Environmental management strategy in response to COVID-19 in China: Based on text mining of government open information

Ailin Kang, Lijun Ren *, Chunyu Hua, Hui Song, Miaoxin Dong, Zhaotong Fang, Mengyuan Zhu

School of Environmental Science and Engineering, Shandong University, Qingdao, Shandong 266237, China

HIGHLIGHTS

- Text mining methods is employed to collect the data from government open information.
- Medical waste treatment and monitoring are the main work during a pandemic.
- China's medical waste treatment capacity has improved during COVID-19 pandemic.
- Epidemic control didn't affect the environment quality of China.
- Positive checklist policies can improve the efficiency of environment management.

GRAPHICAL ABSTRACT

ARTICLE INFO

ABSTRACT

Coronavirus disease 2019 (COVID-19) is a global pandemic and a major health emergency. In the process of fighting against COVID-19, the China Ministry of Ecology and Environment (MEE) responded quickly and set up a working group as soon as possible. This article uses text mining to retrospectively analyze the government's public information on the website of MEE during the epidemic, sort out the timeline of MEE's response to COVID-19. We find that MEE's work during the COVID-19 pandemic is focused on medical waste and wastewater treatment, environment emergency monitoring, pollution prevention, and other environmental management for supporting economic recovery. It drafted three main medical waste management plans, an emergency environmental monitoring plan, and formulated "two lists" – a Positive checklist for Environmental impact assessment (EIA) approval and a positive checklist for supervision and enforcement, to promote the resumption of work and production. 2020 is the final year of China's "three years of fighting pollution prevention and control". In the case of the sudden COVID-19 epidemic, the Chinese environment department has ensured that the quality of the ecological environment has not been affected by the epidemic prevention and control while ensuring the smooth progress of the fight against pollution. China's medical waste disposal capacity has also been greatly improved during this epidemic. The review of China's environmental management strategy in response to COVID-19 can provide a reference for countries in the world that are still in the critical period of epidemic control; it can provide action guidelines for the ecological environment system to respond to sudden pandemic events in the future.

1. Introduction

Coronavirus disease 2019 (COVID-19), also named SARS-COV-2 coronavirus, appeared in December 2019, causing an epidemic in

* Corresponding author.
E-mail address: ljren@sdu.edu.cn (L. Ren).

Wuhan, Hubei province, China (Achak et al., 2020). Countries around the world are still struggling in its vortex (Ibn-Mohammed et al., 2021). COVID-19 has brought a huge impact on the global economy and society (Bashir et al., 2020; Chakraborty and Maity, 2020; Sarkodie and Owusu, 2020), while indirectly affecting the global ecological environment (Anser et al., 2020; Bar, 2020; Rupani et al., 2020). The environmental impact caused by the outbreak has been extensively studied (Rume and Islam, 2020; Saadat et al., 2020). Positive impacts include the reduction of particulate matter and NO_2 concentration in the air (Chen et al., 2020; Lokhandwala and Gautam, 2020), the reduction of noise (Ibn-Mohammed et al., 2021), and the reduction of energy consumption leading to lower GHG emissions (Naderipour et al., 2020; Wang and Su, 2020). The negative effects are mostly due to the massive production of medical waste and wastewater caused by the surge in confirmed cases (Sarkodie and Owusu, 2020; Urban and Nakada, 2020), and mass production of personal care products (Fadare and Okoffo, 2020; Prata et al., 2020; Rhee, 2020). In dealing with these major and complex impacts, the coordination and management at the national level is necessarily needed.

The Ministry of Ecology and Environment (MEE) of China is a component of the State Council and is responsible for the overall coordination, supervision and management of major ecological and environmental issues nationwide. The high efficiency and high quality that China has shown in responding to the COVID-19 pandemic are common to all (Guo et al., 2020). MEE plays a key role of guarantee in the process of responding to COVID-19, for example, in the medical waste treatment (Yang et al., 2021). However, the epidemic is a complex crisis event with great environmental risks, there is still a lack of corresponding research on environmental emergency management for major epidemics (Dong et al., 2020). In that case, systematically analyzing the measures taken by MEE can provide a reference paradigm for the emergency environmental management of sudden major epidemics.

The government open information in the website of government department is the main way for people to gain the government's work dynamics. Government open information such as announcements, notices, news, etc. are unstructured texts. Text mining can be used to find keywords from unstructured texts. These keywords dig out from government open information could represent the focus of government work over a period of time. Text mining technology refers to the use of computer technology to analyze a large amount of text data and to reveal valuable information from further analysis (Ning et al., 2012). This process generally has four phases: information retrieval, information extraction, knowledge discovery, and hypothesis generation (Zhu et al., 2013). Text mining has been widely used in the biomedical field for discovering new knowledge from search issues (Zhu et al., 2013). Due to the rapid growth of digital data in recent years, text mining has attracted a great deal of attention with an urgent need for turning data into useful information. In terms of environmental management, some researchers made some try by text mining. Liu and Hu (2019) collected information on Sina Weibo users and the popular posts and comments related to green buildings for sentiment analysis. Wu et al. (2020) explore the Chinese residents' emotional tendency towards the municipal solid waste sorting policy by text mining on the data of Sina Weibo users and their comments on related popular posts. At present, the methodological research of text mining is still advancing, and the research of using text mining in environmental management is not complete.

In this paper, text mining is used for digging out the valuable information of government open information released by China MEE. By analyzing and summarizing this information, the timeline of MEE in epidemic prevention and control is sorted out, and the focus of MEE in the epidemic is identified and discussed. This study is a practice of using new method – text mining – to study environmental management. And the results of this article can provide a reference paradigm for the emergency environmental management of sudden epidemics in countries all over the world.

2. Methodology and data

The Python programming language is establishing itself as one of the most popular languages for machine learning, scientific computing and artificial intelligence. Its high-level interactive nature and maturing ecosystem of scientific package make it a good choice for exploratory data analysis (Pedregosa et al., 2011). Web crawler is a program or scripts that can crawling information from Internet according to certain rules (Wang et al., 2018). The requests package and bs4 package in Python can be used for gain information from the website as web crawler. Python's jieba package is a Chinese text segmentation (Jieba, 2020). It can efficiently divide a piece of Chinese text into several words according to its own dictionary and user-defined dictionary, which is widely used in Chinese participle (Peng et al., 2015; Liu et al., 2020). The counter subclass in the collections package can be used to count the frequency of the objects (collections, 2020).

This article reviews government public information on the website of China MEE. Use Python to obtain and clean the texts of news, notices, announcements, and other content in the "Environmental News" column in the website of China MEE (http://www.mee.gov.cn/). The operation process is as follows:

1) Text titles collection. Use Python 3.7 to get the titles of the environmental news released from January to September 2020 in MEE to prepare for text screening.
2) Text screening. Use the keywords "novel coronavirus pneumonia", "COVID-19", "medical waste", "resumption of work and production" to screen out articles related to COVID-19.
3) Word segmentation. Use jieba package to segment the selected articles. Since jieba is a dictionary based on the method of word segmentation, we build a new dictionary involves some proprietary vocabulary of environmental management such as "new crown pneumonia epidemic", "Ministry of Ecology and Environment", "medical waste", "medical wastewater", "epidemic prevention and control work", "emergency monitoring", "resumption of work and production", etc. We also define some unmeaning words as stopwords. The new-words dictionary and stop-words dictionary were used to segment the text.
4) Data statistics. Use the Python's collections package and numpy package to count the extracted words. Use spreadsheet software to save the results.

3. Result and discussion

3.1. Text information mining

3.1.1. Change in the number of articles

The change in the number of articles related to a certain job in the government's public information can indirectly show how much the government's emphasis on it. The "Environmental News" column of the MEE's website mainly publishes the work dynamics of MEE, news, announcements, and notices. It is the main channel for MEE to disclose information. We use Python to obtain all the articles published in the "Environmental News" column of the MEE from January 11 to September 30, 2020. There are 497 articles in total. Then we use keywords related to COVID-19 to select articles and 68 articles were screened out (Table 1). The first article related to COVID-19 appeared

Table 1
Categories and number of articles related to COVID-19.

Category	Number
News	46
Notice	6
Announcement	16

on January 22. It can be seen according to Fig. 1 that from January to September 2020, the percentage of articles related to COVID-19 in the environmental news in the total number of articles in the month showed a trend of first increasing and then decreasing, reaching the highest 50% in February, which means in February, half of the work updates released by MEE were related to the control of the new crown epidemic. Compared with the monthly rate of change in the number of people diagnosed with COVID-19 each month in China, it can be seen that February is the most severe period of COVID-19 pneumonia in China, and it is also the most important period of epidemic prevention and control.

3.1.2. High-frequency words and groups

Use Python to perform word segmentation and statistical processing on all articles related to COVID-19 published in the "Environmental News" column of MEE from January 11 to September 30, first we extracted the top 500 high-frequency words, and then manually select words. Incorporate synonyms, delete numbers, adjectives, adverbs, other modifier words, people's names, and place names (only Hubei Province and Wuhan City are among the top 500 high-frequency words). According to the meaning of the remaining words, eight groups can be divided: Environment and Ecology, COVID-19, Epidemic prevention and control, Environmental monitoring, Medical, Economic and Society, Pollution prevention, and Other environmental management. In a further screening of words, nouns that cannot be grouped, such as notices, announcements, and news, etc. are deleted, leaving 53 words in the end. A word cloud can be drawn from the number of occurrences of each word (Fig. 2), the number of words can be found in Table S.1. The size of the words in the picture is related to word frequency and word length. The larger the size of words of similar length, the higher the word frequency; the longer words of similar size, the higher the word frequency. The top ten words with the highest frequency are COVID-19, Work, Epidemic prevention and control, Medical waste, Environmental protection, Ecosystem, MEE, Conference, Ecology, Environmental monitoring. Combined with the analysis of the text, it can be concluded that the MEE in response to COVID-19, the main works are in the treatment of medical waste, environmental monitoring, and pollutant control. In the grouping of the above 53 words, it is found that some words have strong relevance in the two groups. We combined the analysis of the original text to establish the relationship between the groups through the number of words, as shown in Fig. 3, the contact matrix can be seen in Table S.2. Among them, the COVID-19 group only has one word "COVID-19", but it has a relationship with the other groups, so it is evenly divided among the remaining groups. The Environment and Ecology has a close relationship with Other environmental management, Pollution prevention, and Epidemic prevention and

Fig. 2. High-frequency words cloud.

control; Environmental monitoring has the closest relationship with Environment and Ecology. Routine environmental management includes environmental monitoring and pollution prevention. During the period of COVID-19, the focus of environmental management is on epidemic prevention and control. The relationship between Medical and Pollution prevention is relatively close because the treatment of medical wastewater and waste involves the treatment of pollutants. Epidemic prevention and control are most closely related to COVID-19. Besides, COVID-19 has a relationship with the Economic and Society, indicating that epidemic prevention and control is a common work of the whole society and has a relatively large economic impact.

Fig. 1. Change of COVID-19 related articles as a percentage of total articles and the monthly change rate of confirmed number in China from January to September.

Fig. 3. The relationship between different words groups.

3.2. Environmental management was taken by China MEE in response to COVID-19

Regarding environmental emergency management, existing studies have mostly focused on environmental emergency management in industrial parks (Shahab et al., 2018). Due to the low frequency and high uncertainty of major epidemics, there is no mature system for environmental emergency management for major epidemics (Dong et al., 2020). COVID-19 is a complex crisis with greater environmental risks (Saadat et al., 2020). Summarizing the environmental emergency management strategies during the epidemic is of great significance to improving the technical system and management system of environmental emergency management under public health emergencies. Based on the summary of MEE public open information and the results of the above-mentioned text mining, the following will start with the timeline of China's MEE response to COVID-19 and the main measures taken by them to introduce China's environmental management departments' response to major epidemics, with the hope to provide reference for environmental management to other countries.

3.2.1. Timeline of MEE in response to COVID-19

At the end of December 2019, a case of "unexplained pneumonia" was found in Wuhan, Hubei Province, China. The National Health Commission of China launched an investigation and officially announced that the virus can be transmitted from person to person on January 20, 2020. Immediately, Wuhan adopted lockdown measures. Other provinces across the country have also launched emergency responses. According to the information on the department's website, the MEE established a leading group for the response to the epidemic on January 20 to carry out overall planning for the response to the new crown pneumonia epidemic. From the end of January to the end of February, the country is in a critical period of epidemic prevention and control. MEE focused on the treatment and disposal of medical waste and wastewater and corresponding environmental monitoring. From late February to the end of March, the national epidemic situation was gradually brought under control. MEE continued to do well in the treatment and disposal of medical waste, wastewater, and environmental monitoring. At the same time, it issued and implemented emergency management measures such as a positive checklist for environmental impact assessment and for supervision and law enforcement to help

enterprise factories resumed work and production. In particular, the *Guiding Opinions on Coordinating the Control of Epidemics and Ecological and Environmental Protection for Economic and Social Development* released on March 3 planned the environmental protection work in epidemic control and economic and social development to ensure that the phased tasks of the battle for pollution prevention and control were completed. After the end of March, the domestic epidemic was under control, and the focus of national epidemic prevention and control has shifted to mainly target imported cases from abroad. The focus of MEE has also shifted to other tasks such as the battle against pollution under the normalization of epidemic prevention and control. The timeline of MEE in reponse to COVID-19 is shown in Fig. 4.

3.2.2. Treatment and disposal of medical waste and wastewater

MEE issued the *Notice on Doing well in Environmental Management of Medical Wastes in the Pneumonia Epidemic of New Coronavirus* ("the Notice" below) on January 21, requiring local ecological environment departments at all levels to do well in the prevention and control of environmental pollution in the collection, transportation, storage, and disposal of medical waste. For places where an epidemic has occurred, the Notice requires related departments to follow the relevant requirements of the *Medical Waste Management Plan for Responding to the H1N1 Influenza Epidemic* (HB [2009]65) to scientifically respond to and properly dispose of medical waste. Where no epidemic has occurred, it is necessary to pay close attention to the development of the epidemic and do well in the analysis and judgment of the form. Subsequently, MEE issued the *Management and Technical Guidelines for Emergency Disposal of Medical Waste Infected by the Novel Coronavirus Pneumonia (Trial)*; organized the compilation of *Questions and Answers Related to the Emergency Disposal of Medical Waste in Domestic Waste Incineration Facilities* for reference and implementation by localities. From February 11 to June 6, MEE announced the state of medical waste treatment nationwide every week (Fig. 5), subject to social supervision.

The main measures taken in improving the capacity of medical waste treatment include: raising mobile emergency disposal equipment, transforming hazardous waste treatment enterprises to participate in medical waste disposal, using domestic waste incineration power plants for co-processing, and building a new medical waste disposal center. At the beginning of the outbreak, some medical waste in Wuhan was temporarily stored and transported for disposal. Until
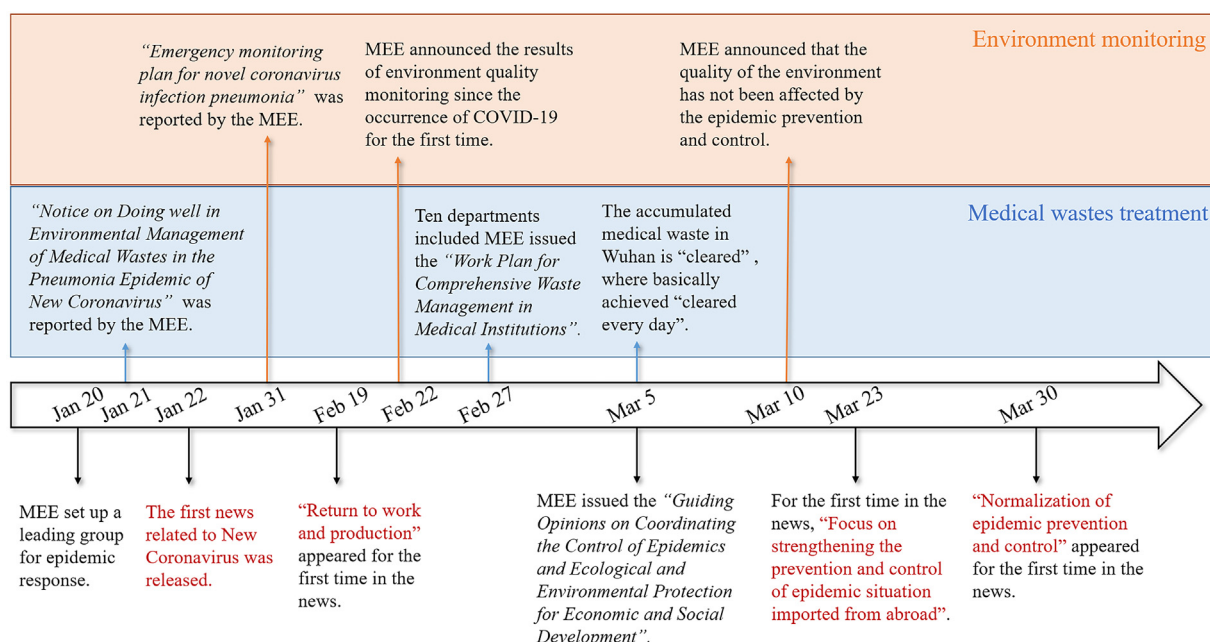

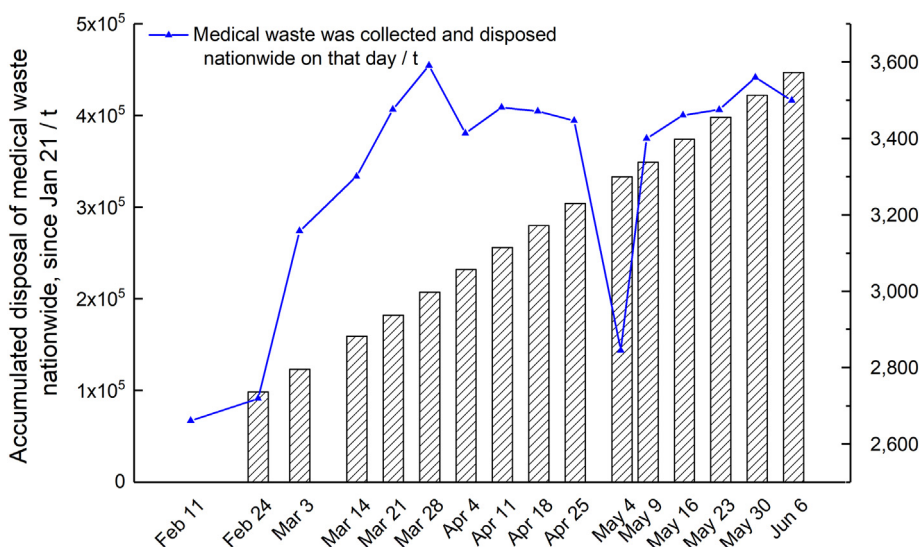**Fig. 4.** Timeline of MEE in response to COVID-19.

Fig. 5. Accumulated disposal of medical waste nationwide since Jan 21 and medical waste was collected and disposed nationwide on the day of every announcement.

March 5, the accumulated medical waste in Wuhan was cleared. From March 6, Wuhan's medical waste will no longer be transported for disposal. The hidden dangers of the transshipment process were eliminated. It can be seen from the Fig. 6 that in the early stage of the epidemic, the processing capacity of medical waste across China had the same upward trend as Hubei Province and Wuhan City. With the epidemic in Wuhan and Hubei Province under control, some border cities such as Mudanjiang City in Heilongjiang Province and Manzhouli City in Inner Mongolia Autonomous Region have increased the level of medical waste disposal due to increased import pressure from abroad, which has caused the national medical waste disposal capacity grows in volatility. As of mid-April, the national medical waste disposal capacity was 6074 t/d, an increase of 23.9% from before the epidemic.

To make up for the shortcomings in the disposal of medical waste and hazardous waste, the National Health Commission and MEE, and other 10 departments jointly issued the *Work Plan for the Comprehensive Treatment of Medical Waste*, requiring that by the end of this year, each prefecture-level city must build a standardized medical waste disposal site; by June 2022, all counties and districts across the country should form a scientific system of medical waste collection, transfer, and disposal, to realize the scientific, effective and safe collection, transfer, and disposal of all medical waste.

3.2.3. Environmental monitoring

Around January 31, MEE issued the *Emergency monitoring plan for novel coronavirus infection pneumonia*, clarifying that the focus of environmental emergency monitoring during the epidemic prevention and control period is to monitor the air and surface water environmental quality; strengthen early warning and monitoring of water sources place, especially the monitoring of additional indicators of epidemic prevention and control such as residual chlorine and biological toxicity. The plan also requires relevant departments to release environmental quality information and emergency monitoring results to the public through various media channels promptly to protect the people's right to know. From February 22, MEE simultaneously reported the environmental monitoring status of medical waste and wastewater across the country through its website.

Through the data of these announcements, it can be found that the concentration of China's main air pollutant $PM2.5$ from March to June decreased by 13–19% compared with the same period in 2019 (Fig. 7). There are lots of studies indicated that in the period of COVID-19 control, the air quality has been improved a lot, especially the particulates and NO_2 (Chen et al., 2020; Lokhandwala and Gautam, 2020; Ghahremanloo et al., 2021). This is mainly because countries have adopted epidemic control measures that restrict travel and the movement of people. Because of the reduction in travel, the use of motor vehicles, mainly gasoline vehicles, has decreased. Besides, changes in
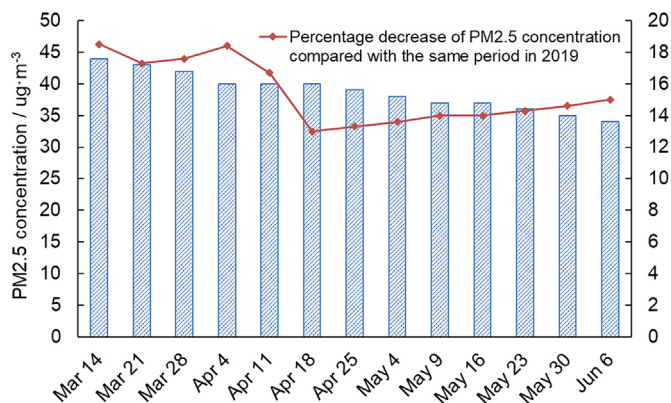

Fig. 6. Medical waste disposal capacity of different levels.

Fig. 7. PM2.5 concentration and the percentage decrease compared to the same period in 2019.

transportation activities and oil demand have also contributed to the improvement in air quality (Bar, 2020; Chen et al., 2020; Cheval et al., 2020). However, according to other news and announcements of MEE, during the epidemic period, the national O_3 concentration has raised. Ozone formation is driven by complex nonlinear photochemistry processes and is mainly controlled by VOC and NO_x emissions. Peralta et al. (2020) pointed out that the drastic reduction of NO_x could be the main reason for O_3 increase. Controlling the tropospheric O_3 concentration has become a key task of "Battle for the blue sky".

The monitoring results of surface water show that compared with the same period last year, the proportion of surface water I-III in the country has increased, about 7–9% (Fig. 8). The conversion of IV-V to I-III water is the main reason for the improvement of water quality. As of June 6, a total of 56,538 monitoring of drinking water sources have been conducted across the country. Residual chlorine was detected in some monitoring, but they were all lower than the effluent standard (0.3 mg/L) of water plants.

In general, according to MEE, the environmental quality of air and surface water, and the safety of drinking water sources place in China have not been affected by epidemic prevention and control.

3.2.4. Other environmental management

In addition to medical waste treatment and environmental monitoring, MEE has also promulgated and implemented other environmental management measures in response to COVID-19. On March 3, MEE issued the *Guiding Opinions on Coordinating the Control of Epidemics and Ecological and Environmental Protection for Economic and Social Development*, which established and implemented the positive checklist of environmental impact assessment (EIA) approval and the positive checklist of supervision and law enforcement.

The positive checklist of EIA approvals has been processed through the exemption of some project EIA procedures to help the project start construction. Its specific content is to strengthen the connection with the pollution discharge permit system; for projects in 10 categories and 30 sub-industries according to *Construction Project Environmental Impact Assessment Classification Management Directory*, which is related to people's livelihood and is included in the *List of Classification Management of Discharge Permits for Stationary Pollution Sources (2019 Edition)*, as well as social service industries, goods storage, logistics and distribution industries that do not involve toxic, hazardous and dangerous goods, will no longer be required to fill in the EIA registration form. Some industries related to people's livelihoods with the feature of overall controllable environmental impact, greater impact by the epidemic, and employment-intensive will be included in the EIA notification and commitment system approval reform pilot, including engineering construction, social service industries, manufacturing, animal husbandry, and transportation and many other fields. For key projects of resumption of work and production, large-scale pig breeding,
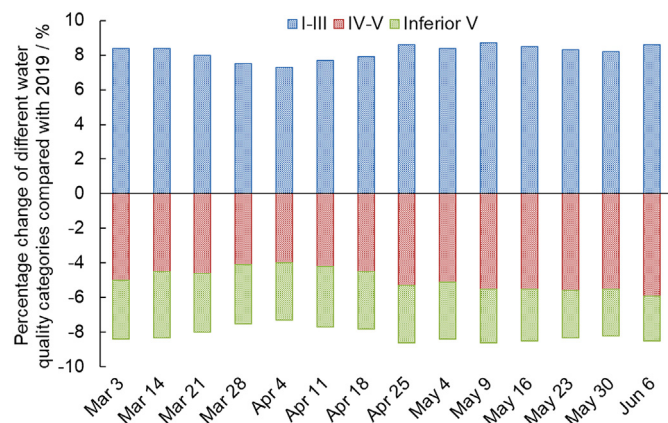
etc., environmental departments will take the initiative to provide environmental review and approval services. In the above process, the environmental departments at all levels are required to use innovative environmental assessment management methods, disclose basic environmental data, optimize management procedures, and realize "no-face-to-face" approval.

The positive checklist of supervision and law enforcement exempts some enterprises from on-site law enforcement inspections, sending a signal to the society that the environment department is willing to help enterprises that comply with environmental protection laws and regulations to overcome difficulties and achieve green development. The main content is: On-site law enforcement will not be carried out for companies that are closely related to the production of epidemic prevention and control materials and the protection of people's livelihood, have low pollution emissions, have a strong ability to absorb employment, and involve major projects and key areas of management practices and high environmental performance. Innovate supervision methods and off-site supervision methods such as remote sensing, drone inspections, online monitoring, video surveillance, energy use monitoring, big data analysis will be made full use in environmental inspections.

Environmental supervision policies should be adjusted and improved on-time following social and economic development and changes in the situation. The introduction of the positive checklist system is first to adapt to the epidemic prevention situation and promote the actual needs of enterprises to resume work and production. The launch of the inventory system is also exploring ways to optimize law enforcement and promote new models of classified management, providing ideas for improving environmental management efficiency.

The outbreak of COVID-19 also poses challenges to global environmental governance (Ibn-Mohammed et al., 2021). In the news released by MEE in September, international conferences on addressing global environmental issues, climate change, green recovery after the epidemic, and planning long-term low-carbon development strategies were reported. During the epidemic, the reduction in GHG emissions, the increased use of renewable energy, and the emergence of the advantages of the circular economy, all provide a direction for people to build a sustainable society. Whether it is dealing with the COVID-19 epidemic or global environmental issues, close international cooperation is required.

4. Conclusion

In response to COVID-19, MEE responded quickly and established a working group to carry out emergency environmental management as soon as possible. To sum up with, when responding to a major epidemic, the ecological environment department first handled the surge in medical waste, and at the same time conducted a large-scale environmental emergency monitoring, and then issued policies to promote social and economic recovery. Specifically, they formulated a work plan to improve medical waste treatment capacity, including raising mobile emergency disposal equipment, transforming hazardous waste treatment technology, making full use of life waste incineration power plants, and build new waste disposal centers, etc. In this epidemic, the national medical waste treatment capacity has increased by 23.9%. MEE organizes emergency monitoring of air and surface water, especially drinking water sources, to ensure that epidemic control wouldn't affect the environment. After the domestic epidemic situation was brought under control, MEE promulgated and implemented positive checklists of environmental impact assessment approvals and supervision and law enforcement to promote the resumption of work of industrial enterprises, which explore new models for improving environmental management efficiency.

Some problems have been discovered during the research of this article. Since text mining is still in its infancy and cannot cover different disciplines, text mining in the environmental field still lacks a

Fig. 8. Changes in surface water quality.

corresponding vocabulary. When using in a certain field, it is still a bit subjective. Therefore, it is necessary to continuously expand and improve the lexicon in future practice to provide efficient tools for environmental management research. Government public information is different from academic papers that have been peer-reviewed. It has a certain purpose and may have the problem of weakening negative information. This is a problem that needs attention in future research. Gray articles and research articles should be comprehensively analyzed, as comprehensive as possible. In addition, this article only sorts out the environmental management process during the epidemic from a macro perspective. Next, the implementation of the two checklists can be studied at the provincial and municipal levels to provide a theoretical basis for improving the efficiency of environmental management.

The impact of the epidemic is far-reaching. The world is currently experiencing a second wave of epidemics. The impact of the epidemic on environmental quality and environmental management models is worthy of further exploration.

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CRediT authorship contribution statement

Ailin Kang: Writing – original draft, Methodology, Data curation. **Lijun Ren:** Supervision, Writing – review & editing. **Chunyu Hua:** Validation, Visualization, Writing – review & editing. **Hui Song:** Validation, Visualization, Writing – review & editing. **Miaoxin Dong:** Validation, Visualization, Writing – review & editing. **Zhaotong Fang:** Data curation. **Mengyuan Zhu:** Data curation.

Declaration of competing interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.scitotenv.2021.145158.

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