserves, scenic spots, historical sites and recuperation areas.*
*2. ** – for urban Residential areas, commercial, traffic-resident mixed areas, cultural areas and rural areas in the planning.*
*3. *** – for atmospheric Severely polluted towns, industrial areas, urban transportation hubs, trunk lines, etc.*

In 2020, the national nitrogen oxide emission was about 10 million tons. Among them, nitrogen oxide emissions from industrial sources were almost 41%; from domestic sources – 3.3%; from mobile sources – almost 56% of the national nitrogen oxide emissions. The area with the largest emission of nitrogen oxides from industrial sources is Shanxi, and the areas with the largest emission of nitrogen oxides from domestic and mobile sources are all in Hebei.

As a result of the analysis, it was found that the areas with the highest nitrogen oxide emissions in China from 2011 to 2020 are as follows: Hebei, Shandong, Guangdong, Liaoning, Shanxi, Henan, Hubei, Jiangsu, Inner Mongolia, Anhui, Sichuan, Zhejiang, and Heilongjiang – 13 provinces. Their total nitrogen oxide emissions in 2011 were 15,898 and in 2020 6,703 million tons. During this time, nitrogen oxide emissions decreased by 2.4 times in these provinces and by 2 times in the whole country (from 24,043 to 11,772 million tons). The maximum reduction in emissions is observed in the provinces of Ningxia (by 3,8 times) and Jiangsu (by 3,2 times). The area with the largest emission of nitrogen oxides from industrial sources is Shanxi, and the areas with the largest emission of nitrogen oxides from domestic and mobile sources are all in Hebei. All these provinces are located mainly in eastern China. By comparing nitrogen oxide emissions and ambient air concentrations the city of Ningbo was finally chosen to analyze the impact of elevated nitrogen oxide concentrations in the region on the environment and human health. Ningbo is industrial and transportation developed city of the most polluted Yangtze River Delta area on the east of China.

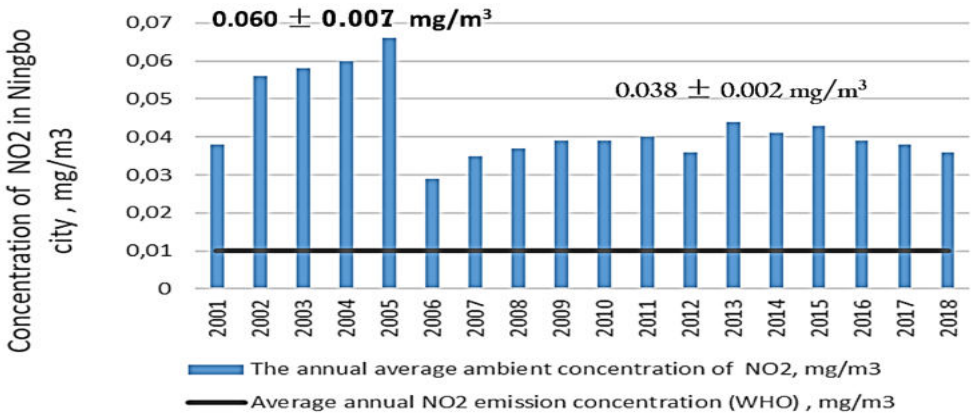

Figure 1 – Dynamics of the annual average ambient nitrogen dioxide concentration in Ningbo, mg/m³ (p=0.05)

From the diagram on the figure 1, it can be seen that in the period from 2002 to 2005, the average annual concentration of nitrogen dioxide in the atmospheric air was especially high. The maximum concentration was recorded in 2005. The average concentration of nitrogen dioxide for this period is significantly higher compared to the period from 2006 to 2018. Nitrogen oxides ambient air concentration began to fell in 2006. In 2012 the government took more measures, for example, old coal-fired boilers and industrial kilns were eliminated, oil and gas recovery and treatment were carried out, technical plans for reducing organic waste gas were studied and formulated, old vehicles were eliminated, sets of black smoke capture systems were build, the vehicle emission inspection and maintenance system were implemented. Thus, the concentration of nitrogen dioxide decreased by 1.6 times. However, the concentration of nitrogen dioxide is almost 4 times higher than the values recommended by the World Health Organization.

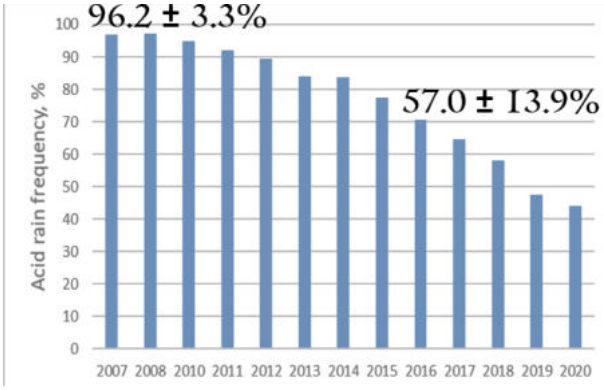

Figure 2 – Dynamics of acid rain frequency in Ningbo, % (p=0.05)

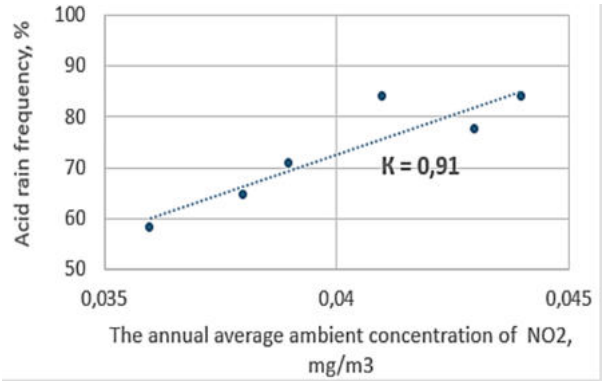

Figure 3 – The relationship between the average annual ambient air concentration of nitrogen dioxide in Ningbo and the acid rain frequency during 2013–2018

Diagram of changes in the acid rain frequency from 2007 to 2020 is on the figure 2. Thus, the indicator of the acid rain frequency has significantly decreased by about 2 times. After 2012, the relationship between the average annual ambient air concentration of nitrogen dioxide in Ningbo and the acid rain frequency (on the figure 3) is directly proportional with a linear correlation coefficient of 0.91.

From 2007 to 2020, precipitation acidity significantly increased by 1.2 times (fig. 4). After 2012, dependence between the average annual concentration of nitrogen dioxide in the atmospheric air and the acidity of precipitation in Ningbo is inversely proportional with a linear correlation coefficient of -0.89. Such a coefficient characterizes a significant relationship (fig. 5).

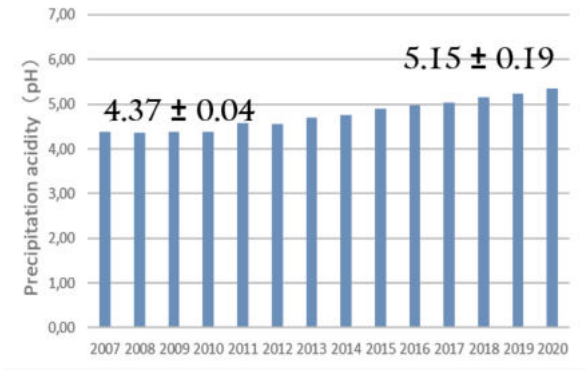

Figure 4– Dynamics of precipitation acidity (pH) in Ningbo, p=0.05

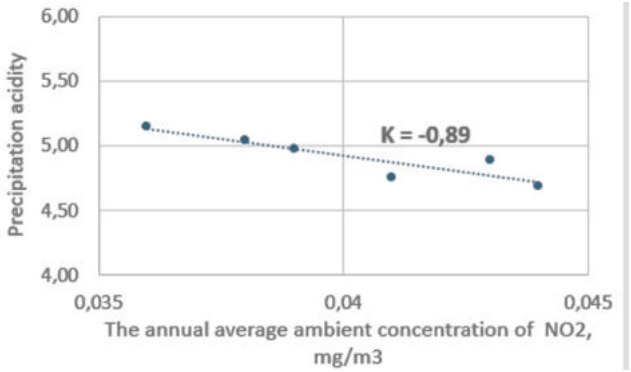

Figure 5 – The relationship between the average annual concentration of NO_2 in the atmospheric air and the acidity of precipitation in Ningbo during 2013-2018

So, it was found that high concentrations of nitrogen dioxide in the air of Ningbo were the cause of low precipitation acidity and high acid rain frequency, as indicated by high values of correlation coefficients.

The high correlation coefficients between nitrogen dioxide air pollution in Ningbo and lung cancer incidence (0.87) on fig. 6 and death from lung cancer (0.93) on fig. 7 indicate a directly proportional significant relationship, which means that in the period before 2011, lung cancer incidence and death from lung cancer have been associated with nitrogen dioxide air pollution.

Thus, it was proved that high concentrations of ambient air nitrogen dioxide in Ningbo caused lung cancer incidence and death from lung cancer from 2006 to 2011. So, in our work it is found that the change of annual average ambient air nitrogen oxide concentration is closely related to the frequency of acid rain and the acidity of precipitation, and also

has an inseparable relationship with the incidence and mortality of lung cancer in residents of Ningbo (China's province Zhejiang).

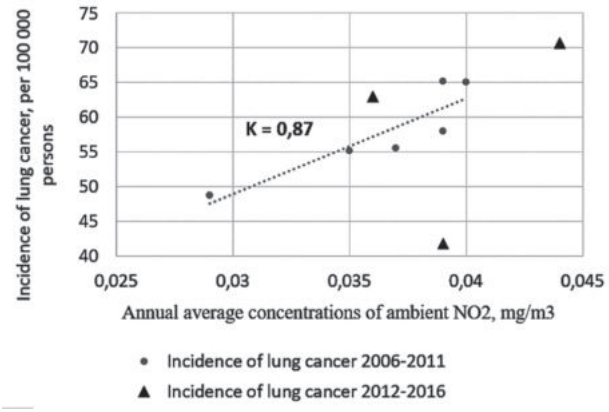

Figure 6 – The dependence of the lung cancer incidence among residents of Ningbo on the average annual ambient air nitrogen dioxide concentration

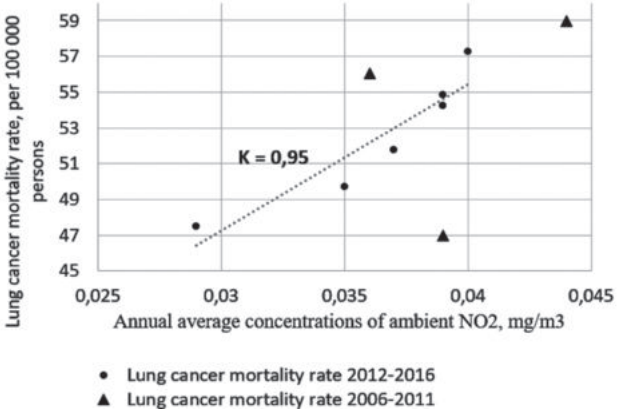

Figure 7 – The dependence of the lung cancer mortality rate among residents of Ningbo on the average annual ambient air nitrogen dioxide concentration

Based on the work done, measures were proposed that would further reduce the impact of nitrogen oxides on the environment:

- to increase the number of wetland ecological parks, forest ecological parks and road green belts;
- to further reduce self-emissions;
- to carry out air pollution environmental protection management system innovation;
- to increase penalties for illegal emissions and illegal discharges;
- to encourage research on urban eco-planning;
- to accelerate the elimination of backward production capacity and technology, and improve the clean production level;
- to promote the coordinated development of economy, society and resources and environment.

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