Design of Geopolymer for Removal of Nitrogen in Industrial Wastewater based on Artificial Intelligence Technology

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Abstract. In the era of big data, as an essential direction of international development in the next few decades, artificial intelligence has an extensive application suitable for all fields of life. Nowadays, artificial intelligence technology is also integrated into production and life. As a new unique material, geopolymer has been widely used thanks to its properties. Due to their special network structure, geopolymer materials have a higher temperature and mechanical properties than other materials, such as cement, ceramics, and metals. The experiment results show that the artificial intelligence technology is very suitable for the geopolymer design for nitrogen removal from industrial wastewater, and the satisfaction is as high as 72.3%. In this paper, industrial wastewater is used as raw material for nitrogen removal, and the future development direction of geopolymer research is analyzed. We hope to provide a novel way for the utilization of industrial wastewater.

1. Introduction
Geopolymer is a new type of chemically activated cementitious material containing many kinds of semi-crystalline or non-crystalline three-dimensional aluminate mineral polymers. Kaolin can be used as the main raw material for geopolymer preparation. Some industrial wastewater with hydraulic activity can also prepare geopolymer, such as blast furnace slag, steel slag, coal ash, brick dust, natural coal stone, etc. Geopolymer has low energy consumption and little emission of three wastes in the production process, realizing sustainable development. Geopolymers can also be recycled. Geopolymer is a new material developed in recent years. It can replace cement in many cases, and its performance is better than that of cement [1-3].

Artificial intelligence technology is convenient for residents' lives; it provides a feasible direction for developing computer network information technology. For the present stage of social development, the critical element is the improvement and innovation of information technology, equipped with its use. In these days, the Internet industry has rapidly developed. Additionally, entrepreneurs do not need to create or purchase servers alone but only focus on products and innovation models and directly participate in leasing services. In this demand, artificial intelligence technology is bound to spread swiftly [4-6].

Geopolymer has the advantages of early strength (up to 15-20 MPa in 4 hours), excellent working performance, and adjustable time. Geopolymer has been considered as strong ice resistance and alkaline corrosion resistance. Strong absorption and fixation ability to heavy metal ions and radioactive materials have also been investigated. It also has high heat and temperature resistance. Several studies have predicted that the service life of geopolymer can reach more than 1000 years without deterioration. Geopolymer is mainly composed of silicate minerals (such as kaolinite) cooked at a specified temperature (600-900℃). The characteristics of low energy consumption and less resource consumption have been widely reported. Its raw materials have the advantages of large source, simple process, low
price, low energy consumption, high mechanical properties, and strong stability. This paper analyses the polymerization mechanism of nitrogen removal from industrial wastewater and the performance characteristics of geopolymer based on artificial intelligence technology. Briefly introduces the development process and application status of geopolymer and summarizes its application prospect in engineering, toxic waste, covering, sealing, and ceramic materials [7-10].

2. Artificial Intelligence Technology and Geopolymer

2.1 Artificial Intelligence Technology
As its name implies, artificial intelligence is a kind of network technology that imitates human thinking and behaviour by using computers. Besides, it also includes the main aspects of psychology, such as realizing logic and improving people's daily lives. With the rapid expansion of artificial intelligence, it has become the leader of intelligent technology. Artificial intelligence enables the computer system to realize the transformation of human thought and behaviour after being input into certain specific programs and completing simulating human life. However, for computer network technology, artificial intelligence can use big data to process more complex and ambiguous information, quickly extract useful information from different data, and directly transmit the valuable information to users after processing. It improves the advantages of artificial intelligence in daily life and the correctness of data processing and dramatically facilitates people's life.

2.2 Geopolymer
Geopolymer belongs to aluminosilicate, a new type of polymer material, commonly known as geopolymer. Since the discovery of geopolymer, its application scope has been expanding. Structurally, its gelation system is a three-dimensional network with crystal and amorphous forms. It is composed of oxygen tetrahedron polymerization, mainly aluminum and silicon elements. The primary raw materials are solid or natural mineral residues. Due to geological reasons, the raw materials are free and easy to carry. The address polymer has the advantages of easy curing control, early strength, fast gel, stable performance, excellent cement performance, temperature resistance, compression resistance, and high-temperature corrosion resistance. Compared with traditional building materials, their characteristics are satisfied, and their prospects are broad. Geopolymer has stable features and is not easy to replace. Its service life can reach 1000 years. Much research has studied the hydration and degumming process of geopolymer with high-tech equipment and instruments. Studies have proposed more details of hydration and degumming of geopolymer. The specific reaction formula is as follows:

$$Al_4O_4[Si_4O_{10}] + 4Na^+ + SiO_2^{4-} \rightarrow Na_4[(AlSiO_4)O_n] \cdot nH_2O \quad (1)$$

$$n(SiO_2O_4\cdot Al_2O_3) + 4nH_2O + NaOH \rightarrow Na^+ \cdot K^+ + n(OH)_3 - Si - (OH)_3 \quad (2)$$

$$n(OH)_3 - Si - O - Al^+ + NaOH \rightarrow Na^+ - Si + (OH)_3 - Al^+ \quad (3)$$

3. Experimental Ideas and Design
Geopolymer is different from traditional organic material polymer. It is not easy to be aged, light, and robust, and it is not easy to be affected by the environment to achieve sustainable development. Geopolymer has the advantages of organic polymer and inorganic silicate rock cement. Due to its unique three-dimensional geological structure, geopolymer has a large thickness and high strength, so it is not easy to penetrate. There are high concentrations of electrolyte in the gate and melt. Therefore, geopolymer can resist low temperature and has the ability of circulation. Simultaneously, its thermal conductivity is low, only about 0.3w / (m · K). It will not oxidize and decompose at 1000 °C, and its high-temperature resistance is excellent. As a professional refractory, geopolymer has a good thermal insulation effect. With the increase of temperature, its linear shrinkage is only 2%. When it is at a high temperature, its linear reduction rate has little change, and its high-temperature performance is satisfied.
4. Applications in water and wastewater treatment

Geopolymers can be potentially used in water treatment and wastewater treatment. Researchers have long discovered the existence of zeolite-like structures in the final products of geological polymerization reactions, which can be used to adsorb and fix heavy metal ions to treat heavy metal wastewater by using geopolymer-like molecular sieve structures. As a green and cheap heavy metal adsorbent, geopolymers have a good adsorption effect on lead, copper, nickel, chromium, cadmium, and other heavy metals [11-12].

Besides, the technology can also be used to adjust the PH value in wastewater treatment. The acid produced by bacteria metabolism will decrease the PH value of the water during wastewater treatment, which affects the stability of the water's PH value. Geopolymers, which contain free alkalis in pore solutions, can neutralize acids and act as buffers to maintain PH stability.

Finally, the addition of copper or silver employing ion-exchange or the addition of nanoparticles can also be used as new antibacterial material. For example, silver silica nanocomposite becomes aluminosilicate matrix water, which can be used as an antibacterial adhesive [11-12].

5. Discussion

5.1 Current Situation Analysis of Industrial Denitrification Geopolymer Based on Artificial Intelligence Technology

According to the experimental results, we investigated and analysed the results, and the results are shown in Table 1. Through experiments, studies have proved that flow experiments are carried out under relevant conditions after adding one-thousandth of lead into geopolymer. After 24 hours, the solution reached equilibrium. At this time, the mobile solution contained only 10 mg Pb per liter. There is no doubt that geopolymer can effectively prevent the outflow of heavy metal ions, and the toxic substances in geopolymer prepared from industrial wastewater will not cause harm. At the same time, geopolymers can be used to seal radioactive metals and toxic metal substances. The research results show that geopolymer can be strengthened rapidly, similar to cement's rapid strengthening. At room temperature, after several hours of hydration, the compression force can reach 20 MPa. With the increase of time, the compression force will continue to increase and reach 100 MPa in a month. Within one day of formation, the geopolymer's mechanical strength can be rapidly increased to 60% of the final strength.

Table 1. Main technical properties of Geopolymer

| project                          | Test 1  | Test 2  |
|----------------------------------|---------|---------|
| Specific surface area / (M2 · kg - 1) | 445     | 445     |
| Density / (kg · M-3)             | 2630    | 2630    |
| Curing temperature / ℃           | 29      | 72      |
| Setting time / h                 | 1.2     | 0.26    |
| Polymer compressive strength / MPa | 85.7    | 83.9    |

In addition, this paper uses two forms: a questionnaire survey and an on-the-spot interview. 1082 citizens were randomly selected as the survey sample. The respondents included students, public residents, and professionals. The purpose of this study was to explore the current situation of geopolymer for nitrogen removal from industrial wastewater based on artificial intelligence technology. It can be seen from Figure 1 that people are very satisfied with the design of geopolymer for denitrification of industrial wastewater based on intelligent technology. In the next few years, with the development of science and technology and the thinking trend that human beings want to release, artificial intelligence technology would be faster. But it will also expand from industrial robots to service robots. Artificial intelligence plays an important role in the design of geopolymer for nitrogen removal from industrial wastewater. Compared with other developed countries, the level of intelligent manufacturing industry
in China is very backward to a large extent. A good application of artificial intelligence technology can effectively develop China's intelligent production and service industry, improve China's competitiveness, and promote China's artificial intelligence technology.

![Figure 1. People's satisfaction with artificial nitrogen removal technology of industrial wastewater](image1.png)

In this paper, the process of nitrogen removal from industrial wastewater is investigated, and the process flow chart of nitrogen removal from industrial wastewater is obtained, as shown in Figure 2. For many years, due to the new decarbonization process and the optimization of the existing process, the plant's raw material consumption and energy efficiency have been greatly improved. To meet the process requirements of low energy consumption, important development work has been completed in the Benfield unit. Only the heat of syngas in the conversion process under the design range of water nitrogen ratio is consumed. This process is called the low heat consumption Benfield process. In the low heat process, the regeneration liquid's pressure is reduced, and the sensible heat input into the regeneration tower solution is converted into steam. Therefore, the heat in the Benfield unit can be partially recovered from the flash regeneration liquid. Because it is the steam generated by reducing the pressure below the regeneration tower's pressure, the flash steam must be pressurized before it can be re-added to the regeneration tower.

![Figure 2. Process flow chart of nitrogen removal from industrial wastewater](image2.png)
5.2. Application Direction of Geopolymer Design for nitrogen removal from Industrial Wastewater under Artificial Intelligence Technology

5.2.1. Realize process production. The application of artificial intelligence in geopolymer design for nitrogen removal from industrial wastewater can greatly improve work efficiency. From artificial intelligence to the realization of computer dynamic simulation and scientific prediction, it contributes a force to factory production and processing management and provides strong technical support. When carrying out planned management activities, it can strengthen employees' behavior management, reduce unnecessary expenses, and then effectively carry out follow-up activities through data processing. To reflect the advantages of artificial intelligence significantly in the design of geopolymer for nitrogen removal from industrial wastewater, operators should start from the status quo, start with an artificial neural network, process and evaluate some network data, detect the working state of computer network technology, and quickly obtain the main functional parameters by using artificial neural network, and compare the parameters and actual processing Production standards, look at the differences between them, so that the results of the comparison can be revealed. The processing results of the computer network can be presented intuitively. Using the weights and thresholds of additional neurons, the input and output values can also be linked to form the best results. In the framework of the artificial neural network, it can process various basic data efficiently. The most important thing is that it can read the operation of infrastructure and some key parameters used by computer network technology and reasonably apply it to the geopolymer design for nitrogen removal from industrial wastewater.

5.2.2. It is used in light, fireproof and high temperature resistant materials. In recent years, the construction fire of external wall thermal insulation materials frequently occurs, which promotes the rapid development of inorganic thermal insulation materials. Geopolymer has attracted increasing attention thanks to its green, strong and non-burning characteristics. It can be cured at room temperature or normal humidity. With Fly Ash Geopolymer as raw material, additives, and stabilizers can be used to prepare easy forming materials. The thermal energy is less than 0.09 (m · K). Therefore, geopolymer is often used in oven, pipeline, and thermal insulation material and so on. It is estimated that geopolymer materials can meet the first class fire protection standard in aircraft applications.

5.2.3. The direction of nuclear waste sealing. All types of radioactive materials formed in nuclear power plants and other radioactive research sites have high costs and processes and are complex. However, geopolymer zeolite has the advantages of simple operation, effective storage of radioactive materials, good stability, and low cost. In this regard, it is rarely used in China, and it would be one of China's main development directions. Compared with traditional materials, geopolymer has special geological properties, which shortens the healing cycle, saves wet curing time, saves cost, and is easy to process. Moreover, the geopolymer material appearance of the composition is similar to that of natural stone to be used as a decorative and sustainable material.

5.2.4. It is applied in the direction of coating development and the treatment of toxic waste residue. In the preparation of coatings, geopolymer can be used instead of organic materials to make the coatings have the special properties of geopolymers, such as fire retardant coatings, environmental protection coatings, anticorrosive coatings, fog coatings, etc. Geopolymer as overburden has broad prospects. Geopolymers can form zeolite materials, absorb toxic substances effectively, and preserve heavy metals and radioactive elements effectively. The specific application needs further research and development.

The most commonly used aluminosilicate raw materials for technique adsorbents are metakaolin and class fly ash activated by sodium hydroxide or silicate. Only a few other aluminosilicate precursors and activators have been studied. It should be noted that metakaolin is purer and more consistent in chemical quality than industrial by-products and is thus more suitable for high-value products. For instance, adsorbents for groundwater softening require a certain level of purity. Showed that sodium-based activators resulted in better capacity than potassium-based activators in the case of ammonium
(NH4+) adsorption by metakaolin geopolymer. Typically, aggregates have not been incorporated in technique adsorbents, but zeolite has been added as a filler in some cases.

6. Conclusion

Artificial intelligence is a novel technology field. Although artificial intelligence technology's current application is still minimal, its broad development prospects are obvious. Given the increasing emphasis on environmental protection worldwide, the emergence and application of artificial intelligence technology have added new vitality to the field of environmental protection and has become a strong technical guarantee for environmental protection work, especially in the production control and environmental automation, which has become an important development trend of environmental protection and environmental assessment in the future. With the progress of industrial technology, there are more kinds of pollutants and more complex components. Furthermore, thanks to geopolymer's various beneficial characteristics, plentiful studies about water and wastewater treatment have remarkably expanded in the last decade. The control, removal, analysis, and evaluation of pollutants will become a new challenge. The arrival of the artificial intelligence era will provide new solutions for pollution control.

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