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Current City Problems in Beijing: Discussion of $PM_{2.5}$ Related Toxic Air Pollution

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Abstract

Recent reports show that an estimated one-fifth of the world's population is suffering from toxic air pollution (Qu, 2013; Liu, 2013; Zhou et al., 2013). This is especially evident in China, where $PM_{2.5}$ covers one-seventh of China's total territory. In order to combat this disaster, three aspects will be included in this paper to analyze Beijing's air pollution management through a scientific and philosophical lens for the future human health in China. The first is to address the dangers of $PM_{2.5}$ to urban environment and city human health. The second approach is to discuss the causing factors of $PM_{2.5}$ in Beijing, such as coal burning, untreated industrial and vehicular emissions, and urban construction waste. The third step is to state the short and long term effective measures of toxic air pollution of $PM_{2.5}$ management in big cities of developing countries. Short term recommended plans stop unnecessary urban construction, reduce outdoor exposure, impose a heavy tax, and collect congestion pricing at peak hours. Long term recommended plans promote the coal gasification process, install smoke emission units, improve public transportation, and support clean energy, such as hydropower, wind power, and solar energy. Since current measures are ineffective, taken as a whole, these approaches will be presented to guide local residents, planners, and governors in developing countries to deal with the toxic air pollution for future healthy city management.

Keywords

Human Health, Toxic Air Pollution, $PM_{2.5}$, Beijing, Pollution Management

1. Introduction

Recent studies state that an estimated one-fifth of the world's population is suffering from toxic air pollution (Qu, 2013; Tian, 2013; Zhou et al., 2013). **Figure 1** shows the worldwide $PM_{2.5}$ pollution, where red means

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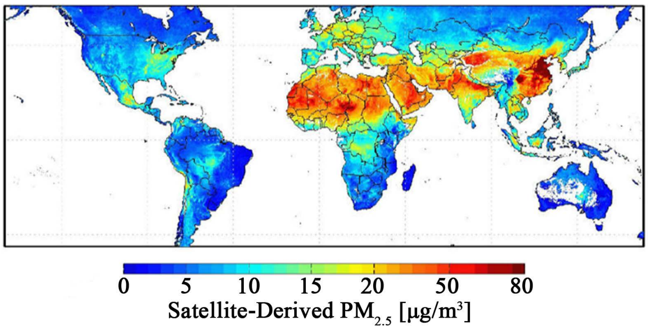

Figure 1. Worldwide $PM_{2.5}$ pollution map. Source: Qu, 2013.

$PM_{2.5}$ (high, hazardous concentration). The World Health Organization estimates that 2.4 million people die from air pollution related illnesses every year (Sierra-Vargas & Teran, 2012). This is especially evident in China, where hazardous $PM_{2.5}$ pollution now covers one-seventh of China's total territory (See **Figure 2**); previously, in the years from 1999-2005, PM_{10} was reported on 90% of the days (Chan & Yao, 2008).

In February 2014, the Air Quality Index score reached over 300 in 33 cities of China, and the road visibility was less than 10 meters (EPA, 2014). A numerical value over 300 means that the air is now classified as being hazardous and is a health alert, according to the Environmental Protection Agency Air Quality Index (AQI) Standards (See **Figure 3**). The air has become toxic in many parts of the country, and Beijing Hospital indicated that in April 2014, 50% of their patients were afflicted with a breathing related illness (Xie et al., 2014). **Figure 4** and **Figure 5** reflect the $PM_{2.5}$ problem in Beijing is extremely predominate, and the average mass concentration has reached more than 100 $\mu g \cdot m^{-3}$ based on the US AQI (Bergin et al., 2001; He et al., 2001; Wang et al., 2005). The daily $PM_{2.5}$ in Beijing is about twice as high as the US Environmental Protection Agency's safety standard (Song et al., 2007; Wang et al., 2005). China's national medical center suggests the best way to deal with this situation is to stay at home and close all the windows or escape to the rural countryside. This is a disaster for the people in urban regions, and also influences all mankind on our planet.

This paper will discuss three aspects to analyze Beijing's air pollution management through a scientific and philosophical lens for the future human health in China. The first is to address the dangers of $PM_{2.5}$ to urban environment and city human health. The second approach is to discuss the causing factors of $PM_{2.5}$ in Beijing, and the third step is to state the short and long term effective measures of toxic air pollution of $PM_{2.5}$ management in big cities of developing countries.

2. The Harmfulness of $PM_{2.5}$ to an Urban Environment and City Human Health

The rapid urbanization and population growth in China is causing serious air pollution, which is becoming a major health problem for urban citizens. PM, or particulate matter, is frequently used to describe the size of the particles suspended in the air, including dust, dirt, soot, smoke, and liquid droplets. The Environmental Protection Agency classifies particles based off of size with aerodynamic particle diameter (dpa) > 10 μm to be super coarse, 2.5 < dpa ≤ 10 μm to be coarse, 0.1 < dpa ≤ 2.5 μm to be fine, and dpa ≤ 0.1 μm to be ultrafine; the smaller the particle, the more dangerous it is considered since they will get deeper in the lungs and even the bloodstream ("Particulate Matter", 2013). **Figure 6** shows a graphic representation of PM particles in comparison to a strand of human hair. Toxicity of the particle can be determined by its source and composition, but the size is especially relevant in determining toxicity in the lungs as it generates reactive oxygen and nitrogen species and interferes with macrophage clearance (Sierra-Vargas & Teran, 2012).

Ostro (2004) and Pyne (2002) indicated that clinical studies showed prolonged exposure in high concentrations of fine particles would result in significant chances of heart and lung morbidity. These particles were found to exacerbate acute and pre-existing respiratory diseases, such as viral infections, asthma, bronchitis and chronic respiratory disease, and increase in people the possibility of cardiac and respiratory disease, and even mortality (Pyne, 2002; Sierra-Vargas & Teran, 2012).

$PM_{2.5}$ is highly related to toxic organic chemicals, heavy metals and so on (Wang et al., 2013). More specifically, NH4, SO_4, NO_3, Elemental Carbon (EC), Organics and other unknown elements are the main components of $PM_{2.5}$ in Beijing (Song et al., 2007). Xu et al. (2007) indicated Beijing has relatively high concentrations of

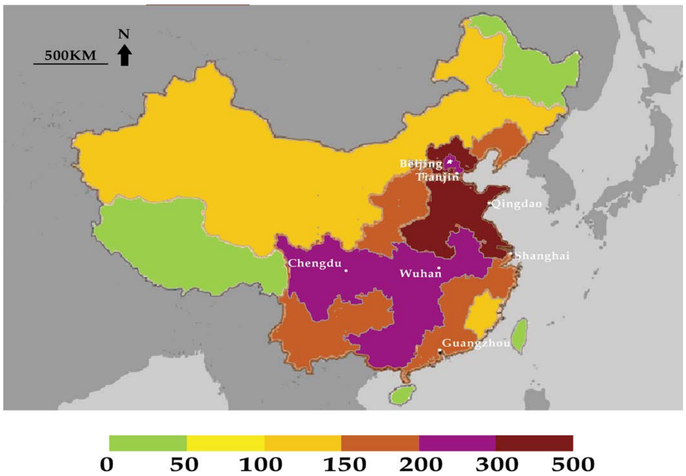

Figure 2. $PM_{2.5}$ concentration in china data. Source: China Centre for Resources Satellite Data. By: Zhu, 2014.

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 to 50	Air quality is considered satisfactory, and air pollution poses little or no risk.
Moderate	51 to 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution.
Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy	201 to 300	Health warnings of emergency conditions. The entire population is more likely to be affected.
Hazardous	301 to 500	Health alert: everyone may experience more serious health effects.

Figure 3. Air quality index. Source: US EPA, 2014.

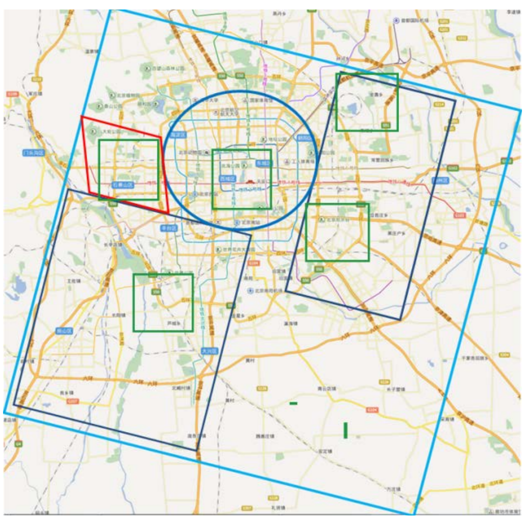

Figure 4. A map of Beijing. Source: Google Maps, 2014.

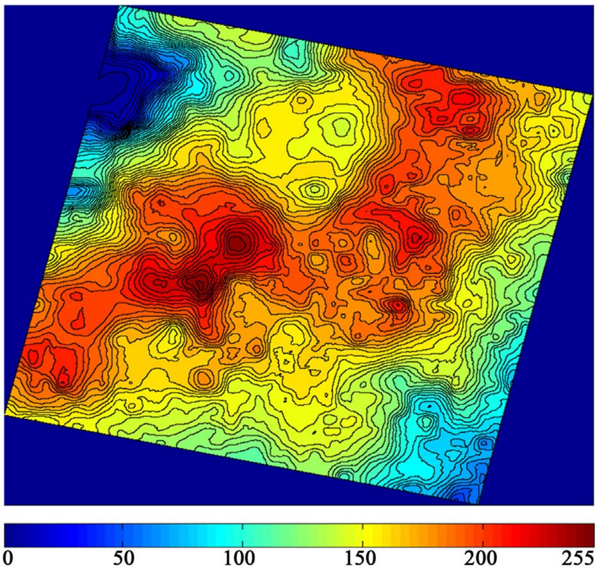

Figure 5. $PM_{2.5}$ concentration in Beijing. Source: China Centre for Resources Satellite Data and Application, 2014.

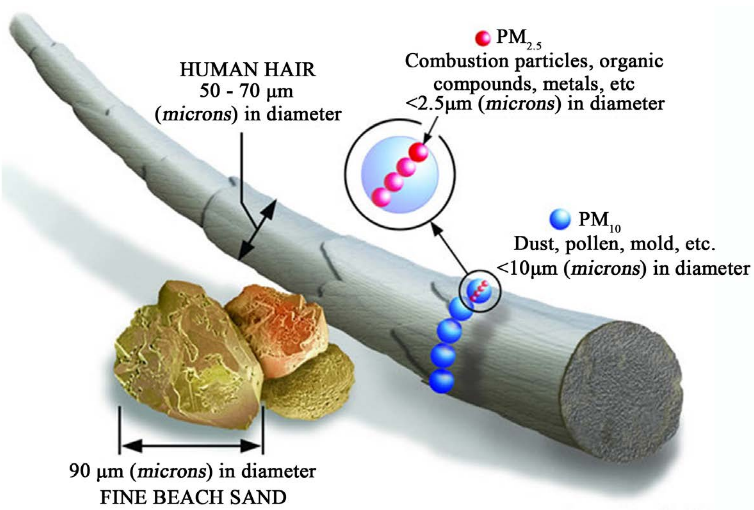

Figure 6. The size of PM particle makeup of $PM_{2.5}$ in Beijing. Source: US EPA, 2014.

Fe, K, and Mn when compared with the yearly average mass concentration of elements of $PM_{2.5}$ in Brisbane, Australia; Lisbon, Portugal; Birmingham, UK and so on (See **Table 1**).

3. Causing Factors of $PM_{2.5}$ in Beijing

There are many reasons for the $PM_{2.5}$ in Beijing; local emissions come from power plants, domestic heating, and industrial, vehicular, and biogenic sources (Chang & Yao, 2008). Coal burning is an especially major source for air pollution (He et al., 2001; Jiang et al., 2013; Pan, 2010; Song et al., 2007; Zhang et al., 2005). Coal, as a major energy source, is widely used in both industry and households (He et al., 2001). In 2011, the US Energy Information Administration (EIA) report revealed China currently burns 47% of world's total coal consumption, which is equivalent to about the total coal usage of the rest of the world combined (See **Figure 7**). China is the biggest coal consumption market in the world due to the low cost of coal and large coal resources in China (the World Coal Association, 2011). This is especially noticeable in winter, when coal becomes the household fuel to provide people with heat; it accounts for 40% of the $PM_{2.5}$ concentrations (Song et al., 2007).

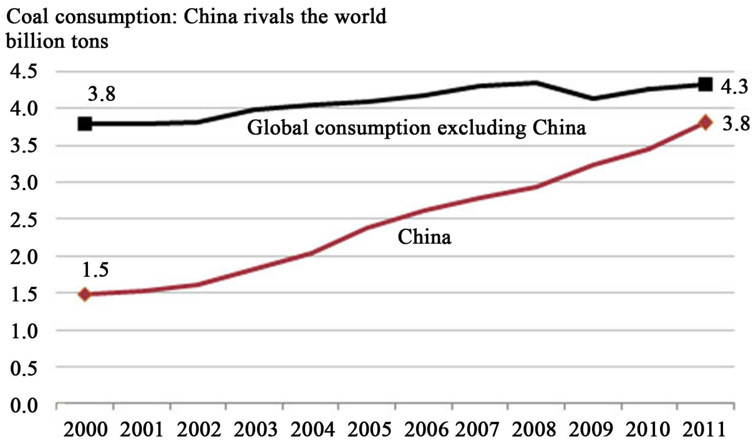

Figure 7. Coal consumption. Source: US EIA, 2013.

Table 1. Mass concentration of elements of $PM_{2.5}$.

Yearly average mass concentration of elements of $PM_{2.5}$ (unit: Lg/m^3)						
Element	Brisbane, Australia[a]	Gent, Belgium[b]	Lisbon, Portugal[c]	Birmingham, UK[d]	Bangkok, Thailand[e]	Beijing, China[f]
Fe	198	240	470	187	891	1344
K	78	97	376	71.5	471	2583
Mn	3.85	8.1	7.06	6.40	22.5	110.6

[a]Chan, & Simpson (1997); [b]Maenhaut, Francois, Cafmeyer et al. (1995); [c]Freitas, Reis, Alves et al. (1995); [d]Harrison, Smith, Pio et al. (1997); [e]Chueinta, & Hopke (2000); [f]Xu et al. (2007).

In addition, the vehicle emissions contribute to the poor air quality in Beijing. The numbers of vehicles have increased 15% annually since the 1990s (See **Figure 8**). There were more than 1.3 million vehicles in 2001 in Beijing, which increased to over 2 million in 2004 (Chan & Yao, 2008). The gas emission was not controlled in vehicle design before 1999. The vehicular emissions, together with emission waste and road dust, accounts for 15% of $PM_{2.5}$ concentration in Beijing (He et al., 2001; Pan, 2010; Song et al., 2006).

Minister Chen Huai from the Ministry of Housing and Urban-Rural Development of China stated that 10 million multi-family residences have been built in Beijing in a ten year period (MOHURD, 2011). The rapid construction of housing makes up 65.3% of China's GDP (Zhang, 2012), but the lack of proper restrictions and environmental concerns has led to large amounts of dust particles and related toxins floating in the air. Beijing, as the capital of China, is trying hard to increase GDP while ignoring the environmental health. Real estate and other urban construction waste account for 17% of sulfates and 14% of nitrates in $PM_{2.5}$ (Sun et al., 2004; Song, 2006).

Finally, based on Paatero & Tapper (1994) and Paatero's (2004) Positive Matrix Factorization (PMF), Song (2006) estimated untreated industrial waste and biomass burning from industries account for 6% and 11%, respectively, of Beijing's $PM_{2.5}$ composition.

4. The Effective Measures of Toxic Air Pollution of $PM_{2.5}$ Management

Despite earlier laws and subsequent amendments, such as the Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution, the air quality in Beijing has worsened. New effective measures need to be enacted in order to reduce Beijing air quality and improve the lives of Beijing's urbanites.

Many scholars and scientists around the world have been coming up with ideas on how to help reduce air pollution. Ideas have ranged from electrostatic vacuum cleaners to relying on rainfall from cloud-seeding to wash the pollution away. However, making changes at the source of the pollution is largely seen as the most effective method. Both short term and long term plans need to be considered.

Figure 8. Traffic in Beijing Source: Xinhua, 2013.

The short term plans are emergency policies that can help in the areas worst polluted. The cities here could stop unnecessary construction and shut down factories that do not meet minimum standards. Outdoor events with fires and BBQs would need to be stopped. Vehicular traffic would also need to be more closely regulated. Currently, only some vehicles can run on certain days, based on odd/even license plate numbers; however, many citizens circumvent this simply by buying multiple vehicles. A check of number of cars owned or imposing a heavy tax could help regulate this. Additionally, requiring private car drivers to pay congestion pricing at peak hours can reduce traffic and raise money for public transportation. Besides trying to limit the amount of pollution, the government would also need to limit the amount of outdoor air exposure. For instance, they could cancel outdoor school events, trips, concerts, and rallies. Reducing the amount of exposure would help alleviate the health issue.

Long term goals also need to be considered. First, concerning air protection, the use of modern technological processes should be largely implemented in factories. For example, Beijing's industrial boilers could use modern management, and industries in Beijing and its nearby cities should promote the coal gasification process and install smoke emission units, especially for the purposes of reducing sulfur dioxide, dust, nitric oxide, and carbon dioxide. The good news is that some steps have been taken by the Beijing government (China Clean Air Policy, 2013). In the early 1990s, the government started to forbid industries from using high sulfur containing resources and forced the industries in Beijing and its nearby cities to desulfurize, denitridize, and de-dust their emitted smoke (He et al., 2007). In 1999, Beijing's annual SO_2 concentration was 80 $\mu g \cdot m^{-3}$, and in 2004 it was reduced to 55 $\mu g \cdot m^{-3}$ (Song et al., 2007). This was an effective measure, and more policies like this need to be put into law.

There are many options available that could be implemented to help protect the air. One example for an improvement would be for the center of the city to install a heating system using a new form of energy. The reliability of coal burning for winter heating would be largely reduced. The government needs to vigorously support the development of clean energy and reduce dependence on traditional energy sources, such as coal and biomass, to promote zero emission energy, for instance hydropower, wind power, and solar energy. Public transportation is another area that could be improved. By increasing the frequency, citizen accessibility and the transport reachability, citizens in Beijing could reduce private vehicle use and vehicular emissions.

While many solutions are possible, it is also crucial that the government enforces all of the policies. Factory emissions and pollution control need to be constantly supervised and tested for efficiency. The government needs to understand the seriousness of air pollution and how it affects everyone. They cannot keep trying to make changes while the big industry owners argue with the lawmakers. Additionally, the longer this goes on, the more of an economic impact this will have on the city. Unsafe air will drive citizens, artisans, businesses, and tourists away. Policies need to be adopted to stop air pollution at the source and keep the citizens safe.

5. Conclusion

Air pollution is a serious threat around the world, but lately it has become an especially significant issue in the city of Beijing. In this paper, we discussed three aspects concerning Beijing's air pollution management: the dangers of $PM_{2.5}$ to an urban environment and city human health, the causing factors of $PM_{2.5}$ in Beijing, and effective measures of toxic air pollution of $PM_{2.5}$ management in big cities of developing countries. The pollution is only getting worse and current laws and regulations are not effective anymore. These approaches can serve as a guide for local residents, urban planners, and government officials of developing countries when planning for healthy city management.

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