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# Review and Research on Medical Waste Recycling Network

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**Abstract:** The mass production of medical wastes has tested the safety of urban public health, and the recovery and disposal of medical wastes is imminent. Under various environmental backgrounds, such as the sudden increase in the number of medical wastes, the late start of the medical waste recycling industry in China, the low disposal rate, and the improper treatment of medical wastes affecting the environment and personal safety, medical wastes should be managed in a timely and standardized manner, and effective strategies should be put forward to minimize the environmental pollution caused by medical wastes. Therefore, in recent years, this paper studies the optimization of medical waste recycling network and summarizes the current research status of medical waste recycling network in academic circles.

**Keywords:** Medical waste, Literature Review, Recycling Network, Site Selection, Path Optimization.

## 1. Introduction

Medical wastes refer to wastes with direct or indirect infectivity, toxicity and other hazards generated in medical treatment, prevention, health care and other related activities in medical and health institutions. With the rapid development of medical technology, the amount of waste produced by medical activities is also increasing. These medical wastes not only contain a lot of harmful substances, but also may carry various pathogens, posing a serious threat to the environment and human health. Therefore, the management of medical waste recycling has become an important problem to be solved urgently in today's society. Medical waste recycling network refers to a systematic network specially designed for the collection, transportation and treatment of medical waste. This network consists of a series of interrelated components, including medical waste sources (such as hospitals, clinics and other medical institutions), collection points, transshipment systems, treatment facilities and supervision and monitoring mechanisms. This paper aims to sort out the current research trend of medical waste recycling management and summarize the characteristics of its research, in order to provide useful reference for the optimization research of medical waste recycling network.

## 2. Organization of the Text

### 2.1. Multi-criteria decision-making method for medical waste

Multi-criteria decision-making method of medical waste is a method that comprehensively considers multiple factors to seek the optimal medical waste management strategy. This method aims to balance environmental protection, human health, economic benefits and social responsibilities, and ensure that medical wastes are treated scientifically, safely and efficiently. The research on this aspect is as follows:

Yu wenyu[1]A multi-granularity hesitant fuzzy language group decision-making method with incomplete weight information which can be applied to the selection of medical waste treatment technology is proposed. Aung[2]The multi-criteria decision-making method is used to evaluate the medical waste in Myanmar, and the feasibility of the proposed framework method for medical waste management evaluation is verified. Simic[3]By combining the recursive feature elimination algorithm of random forest with Fermatean fuzzy environment, etc., an advanced decision support system method based on multi-stage model is proposed for the location selection of medical waste disinfection facilities. Zhao[4]Life cycle assessment method is used to evaluate the emergency treatment scheme of medical waste generated during the epidemic period, so as to select the treatment method with the least impact on the environment. Liu[5]A multi-criteria group decision-making method based on intuitionistic fuzzy set (IFSs) and VIKOR method was proposed to evaluate the capacity of medical waste recovery channel in COVID-19.Chen[6]The multi-granularity fuzzy language information fusion is studied, and the conversion method of membership language term set from target granularity to original granularity is put forward, and this method is applied to the selection of medical waste treatment technology.

### 2.2. Medical waste recycling network construction

The construction of medical waste recycling network is a complex process involving many links and levels, and its core goal is to ensure the safe, efficient and environmentally friendly disposal of medical waste. It mainly includes: site selection of treatment facilities/recycling centers and route optimization of medical waste transport vehicles. The corresponding research is as follows:

Donggandong[7]Aiming at different types and treatment technologies of medical wastes, considering the matching of treatment technologies and the processing capacity of network nodes, a multi-objective mixed integer programming model with minimum cost and risk is constructed, and a feasible solution is obtained by comparing linear weighted summation method, augmented constraint method and augmented weighted Chebyshev method. Wuε[8]A vehicle routing problem (PCGVRP) model focusing on medical waste collection is introduced. The optimal solution is

obtained by using local search hybrid algorithm (LSHA), which includes the initial optimal solution based on particle swarm optimization (PSO) and the final optimal solution by local search, and the initial optimal solution is optimized by SA algorithm. Yu[9]A multi-objective and multi-period mixed integer programming was put forward for the design of epidemic reverse logistics network, and it was applied in Wuhan, China. This study tried to determine the best location of temporary facilities and the transportation strategy for effective management of medical waste in a relatively short time. Chen[10]During the epidemic in COVID-19, a non-contact joint distribution service VRP was proposed, and a hybrid meta-heuristic algorithm was designed to solve it. Tirkolaee[11]A new multi-objective MILP model was developed to establish the sustainable LRP of MWM during the COVID-19 pandemic, and the applicability of the proposed model in the actual case study of Iran was investigated by using the weighted goal programming (WGP) method. Yao[12]Considering the Stackelberg game between local government and medical institutions, etc., a double-level equilibrium optimization model for risk mitigation is developed for the soft path solution of medical waste treatment center location. Yangling gull[13]This paper puts forward the decision-making method of twice AP clustering location of temporary medical waste warehouse and the location method of SEIR infectious disease diffusion model to establish the collaborative optimization model of temporary medical waste disposal warehouse and centralized disposal center under epidemic situation. Liu Xiaoyan[14]Considering the re-use of recyclable resources in medical waste, in order to achieve a win-win situation of economic and social benefits, a bi-level programming model is established to establish path optimization considering cost and risk. Yue Li[15]This paper analyzes the present situation and problems of medical waste treatment in remote areas in China, and puts forward a targeted management model of medical waste in remote areas in view of the objective conditions, transportation distance, technology and other factors existing in remote areas. Wang[16]Considering the economic and environmental benefits comprehensively, a multi-objective and multi-period mixed integer programming model is established to solve the problem of location selection of medical waste recycling facilities, and lingo is used to solve it. Tirkolaee[17]It is pointed out that the generation of medical waste can vary according to the size of the city, and it is suggested that the municipal government outsource the recovery of medical waste in different areas, so as to build a dual-objective mixed integer linear programming (MILP) model and use CPLEX to solve it. Liu[18]In order to improve the transportation efficiency of medical waste from hospital to treatment station, combined with the actual situation of COVID-19 epidemic situation and environmental impact assessment guidelines, the ant colony-tabu hybrid algorithm was used to simulate and test the transportation efficiency of medical waste between hospital and temporary storage yard, thus solving the problem of medical waste disposal based on temporary storage station. Shadkam[19]The cuckoo optimization algorithm is used to design the integrated direct logistics and reverse logistics network, and the effectiveness of the algorithm is designed and verified with the focus on COVID-19 vaccine residue.

## 2.3. Uncertainty in the medical waste recycling network

Because the generation of medical waste is influenced by many factors, such as seasons, epidemics and aging, it is difficult to accurately predict the generation of medical waste, which is an uncertain parameter. For uncertain parameters, Rabbani[20]A multi-product and multi-objective positioning-routing problem is formulated for hazardous waste management. The model first develops in a deterministic form, and then a simulation heuristic integrating NSGA-II and Monte Carlo simulation is proposed to generate a set of pareto optimal solutions in a random environment. Pusong[21]Considering that the amount of waste is a discrete random parameter, this paper studies the two-stage stochastic programming problem of location planning, distribution planning and transportation planning in medical recycling network, and designs a series of Benders decomposition(BD) acceleration methods to solve it, such as effective inequality, strengthening Benders optimal cutting and multiple cutting. Finally, experimental data prove that this method is superior to the pure BD method. Zhao[22]Considering the existence of randomly generated wastes during the epidemic in COVID-19, the scenario-based bi-objective robust method was used to formulate and evaluate the related costs and risks, and three methods, namely, objective programming method, dictionary weighted Chebyshev method and enhanced-constraint solving technique, were used to verify the effectiveness of the model with the actual data of Wuhan epidemic in China. Kargar[23]Robust programming is used to control the uncertain parameters of medical waste quantity, thus a three-objective mixed integer programming model is established, and the optimal quantity, capacity, cost, facility location and type of treatment center technology are determined by using fuzzy objective programming method. Yu[24]Considering that the cost, demand and affected population in the recycling planning network are unknown variables, they are defined as random parameters. The mathematical model is solved by the goal programming (SAA-GP) method based on sample average approximation. Finally, it is verified that the strategic decision made by the stochastic model is more robust to the change of external environment. Lotfi[25]It is suggested to isolate and locate the medical waste under the background of the new epidemic situation to reduce the waste and recycle it, and send it to the waste purchase contractor. Therefore, a two-stage robust stochastic programming considering the elasticity and sustainable demand is constructed, and the risk is considered through the risk condition value (CVaR), which improves the robustness and agility to the demand fluctuation and the network. Govindan[26]Combining the random scene method with queuing theory, a bi-objective mixed integer linear programming model of medical waste circular economy transformation considering the waiting time of trucks is constructed, and an improved enhanced ε constraint method (AUGMECON2) is designed to solve the proposed model. Joneghani[27]From the perspective of sustainable development, medical waste recovery and waste power generation are considered, and a multi-objective mixed integer linear programming model under uncertain conditions is constructed. Possibility programming method is used to deal with the uncertainty of key parameters, and interactive fuzzy method is used to solve it. Li[28]In order to solve the uncertainty of medical waste quantity under the background of epidemic situation, infectious diseases are used to predict

the number of infected people, and a mixed dynamic method model is constructed through time-varying factors and lagging factors.

# 3. Conclusion

The research on medical waste abroad is extensive (evaluation of medical waste treatment process, construction of medical waste recycling network and medical supply chain) and deep, and influenced by the epidemic situation in COVID-19 in 2020, the research on medical waste recycling has risen to a certain extent in a short time, especially for public health emergencies; However, the field of medical waste research has been tepid for domestic academic circles, and most scholars gradually paid attention to the last line of defense of the epidemic until the outbreak of the epidemic. Observing the research on medical waste in China, it is not difficult to find that Chinese scholars are currently exploring the construction of medical waste recycling network and the optimization of distribution path. For the above literature review, it can be found that the research on medical waste recycling management in recent years mainly presents the following points:

## 3.1. Medical waste recycling network modeling

Aiming at the optimization of medical waste recycling network, the modeling of site selection and path optimization mainly has the following characteristics: (1) The optimization of medical waste recycling network often involves multiple objectives, such as economic cost, environmental impact and risk. Therefore, multi-objective optimization modeling is also one of the hot spots in current research. By constructing a multi-objective optimization model, we can comprehensively consider the trade-offs and priorities among multiple objectives, so as to get a more comprehensive and scientific optimization scheme.

(2) The models are usually nonlinear integer programming model, mixed integer nonlinear two-stage programming model, stochastic programming model and robust optimization model.

(3) The network model of medical waste recycling usually considers the flow balance constraint, and some studies on vehicle transportation path optimization consider the vehicle transportation constraints, such as vehicle body capacity constraints, vehicle flow balance constraints and eliminating the constraints of sub-trips.

## 3.2. Model solving

For the constructed model, most researches use heuristic algorithms, such as particle swarm optimization algorithm, genetic algorithm, multi-objective genetic algorithm and cuckoo algorithm, etc. These heuristic algorithms are all suitable for solving large-scale complex problems and can converge to get the optimal solution in a short time. However, for the improvement of the algorithm, most studies have not made a deeper study in this respect, so there is still some research space for the improvement of the algorithm in the field of medical waste recycling.

## 3.3. For uncertain parameters

The optimization of medical waste recovery network includes three problems: location selection of treatment facilities, optimization of distribution path and flow distribution of related resources. Because the decisions involved in these three kinds of problems are comprehensive and timely, the parameters involved in the recovery network, such as cost, waste volume, time and risk, may change with time, which leads to many uncertain factors in the optimization process of the medical waste recovery network and increases the difficulty of the recovery work. Therefore, in order to solve the uncertainty problem in the medical waste recycling network, relevant researchers mainly apply three alternative technologies: fuzzy programming, stochastic programming and robust optimization. Fuzzy programming is often used to deal with uncertain problems because of its high adaptability. Because stochastic programming can describe random situations and uncertainty of variables, scholars at home and abroad have applied it to the field of medical waste recycling. Robust optimization is based on stochastic programming, which analyzes uncertain sets and discrete scenarios, so as to get the optimal feasible solution that meets all constraints.

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