

# The Negative Effects of Air Pollution on the Physical and Mental Health of Harbin City Residents

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## Abstract:

Humanity depends on the atmosphere for their survival, and there are some indicators of the demand for atmospheric quality. However, with the rapid socio-economic development, air pollution has become more and more serious, and its current indicators have deviated farther and farther from the quality indicators. At present, it has become an extremely serious problem related to human survival. In order to improve human living environment in the world, Harbin city is used as an example to make a research on the negative effects of air pollution on the physical and mental health of its residents. Through reviewing a large number of information and taking interviews, a detailed investigation was conducted on the air quality of Harbin city and the health of local residents in recent years. It was learned that the air quality of Harbin City was in a state of serious pollution before 2021. In recent years, under the vigorous government's pollution control, the air quality has improved, but it is still in a state of pollution. Air pollution in Harbin has caused extremely serious effects on the physical and mental health of citizens. In this research I have identified the source of air pollution in Harbin, and put forward feasible suggestions against the source of air pollution, in order to make improvement for the urban environment and resident's well-being in Harbin city. I hope that this research can bring important insights to other cities as well.

**Keywords:** Atmosphere and human well-being, pollution, health and hazard

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## I. INTRODUCTION

According to scientific research, air quality is an important factor for human well-being. People live in the air environment and people breathe air during all the lifetime. A very important factor for humanity reproduction is an unique atmospheric environment, which enables the earth to maintain a temperature and humidity suitable for the growth of all human beings. Humans and various living organisms rely on the 78% proportion of Nitrogen (N<sub>2</sub>) in the earth's atmosphere. It is an indispensable source of fertilizer for plant growth. 21% of the atmosphere is oxygen (O<sub>2</sub>), which is indispensable for the living organisms the breathing and it is also an element of combustion. The third is argon (Ar), and the rest one thousandth parts are very small amounts of carbon dioxide, neon, helium, methane, nitrogen dioxide, hydrogen, etc. The content ratio of nitrogen, oxygen and argon is stable, and the air with a stable ratio is the air quality index that is suitable for human well-being. The air that meets the normal index is considered to be a high-quality air, which is beneficial to human health; the air that does not meet the air quality index is harmful to human physical and mental health.

## **II. RESEARCH RESULTS**

### 2. Overview of the air and health correlation

#### 2.1 The effect of high-quality air on health

According to scientific data, high-quality air is relatively fresh and clean and has a huge effect on both the body and the brain.

##### 2.1.1 Fresh air can provide enough oxygen supply

The human body consumes a lot of energy every day therefore needs a lot of oxygen. Due to fresh air contains more oxygen ions, with the blood circulation, through the gas exchange function of the lungs, oxygen is delivered to the whole body, promotes proper blood circulation, strengthens the body, and promotes the vitality of all tissues in the body<sup>[1]</sup>.

##### 2.1.2 Fresh air is good for the brain

There are generally fewer impurities, dust, and toxic and harmful polluting gases in a fresh air. While breathing a high-quality air, there are usually not too many pollutants and impurities deposited in the lungs and the amount of harmful substances inhaled is significantly lower. As for the mental workers, they usually need a large blood supply to maintain brain nutrition and energy<sup>[2]</sup>. Breathing a fresh air is more beneficial for blood supply to the brain, because it can improve a metabolism, relieve fatigue and stimulate brain cell vitality.

Pure air can soothe nerves-make thoughts more calming and peaceful. According to experiments, the air in the wilderness, mountains, springs, and parks is relatively fresh, which is conducive to the elimination of brain fatigue and the normal activity of nerve cells<sup>[3]</sup>.

#### 2.2 Damage to health caused by poor-quality air

With the development of modern human industrialization, high-quality air is getting more and more precious. In recent years, the atmosphere has been affected by pollution, and its composition ratio has gradually changed. That led to serious decline in atmospheric quality indicators, which has had a serious negative impact on human health.

##### 2.2.1 Poor-quality air affects children's cognitive development

During a scientific research, an experiment was conducted on 202 children between the ages of 8 and 11 in Boston<sup>[4]</sup>. After investigating the mental development of the children and their living environment and after comparing the data, researchers found out that the comprehensive intelligence test of children living in an environment with severe black carbon pollution is lower than that of children living in a fresh air environment. Moreover, the degree of environmental pollution is proportional to the cognitive development of children. The IQ of children under environmental pollution is 34% lower than that of normal children. These children have a large standard deviation in comprehensive ability tests such as vocabulary tests. Due to the traffic is getting bigger and bigger, children usually stay in a high-pollution areas such as underground garages every day, what led to the increasing of health violations. Compared with children who breathe fresh air, children living in areas with heavy traffic and severe air pollution have a larger gap in IQ and memory.

### 2.2.2 Inferior air quality affects endocrine system

Some studies have shown that the pollution caused by automobile exhaust not only seriously affects children's IQ, but also has a greater disturbance to metabolism and endocrine system<sup>[5]</sup>. In addition to the serious impact of automobile exhaust on the physical and mental development of young people, it also poses a greater threat to the human body. Diseases such as cancer and polycystic ovary syndrome in women are caused by long-term endocrine disorders which caused by automobile emissions<sup>[6]</sup>. In their turn, endocrine disorders seriously affect human fertility.

### 2.3 Negative effects of poor air quality on children's mental and psychological well-being

Based on a survey of patients of all ages with mental health disorders<sup>[7]</sup>, poor quality air was found to have serious psychological and psychiatric effects on children. While most research to date has focused on adults, recent years have seen advances in research on mental illness in children. This study followed nearly 7,000 children in thousands of psychiatric emergency rooms over the past five years and found that exposure to air pollution for just one or two days also exacerbated mental illness in children.

Researchers from the U.S. and Denmark studied data on about 150 million people living in U.S. states between 2003 and 2013, and sampled people from the bottom seven and people from the top seven states in terms of air quality. They found out that the first group had a 27 percent higher rate of bipolar disorder than the second.

The study also initially found out that the causes of depression are mostly related to air pollution. In a study of two groups of children living in different environments in the United Kingdom, it was found that children living in air pollution environments were more likely to suffer from depression.

In Denmark, the team tracked 1.4 million people born and raised between 1979 and 2002 and made a research on the correlation of air pollution with their mental illness.

The researcher team also identified patient profiles for bipolar disorder as well as personality disorders and depression at the end of 2016. Analyzing the patients' personal data such as age, gender, and socioeconomic status, the researchers found out that the level of air pollution was directly associated with the probability of developing these types of mental illnesses.

These studies further confirm the strong correlation between air pollution levels and childhood psychiatric symptoms, and point to higher prevalence rates among children living in slums, saying that air pollution has a more severe impact on the psychiatric symptoms of materially deprived children.

### 2.4. Impact of Harbin's air quality on residents' physical and mental health

#### 2.4.1 Harbin air quality survey

According to the data, during 2013 and 2014, the air pollution level in Harbin, the capital of Heilongjiang province, was almost the highest in the country. Air quality index in several districts directly reached the upper limit of 500. This is a statistical chart of the ten cities with the worst air quality in the country at the time of 07:00 on July 25, 2014. Let's take a look at the statistical index Figure 1 below to corroborate Harbin's air body pollution levels, while during 2013 and 2014 Harbin's air quality was generally at the level shown below.

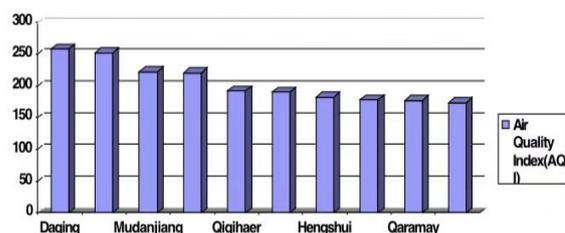


Figure 1. The ten cities with the worst air quality at 07:00 on July 25, 2014

During the 2018-2019 heating period, the province of Heilongjiang had 59 days of heavy pollution, of which, the three cities of Hadasui had a total of 27 days, and nearly half of the province's heavy pollution days occurred in this region. Therefore, to do a good job of joint prevention and control of heavy pollution in Hadasui, to improve environmental quality and make the sky color blue has an extremely important practical significance. By 2020, the effective control of "Hadasui" achieved the ratio of heavy and above polluted days in Harbin City fell by more than 50% compared to 2015 year. Although the Harbin municipal government has taken a series of measures to alleviate the phenomenon of pollution in Harbin, the pollution in Harbin has not been fully eradicated.

According to the test and measurement report information, air pollution has led to repeated hazy weather in Harbin over the years. During the hazy weather visibility is low, and buildings in the distance are hidden in the fog. According to the 2021 monitoring, the concentrations of PM<sub>2.5</sub> (fine particulate matter) and NO<sub>2</sub> (nitrogen dioxide) were quite high among the air pollutants in Harbin's air, with PM<sub>2.5</sub> concentrations at some urban areas once got more than 4,000 what is indicating extremely high concentrations of polluting particles in the air. On the Figure 2 of April 18, 2021, as seen on high-definition visible satellite cloud maps, many parts of the northeast area were covered in a large gray smog, the whole northeast plain looked very polluted.



Figure 2. Harbin haze at the afternoon on April 18, 2021

According to data, the ranking of the worst air quality cities in the whole country on December 11, 2021. Figure 3 is at 6 a.m. that day, Harbin's AQI (air quality index) reached 264, which is considered to be a severe pollution and it has become the worst air quality among the 74 cities that publish PM<sub>2.5</sub> data.

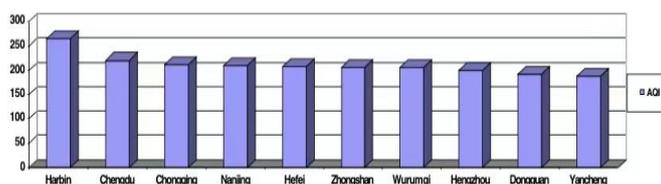


Figure 3. 10 cities with the worst air quality at 6:00 am on December 11, 2021

Although the Harbin municipal government has been working hard on air pollution control, the results have shown slow progress. Harbin city had a smoggy weather in 2022 on a regular basis, mostly in January, April, and June.

### 2.5 Survey on the physical and mental condition of Harbin residents

Air pollution in Harbin has caused serious problems to the physical and mental health of local residents. According to data, since the 21st century, the number of patients suffering from respiratory diseases, cardiovascular diseases, mental and psychological diseases, endocrine disorders in Harbin has significantly increased over the years. Air pollution and endocrine disorders bring great harm to adolescents, while respiratory and cardiovascular diseases pose a life-threatening threat to the elderly, especially during a smoggy weather.

#### 2.5.1 Period of high incidence of respiratory diseases and cardiovascular and cerebrovascular diseases

PM<sub>2.5</sub> has a serious impact on respiratory diseases number. During the heating period from 2009 to 2011, Harbin's air was seriously polluted, showing PM<sub>2.5</sub>. The attendance rate of respiratory diseases was 8.8% (5,637/64,333), 7.2% (5,315/74,226) 7.0% (6,209/88,238), which are higher than 7% of the attendance rate of respiratory diseases in the non-heating period: 9% (6,598/83,257), 6.1% (5,178/85,023), 5.1% (5,974/116,367). The difference is statistically significant (P<0,001). For every 44 µg/m<sup>3</sup> increase in the average daily concentration of PM<sub>2.5</sub> in 2009, the number of patients with respiratory diseases increased by 11.6%; for every 35 µg/m<sup>3</sup> increase in the average daily concentration of PM<sub>2.5</sub> in 2010, the number of patients with respiratory diseases increased by 18.9%: for every 60 µg/m<sup>3</sup> increase in the average daily concentration of PM<sub>2.5</sub> in 2011, the number of patients with respiratory diseases increased by 35.8%. During this period, it was also a high incidence of cardiovascular and cerebrovascular diseases among the elderly population, and the attendance rate has increased year by year since 2011. Statistics are shown in Table I and II.

**TABLE I. 2009 - 2011 Heating period respiratory diseases visit rate**

Attendance rate of respiratory diseases during the heating period from 2009 to 2011			
	2009 year	2010 year	2011 year
Total number of patient visits	64333	74226	88238
Respiratory diseases patient visits	5637	5315	6209
Respiratory diseases visit ratio	8.8%	7.2%	7.0%

**TABLE II. The attendance rate of patients in non-emergency respiratory medicine from 2009 to 2011**

Attendance rate of respiratory diseases during the non-heating period from 2009 to 2011			
	2009 year	2010 year	2011 year
Total number of patient visits	83257	85023	116367
Respiratory diseases patient visits	6598	5178	5974
Respiratory diseases visit ratio	7.9%	6.1%	5.1%

2.5.2 The number of patients with psychiatric disorders is rising.

According to the data of Harbin's psychiatric hospital, in 2016, there were 1,021 patients under the age of 18 and 5,370 patients over the age of 60. In 2018, there were 4,410 patients under the age of 18 and 12,306 patients over the age of 60. Minors have more than doubled in three years and the elderly over the age of 65 are still a high-incidence group of mental diseases. The number of visits to psychiatric centers has increased by nearly 2.5 times in three years. Statistics are shown in Table III. In the research on patients with nephron-encephalopathy, it was found out that their endocrine secretion changed significantly, and the occurrence of depression in this type of condition was significant. The cause of most depression in adolescents is unclear. However, according to the scientific research results, air quality pollution has a great impact on adolescent's mental health and affects endocrine disorders in most patients.

**TABLE III. Data on mental diseases of elders and youngsters in Harbin in the period of 2016 and 2018 (unit: person)**

2016 and 2018 data on mental diseases in Harbin City (unit: person)			
rate	2016 year	2018 year	2016-2018 data growth
Under the age of 18	1021	4410	332%
Over the age of 60	5370	12306	130%

According to the survey data, the number of patients with depression diagnosis admitted to the First Specialized Hospital is still increasing by 20% every year, what is showing an obvious expansion trend of mental disorders. The head of Harbin No. 1 Specialized Hospital provided a record of the admission of patients with depression diagnosis in Harbin No. 1 Specialized Hospital: 129 people were admitted in 2002; 197 people in 2003; 207 people in 2004 and in 2012 the patient number reached 1,200. Statistics are shown in Table 4. From 2002 to 2012, the number of patients increased by 9 times, and this decade was the stage of rapid industrial development in Harbin.

**TABLE IV. Analysis of the number of people with depression in Harbin's No. 1 Specialty Hospital from 2002 to 2012**

The number of patients with depression diagnosis admitted to the First Specialized Hospital in 2002-2012 years				
	2002 year	2003 year	2004 year	2012 year
Patients number	129	197	207	1200
Growth rate after 2012 year	—	50%	60%	830%

### 2.5.3 Residents have serious endocrine disorders.

Since 2002, the residents of Harbin have seriously suffered from endocrine disorders. Most women diagnose endocrine disorders in gynecology. Since 2002, the number of female endocrine patients has increased fifteen times.

During this period, the number of children having developmental disorder or developmental disability has significantly increased. According to pediatric statistics, the number of children's patients has increased more than twenty times from 2002 to 2022.

### 2.6 Analysis of the impact of air quality on the body and mind of residents.

Epidemiological studies have shown that the increase in PM 2.5 concentration has a significant impact on the incidence of cardiopulmonary diseases. Smoggy weather has a serious impact on cardiovascular and mental health. In this study, based on previous investigations during the heating period, it was found out that the attendance rate in the Department of Respiratory Diseases of Harbin Second Hospital increased significantly during the heating period<sup>[8]</sup>.

The overall pollution is increasing year by year since the 20th century. Industrial production emissions, vehicle exhaust emissions, etc. cause great harm to the atmosphere. Air pollution not only has a serious impact on the physical health of the people in Harbin, but also causes certain psychiatric diseases.

#### 2.6.1 The effects of poor-quality air on the respiratory system.

According to Pope, with every logarithmic unit increase in atmospheric PM<sub>2.5</sub> concentration, the respiratory system damage increases by 1.79 times<sup>[9]</sup>. Domestic research believes that PM 2.5 concentration determines the incidence of cardiopulmonary diseases. A large number of studies have shown that all types of air pollution reaching high concentrations will first cause respiratory diseases. Even in a low-concentration pollutant environment, if the exposure time is too long, symptoms such as nose and throat irritation and difficulty breathing will occur. Air pollution, especially for people who originally suffered from respiratory diseases, is more harmful, and asthma patients are more prominent. Such conditions belong to the inflammation of the lungs. The physiological pressure formed by the synergy of ozone and particulate matter, air pollutants such as nitrogen oxides, ozone and heavy metals all seriously damage human lung function. Heavy metals concentration in the air is an important cause of asthma, emphysema, and lung cancer.

## 2.6.2 Factors affecting the cardiovascular system and mental health.

Poor-quality air has formed a lot of smog, and the pressure of smoggy weather is relatively low. People will have a feeling of irritability, which can cause a depression and many other mental disorders. After neuroimaging technology matured, researchers tracked TRAP and found a link between brain metabolic disorders and general anxiety disorders in children. The results showed that this connection reflects the brain's stress-inflammatory response to air pollution. Studies have shown that depression, anxiety and other mental health problems in adolescents increasing year by year with air pollution. The impact of air pollution on mental health even exceeds the impact on physical health.

For some patients with high blood pressure and coronary heart disease, smoggy weather and low air pressure lead to increased morbidity. In smoggy days, the outdoor temperature is low, and the blood vessels experience sudden cooling from indoor to outdoor. Under the action of heat expansion and contraction, blood pressure rises, which can easily cause stroke and myocardial infarction.

## 2.6.3 Inferior air interferes with endocrine factors

At present, toxic substances such as black carbon, sulfur dioxide, industrial chemicals, and heavy metals contained in automobile exhaust are called environmental endocrine disruptors. These toxic substances have a bad impact on humans health by affecting endocrine system. These substances are released into the surrounding environment of industrial zones and many others activity zones, causing many mental disorders, seriously interfering with the normal secretion system of the human body, resulting in endocrine disorders and endangering human physical and mental health in general

Air pollutants not only have several hazards identified in the above studies, but also have damage to all parts of the body, such as skin and hair.

## 2.7 Analysis of air quality problems in Harbin

### 2.7.1 Small effective use of energy sources

At present, the most important reason for air pollution in Harbin is small effective use of energy sources. Although the country is now vigorously advocating the development of new energy, but according to the investigation and research, Harbin's energy composition is unscientific and unreasonable. Coal consumption reaches as much as 60%, while coal used for power generation is less than 40% of the total. In addition, most of the coal is used for direct combustion, which will undoubtedly cause great pollution to the atmosphere. In the process of coal production, Harbin City focused on the increase of production volume, but neglected the control of commercial sulfur coal. The technical level of various types of combustion equipment is not yet developed. In addition, most companies have relatively little capital investment in air pollution control. Therefore, many enterprises still use the old equipment that was "overdue service" in the past. The technical parameters of these equipment are low, the amount of sewage is large, and the effective use of energy sources is seriously insufficient. These are the "culprits" that produce air pollution sources.

### 2.7.2 Long winter heating period.

Heilongjiang Province belongs to a high latitude region, so the winter starts early and it's usually very cold. Generally, heating starts in October and does not stop until April of the next year. At present,

Harbin is still heating by burning coal. A large amount of coal is burned during the long heating period, which will cause great pollution to the atmosphere of Harbin and form a serious smog.

According to research and investigation, after coal combustion in Harbin, a large amount of primary particles with small particle size and a large amount of gaseous pollutants such as SO are emitted in the atmosphere, resulting in a high level of PM 2.5 emission during the heating period. In European and American countries, the urban emission concentration is 0,008 ~ 0,030 mg/m<sup>2</sup>, and the annual average concentration in Los Angeles is 0.005-0.027 mg/m<sup>2</sup>, which is lower than its national emission standard. According to the data, the average emission concentration of Harbin during the heating period from 2009 to 2019 was 0.68-0,095 mg/m<sup>3</sup>, which was 0.97-1.7 times higher than the national standard (0.035 mg/m<sup>3</sup>). According to this ratio, the pollution level of PM<sub>2.5</sub> in the atmosphere of Harbin far exceeds the standard. Statistics are shown in Table V. The data show that the heating period in Harbin is a period of severe PM<sub>2.5</sub> pollution. In addition to the influence of coal burning on the pollution, the influence of Harbin dry climate will also increase PM 2.5 pollution.

**TABLE V. Emissions in Europe and China**

Emissions in European and Chinese cities	
European cities emission standards	0.008~0.030 mg/m <sup>3</sup> ,
Average actual emissions in Los Angeles, USA	0.005-0.027mg/m <sup>3</sup> 37% below standard
Chinese cities emission standards	0.008~0.030 mg/m <sup>3</sup> ,
Harbin Actual Emissions	0.68~0. 95mg/m <sup>3</sup> 97%——170% over the standard

2.7.3 The surge in the number of cars has caused a lot of exhaust pollution.

With the growth of GDP, private cars have entered thousands of families everyday life. According to vague statistics, nearly 1.75 million cars were on the road in Harbin in 2018. The air pollution caused by this huge amount of car exhaust is unprecedented. The most important thing is that the emission of car exhaust has almost a zero distance with human environment. Usually, private cars are dispatched by the whole family. Every time they travel, the whole family directly inhales a large amount of cars exhaust. These exhaust gases directly infringe on people's lungs and other respiratory systems, and seriously affect the endocrine system.

2.7.4 Agricultural waste pollution is getting serious.

The pollution of agricultural waste is also a serious problem. The straw of the crops is the waste of agricultural production. The farmers have not yet mastered the advanced straw treatment technology and traditional treatment method is no longer suitable for today's environment. Due to the accumulation of various pollutants, the atmosphere can no longer withstand even a little pollution. In particular, with the crop harvest getting bigger, the crop waste is also getting larger. The burning of straw produces a large amount of carbon dioxide, sulfurous acid, etc. These pollutants are seriously polluting the air. In addition to the problem of agricultural straw burning, the incineration of municipal waste is also one of the sources

of air pollution. The incineration of municipal waste releases carcinogens that seriously endanger human well-being.

### III. RESEARCH RESULTS

#### 3. Suggestions for Harbin's air quality improvement

##### 3.1. Increasing an attention and strengthening the comprehensive prevention and control of air pollution

Regarding pollution control, the state calls for the development of new energy sources, energy conservation and emission reduction. The Harbin Municipal Government should actively respond to the state's call and find practical solutions to carry out pollution control work.

For the air pollution problems that have occurred, we must do everything possible to adopt technological innovation and optimize resources. Eliminate high-energy consumption, low-energy production, and outdated and backward equipment, and actively introduce new energy sources with high performance and low energy consumption. Strictly prevent inferior lignite and effectively eliminate the source of polluted coal.

Heavily polluted and high-capacity enterprises have to relocate to less populated areas such as suburbs. They should optimize their industrial structure and promote the development of energy-saving and environmental protection technologies. For new projects, it is necessary to set a feasible entry threshold, vigorously develop energy-saving and environmental protection industries, and achieve energy-saving and emission reduction. It is also necessary to actively optimize the coal-fired system to achieve joint prevention and control of pollution.

##### 3.2. Developing clean energy, improving and promoting green travel.

Coal used for heating, industrial coal and vehicle exhaust are all key sources of pollution. Technological innovation must be carried out on coal combustion, using new energy technology to convert coal energy without direct combustion, or using new technology and new energy to use air filtration and clean energy for coal combustion in a timely manner. The use of leaded gasoline on public transport should be prohibited. We should use natural gas or liquefied petroleum gas as fuel instead. It is necessary to promote electric vehicles or hybrid vehicles, and use electricity as much as possible under certain conditions. We should also more use bicycles or to reduce public transport.

##### 3.3. Technological innovations

The environmental governance of Harbin City also depends on scientific and technological innovation. Harbin City should be based on its own actual situation and solve problems head-on. In the issue of straw burning, it is necessary to introduce new science and technology and make full use of straw, both to solve the problem and not to waste resources. In the incineration of urban waste, high-tech technologies must also be adopted, such as safe and environmentally friendly chemical dissolution or waste utilization technologies, in order to solve the problem of urban waste.

### 3.4. Improving of environmental supervision and management system

The Harbin Municipal Government should formulate effective environmental supervision and management regulations. It is necessary to investigate and clean up scattered and polluted enterprises in a timely manner, urge and assist enterprises to quickly transform into a clean energy production model, clean up and ban open-air barbecues in accordance with the law, prohibit traditional ritual of burning money to commemorate the dead and fully restrict the setting off of fireworks and firecrackers. Solve the problem of straw incineration and innovate the use of straw according to local conditions. In terms of adjusting the energy structure and optimizing the space layout, Harbin has formulated a clean heating plan, promoted clean heating in urban areas and already made clean heating boilers installations for villagers in order to control coal-fired energy consumption.

## IV. CONCLUSION

Human demand for air quality has indicators. The air that meets the normal indicators is high-quality air, which is beneficial to human health; the air that does not meet the air quality indicators is poor-quality air, which has great harm to human physical and mental health. The air in Harbin has been seriously polluted, causing great harm to the physical and mental health of local citizens.

The four main sources of air pollution in Harbin are: small effective use of energy sources, burning boilers and heating during the long winter period, a large number of exhaust pollution caused by the surge in the number of automobiles, and severe agricultural waste pollution.

Aiming at these four sources of pollution, four suggestions were suggested to strengthen the comprehensive prevention and control of air pollution: clean energy developing, the energy consumption structure improvement, putting more focus on scientific and technological innovation, and improving the environmental supervision and management system. I hope this work can bring some new enlightenment to the air pollution control, make the sky blue and the air clean and fresh in Harbin city to make people live in a healthy environment.

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