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A Comprehensive Community Environmental Health Improvement Model Oriented Towards Environmental Equity

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Abstract: This paper, based on the foundational principles of community environmental governance and the critical concept of "environmental equity," systematically combines multiple operational aspects to construct a comprehensive community environmental health improvement model. Specifically, it integrates the extension of traditional sanitation management into smart property management, community solid waste resource utilization, artificial intelligence empowerment, and carbon emission reduction coordination. Guided by the balanced protection of residents' environmental rights and the pursuit of sustainable urban living, the proposed framework utilizes front-end micro-environmental governance within property management as a primary strategic approach. Furthermore, it leverages end-of-pipe sanitation resource utilization as essential structural support, while deploying advanced digital platforms and smart technological systems as operational tools. Together, these elements form a highly efficient closed-loop mechanism characterized by "front-end identification, mid-end collaboration, end-of-pipe disposal, and feedback optimization." This innovative paradigm actively promotes the fundamental transformation of community environmental services from extensive, superficial cleaning to comprehensive, data-driven operation. It shifts the focus from reactive end-of-pipe remediation to proactive whole-process governance, transitioning from average resource supply to strictly equitable supply. Ultimately, the model elevates simple sanitation improvement to holistic public health promotion, emphasizing green recycling and broad social collaboration. The proposed strategic path can be effectively utilized by policymakers and stakeholders to promote green property management, significantly improve community environmental health outcomes, and substantially enhance the overall urban grassroots governance system.

Keywords: environmental justice; community health; smart sanitation; waste utilization; carbon reduction; urban governance

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1. Introduction

With the continuous advancement of urban renewal, modernization of grassroots governance, and the "dual carbon" goal, communities are no longer merely places for residents to live. They are gradually evolving into carriers for providing public services, ecological civilization construction, and social governance innovation. The quality of the community environment is closely tied to residents' quality of life and has significant implications for public health, lifestyle changes, and social equity [1]. Traditionally, community environmental governance focused on basic tasks such as cleaning, garbage collection, and maintaining sanitation order. However, as residents' needs and governance approaches have evolved, the scope of environmental governance has expanded significantly. It now includes aspects such as household waste sorting, kitchen waste resource utilization, public space sanitation risk control, protection of the environmental rights of special groups, digital supervision, and the construction of a low-carbon circular system. Despite these advancements, older, densely populated communities and those with relatively weak infrastructure continue to face persistent challenges. These include untimely garbage collection, severe odor pollution, recurring

unsanitary areas, low resource recycling rates, and uneven environmental service quality. Traditional property management services primarily focus on order maintenance and basic cleaning, while end-of-pipe sanitation efforts are limited to collection and disposal. This disconnect in responsibility coordination, process linkage, and technological collaboration hinders the establishment of a closed-loop approach to community environmental governance. In this context, integrating professional sanitation management experience into the property management sector and incorporating end-of-pipe governance capabilities into the front-end of community micro-environment governance becomes essential. This approach should be coordinated with digital technology, resource recycling, and environmental equity principles to enhance community environmental health. Therefore, this paper explores a "comprehensive community environmental health improvement model oriented towards environmental equity." It aims to identify a community environmental governance path that achieves fairness, efficiency, health, and low-carbon goals through the integration of front-end property management, end-of-pipe sanitation collaboration, smart system support, and resource-based operation.

2. Current Challenges in Community Environmental Health Governance

2.1. Long-Term Separation between Front-End Property Management and Back-End Sanitation, Insufficient Closed-Loop Community Governance

Most community environmental governance continues to operate in a relatively fragmented and decentralized manner [2, 3]. Property management companies are tasked with responsibilities such as daily cleaning, maintaining order, and managing garbage collection points. Meanwhile, the sanitation system oversees garbage collection and disposal. Although this division of labor appears clear, it lacks effective coordination and integration. Property management, being closer to residents' daily lives, is better positioned to identify issues such as excessive garbage accumulation, unpleasant odors, improper disposal practices, unsanitary corners, and accessibility challenges for special groups. However, these entities often lack the capacity to address critical aspects such as improving the quality of solid waste classification, integrating resources, and coordinating end-of-life waste disposal. On the other hand, the sanitation system, characterized by its standardized operations and large-scale collection and disposal capabilities, often reacts passively to problems after they arise. This reactive approach makes it challenging to address and maintain the micro-environment within communities in a timely manner. The absence of a unified information platform, an efficient scheduling mechanism, and a clear responsibility loop between the front-end property management and back-end sanitation systems exacerbates these challenges. As a result, garbage sorting efforts frequently remain superficial. For example, kitchen waste often faces issues such as broken bags, leakage, unpleasant odors, and improper mixing at the community level. This prevents the timely identification and diversion of the resource value of recyclables and organic waste. Consequently, community environmental governance often appears to be "busy with appearances at the front end and busy with results at the back end," leading to significant investments of manpower and resources without achieving a stable, efficient, and cost-effective governance chain.

2.2. Solid Waste Management Still Focuses on Collection and Transportation, with Relatively Weak Resource Recycling Capabilities.

From the current management status of many communities, the garbage issue primarily revolves around "removal" rather than comprehensive "management." In evaluating property services, the focus is often placed on whether public spaces are kept clean, garbage bins are emptied on schedule, and resident complaints are minimized. However, this approach frequently overlooks critical aspects such as the accuracy of garbage sorting, the separate collection of kitchen waste, the recycling of reusable materials, and the effective resource utilization of organic waste. Community solid waste management continues to rely heavily on traditional models that prioritize end-stage

pressure transfer, while neglecting the importance of front-end waste reduction and mid-stream coordination. As a result, recyclable and regenerable materials are often mixed into general household waste streams, leading to significant resource wastage and heightened environmental stress. Kitchen waste, in particular, poses a major challenge due to its high water content, rapid decomposition, and strong odor. Insufficient front-end management in communities exacerbates collection pressures, increases the risk of secondary pollution, attracts pests such as mosquitoes and flies, and fosters conflicts among residents [4]. This outdated "cleaning-transfer" logic fails to achieve true green governance and remains disconnected from the broader goals of low-carbon community development. A shift toward more integrated and sustainable waste management practices is essential to address these persistent challenges effectively.

2.3. Significant Disparities in Environmental Services and Insufficient Fairness

While community environmental governance is often perceived as a public service, its practical implementation reveals significant disparities in investment, service delivery, and governance outcomes. Newly constructed residential communities, model areas, or key demonstration zones with high management standards typically benefit from more advanced waste sorting facilities, frequent cleaning schedules, and faster response mechanisms. In contrast, older neighborhoods, suburban regions, densely populated rental zones, and peripheral public spaces frequently face challenges in waste management due to inadequate resources and attention. Furthermore, disparities in access to environmental services among different demographic groups exacerbate these inequities. For instance, elderly individuals often encounter difficulties in waste disposal due to mobility constraints or poorly designed facilities located at inconvenient distances [5]. Similarly, children's activity areas that lack enhanced cleaning and disinfection measures pose direct risks to their health and safety. Additionally, the working conditions, occupational exposure risks, and safety measures for frontline workers, such as cleaners and waste sorting supervisors, are frequently neglected. Achieving environmental equity requires more than just equalizing resources; it necessitates addressing the actual disparities in environmental risk tolerance and service accessibility across various regions and populations. Failure to consider these factors means that even if superficial cleanliness is achieved, underlying inequities persist, undermining the broader goals of fairness and inclusivity in environmental governance.

2.4. The Phenomenon of "Emphasis on Platforms, Neglect of Applications" in Digital Construction

In recent years, smart property management, smart sanitation, and grid-based platforms have been increasingly integrated into community governance frameworks [6]. Despite their theoretical potential to revolutionize environmental governance, many systems remain limited to basic functionalities such as record-keeping, data visualization, and performance assessment. These platforms often fail to translate their capabilities into actionable processes that address practical challenges. For instance, issues like water accumulation in garbage bins, unpleasant odors, frequent complaint hotspots, mismatched waste collection schedules, and weather-related disruptions are theoretically solvable through advanced data analysis and intelligent early warning mechanisms. However, in practice, these problems continue to rely heavily on human judgment and reactive measures. Furthermore, the vast amounts of data collected by these systems are often underutilized, with limited application in optimizing cleaning routes, allocating resources efficiently, coordinating transportation at the end of the line, or evaluating fairness in service delivery. As a result, digitalization frequently devolves into mere "visible tables" and "excessive screenshots," failing to support informed management decisions or enhance front-line governance. Consequently, the potential of smart technology to improve resident experiences and streamline community environmental governance remains largely untapped.

3. Construction of a Comprehensive Community Environmental Health Improvement Model Oriented Towards Environmental Equity

A comprehensive community environmental health improvement model oriented towards environmental equity should be grounded in principles of fairness guarantee, health promotion, digital empowerment, green recycling, and continuous optimization. This model aims to construct a systematic framework encompassing front-end identification, mid-level scheduling, end-of-line treatment, and feedback improvement. At its core, environmental justice serves as the guiding value, influencing the allocation of governance resources, the identification of critical areas, and the protection of environmental rights for diverse groups. Front-end property management plays a pivotal role, encompassing daily environmental inspections, waste sorting, sanitation of collection points, and maintenance of community public spaces. Additionally, it involves end-of-pipe sanitation coordination supported by smart systems to enhance efficiency. Resource utilization and low carbon emissions act as essential extensions, fostering a synergistic relationship between community environmental improvement and sustainable green development. This approach transcends the replication of existing work processes, focusing instead on re-engineering governance logic. It broadens the scope of community environmental issues from end-of-pipe collection to full-process operational matters, while shifting the emphasis of environmental health from outcome-based indicators to comprehensive governance process management goals. By integrating these elements, the model ensures a holistic and equitable approach to community environmental health improvement.

3.1. Front-End Property Management Micro-Environment Governance: Embedding Environmental Management into Residents' Daily Life Scenarios

Through this model, the role of front-end property management evolves from merely cleaning and waste removal to a more comprehensive community micro-environment operation framework centered on environmental health. This approach requires property management to undertake a variety of functions, including maintaining sanitation at waste collection points, conducting risk inspections in public spaces, ensuring proper waste sorting practices, enhancing cleanliness in critical areas, providing guidance to residents, and responding promptly to abnormal situations. Differentiated patrols should be implemented in specific locations such as densely populated buildings, elevator lobbies, entrances and exits of underground parking garages, children's activity areas, elderly activity zones, and less frequented back street corners. Special attention must also be given to the needs of vulnerable groups, such as addressing excessively long disposal routes for elderly residents, ensuring accessibility for individuals with disabilities, and verifying that children's activity spaces adhere to higher safety and environmental standards. By embedding these practices into daily operations, property management companies can effectively integrate environmental equity into their services, transitioning from traditional logistics providers to proactive operators of community environmental health systems [4, 7].

3.2. Mid-Level Digital Collaborative Scheduling: Enabling Smart Systems to Truly Participate in Governance Decision-Making

The application of digital technology in environmental governance models holds transformative potential, shifting the paradigm from reliance on experience-based judgment to robust, data-driven decision-making. Communities can leverage smart property management platforms and advanced sanitation systems to systematically collect and analyze critical data, including garbage disposal volumes, overflow frequencies at disposal points, classification accuracy rates, high-complaint zones, operational routes, collection time alignment, and the efficiency of abnormal event handling. By employing artificial intelligence, trend analysis, and intelligent early warning mechanisms, recurring environmental issues can be identified and addressed proactively. For instance, during periods of high temperatures, the frequency of cleaning and sealing at kitchen waste collection points can be increased to mitigate odor and

hygiene concerns. Similarly, transportation capacity can be pre-adjusted in anticipation of peak waste disposal demands before and after holidays, while targeted inspections and coordination efforts can be intensified for high-complaint buildings, particularly in older residential areas. Furthermore, digital systems enable the assessment of environmental service equity by comparing data across regions, timeframes, and categories. This facilitates the identification of imbalances in resource allocation and potential biases in response strategies. As a result, the concept of "environmental fairness" evolves from an abstract ideal into a tangible, measurable, and actionable governance standard, fostering more equitable and effective environmental management practices.

3.3. End-Of-Life Solid Waste Resource Utilization: Achieving Synergy between Environmental Health and Low-Carbon Goals

Improving community environmental health requires a comprehensive approach that goes beyond front-end cleaning efforts. Strengthening end-of-life waste classification and resource utilization capabilities is essential for achieving sustainable outcomes. After household waste, kitchen waste, recyclables, and other materials are separated at the source, they must be collected and transported in a standardized manner. This ensures that different types of waste are treated appropriately and integrated into a more efficient resource recycling system. Particularly in the management of kitchen waste and other organic materials, it is vital to highlight their potential for resource recovery. Specialized collection methods, sealed transportation systems, and advanced resource recovery technologies can significantly reduce pollution caused by odors, leaks, and vector-borne diseases within communities. By transforming waste from an "environmental burden" into a "circular resource," the overall perception of community hygiene can be improved, while simultaneously promoting carbon reduction and fostering green lifestyles. From a practical standpoint, the effective integration of end-of-pipe resource recovery processes with front-end property management practices is crucial. This linkage enables community environmental health improvements to extend beyond basic sanitation measures, generating multifaceted benefits that encompass ecological sustainability, economic efficiency, and enhanced social value.

4. Implementation Path of Comprehensive Community Environmental Health Improvement Oriented Towards Environmental Equity

4.1. From Average Supply to Differentiated and Equitable Governance

Environmental equity does not imply that all regions or communities should receive identical resources or services. Instead, it emphasizes the need for targeted governance strategies that address the specific risks, conditions, and priorities of different areas and populations [8, 9]. To effectively promote community environmental health improvement, it is essential to move beyond the "one-size-fits-all" approach of uniform service provision and adopt a model of differentiated and precise governance. For instance, in communities with a significant aging population, efforts should focus on enhancing the convenience of waste disposal systems and ensuring the availability of nearby services to meet their mobility constraints. In areas with a high concentration of children, sanitation inspections and vector control measures should be intensified to safeguard their health. Similarly, densely populated rental zones and periods of peak waste disposal demand require optimized layouts for disposal points and adjusted collection schedules to prevent overcrowding and inefficiency. Furthermore, the working conditions of frontline personnel, such as cleaners and waste sorting supervisors, must be improved to minimize occupational exposure risks and enhance their overall well-being. By integrating the diverse needs of various demographic groups and spatial contexts into governance frameworks, environmental services can transition from superficial universal coverage to genuinely equitable and effective service delivery.

4.2. From Cleaning-Oriented to Solid Waste Operation-Oriented

Community environmental governance requires a paradigm shift from focusing solely on "cleanliness outcomes" to adopting a comprehensive "whole-process solid waste operation-oriented" approach [10–12]. This transition emphasizes not only the visible cleanliness of public spaces and the state of trash receptacles but also the entire lifecycle of waste management. It involves understanding the origins of waste, implementing effective sorting mechanisms, ensuring efficient transfer processes, and integrating waste into resource recycling systems. Property management companies play a pivotal role by overseeing classified supervision, providing behavioral guidance, and managing collection sites. Community organizations are essential for coordinating awareness campaigns and mobilizing residents to participate actively in waste management initiatives. Meanwhile, sanitation systems must ensure the proper classification, collection, transportation, and feedback mechanisms to address abnormalities. Special attention should be given to kitchen waste, which necessitates a standardized system for separate collection, prompt removal, secure containment, and resource utilization. This prevents kitchen waste from becoming a high-risk factor for community environmental health. By transitioning from merely "disposing of waste" to "managing solid waste effectively," communities can achieve sustainable environmental health and foster long-term ecological balance.

4.3. From Experience-Based Management to AI-Empowered Governance

As governance systems evolve to address increasingly intricate challenges, traditional methods such as manual labor and routine inspections are proving insufficient for advancing community environmental health management. The integration of AI into governance processes is not intended to replace human involvement but rather to enhance managerial capabilities by enabling earlier identification of issues, optimizing resource allocation, and mitigating risks more effectively. Through the analysis of waste disposal trends, complaint concentration zones, operational cycles, and seasonal fluctuations, digital platforms can generate automated alerts that pinpoint vulnerabilities in governance and identify high-risk periods. This allows property management and sanitation departments to implement more strategic and efficient operational plans. Additionally, AI can detect recurring problem areas, facilitating a shift from reactive service models to proactive prevention strategies. Crucially, under the principle of environmental equity, AI systems should prioritize not only the most efficient locations but also underserved areas that have historically been neglected. By leveraging data to promote fairness rather than superficial performance metrics, AI can contribute to more inclusive and equitable governance outcomes.

4.4. From a Single Hygiene Goal to a Synergistic Goal of Health, Low Carbon, and Equity

Improving community environmental health should not merely aim for a visually clean and orderly environment but should also address the broader dimensions of residents' physical and mental well-being, resource recycling efficiency, carbon emission reduction, and social equity [13]. In essence, community governance must evolve into a comprehensive system of objectives encompassing "hygiene improvement---health promotion---resource recycling---low-carbon development---equitable sharing." Achieving this requires community leaders to balance cost and efficiency considerations with environmental benefits, social impacts, and long-term sustainability when designing governance strategies. For instance, while increasing investment in the resource recovery of kitchen waste may initially pose challenges in terms of management complexity, it offers significant long-term benefits, such as reducing pollution risks, enhancing resource utilization, and fostering the development of low-carbon communities. Furthermore, prioritizing environmental protection for vulnerable groups, though seemingly a matter of service refinement, plays a critical role in enhancing the inclusiveness and public value of community governance. By adopting a multi-objective collaborative approach, the concept of environmental justice can be effectively translated into actionable outcomes. This, in turn, paves the way for higher-quality development in community environmental

health, ensuring that progress is both sustainable and equitable for all stakeholders involved.

5. Conclusion

The comprehensive community environmental health improvement model oriented towards environmental justice represents a significant advancement over traditional approaches to community sanitation management. This model transcends the conventional understanding of community environmental governance as merely cleaning and waste removal, instead integrating multiple dimensions such as front-end micro-environmental management within property services, end-of-pipe sanitation disposal, digital collaboration, resource recycling, and fairness guarantees into a cohesive framework. The paper identifies critical challenges in current community environmental governance, including incomplete governance chains, inefficient resource utilization, limited digital empowerment, and inequities in environmental service access across regions and demographic groups. By placing environmental equity at its core, this model advocates for transformative changes: property services should evolve from basic cleaning operations to environmentally healthy management practices; end-of-pipe sanitation should shift from simple waste disposal to resource-based solutions; digital platforms should advance from mere record-keeping tools to comprehensive governance and decision-making systems; and community environmental goals should expand from achieving cleanliness to promoting overall health, emphasizing green development, low-carbon initiatives, and equitable resource sharing. This innovative model not only addresses residents' growing demand for high-quality living environments but also provides a strategic pathway for advancing green property development, enhancing grassroots social governance, and modernizing urban environmental management systems. Looking ahead, the maturation of smart technologies, resource-based innovations, and collaborative community mechanisms will further refine and expand the applicability of this model. As these advancements progress, this comprehensive approach, grounded in environmental equity, is poised to become a scalable and replicable solution for diverse community types, fostering sustainable and inclusive urban development.

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