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Exploration on Fuzzy Control in Water Pollution Prevention System and Computer-aided Model Construction

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Abstract: Water is the basic resource to maintain human health, promote economic development and biodiversity. However, with the economic growth and the increasingly serious problem of water pollution, it has an impact on the environment and socio-economic development. A comprehensive and accurate assessment of water pollution is essential for the protection of water resources. However, the current water pollution prevention still has problems such as inadequate supervision and detection accuracy, which is not conducive to water pollution prevention. Therefore, this paper constructed a computer-aided model of water pollution prevention system through fuzzy control to help it realize the detection and control of water pollution, so as to reduce pollution and promote environmental development. After applying the computer-aided model for water pollution prevention, the adaptability was 14% higher than before, the water quality prediction effect was 13.4% higher than before, and the water pollution treatment efficiency was 12.5% higher than before. In a word, the computer-aided model can help to quickly detect water pollution sources and improve water sources.

1. Introduction

The causes of water pollution due to the crude economic growth model include low compliance with industrial wastewater standards and low urban wastewater treatment rates, which have led to serious contamination of water resources and reduced or even lost water functions. Water pollution is one of the most serious environmental problems. Therefore, it is necessary to research and develop a universal and functional computer-assisted water pollution management and control system, which is of great significance for the prevention and control of water pollution.

Water pollution control has a significant effect on environmental sustainability. Deletic Ana believed that to effectively control water pollution, it is necessary to understand the traditional and emerging pollutants, deeply understand the natural treatment process, develop advanced purification systems, and understand the ecosystem that may be affected by environmental emissions or pollution [1]. Sheng Jichuan described the existing forms of government in the North and South Pacific, and pointed out the existing problems and potential solutions. Payment for ecosystem services or ecological compensation is the application of neo-liberal environmentalism, which can overcome the shortcomings of the competition [2]. Wang Yubao's empirical results suggested that the pressure to improve environmental quality was greater when instrumental variables such as cell phones and Internet information dissemination were affected, which would prompt the government to protect against industrial water pollution [3]. According to the mixed application of membrane technology with other types of water treatment methods such as adsorption, advanced oxidation process and biological activated sludge, Martini Sri discussed the latest development of membrane technology for sewage and wastewater purification [4]. Singh Upma discussed the impact of industrial wastewater on biological systems through Indian water bodies, and found that industrial growth would promote the pollution of water quality [5]. Tan Poh-Ling analyzed the environmental, social, political and legal conditions that promote or hinder the successful management of diffuse water pollution, and the management method should be changed to focus on resilience [6]. The review work of Panda Pratap Kumar put forward opinions and suggestions for the interpretation of the experimental results by applying the standard concept, and outlined a brief guideline for river water pollution assessment. He also outlined the relationship between different physical and chemical parameters [7]. The above studies have described the role of water pollution prevention, but no model has been built.

Many scholars have studied and analyzed water pollution monitoring. Chen Sophia Shuang suggested the need for an economically feasible approach to early detection of surface water quality in a timely manner [8]. Chen Sophia Shuang analyzed the impact on cross-border water pollution. Environmental protection officials can curb transboundary pollution by reducing the production of polluting enterprises and promoting public pollution reports, and reduce environmental pollution through environmental law enforcement and coordinated governance [9]. Sharma Rohit calculated the water quality of three main rivers in India, indicating the degradation degree of water quality in Indian rivers [10]. Xu Zuxin believed that water quality can be improved by reducing pollution, eliminating leakage, minimizing the discharge of hazardous chemicals and materials, halving the proportion of untreated wastewater, and significantly increasing the recycling and reuse of global goods [11]. Obinna Isiuku Beniah believed that heavy metals and organic pollutants are common environmental pollutants that affect soil, water and air quality. He briefly reviewed the research progress and practical application of phytoremediation in water resources in recent years [12]. All the above studies have described the monitoring of water pollution quality, but there are still some deficiencies in the computer-aided model.

In order to study the specific effect of water pollution prevention, this paper analyzed the fitness of the water pollution prevention system through genetic algorithm, and then analyzed the water quality prediction effect and fitness of the water pollution prevention system and the traditional system through comparative experiments. Through experimental analysis, it was found that the computer-aided model could rapidly predict water quality, and the prediction effect was more accurate. Compared with other literatures, this paper focused on comparing the prediction effects of new and traditional models.

2. Database Design and Thinking of Water Pollution Prevention System

2.1. Database Design of Water Pollution Prevention System

The water pollution system includes different types of data, a large amount of data, many of which are processed and encrypted, and the entire database is in the centralized storage management mode, as shown in Figure 1. The system database uses relational database. First, it is needed to create an entity relationship diagram, and then convert the entity relationship diagram into a relationship model. After that, it is converted into a data model that supports fuzzy control according to its characteristics and limitations, and it is converted into an integrated data repository through the data engine. The database of the system is mainly composed of basic spatial database, thematic spatial database and water pollution database. The basic spatial database includes basic frame data, image data and place name data. The thematic spatial database should include the spatial database related to water pollution. The database includes water pollution database and water pollution spatial data. It is necessary to maintain this geographical database and the water pollution geographical database to disseminate geographical data.

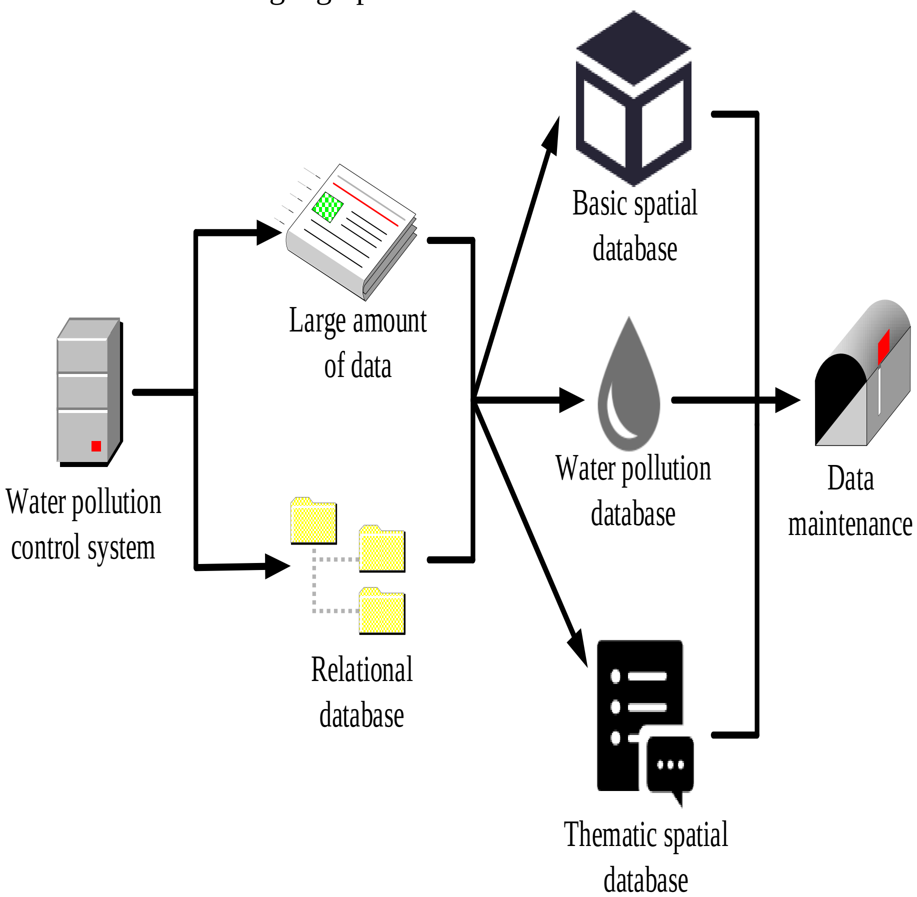


Figure 1. Database design of water pollution prevention system

2.2. Ideas for the Construction of Computer-aided Model of Water Pollution Prevention System

The design of water pollution prevention system is gradually established from three aspects: water resources protection and conservation, water pollution management and wastewater reuse, wastewater management and river restoration. In terms of pollution management and control, the water pollution control system includes six main measures, as shown in Figure 2. It is necessary to maintain river water quality control; Industrial restructuring is needed to promote cleaner production; control measures shall be strengthened for pollutant emission sources, and pollutant disposal and relocation shall be implemented; urban wastewater needs centralized treatment; sewage recycling is required. The full implementation of these six measures would help to comprehensively control the serious degradation of the water environment and thus achieve the national objectives. It can also meet the needs of large-scale economic development in areas with serious water shortage.

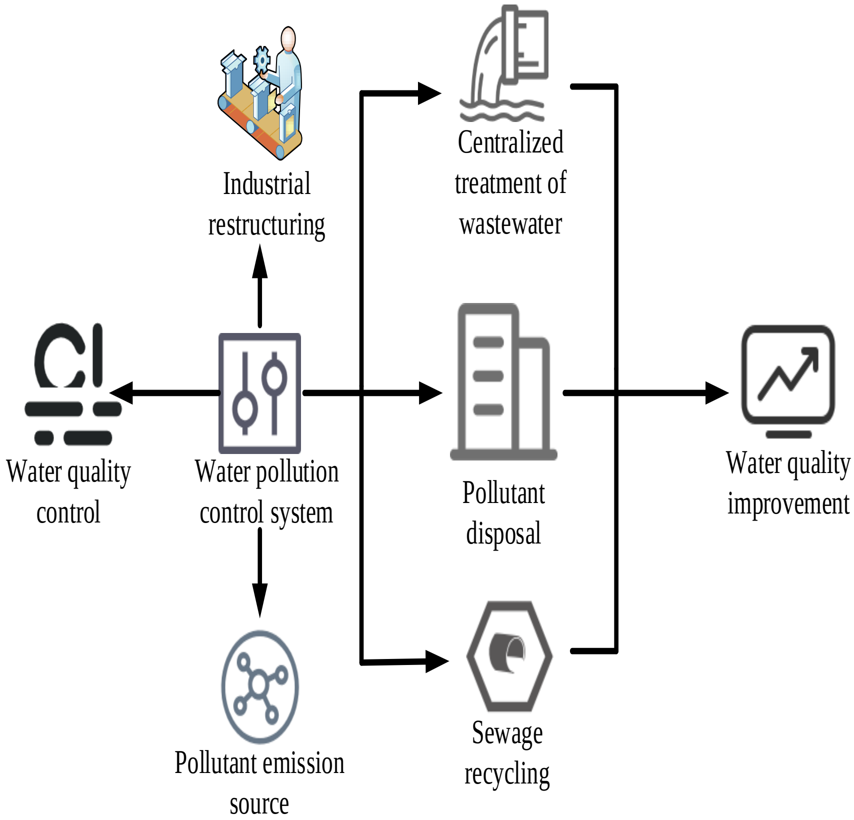


Figure 2. Six main measures for water pollution control system

These water pollution control systems are conducive to protecting rural and urban drinking water sources and groundwater; it can improve industrial and agricultural water quality and restore river functions; through the implementation of wastewater treatment projects, agricultural wastewater reuse projects can be planned, and agricultural ecological degradation can be monitored through irrigation; it can coordinate the water pollution control and social and economic development of the basin, and select the water pollution technical solutions, so as to reasonably control the water pollution; it can apply the best control theory to determine the best technical scheme for controlling water pollution. Biochar can enhance the flocculation, dehydration, adsorption and oxidation processes in the process of urban wastewater treatment, thus contributing to sludge management, odor mitigation and nutrient recovery [13]. The pollutant discharge of enterprises must first comply with relevant industrial standards. Therefore, if the requirements for comprehensive control of pollutant emissions have not been met, corrective actions must be taken. The system allows enterprises to analyze the most appropriate technical solutions according to their decision objectives. From different perspectives, the environment and decision makers are part of the regional sanitation plan, and can also be part of the special plan for water environment restoration. In order to understand the level that can be achieved in the water environment, the decision-making objectives are usually based on the macro analysis of the industry rather than specific companies.

2.3. Auxiliary Model Functions of Water Pollution Control System

The system has multi-layer structure and modular development, with independent modules and open modular interfaces. Damage and replacement of application modules would not affect other modules. Logically, the system has three typical data layers, application layers and performance layers, as shown in Figure 3.

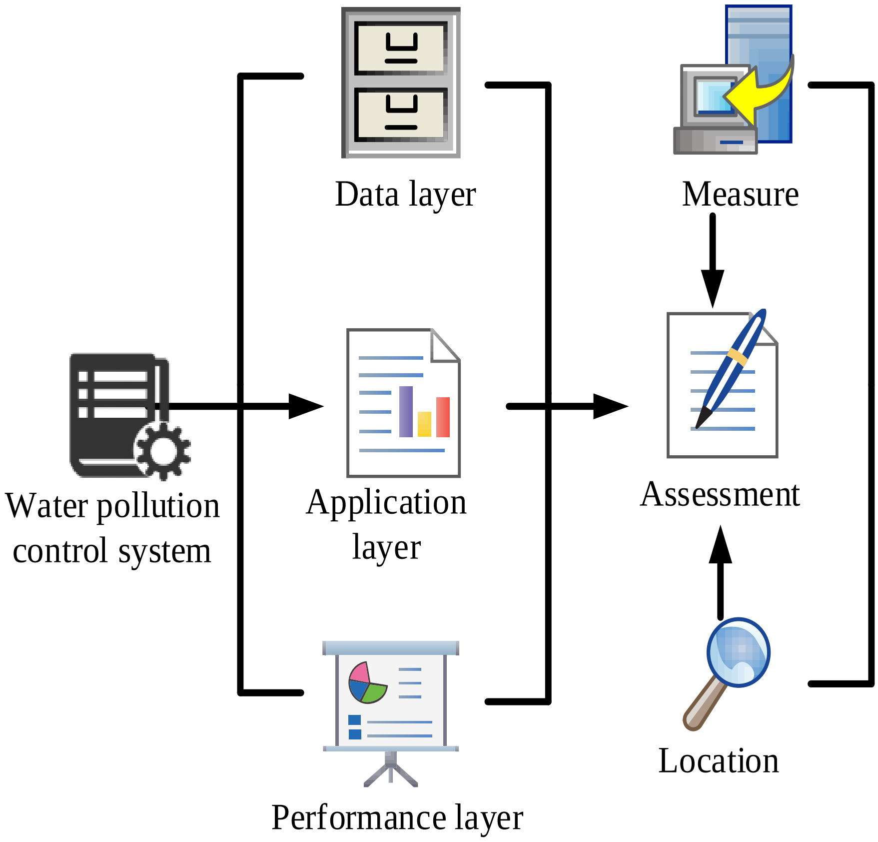


Figure 3. Three typical classification layers in the system

In the browser/server mode, the search engine system provides basic positioning tasks based on the structural framework, such as display, zoom in, zoom out, roaming, eagle eye, telemetry and other electronic cards, and provides basic measurement and positioning, as well as advanced positioning functions, such as buffer analysis. The background maintenance system mainly includes data editing (editing geospatial and attribute data) and database maintenance (creating database, importing data, managing data and applications). For administrators, the automated system based on the system database is used to analyze and model the factors affecting the water environment to improve the efficiency and affordability of water treatment and wastewater reuse [14]. The modeling of water environment change trend and water environment management results ultimately provides the basis for water environment quality management decision-making, thus forming the core of the system.

The computer-aided system has three functional modules, which should include the model for analyzing the emission reduction potential, the water environment quality model and the industrial development decision support model. The model of reducing emission potential aims to explore the maximum potential of the company's emission reduction, and is supported by the best emission reduction technology and the best enterprise choice. The purpose of the water environment quality model is to analyze the reduction of pollutants and the corresponding changes of river water quality after the adoption of the best technology in the industrial wastewater treatment plant. Industrial development decision support model: managers use industrial development decision support model to determine the water pollution recovery plan in the recovery plan, and analyze which industrial combination is most suitable for development and the largest flow.

3. Construction of Computer-aided Model of Water Pollution Prevention System

The quality of water body is an issue that is increasingly concerned by the environment [15]. The computer-aided model of water pollution prevention system is constructed under fuzzy control, which mainly includes the following three aspects.

3.1. Establishment of Spatial Database

The spatial database mainly stores geographic information such as regional terrain, soil shape and its components, including administrative distribution, digital survey, land use, soil type, water system, rivers, etc. In addition, data for factories and other topics should also be stored. Basic spatial data includes vector data and image data.

3.2. Construction of Geographic Information Platform

The system uses the programmable control room to display the space level and automatically generate the theme map. The platform provides developers with fast, easy-to-use and powerful display components. In different development environments, software controls have been placed in windows at the design stage. Data visualization, subject analysis, geographic query, and map information system with various attributes (such as geographic code) can be performed by defining call methods or related events.

3.3. Water Environment Diagnosis and Water Quality Prediction System

Based on the comprehensive index system and index model, the system analyzes and early warning the water quality and pollutant discharge on the spatial scale of the control area and the basin. The water environment early warning system can provide early warning of water environment quality, pollutant discharge and overall water environment conditions. The system also has the function of automatically reporting the aquatic environment status and alarm results, and automatically generating diagnosis and alarm so that users can see and understand the water environment.

4. Application of Genetic Algorithm in Water Pollution Control System

This paper used genetic algorithm to determine the regional optimal planning constraints in the water pollution prevention system as Formula (1):

$$\begin{cases} AY + i \leq Y_0 \\ BY + j \leq Y_0 \\ Y_0 \geq 0 \end{cases} \tag{1}$$

Among them, A and B are the coefficients of water quality monitoring by the water pollution control system; i and j are the water quality concentration vectors of the water pollution control system. Next, the objective function of constructing the water pollution prevention system is:

$$T_i = R_i + q\sum_{j=1}^{k}\alpha_j \tag{2}$$

Among them, q is the penalty factor, and α_j is the importance of water pollution prevention. Finally, the fitness of the control system can be obtained as Formula (3):

$$T(i) = \frac{\exp\left[-\frac{T(i)}{\varepsilon}\right]}{\sum_{j=1}^{n}\exp\left[-\frac{T(i)}{\varepsilon}\right]} \tag{3}$$

Among them, ε is the standard deviation of the system.

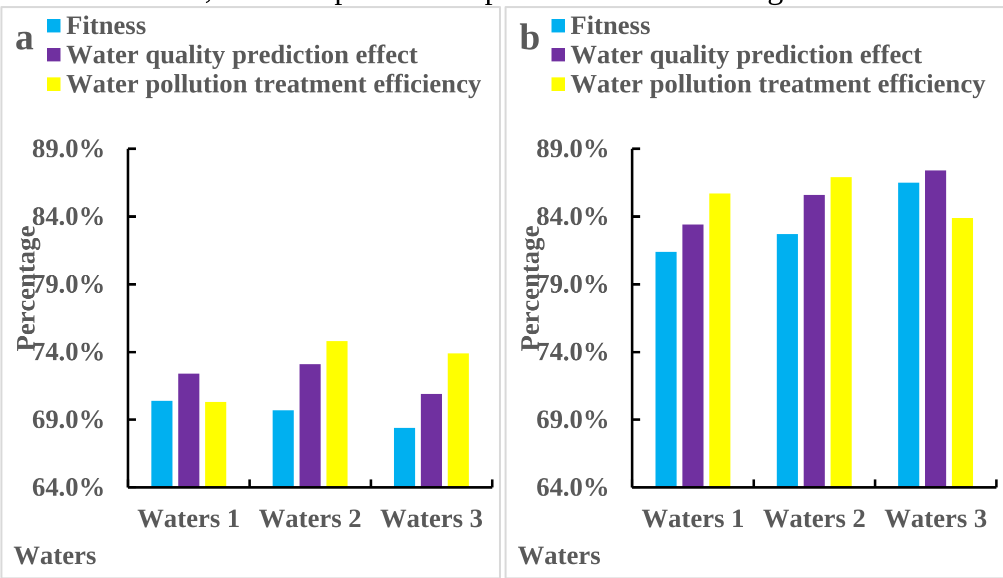
5. Computer-aided Model Experiment of Water Pollution Prevention System

In order to study the specific application effect of the computer-aided model of the fuzzy control water pollution prevention system, this paper analyzed the satisfaction of the water conservancy department with the construction of the computer-aided model of the water pollution prevention system, and then used the genetic algorithm to analyze and study the adaptability of the prevention system, the prediction effect of water quality and the efficiency of water pollution treatment. First of all, this paper investigated the satisfaction of three water conservancy management departments with the construction of the computer-aided model of the water pollution prevention system, of which 50 people were surveyed by each department. The specific survey results are shown in Table 1.

Table 1. Satisfaction of three water conservancy departments with the construction of computer-aided model of water pollution prevention system

	Satisfied	Commonly	Dissatisfied
Management department 1	Forty-three	Four	Three
Management department 2	Forty	Six	Four
Management department 3	Forty-five	Three	Two
Total	One hundred and twenty-eight	Thirteen	Nine

According to the data described in Table 1, the three water conservancy management departments were relatively satisfied with the construction of the computer-aided model of the water pollution prevention system. Among the group with a satisfactory attitude, the management department 1 had 43 people, accounting for 33.6% of the group; there were 40 people in management department 2, accounting for 31.3% of the group; there were 45 people in management department 3, accounting for 35.2% of this group. Among groups with general attitudes, there were 4 people in the management department 1, accounting for 30.8% of the group; there were 6 people in the management department 2, accounting for 46.2% of the group; there were 3 people in the management department 3, accounting for 23.1% of the group. Among the group with dissatisfied attitudes, there were 3 people in the management department 1, accounting for 33.3% of the group; there were 4 people in the management department 2, accounting for 44.4% of the group; there were 2 people in management department 3, accounting for 22.2% of the group. On the whole, the satisfied group accounted for 85.3% of the total number of respondents; the general group accounted for 8.7% of the total number of respondents; the dissatisfied group accounted for 6% of the total number of respondents. Satisfactory managers believed that the model can accurately predict the change of water quality, and can also deal with water pollution in time, improve the adaptability of the system, and expand the carrying capacity of water resources. The unsatisfied managers believed that the model needed more technical support, not only needed to relearn relevant theories, but also needed a certain maintenance cost. Finally, the adaptability, water quality prediction effect and water pollution treatment efficiency before and after the application of the auxiliary model of the water pollution prevention system were analyzed and compared. A total of three water areas were tested, and the specific comparison is shown in Figure 4.



a. Before applying the model *b. After applying the model*

Figure 4. Changes in adaptability, water quality prediction effect and water pollution treatment efficiency before and after the application of auxiliary model of water pollution control system

Figure 4a shows before the application of the auxiliary prevention and control model, and Figure 4b shows after the application of the auxiliary prevention and control model. According to Figure 4a, the fitness of water area 1 was 70.4%, the water quality prediction effect was 72.4%, and the water pollution treatment efficiency was 70.3% before using the auxiliary model for prevention and control; the fitness of water area 2 was 69.7%, the water quality prediction effect was 73.1%, and the water pollution treatment efficiency was 74.8%; the fitness of water area 3 was 68.4%, the water quality prediction effect was 70.9%, and the water pollution treatment efficiency was 73.9%. According to Figure 4b, after applying the auxiliary model of prevention and control, the fitness of water area 1 was 81.4%, the water quality prediction effect was 83.4%, and the water pollution treatment efficiency was 85.7%; the fitness of water area 2 was 82.7%, the water quality prediction effect was 85.6%, and the water pollution treatment efficiency was 86.9%; the fitness of water area 3 was 86.5%, the water quality prediction effect was 87.4%, and the water pollution treatment efficiency was 83.9%.

Through comparison, it can be seen that the adaptability after using the computer-aided model for water pollution prevention was 14% higher than before, the water quality prediction effect was 13.4% higher than before, and the water pollution treatment efficiency was 12.5% higher than before. On the whole, the adaptability before applying the control model was 69.5%, the water quality prediction effect was 72.1%, and the water pollution treatment efficiency was 73.0%; after applying the control model, the adaptability was 83.5%, the water quality prediction effect was

85.5%, and the water pollution treatment efficiency was 85.5%. The computer aided model in the water pollution prevention system can quickly improve the water quality detection effect and facilitate the management personnel to deal with it in time.

6. Conclusion

Water pollution has a negative impact on economic development and human health, but the unpredictability of water quality is not enough to prevent water pollution. In order to effectively prevent and control water pollution, a computer-aided model can be constructed using fuzzy control, which is helpful to predict water pollution and lay a foundation for preventing water pollution. Computer models provide complete storage and seamless linkage of spatial data and objects. Model systems can be used to manage models to simulate complex structured decision-making processes and to control water pollution. In addition, the system can help solve water pollution problems and improve the efficiency of water pollution treatment.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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