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Retraction

Retracted: Development of Urban Waste Recycling Industry from the Perspective of Ecology

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Manipulated or compromised peer review

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] Q. Luo, "Development of Urban Waste Recycling Industry from the Perspective of Ecology," *International Journal of Antennas and Propagation*, vol. 2022, Article ID 9087177, 10 pages, 2022.

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Research Article

Development of Urban Waste Recycling Industry from the Perspective of Ecology

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Urban garbage has become an important field affecting the healthy development of urban ecology, and urban ecological environment protection has naturally become a crucial part in the process of modern urban development. Deepening the relevant concepts of ecological and environmental protection also makes modern cities pay attention to the recycling and utilization of waste resources. This work is combined with the development status of urban waste recycling industry. Taking urban construction waste and domestic waste as examples, this paper focuses on the operation model and development path of urban waste recycling industry. For example, in the aspect of domestic waste treatment, the resource industrialization path of incineration fly ash is proposed, focusing on the water washing and dechlorination of incineration fly ash, the production of unburned ceramsite from water washed fly ash, and the separation and recovery of inorganic salts in fly ash water washing solution. The results show that the recoveries of NaCl, KCl, and $CaCl_2$ are 96.21%, 95.85%, and 94.72%. Through the analysis of social, environmental, and economic benefits, the government, scientific research institutions, and enterprises are encouraged to make joint efforts to develop the construction waste recycling industry, so as to fundamentally solve the current situation of "mountains of garbage and cities surrounded by garbage" in China.

1. Introduction

For a long time, the development of cities has always been the most favorable confirmation of the human social and cultural progress, scientific and technological development, and degree of civilization. At the same time, it is also a key link directly related to the healthy development of national social economy. On the other hand, the continuous increase of urban construction waste and living garbage has virtually increased the pressure on the urban environment, and the overall environmental pollution of the city is becoming more and more serious [1]. In the face of more and more urban domestic waste and construction waste, how to deal with and make good use of these wastes from the perspective of ecological and environmental protection has become an important issue to be considered for the green and healthy development of modern cities. From the perspective of ecology, gradually realizing the resource utilization, harmless treatment, and reduction development of urban construction waste and domestic waste is an effective means to solve urban waste scientifically and effectively [2]. Therefore, from the perspective of ecological and environmental protection, starting with the development status of modern urban waste recycling, this paper focuses on the operation model and development path of urban waste recycling industry. In terms of domestic waste treatment, the resource industrialization path of incineration fly ash is proposed, focusing on the research on the water washing and dechlorination of incineration fly ash, the preparation of unburned ceramsite from water washed fly ash, and the separation and recovery of inorganic salts in the water washing solution of fly ash, as shown in Figure 1 [3, 4].

2. Literature Review

There is an obvious gap between developing and developed countries in the research of garbage problem. In world organizations such as the joint program, developed

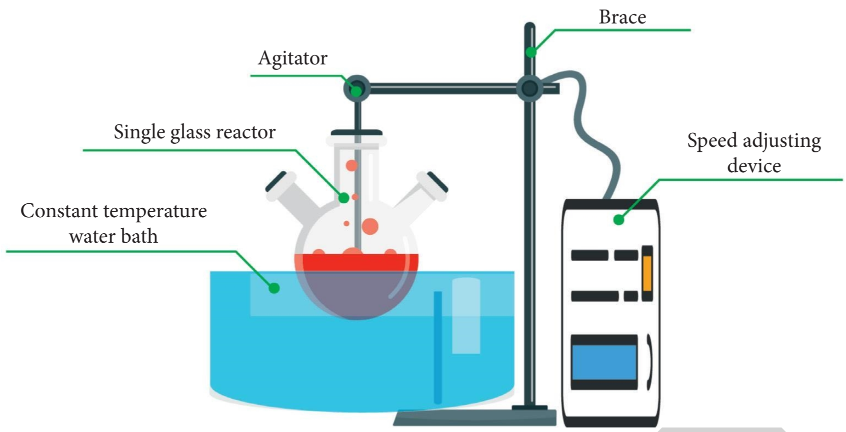

Figure 1: Water washing experimental system.

countries have detailed databases describing the characteristics of their municipal solid waste, including the amount, rate, and composition of municipal solid waste [5]. The research on municipal solid waste treatment includes the application of technology, such as quantitative analysis of resource utilization rate and determination of resource utilization quota under sustainable state, and construction of key ecological model for strategic management of municipal solid waste. Comprehensively considering the impact of ecology and economics and integrating the methods of multidimensional optimization selection of life cycle, many scholars have studied the relationship between various pollution and functional obstacles caused by municipal solid waste landfill and incineration and external costs, which provides effective support for the decision-making process. The material and cost of landfill are determined by the optimization model, and the decision-making scheme is optimized by the simulation model [6]. Developed countries have also carried out more extensive research on the impact of psychological and socioeconomic factors on human behavior. Psychological research aims to know residents' attitude toward municipal solid waste recycling through self-statement of personal behavior and comparison with actual behavior in the form of questionnaire. Consumption pattern, education level, gender, age, and income level are the main factors related to classified recycling in social economics.

Based on the current research, Li. and others found that the content of soluble chloride (NaCl, KCl, $CaCl_2$, etc.) in fly ash decreased rapidly after water washing [7]. Chen and others found that water washing can remove chlorine salt in fly ash, and Al, Si, Ca, and other substances will not be washed away, which provides the possibility for its subsequent use in making cement, ceramsite, and other materials [8]. Yang and others studied the removal rate of chlorine ions from fly ash under different water washing parameters. In order to further improve the removal efficiency of chlorine salt in fly ash, carbon dioxide can be introduced during water washing to increase the solubility of mixed solution [9]. Cao and others mixed fly ash with cement to make cement solidified-body and studied the effect of the amount of fly ash added in the solidified body on its performance [10]. He and others prepared belite cement with high strength and high corrosion resistance by low temperature calcination technology with fly ash and lime as main raw materials [11]. Xu and others used fly ash with low calcium content to prepare cement and studied the water consumption, fluidity, setting time, stability, and dry shrinkage of cement. The water consumption, setting time, and stability of cement also increase, and the dry shrinkage rate of cement decreases. At the same time, the addition of fly ash can reduce the strength of cement samples [12]. Studies by Li and others show that fly ash can be used as raw materials to prepare alinite ecological cement with high compressive strength, and metal ions and chloride ions in fly ash can improve the characteristics of cement, improve the flammability of cement raw meal, and promote the formation of cement [13]. Nadori and others discussed the feasibility of using waste incineration fly ash to make high-strength concrete by conventional process means, took the lead in successfully developing high-strength concrete meeting industrial application conditions in China, and confirmed that fly ash can be used to make concrete [14]. Cui and others used limestone and fly ash to replace cement to prepare concrete and made in-depth research on its working performance, mechanical properties, and microstructure. The results show that the concrete prepared with the mixture of 50% cement and 50% limestone powder and fly ash has small slump loss within 60 min and the compressive strength meets the requirements [15]. Jian and others studied the feasibility of replacing cement with fly ash mass in a ratio of 40~70% to produce mass concrete and analyzed its compressive strength and hydration characteristics [16].

3. Analysis of the Current Situation of Resource Utilization and Industrialization of Urban Construction Waste in China

3.1. Estimation of Urban Construction Waste Output. The annual growth rate of construction waste is about 10%. Especially after the financial crisis in 2008, the production of construction waste in China shows a rapid growth trend. The annual growth rates of construction waste in 2010 and 2011 are 13.06% and 14.05%, respectively. Its cumulative value is even more terrible, nearly 12×108 t in 2011. If China does not step up the rapid development of construction waste recycling, construction waste will become a major burden on China's development. According to statistics, the amount of construction waste generated by brick concrete and frame structures in urban areas is about 1.0~1.5 t/m^2; the output of other wooden and steel structures is about 0.5~1.0 t/m^2. According to the statistics of a Chinese housing company, about 1.35 t of construction waste is produced by 1 m^2 of housing [17, 18]. Therefore, considering the structural characteristics of the current demolished buildings, it is determined that the demolition of 1 m^2 of buildings will produce about 1.30 t construction waste.

3.2. Prediction of Construction Waste

3.2.1. Establishment of Grey Prediction Model GM (1,1). The so-called grey system refers to the system in which some information is clear and some information is unknown. The grey system theory is aimed at the system with incomplete information. It studies and predicts the unknown field through the known information, so as to understand the whole system. The grey prediction model GM (1,1) aims to reduce the influence of random factors by accumulating the original discrete data, so as to generate regular data. In this paper, the annual growth system of construction waste contains not only clear information, but also unknown and uncertain information. At the same time, through the estimation of the annual output of construction waste, the data has an obvious upward trend, and its prediction has high accuracy [19]. The specific steps are as follows.

First, nonnegative original data sequence is as follows:

$$X^{(0)} = \left\{ x^{(0)}(1), x^{(0)}(2), \ldots, x^{(0)}(n) \right\}, \quad (1)$$

where

$$X^{(0)}(k) \geq 0, k = 1, 2, \ldots, n. \quad (2)$$

The generated sequence of one-time accumulation of the original data weakens the randomness and volatility of the original data and strengthens the regularity of the data, resulting in the following:

$$X^{(1)} = \left\{ x^{(1)}(1), x^{(1)}(2), \ldots, x^{(1)}(n) \right\}, \quad (3)$$

where

$$X^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i), k = 1, 2, \ldots, n. \quad (4)$$

The superscript "0" indicates the original sequence, and the superscript "1" indicates the cumulative production sequence at one time.

Let $Z^{(1)}$ be the nearest mean generation sequence of $X^{(1)}$:

$$Z^{(1)} = \left\{ Z^{(1)}(2), Z^{(1)}(3), \ldots, Z^{(1)}(n) \right\}, \quad (5)$$

where

$$Z^{(1)}(k) = \frac{1}{2}\left(X^{(1)}(K) + x^{(1)}(K-1) \right), K = 2, 3, \ldots, n. \quad (6)$$

Then, the definition type of GM (1,1), that is, the grey differential equation model of GM (1,1) model, is as follows:

$$X^{(0)}(K) = Z^{(1)}(K) = b. \quad (7)$$

If (8) is a parameter column and satisfies the following formula:

$$\hat{a} = (a, b)^T, \quad (8)$$

$$Y = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ \cdots \\ x^{(0)}(n) \end{bmatrix}, B = \begin{bmatrix} -z^{(1)}(2) & 1 \\ -z^{(1)}(3) & 1 \\ \cdots & \cdots\cdots \\ -z^{(1)}(n) & 1 \end{bmatrix}, \quad (9)$$

then the least squares estimation parameter column of GM (1,1) model $x^{(0)}(k) = z^{(1)}(k) = b$ satisfies the following:

$$\hat{a} = \left(B^T B \right)^{-1} B^T Y. \quad (10)$$

Then, we have the following.

The whitening equation of GM (1,1) model is as follows:

$$\frac{dx^{(1)}}{dt} + ax^{(1)} = b. \quad (11)$$

The time response sequence of GM (1,1) grey differential equation is the GM (1,1) prediction model:

$$x^{(1)}(k+1) = \left(x^{(0)}(1) - \frac{b}{a} \right) e^{-a} + \frac{b}{a} \quad k = 1, 2, \ldots, n. \quad (12)$$

The restore value is as follows:

$$\hat{x}^{(0)}(k+1) = \hat{x}^{(1)}(k+1) - \hat{x}^{(1)}(k), \quad k = 1, 2, \ldots, n. \quad (13)$$

The above three equations are the prediction equation.

3.2.2. Accuracy Test of GM (1,1) Model. The absolute residual sequence is as follows:

$$\begin{aligned} \Delta^{(0)} &= \left\{ \Delta^{(0)}(k), k = 1, 2, \ldots, n \right\}, \\ \Delta^{(0)}(k) &= \left| x^{(0)}(k) - \hat{x}^{(0)}(k) \right|. \end{aligned} \quad (14)$$

The sequence of relative residuals is as follows:

$$\varphi = \{ \varphi_k, k = 1, 2, \ldots, n \}, \varphi_k = \frac{\Delta^{(0)}(k)}{x^{(0)}(k)}. \quad (15)$$

Calculate the average of the original sequence:

$$\overline{x}^{(0)} = \frac{1}{n} \sum_{k=1}^{n} x^{(0)}(k). \quad (16)$$

Calculate the mean square deviation of the original sequence:

$$S_1 = \left(\frac{\sum_{k=1}^{n} \left(x^{(0)}(k) - \overline{x}^{(0)} \right)^2}{n-1} \right)^{1/2}. \quad (17)$$

Calculate the mean of the residuals:

$$\overline{\Delta} = \frac{1}{n} \sum_{k=1}^{n} \Delta^{(0)}(k). \quad (18)$$

Calculate the mean square deviation of the residuals:

$$S_1 = \left(\frac{\sum_{k=1}^{n} \left(\Delta^{(0)}(k) - \overline{\Delta} \right)^2}{n-1} \right)^{1/2}. \quad (19)$$

Calculate variance ratio:

$$C = \frac{S_2}{S_1}. \quad (20)$$

Calculate small residual probability:

$$p = P\left(\left| \Delta^{(0)}(k) - \overline{\Delta} \right| < 0.6745 S_1 \right). \quad (21)$$

3.2.3. Prediction of Construction Waste. The prediction results of China's construction waste production in 2017 and 2020 are shown in Tables 1 and 2 and Figures 2and 3.

Comparing the original value of construction waste with the predicted value, we get the fitting curve between the original value of construction waste output and the predicted result shown in Figure 3.

Table 1 and Figure 3 show that the initial annual production cost of waste production in 2006–2016 was close to the estimated cost. The Gray Prediction GM (1,1) model has been shown to be accurate in estimating annual construction waste, and China's annual waste disposal volume will grow at an annual rate over the next four years. 15%. By 2020, China's annual garbage output is expected to exceed 21 × 108 tons, an increase of more than 70% over 2016, which is largely in line with the reality of China's urban development, commerce, and construction. If such a large amount of construction waste is not disposed of reasonably, it will not only occupy land resources and pollute the natural environment, but also destroy the living environment, affect the city appearance, and greatly hinder urban development [20, 21]. Therefore, the recycling of construction waste is required and forced by the situation and has become an industry in urgent need of development in China.

4. Water Washing of Municipal Solid Waste Incineration Fly Ash and Treatment Experiment of Water Washing Solution

4.1. Source of Experimental Fly Ash. The ash used in the experiment was obtained from a waste incinerator in Gaoantong, Beijing. The solid waste incineration plant has introduced SN grate technology from Tianxion, Japan, and is equipped with SNCR desulphurization and dehydration [22]. Part of the ash was dried in the oven at 105 C for 3 hours, drained, ground, filtered, and checked by an X-ray fluorescence spectrometer (XRF), as shown in Tables 2 and 3 and Figures 4–6.

Tables 2 and 3 and Figures 4 and 5 shows that the high content of chlorine salt will cause corrosion to building materials, so the original fly ash must be treated before it can be used for the subsequent production of unburned ceramsite [23]. The SO_3 content of the initial ash is up to 26.7% due to the reaction of SO_2 and heating during combustion [24]. Figure 6 shows that the variance of the incineration ash in general has a significant difference, with the highest particle size of up to 30 mm or about 65% being ash. Productivity during incineration is minimal. Total ash

Table 1: Output of urban construction waste in China from 2017 to 2020.

Particular year	2017	2018	2019	2020
Estimate	143266.9	164751.8	189458.7	217870.7

Table 2: XRF analysis results of original fly ash (1).

Component	Mass fraction (%)
SO_3	26.71
Na_2O	26.58
CaO	11.43
Cl	9.59
SiO_2	7.179
K_2O	5.208
Br	3.519
F	3.35
Al_2O_3	1.55
Fe_2O_3	1.108
ZnO	0.9022
SnO_2	0.8608
P_2O_5	0.857

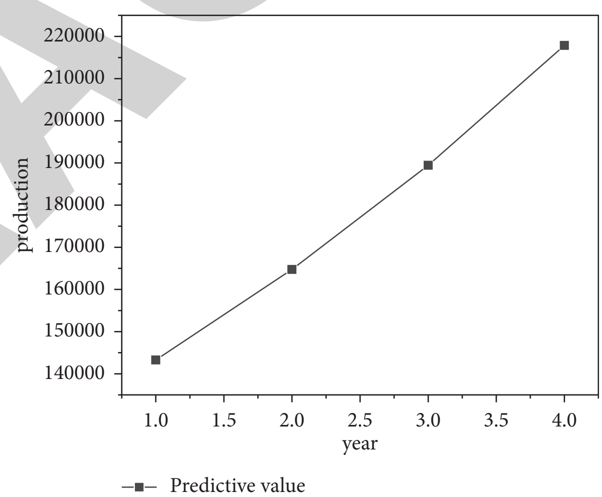

Figure 2: Output of urban construction waste in China from 2017 to 2020.

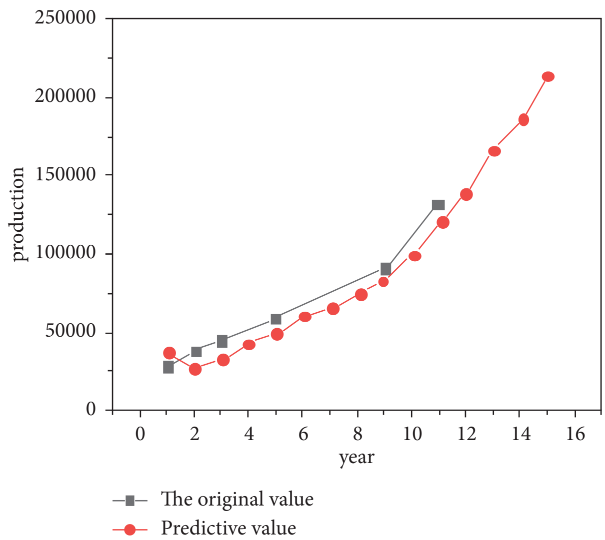

Figure 3: Fitting curve of annual output of construction waste in China.

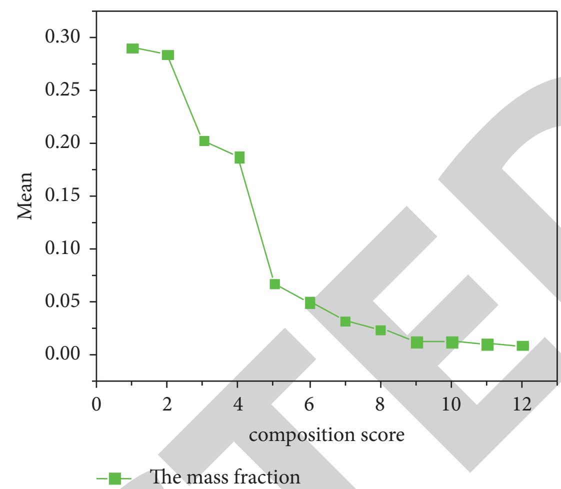

Figure 5: XRF analysis results of original fly ash (2).

Table 3: XRF analysis results of original fly ash (2).

Component	Mass fraction%
MgO	0.292
TiO_2	0.285
CuO	0.2038
PbO	0.189
BaO	0.069
Cr_2O_3	0.0503
Sb_2O_3	0.0325
CeO_2	0.025
ZrO_2	0.014
MnO	0.014
As_2O_3	0.0104
SrO	0.008

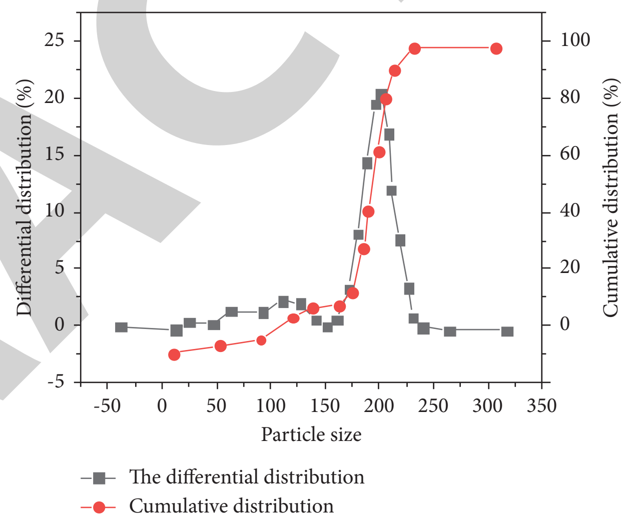

Figure 6: Particle size diagram of fly ash.

over 117 um is almost zero due to the fact that the ash grows in the slag along with some incomplete material.

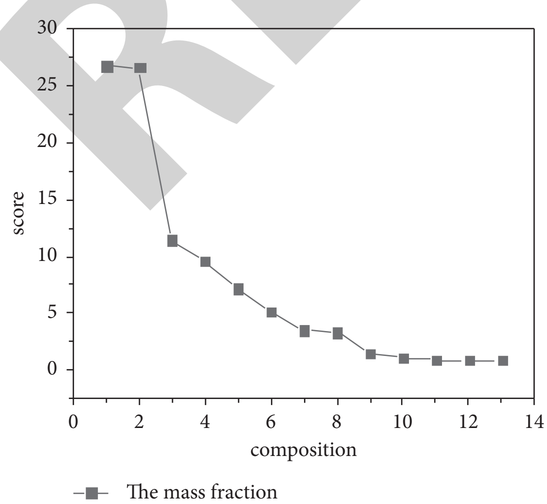

Figure 4: XRF analysis results of original fly ash (1).

4.2. Experimental System and Method

4.2.1. System. Fly ash contains a large amount of soluble chlorine salt, which is directly dissolved in water after washing to form high chlorine salt wastewater. This wastewater will be directly discharged without treatment, which will cause the death of soil organisms and plants and seriously damage the ecological environment. This section mainly deals with the chlorine salt in the water washing solution. The process flow chart of the treatment experiment is shown in Figure 7. Firstly, take the fly ash water washing solution under the best experimental parameters of fly ash water washing treatment, and analyze its main components. The results are shown in Table 4.

In Table 4, the content of chloride ion is as high as 45418.7 mg/l, far more than 1%, belonging to the range of high salt wastewater. Take 100 ml fly ash water washing

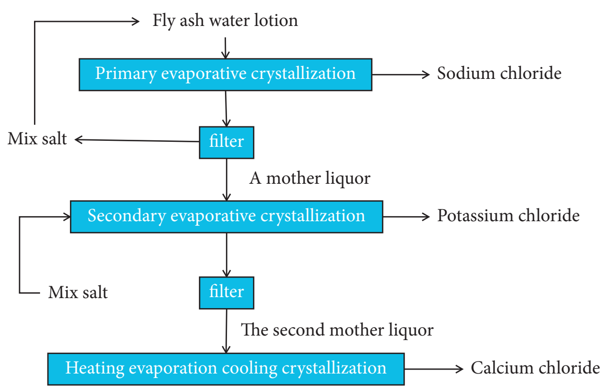

Figure 7: Experimental process flow of fly ash washing solution treatment.

Table 4: Main components of fly ash washing solution.

Material	Na^{+}	K^{+}	Ca^{2+}	Cl^{-}	Zn^{2+}
Concentration	14369.2	4341.4	768.78	45418.8	0.04

solution and place it on the heater for heating. By adjusting the temperature of the heater, controlling the evaporation temperature in the aqueous solution, and measuring the changes of M (NaCl)/M (KCl), *m* (KCl)/M (CaCl2), and *m* (NaCl)/M ($CaCl_2$) in the water washing solution, the separation temperature of NaCl, KCl, and $CaCl_2$ is obtained, so that the chloride salt in the water washing solution can be crystallized and separated, and finally NaCl, KCl, $CaCl_2$, and other products can be obtained.

4.2.2. Detection and Analysis Method. In order to detect the chemical water washing and analyze its element composition and the change of composition before and after treatment, the fly ash is detected by X-ray fluorescence spectrometer. The model and data are shown in Table 5.

(1) Sample preparation by crushing: dry the sample into powder, and grind it to 300 mesh–400 mesh.

(2) Samples: put the samples in X-ray fluorescence spectrometer sample cup for analysis.

In order to understand the mineral phase composition in the fly ash and the reason for the decrease of chloride content after water washing, X-ray diffractometer (XRD) is selected to detect the fly ash before and after water washing. The model and parameters of the instrument are shown in Table 6.

4.2.3. Detection of Heavy Metal Leaching Toxicity. The national standard leaching toxicity leaching method of solid waste—horizontal oscillation method (GB5086.2–1997)—was used to carry out the leaching toxicity experiment, and the leaching concentrations of heavy metals copper, zinc, lead, cadmium, and chromium in fly ash and unburned ceramsite were determined by inductively coupled atomic emission spectrometry [25]. The specific test methods are as follows:

Table 5: Main technical indexes of XRF instrument.

Project	Parameter
Model	S8 tiger
Maximum output power	4 kW
Excitation current	5–170 mA
Excitation voltage	20–60 kV
Ceramic light tube	75 μm ultrathin beryllium window rhodium target
Optical positioning goniometer	The positioning accuracy is better than $\pm 0.001^{\circ}$, and the angle reproducibility is better than $\pm 0.0001^{\circ}$

Table 6: Main technical indexes of XRD instrument.

Project	Parameter
Model	Smart lab 9 ∗
Maximum output power	3 kW
Closed X-ray tube	Cu target
Rated voltage	20–60 kV
Minimum focal spot size	$0.4 * 8\,mm^2$
Goniometer system	20 scanning range: $-3^{\circ}\sim160^{\circ}$
Maximum size of testable sample	250 mm (L) ∗ 250 mm (W)

4.3. Test Results and Analysis of Fly Ash Washing

4.3.1. Effect of Liquid-Solid Ratio on Chloride Ion Removal. 100 g fly ash was taken from the experiment. The washing time was 15 min, and the washing temperature was 25°C. The mixed solution after water washing is vacuum-filtered through a Brinell funnel paved with two layers of qualitative filter paper. The liquid-solid comparison is shown in Figure 8. The concentration of chloride ions in the ash before and after washing with water under different conditions and the rate of emission of chloride ions are shown in Figure 8.

4.3.2. Influence of Washing Time on Chloride Ion Removal. Take 100 g fly ash, and set the washing temperature at 25°C, the liquid-solid ratio at 6 ml/g, and the stirring speed at 170 ± 10 r/min. Wash the fly ash for 5, 15, 25, 35, 45, and 55 min. Under different washing time conditions, the chloride ion content and chloride ion removal rate in fly ash before and after washing are shown in Figure 9.

As can be seen from the figure, the length of the cleaning time is less effective at removing chloride ions from the ash. But as the cleaning time increased, the chloride ion emission increased to 86.7%. This is because chloride salts, such as sodium chloride, potassium chloride, and calcium chloride, are soluble in water and dissolve rapidly in liquid phase. Thus, the rate of chloride ion removal has not improved much over time. In addition, the cleaning delay in the project will actually increase the operating costs of the entire

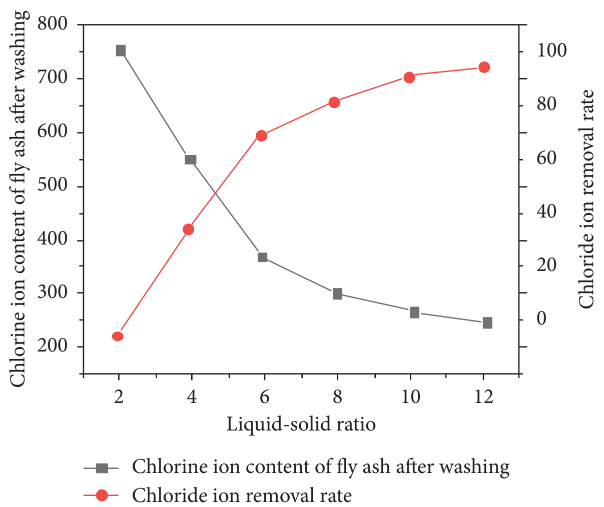

Figure 8: Effect of liquid-solid ratio on chloride ion removal in fly ash.

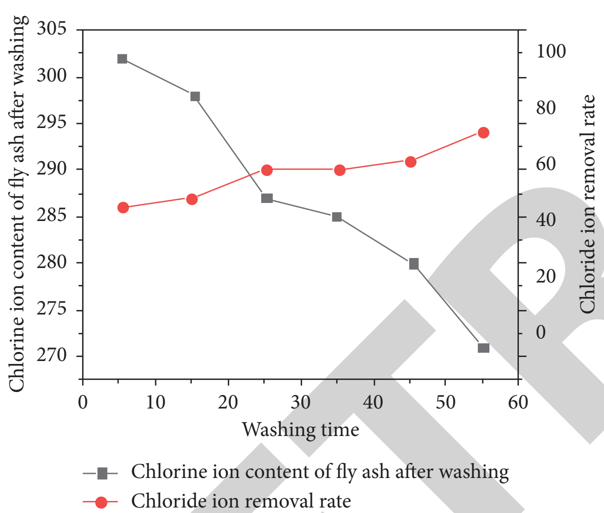

Figure 9: Effect of washing time on chloride ion removal from fly ash.

washing equipment. Therefore, the cleaning time is finally defined as 5 minutes, while the removal rate of chloride ions reaches 85.2%.

4.3.3. Influence of Water Washing Temperature on Chloride Ion Removal. Wash the fly ash at the washing temperatures of 25, 30, 40, 50, 60, 70, and 90 min. Under different water washing temperatures, the chloride ion removal rate of the chloride ion content meter in the fly ash before and after water washing is shown in Figure 10.

The amount of chloride ion release also gradually increases, as shown in Figure 10. When the washing water is hot, about 70°C, the rate of chloride ion removal remains almost unchanged. The rate of removal of chloride ions gradually increases with temperature, but the conversion rate is not very good. Therefore, hot wash water has an impact on the removal of chloride ions in the ash. As the

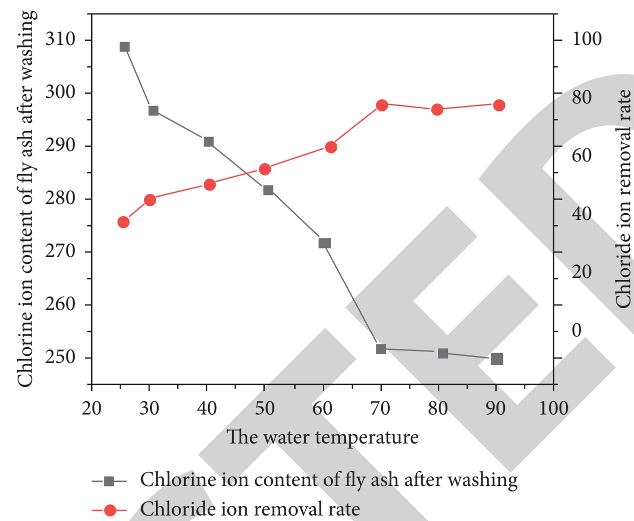

Figure 10: Effect of water washing temperature on chloride ion removal from fly ash.

solubility of chloride salts in the ash increases with increasing washing temperature, the rate of dissolved chloride ions also increases, and the effect of chloride ion removal increases with increasing temperature. As the temperature rises to 70°C, the effect of the chloride ion removal changes slightly as some of the soluble chemicals and solids in the ash dissolve.

4.4. Experimental Results and Analysis of Fly Ash Washing Solution Treatment

4.4.1. Primary Evaporation Crystallization Separation Temperature. According to the analysis results in the previous section, the crystallization separation temperature of NaCl and KCl is further analyzed to determine the primary evaporation crystallization separation temperature. Take a certain amount of water washing solution of fly ash, heat and crystallize it in the range of 112–116°C, and stop heating at different temperatures; after settling for 5 minutes, filter the bottom crystal while it is hot, and measure the change of mass fraction of NaCl and KCl in the solution with temperature, as shown in Figure 11.

4.4.2. Secondary Evaporation Crystallization Separation Temperature. The crystallization separation temperature of KCl and $CaCl_2$ was further analyzed to determine the secondary evaporation crystallization separation temperature. The solution after primary evaporation crystallization separation is heated and evaporated. The mass fraction of NaCl, KCl, and $CaCl_2$ in the solution changes with temperature, as shown in Figure 12.

The solution separated from NaCl and KCl was heated and evaporated. After heating to 135°C, the temperature was reduced and crystallized to obtain CaCl2 · 6H2O. According to the primary and secondary evaporative crystallization separation temperature determined above, the water washing solution is subjected to cyclic evaporation

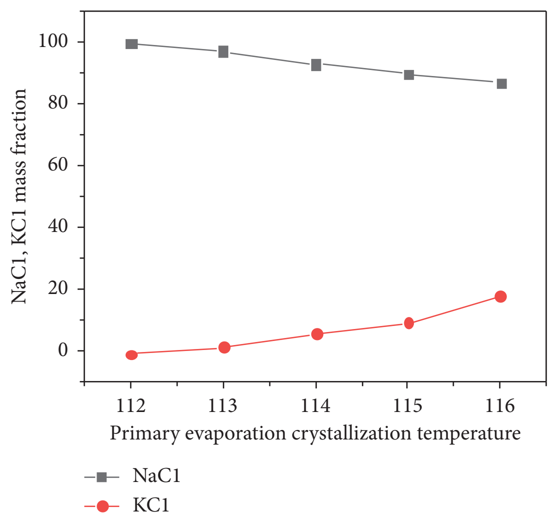

FIGURE 11: Effect of primary evaporation crystallization temperature on chloride content.

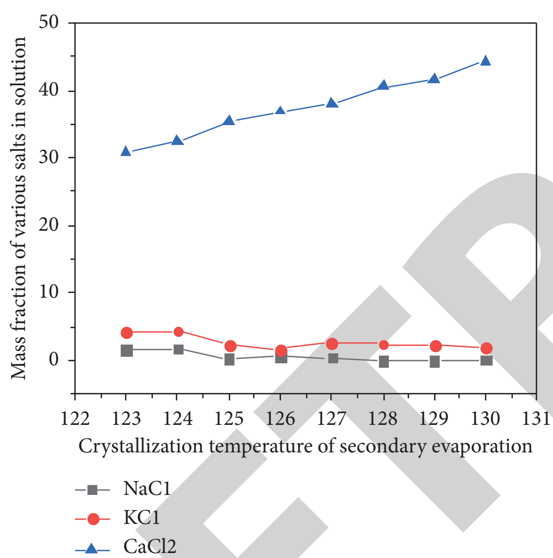

FIGURE 12: Effect of secondary evaporation temperature on chlorine salt in mother liquor.

treatment. Finally, the recoveries of NaCl, KCl, and $CaCl_2$ in the effluent washing solution are 96.21%, 95.85%, and 94.72%. Through the evaporation crystallization treatment of fly ash washing solution, not only are the chloride content in the washing solution and the harm of wastewater discharge reduced, but also the chloride can be recovered and reused.

4.5. Result Discussion. The chloride ion in fly ash was treated by water washing method. The filter solution after water washing of fly ash was treated by evaporation separation technology, and the suitable crystallization separation temperature of NaCl, KCl, and $CaCl_2$ in the water washing solution was analyzed. The main results are as follows:

(1) According to the results of the ash particle size analysis, the particle size is 16–117 mm, the particle size is less than 70 mm, about 98% of the total volume, and the total ash is less than 0.4 mm or more, more than 155 mm. The fact that it is almost zero indicates that the ash is very small.

(2) The maximum emission of chloride ions in ash is 88.72%. The ratio of liquids to products has the highest efficiency of chloride ion removal, while washing time and temperature have the least impact on chloride ion removal.

(3) The experimental results of evaporative crystallization of fly ash water washing solution show that the primary evaporative crystallization separation temperature of NaCl and KCl is 113°C, and the secondary evaporative crystallization separation temperature of KCl and $CaCl_2$ is 128°C. Through the cyclic evaporation treatment of fly ash water washing solution, the recoveries of NaCl, KCl, and $CaCl_2$ in effluent washing solution are 96.21%, 95.85%, and 94.72%.

(4) After washing the ash with water before and after testing with an electrometer, most of the ashes are gradually transformed into a spherical or oval shape. The crystalline solution that begins to adhere to the ash does not come to the surface of the wash ash, indicating that most of the chlorine salts in the ash are removed after rinsing with water.

(5) The XRD results showed that the mineral phase in the ash was chlorine salts (NaCl, KCl) and calcium salts (Ca (OH) 2, CaSO4), of which NaCl and KCl were chlorine salts. After washing with water, the chloride content in the ash is reduced, and CaSO4 • 2 (H_2O), SiO_2, $CaCO_3$, and other chemicals are formed, which guarantees the production of ash expanded clay as raw material.

5. Conclusion

The data were reported to study the theory of waste generation and recycling, to examine it for recycling, and to show that the development of waste in China has been increasing every year. In 2015, the city's annual waste was expected to exceed 21 × 108 tons, an increase of more than 70 percent over 2011. From 2001 to 2011, the growth rate of construction waste exceeded 10%, while from 2012 to 2015, the annual growth rate reached 15%. These data will provide basic data and theoretical basis for China's construction waste recycling management, policy, and technical decision-making and serve as the basic starting point for the research on China's construction waste recycling. The development of construction waste recycling is directly related to the social environment and the economic benefits of participating enterprises. This paper uses the method of economic mathematics to establish the economic benefit evaluation model of construction waste recycling. Case analysis shows that the economic benefits of urban construction waste recycling in China are considerable and attract more enterprises and individuals to invest in the construction waste recycling industry. Through the analysis of social, environmental, and economic benefits, the government, scientific research institutions, and enterprises are encouraged to make joint efforts to develop the construction waste recycling industry, so as to fundamentally solve the current situation of "mountains of garbage and cities surrounded by garbage" in China. This study confirms that the production of unburned ceramsite with water washed fly ash, cement, and silica sol has good economic, environmental, and social benefits, but the experiment is still in the laboratory stage, and there are many uncertain factors in the actual industrial application process. It is suggested that its reliability is further verified in the industrial scale production of unburned ceramsite.

Data Availability

The labeled dataset used to support the findings of this study is available from the author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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References

[1] B. Zhou, B. Lei, L. Hou, L. Huang, X. Lian, and B. Zhou, "Research on the harmless and recycling treatment technology of drilling waste mud based on changqing oilfield," *IOP Conference Series: Earth and Environmental Science*, vol. 804, no. 2, p. 8, Article ID 22106, 2021.

[2] X. Wan, X. Yang, Q. Wen, J. Gang, and L. Gan, "Sustainable development of industry–environmental system based on resilience perspective," *International Journal of Environmental Research and Public Health*, vol. 17, no. 2, p. 645, 2020.

[3] Y. Peng, "Study on the path of building a sports and leisure town with 10, 000 mu ecological tea garden in western hunan under the background of rural revitalization," *Modern Economics & Management Forum*, vol. 3, no. 1, pp. 1–5, 2022.

[4] Y. Zhang, "China's green urbanization in the perspective of ecological civilization," *Chinese Journal of Urban and Environmental Studies*, vol. 9, no. 1, Article ID 2150001, 2021.

[5] F. Su, J. Chang, X. Li, D. Zhou, and B. Xue, "Urban circular economy in China: a review based on Chinese literature studies," *Complexity*, vol. 2021, no. 3, 10 pages, Article ID 8810267, 2021.

[6] J. Zhao, Y. Bai, C. Zhang, J. He, and S. Li, "Research on the coordination degree of ecological protection and high-quality development of urban agglomerations in the yellow river basin," *E3S Web of Conferences*, vol. 271, no. 2, Article ID 2008, 2021.

[7] R. Li, "Research on the sustainable development of rural e-commerce tourism based on the big data analysis from the perspective of urban and rural development balance," *Journal of Physics: Conference Series*, vol. 1744, no. 3, Article ID 32216, 2021.

[8] S. Chen, Y. Sun, M. Lu, and M. Jiang, "Research on urban commercial complex design based on ecological concept-a case study of the roof in shanghai," *IOP Conference Series: Earth and Environmental Science*, vol. 676, no. 1, p. 6, Article ID 12015, 2021.

[9] J. Yang, "Research on the development of leisure sports in coastal cities based on ecological environment," *Journal of Coastal Research*, vol. 115, no. 1, p. 166, 2020.

[10] Y. Cao, J. You, Y. Shi, and W. Hu, "Research on the green competitiveness index of manufacturing industry in yangtze river delta urban agglomeration," *Problemy Ekorozwoju*, vol. 16, no. 1, pp. 143–156, 2021.

[11] G. He and J. Ruan, "Study on ecological security evaluation of anhui province based on normal cloud model," *Environmental Science and Pollution Research*, vol. 29, no. 11, Article ID 16549, 2021.

[12] Z. Xu and Y. Yin, "Regional development quality of yangtze river delta: from the perspective of urban population agglomeration and ecological efficiency coordination," *Sustainability*, vol. 13, no. 22, Article ID 12818, 2021.

[13] B. Li, J. Zhang, J. Liu, and H. Qin, "Environmental protection of resource-based cities around the bohai sea from an ecological perspective," *IOP Conference Series: Earth and Environmental Science*, vol. 781, no. 3, p. 6, Article ID 32035, 2021.

[14] N. Nadori, "An ecological perspective on reading development: a theoretical framework to guide empirical research," *Journal of English Language Teaching and Linguistics*, vol. 5, no. 2, p. 261, 2020.

[15] X. Cui, S. Yang, G. Zhang, B. Liang, and F. Li, "An exploration of a synthetic construction land use quality evaluation based on economic-social-ecological coupling perspective: a case study in major Chinese cities," *International Journal of Environmental Research and Public Health*, vol. 17, no. 10, p. 3663, 2020.

[16] J. Ying and L. Wenbo, "Research on China's renewable energy strategic development strategy from the perspective of sustainable development," *IOP Conference Series: Earth and Environmental Science*, vol. 510, no. 3, p. 6, Article ID 32026, 2020.

[17] V. Dakos and S. Kefi, "Ecological resilience: what to measure and how," *Environmental Research Letters*, vol. 17, no. 4, p. 22, Article ID 43003, 2022.

[18] T. Paap, M. J. Wingfield, T. I. Burgess, J. R. U. Wilson, D. M. Richardson, and A. Santini, "Invasion frameworks: a forest pathogen perspective," *Current Forestry Reports*, vol. 8, no. 1, pp. 74–89, 2022.

[19] T. M. Cihon, A Borba, M. Benvenuti, and I. Sandaker, "Research and training in culturo-behavior science," *Behavior and Social Issues*, vol. 30, no. 1, pp. 237–275, 2021.

[20] F. Salehipour-Bavarsad, H. Riahi, M. A. Hejazi, and Z. Shariatmadari, "Screening terrestrial and aquatic strains ofdunaliellafrom the eco-taxonomical perspective: a comparative study on fatty acid compositions as habitat indicators," *Journal of Applied Phycology*, vol. 34, no. 1, pp. 461–474, 2021.

[21] J. Feng, Y. Q. Tang, S. Xue, and K. Zhang, "Study on cooperative strategies of rural water environment governance ppp project between companies and farmers from the perspective

of evolutionary game," *Environment, Development and Sustainability*, vol. 24, no. 1, pp. 138–155, 2021.

[22] G. U. Tumlu and R. Akdoğan, "Persistence in the face of ecological challenges: a phenomenological study of parents of children with disabilities in Turkey," *International Journal for the Advancement of Counselling*, vol. 44, no. 1, pp. 17–38, 2021.

[23] T. Mizunoya, N. Nozaki, and R. K. Singh, "Impact of the municipal merger on watershed management: a study of Lake Kasumigaura, Japan," *Asia-Pacific Journal of Regional Science*, vol. 5, no. 2, pp. 673–704, 2021.

[24] A. Elbaz and M. T. Guneser, "Multi-objective optimization method for proper configuration of grid-connected pv-wind hybrid system in terms of ecological effects, outlay, and reliability," *Journal of Electrical Engineering & Technology*, vol. 16, no. 2, pp. 771–782, 2021.

[25] T. Semeraro, A. Scarano, R. Buccolieri, A. Santino, and E. Aarrevaara, "Planning of urban green spaces: an ecological perspective on human benefits," *Land*, vol. 10, no. 2, p. 105, 2021.