Exploration of Standardized Greening Applied in Improving Air Environment in subway Cars

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Abstract. The main contradiction in our society has been transformed into a contradiction between the people’s growing need for a better life and the lack of development imbalance. Nowadays, with the development of high quality and encouraging green travel, People's pursuit of travel comfort and high quality of travel environment is getting higher and higher. This paper analyses the problems existing in the current high-speed development of subway transport industry and its air improvement mode, puts forward a new greening product scheme designed with standardization concept, and preliminarily analyses its application value. It has certain value to enhance the passenger experience, reduce the damage to the staff around the subway, promote high-quality life, and alleviate traffic congestion.

1. Introduction
The report of the 19th National Congress of the Communist Party of China pointed out that socialism with Chinese characteristics has entered a new era. The main contradiction of our society has been transformed into a contradiction between the growing needs of the people's better life and the imperfect development imbalance. In the decades of reform and opening up, standards have played an increasingly important role in ensuring the quality of products that are closely related to people's lives, and in standardizing the service process. However, with the improvement of people's living standards, people are not only pursuing the safety and efficiency of travel, but the comfort of travel and the high quality of travel environment. In the context of encouraging green travel, how to continue to use the standardized development concept, adopt multi-modal cooperation, enhance the rail transit experience for metropolitan congestion, and improve the working environment of the employees around the subway, thereby improving the quality of metro transport services. To protect the physical and mental health of passengers and staff is a direction worth exploring and researching.

2. Situation Analysis

2.1. Rapid development of urban metro transportation industry
With the emergence of traffic congestion, public transportation has become the choice of more and more people. The subway has been widely favored by people because of its advantages of strong passenger capacity, safety and speed, and ground space saving. According to the Science China Network, more than 120 million people commute by subway every day, 4.8 million in London, 5.3 million in Paris, 6.8 million in Tokyo, and more than 9 million in China. The office workers in Beijing take about 2 hours. According to the statistics of Beijing Metro, the 16 operating lines under the
jurisdiction of Beijing Metro Company carried a total of 3.116 billion passengers, with an average daily average of 8.537 million passengers in 2018. The passenger traffic of the year was 10.109 million passengers. At present, many cities in China have already opened subway lines.

2.2. Problems in the urban subway transportation industry

2.2.1 Air pollution problems

With the improvement of people's living standards, people pay more and more attention to environmental comfort. The Panzhishi Center for Environmental and Energy Research[1] carried out a research project on “Airway pollution exposure level differences and corresponding health effects of commuters in Beijing subway” in 2016-2017, and the ambient air particulate matter PM2.5 of Beijing's ten subway lines. Monitoring was carried out. The survey results show that the average concentration of the subway is 150 μg/m³, while the average concentration of PM2.5 in the outdoor environment in Beijing is 86 μg/m³. Moreover, whether in the heating season or the non-heating season, the PM2.5 concentration in the subway is higher than that in the outdoor air at the same time. During the monitoring period, Line 8 and Line 13 were much higher than the national secondary air quality standard. Not only does the domestic subway have excessive PM standards, but similar situations exist in foreign subways. Vania Martins [2], Teresa Moreno, etc. [3] measured the particulate matter in eight lines in the Barcelona metro system in Spain and in different depths and different tunnel sizes in 2014 and 2015, and found that in the system, due to the wear of the wheels and brake discs on the track, the PM2.5 content of the platform will vary greatly. In the cabin, due to the ventilation and air conditioning system and the air filter, the PM2.5 concentration in the cabin will be lower than that on the platform in most subways. In 2014, the study of King's College London in England [4] showed that the air quality in the subway was the worst in various indoor and outdoor environments. The University of Toronto study in 2017 [1] showed that the PM2.5 in the subway is also higher than the outdoor, even a difference of 10 times. Toronto's outdoor PM2.5 concentration averages 10 μg/m³, while the subway will reach 100 μg/m³. In addition, in recent years, domestic scholars have conducted comparative studies on other polluted air and standard indicators in the subway, as shown in Table 1.

| Researchers | publish annual | Statistical object | statistical indicators | Reference Standard Number | Statistical results |
|-------------|----------------|--------------------|------------------------|---------------------------|--------------------|
| Y. X. WANG  | 2014           | Station halls, platforms and carriages of 5 stations on a certain line of Zhengzhou Metro were randomly selected. Train compartments, platforms and outdoor of five lines in Beijing | CO, CO₂, PM10, Formaldehyde, Total number of airborne bacteria, Volatile Organic Compounds | GB9672-1996, GB9673-1996, GB/T18883-2002 | Inhalable particulate matter of all sites exceeded the standard, the total number of air bacteria exceeded the standard, and CO, CO₂, formaldehyde and total volatile organic compounds met the hygienic requirements. |
| B. Y. Liu   | 2016           | Metro carriages of 7 lines in Beijing at different times | Temperature and relative humidity, CO₂, particulate matter | GB9673-1996, GB/T18883-2002, GB3095-2002 | The concentration of CO₂ in the carriage exceeded the standard seriously in the morning and evening peak period, and the peak concentration exceeded the standard concentration by 2-3 times. The concentration of CO and PM2.5 in the carriage generally exceeded the standard, and the volatile organic compounds met the hygienic requirements. |
| K. WANG     | 2018           | Four stations for Phase 2 and Phase 3 of a metro line in Shanghai | Total number of airborne bacteria, Inhalable particulate matter | GB9672-1996, GB/T18883-2002 | Air supply pollution level of air conditioning and ventilation system in the subway is lower than hygienic standard as a whole. The contents of formaldehyde and ammonia exceeded the standard values, while the contents of TOVC and PM2.5 were within the standard values, but the indoor environmental quality grade was the third grade. |
| L. Su        | 2018           | A Metro carriage | Formaldehyde, ammonia, TOVC, PM2.5 | GB/T18883-2002 | The contents of formaldehyde and ammonia exceeded the standard values, while the contents of TOVC and PM2.5 were within the standard values, but the indoor environmental quality grade was the third grade. |
Notes: Environmental Air Quality Standard (GB 3092-1996), Public Transportation Waiting Room Health Standard (GB 9672-1996), Public Transportation Vehicle Health Standard (GB 9673-1996), Indoor Air Quality Standard (GB/T 18883-2002), Metro Design Standard (GB 50157-2003), Environmental Air Quality Standard (GB 3095-2012).

From the above studies, it is found that inhalable particulates generally exceed the standard. In addition, other toxic gases, such as formaldehyde, also have different degrees of pollution. Although some indicators do not exceed the standard limit, there are risks.

2.2.2 Harm of Polluted Gases
That various pollutants which can cause damage to human body is well known. Taking respirable particulate matter as an example, a group study by the American Cancer Society showed that if the concentration of PM2.5 in the atmosphere is higher than 10 μg/m$^3$ for a long time, the risk of death begins to rise. For every 10 μg/m$^3$ increase in concentration, the overall risk of death increases by 4%, the risk of death from cardiopulmonary disease increases by 6%, and the risk of death from lung cancer increases by 8% [10]. In addition, formaldehyde is also highly toxic, especially harmful to children or pregnant women, long-term exposure can cause pregnancy syndrome, leading to abnormal chromosomes, leukemia or mental decline in newborns [11]. The pollutants in the subway cars will bring greater safety risks to passengers and workers around the subway.

2.2.3 Air comfort issues
In addition to air pollution, air odor, comfort and other aspects are also important factors. Hu Songtao et al [12] found that 5 cities (Shenyang, Beijing, Shanghai, Guangzhou, Kunming) have an average rate of dissatisfaction with subway air quality of 18% after researching the winter and summer of 2014-2016. What’s more, the rate of air dissatisfaction has reached 25% in summer. The comfort of the subway ride has become a factor that can not interfere with passengers choosing the subway as a public transport.

2.3. Existing methods and problems
Excessive concentration of pollutants in the subway car will cause some damage to the health of the passengers, and the odor will also cause physical discomfort. When people face with multiple choices, it will reduce the trend of choosing the subway as a public transport. At present, there are two main ways to improve the air in the subway car. The first one is to blow through the central air conditioner, and the second is to sterilize. The central air-conditioning blower can effectively reduce the concentration of carbon dioxide and improve the temperature, humidity and odor. However, the subway station often develops into a commercial area where people flow. The concentration of bacteria on the ground is high, and the bacteria on the ground are easily brought directly into the station by passengers. The concentration of bacteria in the subway car is increased. In addition, the quality of ventilation is affected by factors such as the age of the air conditioner, the frequency of cleaning, the degree of responsibility of the cleaning personnel, and the quality of the source gas. Moreover, the quality of the air supply air supply will directly affect the quality of the air in the subway car and even around the car. In addition, if the air-conditioning wind speed is set too high, it will easily lead to excessive or too low temperature in the carriage, causing discomfort to the passengers. Although the central air-conditioning in the subway has reduced the concentration of carbon dioxide and other polluting gases, it has not completely eliminated the polluting gas. If it is simply discharged from the car, it is not conducive to the improvement of the surrounding environment with high density of bacteria. The second method of sterilization can effectively alleviate the damage caused by microorganisms and bacteria to workers and passengers. However, secondary pollution may result from some disinfection methods. A lot of researches have been done on the sanitary pollution of centralized air conditioning and ventilation systems in public areas of metro stations [8][13][14]. Commonly used methods at home and abroad are disinfectant, ultraviolet radiation, high-efficiency filtration, electrostatic precipitator, etc. The ventilation system is cleaned
and disinfected. However, these methods have limitations, and some methods may also cause secondary pollution. Some studies have found that electrostatic disinfection (in recent years, air-conditioning ventilation systems in new subway lines in cities such as Shanghai and Beijing) are prone to generate harmful gases such as ozone and nitrogen oxides; ultraviolet radiation is limited by the length and wind speed of the irradiated area. The single-time exposure time of the circulating air in the pipeline is short, and the disinfection effect is not satisfactory. The cost and energy consumption of the high-efficiency filter used in the public areas such as the subway is very high, and it is difficult to promote and apply; most of the disinfectant has a pungent odor. Not conducive to the improvement of the subway ride experience. Therefore, a variety of methods are needed to effectively combine.

3. Standardized product plan

3.1. Product Solution
In order to improve the air quality of underground space in and around Metro carriages, make up for the shortcomings of existing measures, fundamentally reduce or even remove harmful polluted gases, beautify the environment, reduce the damage caused by polluted gases to Metro staff and passengers, and enhance the comfort of public transport, the way of putting potted plants in Metro carriages is studied and put forward. In order to improve the stability of plants, a method of combining the existing subway internal structure with the load-bearing device of specific mechanical structure (plant rack) is proposed to realize the air-improving potted plants entering the subway. The plant rack can be placed under the seat of the Metro carriage or over the head of the seated passengers. It can not affect the air conditioning and ventilation in the car and the view of the window. The structure of the plant shelf should be able to be disassembled at any time according to the requirements of cleaning or placing.

3.2. Implementation Method
As for the function realization, the maintenance and users of plant racks can adjust the plant species and quantity on the plant racks according to the types of polluted gases and the severity of pollution in the subway carriages in different areas and periods. The height of potted plant pots should match the appearance structure of the plant racks to prevent the tilting or sliding out of the plant racks. At the same time, we should also consider that we can standardize the design of each component of the plant shelf according to the possible contamination and deterioration in the actual use process, so as to facilitate disassembly, replacement and cleaning.

3.3. Size and Material
As for the dimension and material of the botanical rack, standardized thinking can also be used. The dimension of the botanical rack should be combined with the internal structure size specifications of the existing metro in different areas, and matched with them. At the same time, a set of standardized series specifications parameters should be adopted to meet the needs of different batches or models of carriages. The selection of fitting materials should meet the performance requirements of different applications, such as hardness, stiffness, elasticity and so on. What’s more, the requirements of environmental protection and waterproofing should also be taken into account. For example, steel or rigid environmental protection plastics can be considered for some supporting or auxiliary supporting components.

4. Feasibility analysis

4.1. The Role of Potted Plants
Plants can reflect environmental pollution, degrade pollutants, absorb harmful gases and purify air. Wolver ton B C et al. [15] found that green plants such as Cymbidium davidianum and Heguoyu can absorb formaldehyde gas in the air. In a closed space, after 24 hours, these plants can reduce the
formaldehyde content in the air by more than 60%. Zhang Yingying et al. [16] pointed out that the selection of plants with strong purification ability in the subway carriage can not only green and beautify the environment, but also purify the environment. The suitable plants in the subway are also studied, and the names of plants that absorb different harmful gases suitable for the subway environment are listed. Zhang Xin [17] analyzed the functions of the applied plants in the subway station, and made a function analysis table of the applied plants in the subway station, and listed the functions of many plants in detail. It can be seen that there are potted plants suitable for survival in the subway carriage, and the effect of absorbing various polluted gases in the carriage can be achieved.

4.2. Security considerations
Safety is the most important and the most needing concern. The security of the scheme depends mainly on the structure design of the plant rack and the fixing method. By choosing plant scaffolding with better wrapping property, the structural design scheme can realize multiple protection of stability of plant scaffolding by means of multiple fixed connection (rigid connection or flexible connection according to different location requirements) with existing structure at the same time, thus effectively improving the security of the scheme and effectively avoiding the occurrence of safety accidents.

4.3. Benefits of Standardized Products
The use of this standardized product will effectively absorb harmful gases in Metro carriages, fundamentally improve the air environment in Metro carriages, achieve good functional integration with air conditioning in Metro carriages, improve the environment of staff around Metro carriages, enhance Metro ride feeling and comfort, and effectively enhance the proportion of public choice of Metro as a public transport. And alleviate the pressure of metropolitan ground traffic, improve the overall efficiency of urban travel.

5. Conclusion
At present, China's economy is shifting towards a high-quality development direction, and people are increasingly demanding travel environments that are closely related to their lives. At present, the densely populated large cities are paying more attention to the extension of the transportation route and the expansion of the layout. The improvement of the air quality in the subway car is often limited to the use of traditional subway air conditioners. The limitations and inherent problems of the air-conditioning of the subway, research and design more standardized products that can effectively improve the air of the subway is an important research direction. The improvement of the air environment of the subway can effectively protect the health and comfort of the employees and passengers around the subway, improve the quality of life, increase the proportion of green travel, ease traffic congestion, and comply with the current trend of encouraging green travel and high-quality development.

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