

Research on the Application of Municipal Solid Waste Classification Based on Big Data

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Abstract: With the acceleration of urbanization and the surge in the amount of municipal waste generated, traditional waste treatment methods such as landfill, incineration and composting, although they have their advantages and disadvantages, can no longer meet the needs of resource conservation, environmental protection and sustainable development. As an effective way to alleviate this problem, the necessity and urgency of waste classification are becoming more and more prominent. This paper discusses the research on the application of urban living garbage classification based on big data technology, analyzes the advantages of big data technology in living garbage classification, introduces the relevant application examples, and puts forward the existing problems and challenges, hoping to provide some new ideas and thoughts for the future work of garbage classification and to promote the promotion and implementation of garbage classification work.

Keywords: Big Data; MSW; Waste Classification.

1. Introduction

The acceleration of urbanization and the concomitant improvement of living standards have resulted in a dramatic increase in urban domestic waste generated. As evidenced by data from the National Bureau of Statistics, the overall trend of domestic waste removal from 2013 to 2022 is an increase. Over a decade, the volume of domestic waste removal increased markedly, from 172.39 million tons to 244.45 million tons. This indicates a growing necessity for waste disposal services.

The conventional methods for the disposal of municipal waste encompass landfills, incineration, and composting. However, landfill treatment requires a significant amount of land resources, and the fermentation process produces methane and other greenhouse gases, which contribute to global warming and have a detrimental impact on the environment. Incineration can markedly diminish the volume of waste and the heat generated can be employed to produce electricity or heat. However, it necessitates rigorous monitoring of pollutant emissions, including dioxins and other toxic substances. While current technology allows for the elimination or control of dioxins generated during incineration to a sufficiently low safe level, challenges remain, including the unsuitability of mixed domestic waste for incineration and the high cost. Composting is an appropriate method for treating organic waste, including food scraps and plant cuttings. However, due to the presence of numerous non-degradable components in mixed waste, the sorting process is costly and the quality is difficult to guarantee. This makes the composting plant an economically unviable proposition, resulting in difficulties in maintaining it and ultimately leading to its closure [1].

The term "garbage" has been critiqued as a misplaced resource. A significant proportion of waste materials have the potential to be recycled or reused and thus retain economic and resource value. The separation of recyclables and hazardous waste from domestic waste through waste separation can result in a notable reduction in the quantity of waste requiring disposal, thereby alleviating the burden on waste treatment facilities. Through the implementation of

effective waste recovery and treatment strategies, it is possible to transform these "misplaced resources" into valuable resources or products, thereby achieving the recycling of resources and sustainable development. Therefore, the necessity and urgency of implementing a system of garbage classification is becoming increasingly apparent.

In recent years, China's government has attached great importance to the classification of household garbage and introduced a series of policies and measures to promote the popularization and implementation of garbage classification. In 2017, the Implementation Plan for the Domestic Waste Classification System forwarded by the General Office of the State Council had already proposed that mandatory classification of domestic waste should be implemented first within the urban areas of some key cities. Subsequently, since 2019, China has fully launched the classification of domestic waste in cities at the prefecture level and above across the country. The implementation of these measures aims to promote the formation of a garbage classification system based on the rule of law, promoted by the government, with the participation of all people, urban and rural integration, and adapted to local conditions, to achieve the goals of garbage reduction, resource utilization and harmlessness, and to promote the construction of ecological civilization and sustainable development. Nowadays, China's garbage classification system has basically realized the transformation from nothing to something, from disorder to order, and many cities have implemented garbage classification policies. In some cities, garbage classification collection, transportation and treatment facilities have begun to take shape, but overall, it is still in the development stage, and there are still many deficiencies that need to be improved. For example, some localities and the public do not have a good understanding of the importance of garbage classification and lack sufficient awareness of and participation in classification. Community governance capacity is weak, and the ability to mobilize and organize the public to participate in garbage classification is limited. At the initial stage of garbage classification, there were problems such as unclear classification, mixed loading and transportation, and low levels of resource utilization.

2. Advantages of Big Data Technology in Domestic Waste Classification

With the rapid development of information technology and the increasing demand for data processing, big data technology continues to develop and improve, gradually moving from theory to practice and being widely used in various industries. Big data technology can provide support for the monitoring and detection of municipal domestic waste, the investigation and enforcement of environmental protection departments, and the planning and execution of environmental governance [2]. Compared with traditional domestic waste classification, domestic waste classification based on big data technology has more significant advantages.

2.1. Improved Management Efficiency

Integration of intelligent sensor technology with big data analytics enables real-time monitoring of waste quantity and classification. This allows for comprehensive supervision of the entire waste management process, including delivery, collection, temporary storage, and transportation. Timely feedback is provided to city managers, facilitating effective oversight. By conducting a comprehensive examination of the manner in which residents dispose of their garbage, the types and quantities of garbage generated, and other pertinent data, it becomes relatively straightforward to ascertain the extent to which garbage classification has been implemented and to evaluate the efficacy of such classification in a more precise manner. The distribution of urban garbage exhibits temporal and spatial variability. There are notable discrepancies in the composition of domestic waste across diverse geographic and human environments, as well as across varying levels of urbanization [3]. The use of big data technology allows for the personalization of analysis across different regions, thereby assisting managers in the adjustment of management strategies and resource allocation, as well as the formulation of waste classification policies that align more closely with the actual situation.

2.2. Optimization of Resource Allocation

The big data platform, when combined with machine learning and computer vision technologies, is capable of recognizing a multitude of waste types and automatically classifying them, thereby reducing the necessity for manual intervention and improving the efficiency and accuracy of the classification process. By accurately classifying and recycling materials, more resources can be recovered, thereby reducing waste and pollution and promoting sustainable urban development. By analyzing historical garbage data and combining it with machine learning algorithms, big data models can predict trends in garbage generation, thereby facilitating a more comprehensive understanding of the situation and analysis of the underlying causes by city managers. Furthermore, relevant departments can adjust the frequency of garbage collection according to the layout and capacity of the garbage disposal facilities, as well as reasonably set the number and distribution of garbage bins. This optimizes the waste separation and recycling system, thereby improving the classification accuracy.

2.3. Enhancing Resident Engagement

The analysis of public classification habits, preferences, and participation levels can be conducted using big data platforms. Based on the analysis results, city administrators

can disseminate customized classification guides, tips, and educational materials to different groups in a targeted manner, thereby facilitating personalized education and publicity. Based on the findings of the data analysis, communities can implement point-based reward and incentive mechanisms. One such mechanism is a point system that awards residents for correctly sorting garbage. These points can then be exchanged for in-kind rewards or service discounts. Such a mechanism has the potential to significantly enhance the positive initiative of residents in garbage classification. Furthermore, the community can provide an online interactive platform for big data, utilizing charts, maps, and other forms of visual representation to illustrate the effects of classification. This allows residents to comprehend the positive impact of their efforts. Furthermore, residents may utilize the platform to submit inquiries, recommendations, and feedback about classification. By doing so, they can contribute to the resolution of issues and enhance interactivity and engagement.

3. Big data-based Application of Domestic Waste Classification

3.1. Building A Comprehensive Waste Data System

The first task of big data technology is data collection, and data collection is the basic link of big data applications. In the intelligent classification management of urban living garbage, the sources of data are diverse, covering Artificial Intelligence of Things (AIOT) devices, information collection technology, and manual collection and reporting. Data collection involves multiple dimensions, such as the source of garbage generation, type of garbage, quantity of garbage, time and place of putting garbage, etc. The more dimensions there are, the more comprehensive the analysis of garbage classification will be. With the help of smart garbage cans, IoT sensors, video surveillance and other devices, we can collect key data such as the amount of garbage and the status of waste classification in real time and accurately. Through mobile apps, smart cards and other means, we can also collect data on residents' waste-sorting behavior to understand their sorting habits and preferences. Combining data on external factors such as weather and holidays allows further exploration of information such as the impact of these factors on waste generation. Different data collection methods can obtain more diverse data, build a more comprehensive waste data system, and obtain more integrated information.

3.2. Improve Data Quality and Availability

Collected raw data often have problems such as missing, anomalies, duplicates, etc., and need to be preprocessed to improve data quality and usability. The preprocessing steps include data cleansing, data integration, data transformation, and data statute. Data cleansing is mainly designed to detect and correct or delete erroneous data records. Data usability is ensured through specific operations such as removing invalid data, filling in missing values, and handling outlier data. Data integration combines data from multiple data sources to obtain a more comprehensive data set. Data transformation is the process of converting raw data into a form suitable for analysis or modeling. Data Statute technology, which compresses and refines massive amounts of data to reduce the complexity and cost of subsequent analysis. These steps can improve the quality of the data set, maintain the consistency

of the data set, and make it more suitable for subsequent analysis.

3.3. Digging into the Deeper Rules of Waste Classification

Data analysis is the core link of big data technology. In urban living garbage classification, the pre-processed data can be analyzed in depth through data mining, machine learning, deep learning and other technical means. For example, by using association rule mining technology, it is possible to find out the putting pattern and correlation relationship between different garbage types; through clustering analysis, it is possible to classify the garbage classification behaviors of citizens into different patterns, to formulate a more accurate classification strategy; with the help of time series analysis, it is possible to predict the amount of garbage generated and the distribution of garbage types in the future period, to provide scientific basis for the garbage collection and treatment. It can also be combined with GIS technology and BP neural network to realize the monitoring and early warning of pollutant emissions from facilities, quickly locate and identify pollution problems, and remind the relevant departments to solve the problems in time [4]. By analyzing different datasets, we can extract valuable information and continuously explore the potential laws hidden in them.

3.4. Innovative Waste Separation Management Model

The practice of applying big data technology is the key to empowering urban household waste classification. Based on the results of data analysis, we can innovate the management mode and method of garbage classification. For example, we can develop an intelligent garbage classification system to guide citizens to put garbage correctly through image recognition and voice recognition technology. We can also establish a garbage classification supervision platform to monitor garbage classification in real-time, and detect and correct irregularities in a timely manner. Through feedback from data analysis, we can optimize the routes and schedules of garbage collection and transportation, and improve the efficiency of garbage collection and transportation and the quality of service. In addition, we need to continue to deepen the integration of big data technology and garbage classification business, and promote the in-depth development of garbage classification through technological innovation and model innovation.

4. Challenges

4.1. Data Collection and Quality

Since waste management involves many departments and sectors, the data sources are very diverse. It is difficult to collect and process data, and today's data collection technology for waste classification needs to be improved. To solve this problem, we need to establish a comprehensive data collection and analysis system. If the data between different departments or organizations are not interconnected, the so-called "data silo" phenomenon, or "data barriers", may be formed [5]. Therefore, it is very important to strengthen cross-sectoral cooperation and coordination. It is necessary to establish a cross-sectoral working mechanism and information-sharing platform to prevent the emergence of "data barriers". At the same time, it is also necessary to strengthen the training and education of relevant personnel to

improve data literacy and analytical ability to ensure the quality of data collection.

4.2. Data Privacy Protection

In the current era of extensive data collection, the issue of data privacy protection has consistently emerged as a significant concern, including in the context of household waste sorting. The protection of residents' privacy from disclosure is a pivotal and significant concern when collecting and utilizing data about residents' garbage disposal. It is therefore imperative that the utilization of big data technology be accompanied by the establishment of rigorous data security protection mechanisms. For instance, encryption, anonymization, differential privacy protection, data access control, and other technical measures are employed to safeguard personal privacy throughout the data lifecycle, including collection, transmission, storage, and utilization [6]. Furthermore, public awareness of personal privacy protection is on the rise. As a result, it is imperative to establish transparent data use regulations, bolster public trust in big data applications, and encourage active public participation in the utilization of big data technology for waste classification.

4.3. Technical and Financial Inputs

The implementation of big data technology is a challenging undertaking. Moreover, the majority of big data technologies are integrated with sophisticated sensors, image recognition capabilities, and other advanced technologies. The deployment of these technologies necessitates a substantial initial investment in technology and capital. The high costs associated with big data technology make it challenging for many regions to support such expenses, which in turn limits the widespread adoption of big data technology across a diverse range of regions. Consequently, governments and enterprises must augment their investment, advance technological innovation and industrial upgrading, and diminish equipment costs. Concurrently, regions must enhance their capacity for exchange and collaboration with global frontiers of technology, facilitating the introduction and assimilation of advanced technological outcomes to elevate their technological standing.

5. Conclusion

The advent of big data technology has given rise to novel concepts and methodologies for the classification of urban waste. The implementation of big data technology can address the limitations of traditional garbage classification methods, including low accuracy and poor efficacy. Furthermore, it can facilitate the advancement of urban garbage management practices to a more scientific and refined level. For the relevant departments, big data technology will serve as a crucial tool in the implementation of waste classification. For the general public, the implementation of big data technology will facilitate the process of garbage classification, thereby enhancing their willingness to engage in this activity. The implementation of waste classification will undoubtedly result in a significant improvement in the utilization of resources and a reduction in environmental harm. Furthermore, big data technology serves as an invaluable aid in the field of garbage classification. It is anticipated that as big data technology continues to evolve and advance, the challenges it currently faces will be progressively addressed, the associated policies will become increasingly refined and detailed, and the waste classification

process will become more intelligent and efficient. The role of big data technology in promoting green urban development and the construction of an environmentally conscious China will continue to expand.

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