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Editorial

Resource Utilization of Solid Waste and Water Quality Evaluation

Ning Yuan

School of Chemical and Environmental Engineering, China University of Mining and Technology, Beijing 100083, China; ning.yuan@cumtb.edu.cn

1. Introduction

The rapid development of industrialization and urbanization has inevitably resulted in the generation of innumerable solid wastes and water contamination. Solid waste refers to solid-state or semi-solid discarded trash that loses its original value and is discharged into the environment. According to various sources, solid waste can be divided into industrial, agricultural, and municipal solid waste. Solid waste not only occupies a great deal of space but may also cause pollution to air, soil, and water resources, and even affect human health. Therefore, it is necessary to implement the treatment and resource utilization of solid waste. The conventional treatment techniques include incineration, composting, landfill, and so forth. However, these treatment techniques would result in secondary pollution. Most of the solid waste contains recyclable components, which can be converted into various resources and transform trash to treasure [1].

With continuous industrial development, the resource utilization of industrial solid waste has aroused intense interest because of its diverse types, enormous quantity, and high resource utilization difficulty. Resource utilization can maximize the value of solid waste and improve social benefits. Some industrial residues have been applied in the fields of the construction industry, mine backfill, soil reclamation, and so forth. For example, crushed coal gangue and tailings can be utilized as aggregates, while fly ash and slag are commonly used as cementitious materials [2,3].

Except for large-scale utilization, the high value-added utilization of solid waste has been exploited due to its physicochemical properties [4]. The relevant applications include the extraction of rare metals and alumina, the fabrication of catalysts and molecular sieves, etc. [5,6]. Industrial residues with a high content of aluminosilicate have been employed for the fabrication of various types of porous materials, such as zeolites and mesoporous silicas [7,8]. Intriguingly, a type of crystalline nanoporous materials, metal–organic frameworks, have been recently synthesized from several categories of industrial solid waste [9,10]. The material utilization of industrial solid waste has become a hot topic, and beyond porous materials, many other novel materials have also been successfully obtained from industrial residues.

Human activities have not only resulted in the emission of diverse solid waste but also affected various water environments. Clean water is vital to individual health and public security. To access clean water resources, the evaluation of water quality and the analysis of water pollution are the prerequisites and foundations. Many efforts have been made in this area [11,12]. It is worth mentioning that solid waste-derived materials have been applied to purify the wastewater through physical, chemical, and biological methods. As a common bulk solid waste, coal fly ash has been widely investigated for the fabrication of adsorbents and catalysts, and the derived materials have exhibited excellent performance in wastewater treatment [13].

This Special Issue titled "Environmental Interface Chemistry and Pollution Control" in *Sustainability* aims to set up a forum for environmental pollution issues. The scope of this Special Issue covers research on environmental interface chemistry, pollution control, and environmental materials. In view of the published contributions, it is a collection of

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related research that mainly provides new insights into the resource utilization of solid waste and water quality evaluation.

2. Contributions

The collection of this Special Issue includes ten contributions, with themes mainly covering the resource utilization of solid waste and water quality evaluation. Among these contributions, six papers deal with the resource utilization and environmental influence of solid waste. The involved solid waste can be categorized into two types, namely, industrial solid waste and medical waste. The former includes coal fly ash, bottom ash, gasification slag, desulfurized gypsum, coal gangue, silica fume, blast furnace slag, gold tailings, red mud, soda residue, and so on. We will first present the contributions concerning the resource utilization of industrial solid waste.

Yuan et al. (Contribution 1) confirmed the feasibility of the production of controlled low-strength material (CLSM) by employing five types of coal-based solid wastes (coal fly ash, bottom ash, gasification slag, desulfurized gypsum, and coal gangue) and a small proportion of cement. The performances of the obtained fresh mortar (flowability, bleeding, setting time, and fresh density) and hardened mortar (compressive strength, porosity, absorption, and dry density) were carefully examined to evaluate whether they can meet the requirements of American Concrete Institute Committee 229. Furthermore, the effects of the mixing amount and ball-milling time of bottom ash on the properties of fresh and hardened CLSM specimens were studied. Also, the microstructures of CLSM specimens at 28-day curing age were investigated using the X-ray diffraction technique and scanning electron microscopy.

Liu et al. (Contribution 2) utilized fly ash and silica fume as supplementary cementitious materials (SCMs) to mix with the pre-synthesized natural hydraulic lime (NHL). The fabricated NHL was obtained by mixing limestone and diatomite and then doped with a small quantity of B_2O_3 or B_2O_3/Na_2CO_3 as a stabilizer. This work emphatically discussed the effects of ion doping (B and B/Na) and SCMs (fly ash and silica fume) on the compressive strength of NHL. The introduction of fly ash and silica fume can enhance the compressive strength of specimens, which was further improved by ion doping based on the coupling effect. The incorporation of silica fume remarkably boosted the early strength of the NHL specimens because of its high pozzolanic activity, whereas fly ash improved the late strength of the NHL specimens with consideration of its slower pozzolanic reaction degree. It is worth noting that the ion doping and introduction of SCMs can promote the hydration reaction and further enhance the compressive strength under the synergistic effect.

Cui et al. (Contribution 3) reported the blast furnace slag–gold tailings–red mud ternary composite cementitious material (SGRCM), which can mitigate environmental pollution and reduce production costs. Three types of bases (NaOH, KOH, and Na_2SiO_3) were adopted as activators for the ternary composite system. The compressive strength of alkali-activated SGRCM at a 28-day curing age can reach 43.7 MPa. According to the XRD, SEM, and EDS analyses, the main hydration products were C-A-S-H and ettringite, which were attributed to the enhancement of compressive strength. Moreover, the heavy metal ion leaching experiment results certified that the heavy metal ion can be consolidated in the SGRCM ternary composite cementitious material. The findings of this work demonstrated that Na_2SiO_3-activated blast furnace slag–gold tailings–red mud ternary composite cementitious material can replace cement to some extent.

Zhang et al. (Contribution 4) prepared a new alkali-activated composite binder based on soda residue and blast furnace slag and further investigated its mechanical properties and microstructure, which provided a solution to resolve the environmental pollution issue caused by alkali residues. The effects of Na_2O content, soda residue–blast furnace slag ratio, and water–binder ratio on the compressive strength at different curing ages (3, 7, 28, and 56 d) were explored. The optimal level of Na_2O content was 3.0%, at which the compressive strength was 27.8 MPa. As revealed in the XRD analysis, the main mineral compositions of the hydration products were C-(A)-S-H gel, ettringite, hydrocalumite, and calcium hydroxide. The experimental results disclosed that an appropriate Na_2O content can promote the structure density and enhance the strength, whereas an excessive Na_2O content would hinder strength development.

In subsequent work, Zhang et al. (Contribution 5) aimed to optimize the mechanical performance of alkali-activated soda residue–ground granulated blast furnace slag (SR-GGBS) cementing materials by regulating the curing methods, temperatures, and times. The findings showed that high-temperature curing can prominently enhance the early strength of the prepared SR-GGBS cementing materials. By comparing the compressive strengths and microstructural results, the optimal curing condition was determined to be 60 °C for 12 h. However, a further increase in temperature reduced the mechanical performance, and shrinkage cracks appeared in the test specimen. Therefore, in view of energy conservation, the room-temperature curing method can be considered in case of an undemanding requirement for early strength.

Besides industrial solid waste, an intriguing work from Slovenia on a kind of medical waste, disposable surgical masks (DSMs), is included in this Special Issue. Erjavec et al. (Contribution 6) focused on the problematic micro/nanoplastic pollution issue resulting from DSMs, with quantities dramatically amplified by the COVID-19 pandemic. In their work, DSMs from different sources in Slovenia were collected to make the waste samples more heterogeneous. During the leaching and degradation processes of DSMs, the potential water pollution triggered by micro/nanoplastics and other harmful components may emerge. The experimental findings revealed that DSMs contained a high content of chlorine elements, indicating the existence of halogenated organic compounds. Nevertheless, when DSMs were exposed to leaching, moisture, temperature, and UV radiation during a short period, a considerable amount of micro/nanoplastics were detected, which was the main problem. Finally, several recommended strategies were proposed, including stricter management, effective recycling, reuse, resource utilization, biodegradable alternatives, and ecotoxicological measures.

Two papers from China are presented on this topic of water quality evaluation. Zhang et al. (Contribution 7) evaluated the water environment quality and analyzed the pollution source of a river in southwest China (Tuojiang River) by selecting chemical oxygen demand, ammonia nitrogen, and total phosphorus as evaluation indicators. The results demonstrated that grey water footprint declined, suggesting an improvement in the water environment quality. Total phosphorus accounted for the largest percentage of the pollution sources of the grey water footprint. Farmland and stock breeding pollution were the dominant sources of the grey water footprint and contributed major influence factors for the water environment. This research suggested that the water environment quality in the Tuojiang River has been improving. On account of these findings, some constructive suggestions were proposed in this work. Feng and Yang et al. (Contribution 8) performed a water chemical characteristics and safety assessment of the Chenbarhu Banner coalfield in northeast China (Hulun Buir). The results disclosed that Na^+ and HCO_3^- were the dominant chemicals in the groundwater. The main chemical types of surface water, river water, and confined water were revealed, respectively. Further analysis illustrated that rock leaching and ion exchange were the dominant influencing factors of hydrochemical characteristics. This work showed that the groundwater quality was mainly polluted by breeding, industrial and agricultural pollution as well as domestic sewage instead of the local coal mine and coal chemical plants. The aforementioned studies provided significant references for the quality evaluation and pollution analysis of both surface water and groundwater.

Cement and concrete materials have shaped modern civilization. Two papers address this topic. Gao et al. (Contribution 9) investigated the effects of continuous loading and wet–dry cycles on the deterioration of concrete strength. The concrete strength was evaluated by uniaxial compression, and the strength deterioration mechanism was proposed by employing acoustic emission and nuclear magnetic resonance techniques. Li et al. (Contribution 10) developed a fluid–solid coupling similar material by adopting stone (5–20 mm) as aggregate and Portland cement (P.O 32.5) as a binder. The fluid–solid coupling similar materials possessed the following characteristics: loose structure, high porosity, and good permeability. The constructed material with a low uniaxial compressive strength of 0.394–0.528 MPa did not disintegrate in water. The influence of the water–cement ratio on the elastic modulus was studied, and the constitutive model was further established based on the Weibull distribution.

3. Conclusions

The contributions in this Special Issue will advance the research on the resource utilization of solid waste and water quality evaluation through new methods and strategies. This collection delves into the material utilization of several kinds of industrial residues, which realizes the generation of a series of materials, including controlled low-strength filling material and composite cementitious materials. Apart from industrial residues, the collection also discusses the potential micro/nanoplastic pollution from disposable surgical masks. Also, it presents the water environment quality of two different areas, viz., surface water in southwest China (Tuojiang River) and groundwater in northeast China (Hulun Buir). Moreover, two contributions are focused on cement-based materials, which exploit the deterioration of concrete under continuous loading and wet–dry cycles, and the excellent performance of a fluid–solid coupling similar material. The research presented in this collection will offer an important reference to further exploration in this realm. Future efforts can be made in the crossing research between the material utilization of solid waste and wastewater purification.

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