Data mining-based air pollution characteristics and real-time monitoring of college students’ physical and mental health

Xiaomei Wu · Xuejun Ma

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Abstract
Due to the significant impact of air pollution on visibility, it is also the most visible environmental problem for the public. This paper analyzes the application scenarios of data mining in the air pollution monitoring system, combined with the target of air pollution anomaly detection, mainly researches classification algorithms and outlier detection algorithms, and proposes an air pollution feature detection method based on data mining. A large number of experiments were carried out before the system integration to verify its effectiveness. Based on the abovementioned new architecture, this paper designs and implements an air pollution real-time monitoring system, which can display air pollution data in real time through rich charts, and integrates and applies air pollution anomaly detection methods to the system’s alarm module. The system can help data center managers monitor the air pollution in the data center and notify the managers to check the atmospheric abnormalities in time. In this article, data mining is also applied to the real-time monitoring of college students’ physical and mental health. A real-time monitoring system is designed for college students’ physical and mental health. A new system architecture is proposed through frequent data push and data IO scenarios, which can effectively monitor the physical and mental health of college students. In this article, data mining technology is used to monitor the characteristics of air pollution and the physical and mental health of college students in real time, which provides a new method for the treatment of air pollution and the protection of the physical and mental health of college students.

Keywords Data mining · Air pollution characteristics · College students · Health monitoring

Introduction
As the size of the data center increases, there is an exponential increase in power consumption. Data centers face challenges such as reducing energy consumption, reducing costs, and improving resource utilization. Reducing energy consumption during operation through monitoring and control means is an important way to achieve energy saving in data centers (Bhutto et al. 2013). The current energy consumption data monitoring system relies on managers to set thresholds to determine whether historical energy consumption is abnormal (Chang et al. 2011). The setting of the threshold depends on the subjective judgment of manpower, and this measure lacks comprehensive and more accurate data support (Cordier et al. 2020). On the other hand, more and more real-time energy consumption data are stored in the energy management platform (Deng et al. 2017). There is usually a wealth of knowledge hidden behind these historical energy consumption data (Fan and Ma 2018). The large amount of data makes conventional methods stretched, and data mining methods have achieved good application effects in many fields (Fan et al. 2017). Therefore, it is of great practical significance to study a new type of energy consumption data monitoring system and realize the application of data mining methods in the system. With the continuous acceleration of modern economic and social development, the speed of urban industry and urbanization has gradually accelerated, the income level of the people has increased significantly, and the quality of life of the country and enterprises has improved (Hou et al. 2016). However, economic growth is causing more and more serious environmental...
pollution, and the destruction of the ecological environment has a great negative impact on human life and health (Huang 2017). Therefore, there is an urgent need to use data mining methods to monitor air pollution characteristics in real time (Hussain and Abed 2019). At the same time, the continuous reform of the education system and Chinese universities have gradually expanded the scale of school management, and are facing challenges that make student management more difficult (Li 2017). The management of student health monitoring is an important part of university management. Under the background of university expansion, facing the problem of expansion, the health care system responsible for students continues to increase (Li et al. 2000). It is necessary to actively reorganize the medical care of college students and integrate it with data mining (Li et al. 2015). The advantage of this technology is to digitally manage student health file information, improve the degree of student health management informatization, and complete the construction of a new college student health management system (Li et al. 2017). In order to establish a health management system for college students through university computerization, it is necessary to summarize the experience of establishing a health management system, and combine the health monitoring issues of college students with the status quo of college health management to find an effective method (Liu et al. 2019). We improve the health of college students by fully implementing our health care strategy and college student health management strategies, and use streamlined management to meet the needs of technological innovation and development in the new era of college medical care (Qiao et al. 2017).

Materials and methods

Overview of the study area

As of the end of 2020, the permanent population of City A is 10,300,400, and the number of car ownership is 3,256,300. The complex energy structure has led to the widespread distribution of local man-made air pollution sources. In addition, City A is rich in educational resources, with 63 ordinary colleges and universities, 44 postgraduate training units, and 842,400 students. City A is also a famous tourist city. As of the end of 2018, the administrative region of City A had registered 93 tourist attractions. In 2018, it received a total of 247,387,500 domestic and foreign tourists. City A is the starting point of the ancient Silk Road, and it also plays an important role in the modern “Silk Road Economic Belt”. It is an important bridge for economic and cultural exchanges between China and the West. The geological structure of City A covers two units of the North China Platform and the Qinling Geotrough Fold Belt. About 130 million years ago, the Yanshan Movement created a large fault at the northern foot of the Qinling Mountains. Since the end of the third stage about three million years ago, the movement of the new structure of the Jinling trough fold belt on the south side of the stunning floor has become very active. The peaks have formed a kind of forest and rise sharply from north to south, and the north side of the large fault belongs to the North China region. The Weihe fault platform continues to sink, causing lakes to converge to form riverbed alluvial deposits. About 2 million years ago, the lake surface was gradually shrinking. The river was formed by the joint action of eolian loess cover layer and Weihe alluvial layer. The topographical contrast between forests and mountains became stronger. City A was built on the second terrace of the Weihe Plain, and City A is located in the transitional area from the humid climate of the southeast coast to the arid climate of the northwest inland. It has two climatic characteristics and is strongly influenced by the topographic factors of the region. It belongs to the temperate zone and has Humid monsoon climate. The average annual temperature in City A is 13°C to 17°C, the average temperature in January is −1.2°C to 0.0°C, and the average temperature in July is 26°C to 26.5°C. However, due to the special topography of the Guanzhong Basin, the precipitation in summer and autumn is higher than that in the surrounding areas. In winter and spring, it is also blocked by surrounding mountains. The intensity of the cold northwest air reaches the basin and weakens. In addition, the warm and humid air from the south sinks across the Qinling, so that the temperature of City A will not be too rapid in winter and spring.

Research data

The six air pollutants data in this article come from the provincial air quality network monitoring and management platform. The monitoring data from January 1, 2020 to February 28, 2021 is analyzed as a typical time period, and the time resolution of the data is 1 h. The eight environmental and air national control monitoring points in City A have passed the certification of the China Environmental Monitoring Station (including clean reference points). The distribution points are

| Table 1 | Information of air pollution monitoring sites in City A |
|---------|--------------------------------------------------------|
| Unique number | Area | Longitude | Latitude | Control level |
| 610100059 | Area A | 108.882 | 34.2749 | State control |
| 610100052 | Zone B | 108.993 | 34.2629 | State control |
| 610100091 | Area C | 109.06 | 34.2572 | State control |
| 610100092 | Zone D | 108.94 | 34.2324 | State control |
| 610100055 | E area | 108.94 | 34.2713 | State control |
| 610100093 | F area | 108.883 | 34.2303 | State control |
| 610100053 | G area | 108.935 | 34.3474 | State control |
| 610100054 | H area | 108.906 | 34.1546 | State control |
listed in Table 1. The data involved in the calculation has been reviewed and corrected.

Research methods

Data mining

The main objects of structural health monitoring include temperature, air humidity, wind load, seismic input, traffic load, scouring, displacement, deflection, acceleration, etc. Based on these structural health monitoring data, structural damage identification and performance evaluation can be carried out. However, the current domestic large-scale engineering structures with SHM systems are still in the initial stage, and most of the monitored structures have not yet shown significant damage. Therefore, based on the normal environmental load and the monitoring data under the normal structure, a statistical model under the normal operation of the structure can be established. When the environmental load or structure has abnormal conditions, the monitoring data will fluctuate, so as to identify the possible abnormal conditions during the operation of the structure. Structural anomaly recognition based on data mining can effectively extract information from massive monitoring data, and perform real-time anomaly detection on environmental loads and structural responses, which lays the foundation for further structural damage identification and performance evaluation. This article will give examples to illustrate the application of commonly used data mining models in structural anomaly recognition.

Air pollution analysis method

First, based on the survey results and data availability, we establish a classification system for atmospheric particulate pollution sources applicable to City A, and further determine the target pollution sources involved in the source list. Through the integration of environmental statistics, investigations by relevant departments, and existing pollution source surveys, the scope and quantity of various types of pollution sources can be determined. Then, based on the existing monitoring data, actual calculations of key enterprises, and extensive literature research, a preliminary release coefficient database was established, and localized corrections were made based on the actual situation of pollution sources in City A. The emission of air pollutants is calculated based on the energy usage of the pollution source and pollutant emission factors. The emission factor method calculates the amount of pollutant emissions related to the activity level of the pollution source, such as the combustion technology and treatment facilities used by the pollution source. The errors in emission inventory come from application errors and statistical errors in model calculation and statistical analysis.

A. Calculation of pollutant emissions from industrial sources

\[ C_i = \sum_j \sum_k A_{j,k} E_{i,j,k} \]  

B. Calculation of pollutant emissions from waste incineration sources

The calculation formula for non-point source emissions from waste incineration is as follows:

\[ E_i = \sum_j A_j E_{i,j} \]

C. Calculation of pollutants from motor vehicle emission sources

In this study, the annual emission of certain pollutants from motor vehicles is obtained according to “Measurement Method for Air Pollution Emissions from Motor Vehicles in Urban Areas”. The specific calculation formula is as follows:

\[ C_w = \sum_j P_j M_j E_{i,w} \]

D. Calculation method of non-point source pollutants

1. The calculation formula for the emission of pollutants from household sources is as follows:

\[ C_i = \sum_j A_j E_{i,j} \]

2. Non-point source of fugitive dust emission

\[ C_i = \sum_j A_j E_{i,j} \]

Results

Assessment results of current air quality

It can be seen from Table 2 that, as a whole, the annual average concentrations of PM10, PM2.5, SO2, NO2, CO, and O3 in City A have changed significantly from 2016 to 2020. The concentration of PM10 peaked in 2018, and then decreased year by year; PM2.5 concentration and NO2 concentration have the same changing trend, both of which increased year by year from 2017, reached the peak in 2019, and then decreased year by year; SO2 and CO concentration values showed an overall trend declining trend; the concentration of O3 will increase year by year from 2017 to 2020, and there will be a greater degree of decline in 2020 than in 2019. The concentration values of various pollutants in 2020 have
dropped to a greater extent than in 2019, indicating that strong pollution control measures have played a role in 2020, such as the control of dust from construction sites and roads, the conversion of coal to clean energy, the elimination of scattered polluting enterprises, and measures such as meeting vehicle exhaust emission standards.

It can be seen from Fig. 1 that there are a total of 188 good days in 2020, of which 21 days are excellent, accounting for 6%, good 167 days, accounting for 46%, and pollution days are 177 days, of which 114 days are slightly polluted, accounting for 31%. Moderate pollution is 34 days, accounting for 9%, severe pollution is 24 days, accounting for 7%, and severe pollution is 5 days, accounting for 1%.

It can be seen from Fig. 2 that the polluted days above light pollution are concentrated in the heating period from January to March and November to December and the high temperature period from June to August. The polluted days above heavy pollution are mainly concentrated in the heating period, of which January is the most polluted. The months with more good days are April, May, July, September, and October, mainly in spring and autumn.

In Fig. 3, it can be seen that the major pollutants have changed significantly with the changes of the moon. The major pollutants from January to March and November to December are mainly PM$_{2.5}$, and the major pollutant from April to May is PM$_{10}$, the main pollutant in summer from June to August is ozone, and the main pollutant in autumn from September to October is nitrogen dioxide.

**Evaluation results of air pollutants**

In 2020, the AQI and mass concentration data of PM$_{10}$, PM$_{2.5}$, SO$_2$, NO$_2$, CO, and O$_3$ will be classified and analyzed using the data from the National Air Quality Monitoring Station of City A instead of calculating every hour and every day. By 2020, the number of effective days in City A will be 188 days, and the number of days beyond mine damage (AQI>100) will be 177 days. In Fig. 4, it can be seen that the high AQI values are mainly concentrated in January to March and November to December, and the good conditions are mainly concentrated in April and May and between September and October. The AQI is shown in Fig. 4.

The annual average concentration of PM$_{10}$ in 2020 is 122 $\mu$g/m$^3$, and the specific situation is shown in Fig. 5.

The annual average concentration of PM$_{2.5}$ in 2020 is 63 $\mu$g/m$^3$. The specific situation is shown in Fig. 6.
The annual average concentration of SO$_2$ in 2020 is 15μg/m$^3$. The specific situation is shown in Fig. 7.

The annual average concentration of NO$_2$ in 2020 is 55μg/m$^3$. The specific situation is shown in Fig. 8.

The annual average concentration of CO in 2020 is 1.5μg/m$^3$. The specific situation is shown in Fig. 9.

The annual average concentration of O$_3$ in 2020 is 98μg/m$^3$ as shown in Fig. 10.

**Air pollution particulate matter emissions**

In 2020, the PM$_{10}$ emissions of air pollutants in City A will be 27,151.35 tons, and the PM$_{2.5}$ emissions will be 14,767.92 tons. These include industrial sources, medical waste incinerators, road transportation sources, non-boiling point sources other than houses, and non-point construction dust. For source emissions, refer to Table 3 for details.

According to calculations, the emissions of PM$_{10}$ and PM$_{2.5}$ from industrial resources in City A in 2020 will be 11,514.25 tons and 7483.17 tons, respectively, as shown in Table 4. Among them, the main sources of PM$_{10}$ are electricity, heating and supply, chemical raw materials, and chemical product manufacturing, accounting for 74.05% and 19.54%, respectively. In the industrial power supply, the main power supply of PM$_{2.5}$ is the same as that of PM$_{10}$, the contribution rate of heating and suppliers is 81.16%, and the chemical industry is 13.85%.

Diesel vehicle exhaust not only contains particulate matter, but also emits gaseous pollutants, such as NOX and VOCS. Through photochemical reactions, NOX and VOCS are converted into secondary particles, which have an adverse effect on human health. With the rapid economic development, the number of cars in City A has increased rapidly in recent years. According to the “Xi’an 2020 Statistical Yearbook”, as of the end of 2019, the number of cars in City A was 3.267 billion. Automobile exhaust is one of the main sources of particulate matter in City A. The specific list is shown in Table 5. The estimation of motor vehicle emission factors is the most basic problem for effective control of motor vehicle pollution. Models such as MOVES, COPERT, and IVE are currently the most commonly used methods to determine the emission factors of domestic and foreign road vehicles. Tao Shuangcheng et al. calculated the emission factors of gaseous pollutants from vehicles in the Guanzhong urban agglomeration based on the further partial correction of the parameters based on the MOVES model. According to Tao Shuangcheng’s research, the automobile
pollutant emission factors in City A and the sixth stage automobile emission standards formulated by Province A have been determined. In addition, the average annual mileage of each vehicle type in this survey is determined based on the average mileage of each vehicle type recommended in the “Technical Guidelines for Non-road Driving Pollutant Emissions Inventory”.

Discussion

Analysis of air pollution control countermeasures

Control key industries and reduce total pollution

In order to make special modifications to industry organizations that emit large amounts of pollutants, such as electricity, heating, ferrous metal smelting and rolling processing, paper and paper products, chemical raw materials and chemical product manufacturing, textiles and computer communications, they must be assessed (Wang et al. 2010). Companies that do not meet environmental protection requirements should relocate as soon as possible, and those companies that are technologically backward and eager for change and governance should be completely closed (Wang et al. 2014a). The SO2 in City A mainly comes from the production and supply of electricity, heat, and industrial SO2 emissions from industrial combustion sources. Companies must sign SO2 emission reduction obligations. In addition, it is necessary to carry out environmental law enforcement activities and impose penalties on companies that exceed illegal emissions and legal standards (Wang et al. 2014b).

Eliminate outdated production technologies and processes, and promote clean and efficient production technologies

The air pollutants emitted during the product manufacturing process are very high. During the production of the product, the CO emissions in the city air accounted for 65.39%, and the VOCS emissions accounted for 30.46%. Therefore, it is necessary to strictly control the quality of product raw materials, monitor product manufacturing technology, review production equipment, and select environmental protection facilities (Wang et al. 2014c). In accordance with the requirements of the “Volatile Organic Compound Pollution Improvement Plan for Major Industries in City A”, we will investigate the major industries that emit volatile organic compounds. The government must promote clean and efficient production technologies to achieve a win-win situation of increasing product output and reducing pollutants.
Minimize coal consumption and actively adopt clean energy

The main energy source for industrial combustion in City A is raw coal. The low energy consumption efficiency and insufficient energy consumption structure have brought constant pressure to the atmospheric environment and caused serious environmental pollution problems. Therefore, it is necessary to change the current energy consumption situation in City A. Coal-consuming industries must arrange and implement plans to eliminate outdated production capacity. At the same time, they must strengthen the use of clean energy, increase the utilization rate of natural gas, etc., and accelerate the establishment of a natural gas network management system in City A, which requires more scientific development, and use renewable energy (Wang et al. 2016).

Controlling dust pollution from unorganized buildings

The contribution rate of non-point-shaped unorganized building dust sources to PM$_{2.5}$ is 18.32%, and the contribution rate to PM$_{10}$ is as high as 23.94%. Therefore, building dust must be managed. At the construction site, it is necessary to take measures to enclose it, install cleaning devices, and install car wash tanks and sedimentation tanks. At the construction site, building materials and construction waste that are randomly stacked must be given attention, and the construction personnel must cover the materials. At the same time, it is stipulated to spray water on the construction site regularly every day to minimize the dust pollution during the construction of sprinklers.

Controlling exhaust pollution from motor vehicles

In City A, since the contribution rate of automobile exhaust to CO is as high as 24.55% and the contribution rate to VOC is as high as 69.15%, it is necessary to further suppress the pollution of automobile exhaust. City A has a high population density. In terms of road improvement, transportation cost reduction, and environmental protection indicators, it can effectively improve the driving conditions of buses, the planning and construction speed of exclusive bus lanes, the establishment of high quality and high efficiency, and the increase the share of public transportation and city buses, and the use of clean vehicles are also important means to reduce vehicle exhaust pollution in City A. At the same time, it will promote the promotion of a series of clean vehicles such as electric vehicles, hybrid vehicles, ethanol fuel vehicles, and hydrogen fuel vehicles (Wei et al. 2017). Government departments should strengthen the monitoring of vehicle exhaust, strengthen the construction of vehicle exhaust measurement facilities, and quickly announce that the excess exhaust cars are illegal, and it is forbidden to drive excessively or produce black smoke cars on the road (Xing et al. 2013).
Current situation of college students’ physical and mental health management

Health problems of college students

The health problems of modern college students can be divided into mental disorders and physical health problems. Mental health problems of college students refer to mental disorders in certain universities, although the levels of mental disorders of students are different. But in interpersonal communication, paranoia, depression, and obsessive-compulsive disorder are particularly prominent among college students, which seriously affect the physical and mental health of students (Xu et al. 2012). In recent years, the proportion of students with psychological barriers in the total number of college students has increased year by year. The high incidence of psychological barriers among college students is increased employment pressure, life adjustment disorders, and emotional and interpersonal problems, which make most college students have low self-reliance. After entering university, they do not know how to communicate with others, so they lack the ability to deal with interpersonal relationships. At the same time, after entering the university, if the living environment changes and you cannot adapt to the environment, the psychological burden will increase. In addition, in an open campus, students are free to fall in love. If we do not have interpersonal experience or the ability to deal with emotions, we will be more susceptible to emotional entanglement, and negative emotions such as anxiety or depression will appear. The increasingly difficult employment situation will increase students’ psychological pressure and cause students’ psychological health issues. The main cause of physical health diseases among college students is usually low health awareness and neglect of the mastery of medical knowledge. Due to the lack of health knowledge, it is difficult for students to learn and develop good hygiene habits. At the same time, they do not pay attention to personal oral hygiene and do not understand the knowledge of infection prevention. In addition, most students have irregular work and rest periods, have bad eating habits, and they do not actively participate in sports. This situation will affect and cause physical health and other issues.

The status quo of college students’ health management

In order to solve the problem of physical and mental health of college students, it is necessary to study the health management status of college students. Health care refers to the health monitoring of the health of a group or individual, and the protection of the physical and mental health of the group or individual. At this stage, most universities will focus on the work of the school hospital, sports health education, psychological counseling education, etc., so as to carry out student health experience, collect medical information from the students in the school hospital, strengthen the students to exercise, and carry out student health management. At the same time, education on the physical and mental...
health of college students is necessary to complete the task of health care. Of course, these health care systems have the problem of insufficient tolerance. Universities must use the latest information technology combined with the latest technology to manage student health file information in order to implement student health management in the context of the Internet. The health care sector needs to be closely linked with the reform of the health education of college students. These health care systems can comprehensively protect the physical and mental health of students.

Physical and mental health monitoring system for college students

Improve the management organization

In order to establish a health care system for college students, universities need to improve their school’s health care institutions. Traditional health care institutions in universities include school hospitals, sports departments, and psychological education departments. The health needs of the establishment of the network technology department must be considered to manage the health of students. The management system has the problem of insufficient establishment of educational institutions. Therefore, universities should integrate various departments of the school to use the participation of the Internet to improve the health care system for college students and establish a new student health care system. For example, the university should establish the original sports department, and at the same time establish a network technology department for college student health care. On the basis of the psychological education department and the school hospital, the person in charge of student health management must be selected, and a school management department must be established to select high-quality students, and a student management department should be established, at the same time, mental and physical health management services must be provided. Therefore, universities should strengthen the links between departments, and organically take charge of all aspects of college students’ health care, while integrating information technology to establish and promote a seamless communication mechanism between departments and to share student health information in a timely manner. Multiple departments can provide students with more comprehensive and effective health care services to ensure students’ physical and mental health.

Strengthen health education

In the context of the Internet, universities should make full use of the advantages provided by the Internet background to carry out educational reforms, strengthen health education for college students, and establish a medical care system for college students. First of all, it is necessary to strengthen the publicity of university campus health knowledge, and use campus broadcast campus information committee, campus website to convey health knowledge, disease prevention knowledge and health habits guidance to students. If we have problems with our mental or physical health, we must actively seek counselors, participate in psychological consultations or take the initiative to go to the school hospital for medical examination or treatment. These teaching

| Table 3 | Inventory of atmospheric particulate pollution source emissions in City A in 2020 |
|---------|-------------------------------------------------------------|
|          | Industrial source | Medical waste incineration source | Road mobile source | Resident life source | Non-point source of construction dust emission | Non-point source of fugitive emissions from major industries | Non-point source of agricultural straw incineration |
| PM$_{10}$ | 11,514.20 | 1062.40 | 6377.80 | 376.01 | 6973.20 | 635.47 | 212.25 |
| PM$_{2.5}$ | 7483.12 | 712.03 | 4504.77 | 177.45 | 1228.79 | 471.60 | 190.14 |
methods to strengthen the promotion of health knowledge are aimed at strengthening students’ self-care and improving the effectiveness of college students’ overall health care. Therefore, universities should exercise the leadership of health educators and require school counselors to provide students with psychological counseling services on a regular basis, and provide long-term psychological counseling training for students and solve psychological problems to ensure that students can recover their mental health as soon as possible. In the school physical education department, it is necessary for physical education teachers to organize and conduct physical education on a regular basis to explain health knowledge to students, recognize the importance of physical education, promote life-long sports habits, realize university health education, and provide students with medical care.

**Conclusion**

In this article, we use the fuzzy comprehensive evaluation method to assess the air quality of City A, determine the air quality level of the city, and determine the main air pollutants, analyze the characteristics of the main air pollutants over time, study the impact of weather conditions, and study the impact of air quality. At the same time, data mining technology is used to characterize the main air pollutants in City A and analyze the contribution of various pollutant sources. Studying the characteristics of air pollution through monitoring and control means is an important way to achieve atmospheric governance. On the other hand, data mining methods have achieved good application effects in many fields. It is of great practical significance to study how to apply data mining methods to the physical and mental health monitoring system of college students. This paper investigates existing data mining algorithms and finds the application scenarios of data mining algorithms in air pollution characteristic monitoring systems. Combining with the goal of air pollution feature detection, it mainly studies classification algorithms and outlier detection algorithms. A real-time data anomaly detection method for air pollution is proposed. A large number of experiments are performed to verify its effectiveness, and its application to air pollution features is studied. Possibility of monitoring system alarm management module must also be considered. In this article, a new type of physical and mental health monitoring framework for college students is proposed. By adding a middle-tier server, the request IO operation is separated from the computing business. The business server focuses on processing business logic, which effectively reduces the load of the business server. The system has good scalability. Later, as the scale of business computing increases, business servers can be dynamically added and load balancing can be added. Based on the above architecture, this paper designs and implements a real-time monitoring system for college students’ physical and mental health, which can display data in real time through rich charts, and integrates and applies energy-consumption anomaly detection methods to the system’s alarm module. The aim is to use data mining technology to summarize the experience of establishing a health management system for college students, improve the quality of health management work for college students, and improve the health management system for college students. Starting from the physical and mental health of college students, we analyze the health management status of college students, and implement strategies such as improving management institutions, strengthening health education, and conducting health monitoring to protect the physical and mental health of college students.

**Table 4** Emission factors of industrial particulate matter

|                  | Coal-fired power plant | Raw coal | Natural gas | Gasoline | Diesel oil |
|------------------|------------------------|----------|-------------|----------|------------|
| PM$_{10}$ (kg/t) | 0.87                   | 1.61     | 0.24        | 0.25     | 0.31       |
| PM$_{2.5}$ (kg/t) | 0.62                   | 0.74     | 0.17        | 0.125    | 0.31       |

**Table 5** Inventory of motor vehicle ownership and particulate matter emissions in City A in 2020

| Ownership (vehicles)      | Motorcycle | Large buses | Medium bus | Minibus | Medium truck | Light truck |
|---------------------------|------------|-------------|------------|---------|--------------|-------------|
| PM$_{10}$ factor g/(km. vehicles) | 0.032  | 0.173       | 0.103      | 0.028   | 0.399        | 0.063       |
| PM$_{2.5}$ factor g/(km. vehicles) | 0.027  | 0.141       | 0.077      | 0.011   | 0.322        | 0.041       |
| Average annual mileage (km) | 5500   | 100,000     | 35,000     | 18,000  | 45,000       | 30,000      |
| PM$_{10}$ emissions (kg)   | 23,630.46 | 346,882.30 | 3,424,299.00 | 924,494.30 | 1,278,054.86 | 380,443.80  |
| PM$_{2.5}$ emissions (kg)  | 19,938.20 | 282,719.10 | 2,559,913.00 | 363,194.20 | 1,031,412.69 | 247,590.40  |
Declarations

Conflict of interest  The authors declare no competing interest.

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