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The effects of CO_2 and NH_3/NO_x emission from private vehicles to commute school on smog in Beijing and solutions

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Research

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ABSTRACT

Smog, a severe threat to people's health, has emerged as an intractable issue that both the government and the public cannot afford to ignore. PM2.5 is the key component of smog which includes CO_2 and NH_3/NO_x, and could cause many diseases. Vehicle exhausts contribute 31- 42 percent to the source of smog, and we have found that many students from both elementary and middle schools prefer to take private vehicles to commute to school in Beijing. However, there is not enough quantitative evidence to evaluate the emission of private vehicles and the reduction we do as a student. Our research shows 39% high school students in Beijing from elementary and middle schools preferred to take private vehicles to school. This transportation style will emit lots of CO_2 and NH_3/NO_x. Based on the formula of C footprint, the emission of CO_2 from private vehicles was approximately 700,000t, which is 23 times higher than that of public transportation, and the estimated CO_2 and NH_3/NO_x emission contribution to PM2.5 are about 6.0-10.0%. Therefore, the compound of CO_2 and NH_3/NO_x emitted from student's traffic played an important role in increasing smog level. This article argues that carpooling could serve as a solution to air pollution by reducing vehicle exhausts, easing traffic jam and promoting green lifestyle. We also explore new approaches to contribute to environment protection by low cost. This work provides a better understanding of the effects of CO_2 and NH_3/NO_x emission from private vehicles to commute school on smog in Beijing and can benefit both air quality management by low cost.

Key words: *Smog, CO_2 and NH_3/NO_x Emission, Private Vehicles, Commute School, Solution impact*

1.INTRODUCTiON

Gloal climate change has become a worldwide proble m. Climate warming led to smog [1]. In China, particulate pollution is a serious environmental problem that is influencing air quality, regional and global climates, and human health. PM2.5 pollutions is the key component of smog, which consists of airborne with aerodynamic diameters of less than 2.5μm. Epidemiological evidence shows that it cause lung morbidity, serious respiratory and cardiovascular diseases, and even death [2,3]

The global warming caused by air pollution will threaten human health [4].

Over the past 40 years, China's rapid industrialization and urbanization has created a growth miracle in the world, but unfortunately it has also left the country with a thick, gray haze. The increasing PM2.5 concentration showed very severe impact on people's life in Beijing [5,6]. Beijing and a substantial part of China are experiencing chronic air pollution. The main pollutants are fine particulate matter, and PM2.5 in particular [7]. In recent years, the Chinese government had spent two trillion RMB (2.7% of the GDP) on environment protection and declared a war against air pollution [8,9]. Some believe that economic prosperity should never be achieved at the cost of clean air and insist that the government should intensify efforts to crack down on polluters. However, others who take economic growth as the top priority argue that curbing air pollution will sacrifice economic gains. Is it possible for us to balance economic development and environmental protection? To solve this massive problem needs not only the efforts from research community and air quality management of government but also the supports from every citizen. The goal of our study will provide the quantitative evidence which may contribute to environment protection by low cost.

It is noteworthy that that there are 22 million inhabitants in Beijing, and 300 million immediately to the south in the North China Plain (NCP). According to the published data, vehicle exhausts contribute 31- 42 percent to the source of smog in Beijing[10]. Chemical composition and source apportionment of PM2.5 collected during the high pollution events at the urban sites of Beijing mainly included CO_2, NH_3, NO_x, SO_2 and other VOCs [11]. We have found that many students from both elementary and middle schools prefer to take private vehicles to commute to school. In Beijing, there are around 5.619 million private vehicles and 1.696 million students in Beijing in 2015 [12]. It is estimated that vehicles contributed 24, 29 and 20 % to national nitrogen oxides (NOx), nonmethane volatile organic compound (NMVOC) and CO_2 emissions, respec- tively, in China in 2006, with higher contributions in urban areas (e.g., 40, 41, and 52 %, respectively, in Beijing)[13]. Therefore, the CO_2 and NH_3/NO_x emission of private vehicles contributed by school commute may enhance Beijing's PM2.5 pollution. However, there is not enough quantitative evidence to evaluate the emission of private vehicles and the reduction we do as a student.

Therefore, the goals of our study focused on investigating preferred modes of transportation for commuter student, and further quantifying C footprint and NH_3/NO_x from private vehicles to estimate emission contribution of CO_2 and NH_3/NO_x to PM2.5 levels. Importantly, we will provide suggestions and approaches for school carpool service based on the scientific evidence. Carpooling is something that we, as high school students, should do to solve this problem at minimal cost. This study may also turn out to be a scientific and feasible solution for policy makers and urban planners to improve urban environment. We hope to solve big problems through small actions.

2. METHODOLOGY

2.1. Collected data from survey

We investigated which transportation tools the elementary and middle school students prefer to choose to commute to school. The questionnaires were designed for the internet-based research. The website:https://www.wenjuan.net/s/YZNZBvT[14].

2.2. Carbon footprint and emission of greenhouse effect

Based on our collected data, we quantified Carbon

footprint from private vehicles with this formula: Kilometer/year*0.25kgCO_2/Kilometer = ____ kg CO_2 per year [15].

2.3 Ammonia emission calculation of greenhouse effect

Based on our collected data, we quantified ammonia emission from private vehicles with this formula: Kilometer/year * 0.028kg NH_3 /Kilometer = ____ kg NH_3 per year [16].

2.4 NO_X emission calculation of greenhouse effect

Based on our collected data, we quantified NO_X emission from private vehicles with this formula: Kilometer/year*0.015kg NO_X /Kilometer = ____ kg NO_X per year [17].

3. RESULTS AND DISCUSSION

3.1. Investigating Preferred Modes of Transportation for Commuter Students

The research indicated that students preferred to use private vehicle to commute school. The results shows 38.6% high school students in Beijing from elementary and middle schools preferred to take private vehicles to commute school (Fig.1). More than 50% students take 10 -30 mins to commute to school due to severe traffic jam (Fig.2), which leads to a higher level of exhaust emission. More than 50% students expressed that using private vehicle could led to severe traffic jam and smog (Fig.3).

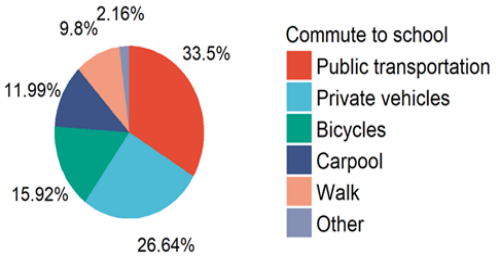

Fig.1. The preferred modes of transportation for commuting school students

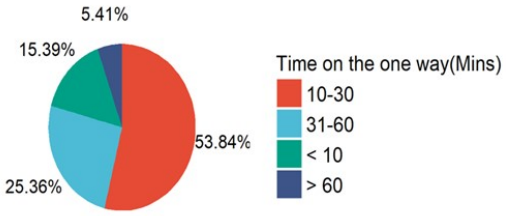

Fig.2. The time spent by commuting school students

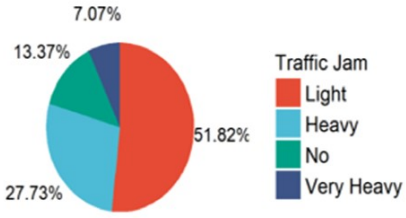

Fig.3. The analysis of severe traffic jam from students' transportation

3.2. Quantifying CO_2 Emission from Private Vehicles of Commuting to School

The CO_2 emission of vehicles was estimated based on quantifying C footprint from private vehicles of commuting to school. According to the data from survey, the distance of commuting to school per day was 19042km (Table 1), and the CO_2 emission per day was 4760.5kg. Based on 273 days of school year, the CO_2 emission per year was 1299616.5 kg (Table 2). In Beijing, there are around 5.619 million private vehicles and 1.696 million students [12], the CO_2 emission from students in Beijing per year reached 778,851,443kg. Based on the formula of C footprint, the emission of CO_2 from private vehicles was approximately 700,000t, which is 23 times higher than that of public transportation. Therefore, carpooling could serve as a solution to air pollution by reducing vehicle exhausts, easing traffic jam and promoting green lifestyle.

3.3. Quantifying NH_3 and NO_x Emission from Private Vehicles of Commuting to School

Motor vehicle ammonia (NH_3) and NO_x emissions have attracted increasing attention for their potential to form secondary aerosols in urban atmospheres. The NH_3 and NO_x emission of vehicles was quantified based on the distance of commuting to school from private vehicles of commuting to school (Table 1). Based on the formula of NH_3 and NO_x emission, the NH_3 emission from students in Beijing per year was 87,231,361.6 kg and NO_x emission were 46,731,086.6 kg. Compared to CO_2 emission, the NH_3 and NOx emission may show lower contribution to PM2.5 level in smog.

Table 1. The distance of commuting to school per day based on the data from survey

Items	Distance from home to school （Km）	Percentage of students （%）	Total Kilometer per day（km/day）
	<5	29.19	2552
	6-10	39.25	6435
Students from survey	11-15	18.48	5050
	>15	13.08	5005
Total from survey			19042

Table 2. The CO2 and NH3 / NOx emission from private vehicles of commuting to school

	Total from survey students in Beijing	Estimating from
	The CO_2, NH_3 and NO_x emission per day	
The CO_2 emission per day(kg/day)	4760.5	2,852,935.7
The NH_3 emission per day(kg/day)	533.2	319,528.8
The NOx emission per day(kg/day)	285.6	171,176.1
	The CO_2, NH_3 and NO_x emission per year	
The CO_2 emission per year(kg/year)	1,299,616.5	778,851,443.0
The NH_3 emission per year(kg/year)	145,557.1	87,231,361.6
The NOx emission per year(kg/year)	77,976.9	46,731,086.6

3.4. The Contribution of CO_2 Emission from Students Transportation to Smog

According to the data of green book on global warming in 2016, the total CO_2 emission was estimated 143.49 Million Ton, and the student's transportation was responsible for about 0.6-1.0% percent of CO_2 emission (Table 3). Actually, the very severe traffic jam increased more than10 times higher than normal transportation, and NH_3 and NO_X is also one of main emissions from traffic [11]. We further analyze that the student's transportation is responsible for more than 6-10 percent of CO_2 and NH_3 and NO_X emission. Therefore, the combination of CO_2 and NH_3 and NO_X emission from student's traffic played an important role in increasing smog levels.

Table 3. The CO2 emission in different countries in 2015

Country	Population （Million）	CO_2 emission (Million Ton)
American	324.2	5485.0
China	1339.72	9153.9
Austria	24.3664	400.2
Germany	85.2163	753.6
Hongkong	7.0976	91.2
Beijing	21.00	143.4（estimated）

3.5. Proposing Solutions to Reduce Smog Based on Scientific Evidence

The above results indicated that we needed to take action on decreasing the use of private vehicles to school. Starting a school bus program is a large task and will take time, therefore, we will create a local plan about carpooling in our school. From there, we saw the need for an app that enables students to arrange a carpool ride to school to reduce the smog. We will design a platform which will let students or teachers choose schoolmates or colleagues whose homes are near to them and commute to school together in one private car. Beyond that, carpooling will also significantly reduce traffic congestion, thereby diminishing the accumulation of air pollutants. Though there are policies to limit the use of cars with certain license plate numbers, Beijing still remains one of the most congested cities in the world. Los Angles faces pretty much the same

condition with Beijing in the mid 20 century. In the 1950s, Los Angles also suffered from smog, and it had taken them 60 years to control the pollution in the region. One of the policies is to design a carpool lane of the highway and ring road in the city. This specific lane only allows the car that contain two or more people [1] .This policy not only serves as an effective solution to traffic jam, but also helps reduce the concentration of PM2.5. Beijing and China should follow this policy in order to encourage people to start carpooling. Therefore, school bus or carpooling could serve as a solution to air pollution by reducing vehicle exhausts, easing traffic jam and promoting green lifestyle (Fig.4). Importantly, this work provides scientific and available evidence for policy makers and company that could provide school bus service.

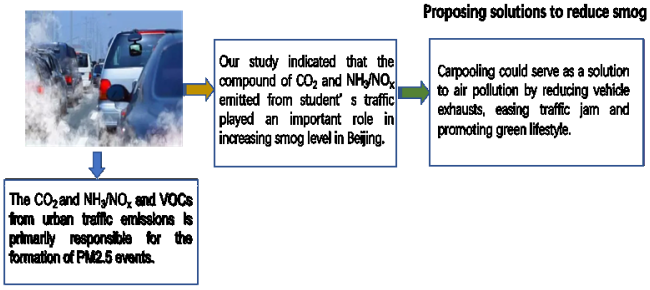

Fig.4 Schematic diagram of the effects of CO2 and NH3/NOx emission from private vehicles to commute school on smog and proposing solutions

4. CONCLUSION

On-road transportation contributes significantly to air pollutant emissions in China because of the substantial vehicle growth during the past three decades. We used data collected from school students which include their home address online to calculate the CO_2 and NH_3/ NO_X emission from student's traffic and its effects on smog in Beijing. The CO_2 and NH_3/ NO_X emission from student's traffic played an important role in increasing smog levels. From our research, we were able to draw the following conclusions.

First, our results showed about 38.6 % students like to use private vehicle to commute school. About 50% of students take 30-60 mins to go to school. We quantified C footprint from private vehicle of students was about 23 times higher than that of public transportation, and the CO_2 emission contribution estimates are about 6.0-10.0%. Therefore, the CO_2 and NH_3/ NO_X emission from student's traffic played an important role in increasing smog level.

Finally, the results indicated that we needed to take action on decreasing the use of private vehicles for school commuting. Starting a school busing program is a large task and will take time, therefore, the ideal result is that we can have a carpooling platform on our school website, which can help reduce the air pollutions to some extent. If such carpooling practice is gaining more and more popularity in Beijing, carbon and nitrogen emission from school commuting should be significantly reduced. Under this situation, it is important to let everyone know their own significance in decreasing smog and make their own contribution to environmental protection [18]. With everyone motivated to carpool, there will be more than 10% decrease of CO_2 and NH_3/ NO_X emission in Beijing, and this will save a large sum of money on fiscal expenditure to regulate pollution.

If the implementation of the car-pooling plan is successful, it will not only reduce carbon and nitrogen emission in Beijing, but also optimize the traffic system in this modern city. This plan may turn out to be a scientific and feasible solutions for policy makers and urban planners to improve urban environment.

What's more, carpooling offers a low-cost commuting choice to individuals and encourages people to go green in their everyday life. Besides environmental benefits, carpooling can also bring about economic and social benefits, including less expenditures, comfortable trips, flexible plans. If everyone could find out the "profit" that carpool brings to him or her, it is certain that more and more people will join carpooling in daily life. With all these benefits offered by carpooling, people will be more likely to enjoy green lifestyle and share a green future.

In conclusion, economic development and environmental protection are not contradictory. While every citizen can realize that he or she could play a constructive role to solve this massive problem. We can

always deal with the pollution problem by coming up with ideas like carpooling, which everyone takes part to solve this problem by improving his or her small actions in daily life. This will also benefit the economic growth, so most companies and factories don't need to sacrifice for reducing the smog.

We believe that carpooling could play an important role in environmental protection. It will directly reduce the emission of the pollutants and it will also be beneficial to the traffic system in the metropolis. Last but not least, carpooling will strike a balance between environmental protection and economic development. In a long run, this will not only be beneficial to the economic growth, but also to our environment.

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