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Water Pollution Problems and Prevention Strategies in Environmental Engineering Based on Virtual Reality Technology

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Abstract: The water pollution accident in environmental engineering is a sudden, multifaceted, unorganized and destructive accident. However, with the rapid development of social production, the rapid development of industrialization has led to more and more pollution accidents, which has a significant impact on the local ecological environment and residents. Virtual reality (VR) technology can conduct virtual simulation of water pollution accidents, and timely monitor and eliminate water pollution accidents. This paper introduced the significance of environmental protection engineering and VR technology, and used OpenGL to simulate the virtual scene of water pollution accidents in environmental engineering. Firstly, three-dimensional (3D) scene simulation was carried out, then numerical simulation was carried out according to the characteristics of wastewater discharge. Finally, the entity and background were drawn to complete the virtual simulation of water pollution accidents. The experimental part used the water pollution accident virtual scene to treat the sewage, and compared it with the real water pollution situation. The experimental results showed that the virtual simulation scene can effectively reduce the COD (Chemical Oxygen Demand) content in the sewage and improve the water quality grade. The COD content in the sewage was reduced from 18.4mg/L to 13.9mg/L, and the water quality was greatly improved.

1. Introduction

Environmental issues are very important to human society, and the environment is the natural resource on which human beings depend for survival. However, today, ecological destruction occurs from time to time and seriously affects human health, which is why environmental

engineering appears. The emergence of environmental engineering has effectively alleviated environmental crises such as environmental damage and pollution. Through a series of effective measures and scientific environmental management, the environment can be more effectively used for the benefit of mankind.

At present, many scholars have studied water pollution. Evans Alexandra EV reviewed the knowledge of selected areas of agricultural water pollution, and identified future research needs [1]. Long Bui Ta considered the inverse problem in controlling river water pollution [2]. He Mingjing discussed the application of biochar in water pollution control in the context of sustainable development [3]. Yan Yan conducted ecological risk assessment on surface water pollution [4]. Wang Yubao evaluated the status of industrial water pollution and its prevention and control trend [5]. Li Z H O U studied the impact of river length system on water pollution [6].

Many other scholars have conducted relevant research on water pollution. Rink Karsten integrated a large number of heterogeneous data sets related to various hydrological divisions into a virtual geographical environment for water pollution control [7]. Suriadikusumah Abraham used the pollution index method to analyze the water quality of rivers [8]. Khatri Punit proposed a sustainable water quality monitoring system [9]. Morin-Crini Nadia reviewed water pollution cases of emerging pollutants worldwide [10]. Badar Zia Ul discussed the shortcomings and weaknesses of Pakistan's water-related institutions for the management of water pollution [11]. He Xiaodong quantified surface water pollution and its main influencing factors [12]. Although there are many studies on water pollution problems, it is necessary to continue to study prevention and control methods for the increasingly serious water pollution problems in environmental engineering.

In order to improve the prevention and control effect of water pollution in environmental engineering, this paper uses VR technology to study water pollution. This paper first briefly introduced environmental protection and water pollution prevention, and then introduced the interactive, immersive and imaginative characteristics of VR technology and the composition of VR system. The virtual scene of water pollution accident in environmental engineering was constructed by using VR system. Firstly, the 3D scene was constructed, and then the hydrogeological conceptual model, groundwater flow digital model and groundwater solute transport model obtained from the wastewater discharge pollution accident were numerically simulated. Finally, the background and entity were drawn to complete the construction of the water pollution accident virtual scene.

2. Environmental Protection Works

In recent years, due to industrial development, the discharge of industrial gases and wastewater has caused serious environmental pollution. Environmental projects refer to environmental problems that must be solved by specific organizations and relevant technical personnel. At present, environmental protection projects mainly include air pollution prevention, solid waste prevention and water pollution prevention, which can be divided into wastewater treatment and waste treatment when applied to real life [13].

Water pollution prevention measures in environmental protection projects are shown in Figure 1.

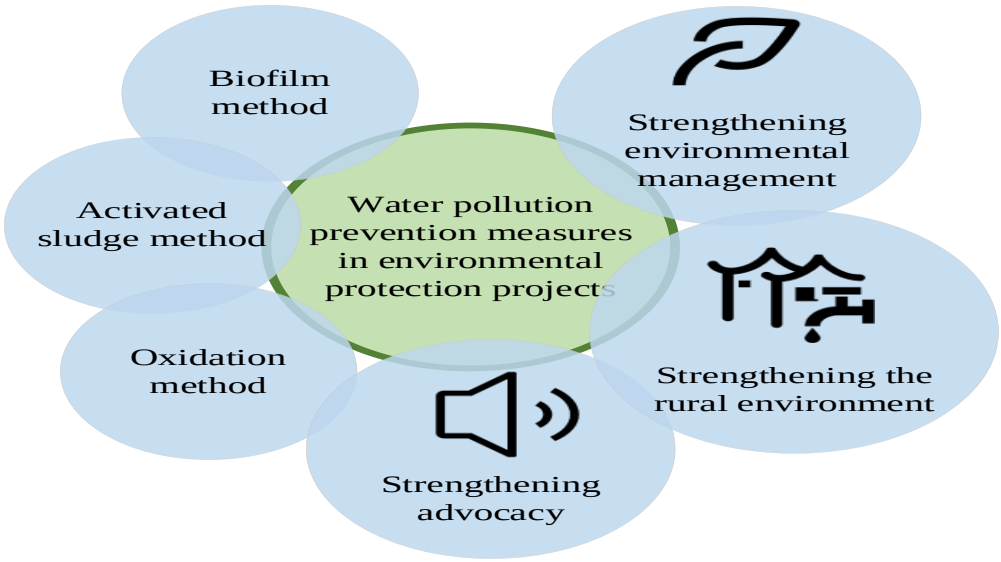


Figure 1. Water pollution prevention measures in environmental protection projects

The environment is vital to human survival. Trees can purify the air, block wind and sand, and absorb carbon dioxide from the air. Planting trees around the construction site can reduce noise. Water is the source of human life. Without water, human beings cannot survive. The serious situation of water pollution has aroused the high attention of the water resources management department. Water resource management is the requirement of social sustainable development and an important means of building a water-saving society. It can effectively protect the environment from the impact of global warming, and large-scale land pollution would also be improved to a certain extent. It would also be effective in reducing the formation of acid rain and curbing the emission of toxic gases. In order to minimize air pollution, environmental problems must be solved as soon as possible. Only by establishing a reliable, efficient and coordinated management system can people cope with serious environmental pollution. This can effectively solve economic problems, and improve the social management and public services of water resources, thus promoting the ability of rapid development of a healthy environment [14].

3. VR Technology

The VR system is shown in Figure 2.

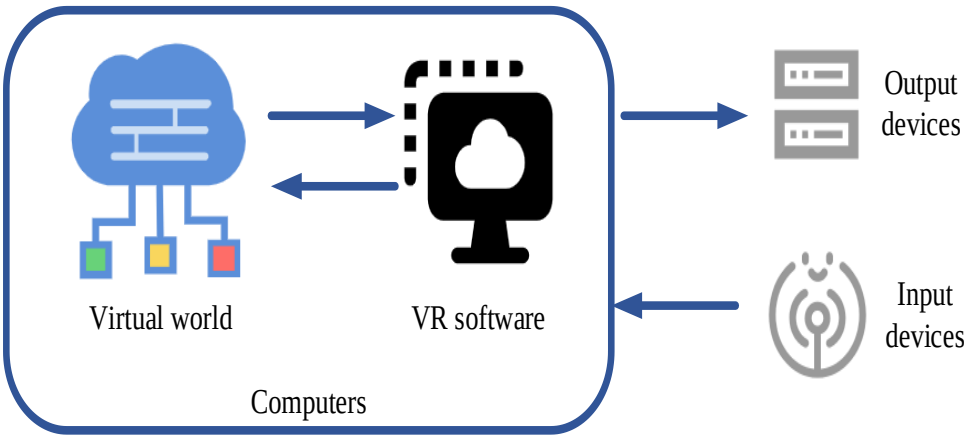


Figure 2. VR system

3.1. Interactivity

This means the authenticity of the object in the virtual environment and the natural feedback level of the environment (including real-time feedback). This interaction is mainly generated by various special interactive 3D devices (such as headphone screens, data gloves, etc.).

3.2. Immersion

This means the extent to which users feel they exist in the simulation environment. Immersive experience is considered as the performance standard of VR system. The reason for immersion is that users have similar sense of existence or illusion with real objects in the computer environment, so the following characteristics are required:

Multi-sensory: the ideal VR needs a variety of sensory functions that human beings have. For example, the virtual scene must be able to move in multiple directions from the human perspective, with more realistic texture, light, sound and video effects than reality, and users can feel the reaction of the virtual object when processing the virtual image.

Autonomy: in order to act independently and interact with users, virtual objects must have certain dynamic performance and conform to natural laws or laws introduced by designers. When an object is stressed, it would move up, tilt or fall from the table to the floor. Self-regulation is the ability of an object to regulate itself in a virtual environment according to the laws of physics [15].

3.3. Conceptual

Intelligent application objects and sufficient imagination can significantly improve performance and reduce labor intensity, thus improving product development quality. The application of VR system is the parallel work of VR and designers. Through VR technology, people have a sensitive and rational understanding of the integrated virtual environment, both qualitative and quantitative. In this way, concepts can be deepened and new ideas can be generated to actively research and explore information, rather than passively receiving it. It can continue to rely on the creativity and imagination of VR.

Through the “immersion”, “interactivity” and “conceptualization” of VR technology, participants can immerse themselves in the virtual environment, even transcend the virtual environment, and freely access and interact with the virtual environment. Therefore, human emotion is very important in the whole system.

4. Implementation of Water Pollution Accident Virtual Scene in Environmental Engineering

In recent years, scientific visualization, computer animation and VR have become the three most popular topics in computer graphics. The basis of these three popular technologies is 3D graphics. When people find it easiest to understand complex data in visual form, 3D graphics develop rapidly. Now information graphics is 3D. In this era, 3D graphics have become ubiquitous and widely used in all fields of life.

OpenGL is an open 3D graphics software, which greatly simplifies 3D graphics and provides good conditions for real 3D rendering.

4.1. 3D Scene Simulation

The visible 3D part is projected onto the layer. The scene data in the user command would be converted into processing items (the cut only retains the visible part). After vertex processing, these

coordinate data would be raster (projected) and pasted into the surface structure to create 2D segments.

Two-dimensional processing: After the necessary processing of each segment, the pixel can be obtained, and the pixel parameters are stored in the corresponding buffer memory. These processes determine whether the segment is locked and write only visible pixels to the buffer memory. After editing, the image of the current scene can be got.

Display: The buffer pixels can be displayed in the window, depending on the window system used. Windows S uses the WGL interface to send the hierarchical image generated by OpenGL to the GDI-DC window, and finally the GDI system performs the DC mapping operation. It supports special DC, such as DC printer. These DCs can use, store, or print graphics created by OpenGL in memory.

This process is completely automated. Of course, it can only be partially controlled or used. For simple application development, OpenGL can only work well in the first step. Advanced and fast servers can render colors, and clients can render networks, just send data and get photos.

4.2. Numerical Simulation of Wastewater Discharge Pollution Accident

4.2.1. Hydrogeological Conceptual Model

In the simulation area, rainfall is dominant in the aquifer, so the aquifer in this area is described as an unstable 3D isotropic conductor. The boundary of the flow simulation area in the west, upstream and downstream of the area is the boundary of horizontal discharge added to the model in the form of injection wells. This is the boundary of radial flow of the model, and the other boundary is the boundary of zero flow. The lower limit of the calculation area is the limit of the water barrier. The upper layer is filtered by precipitation and irrigated through the vent.

4.2.2. Groundwater Flow Mathematical Model

According to the conceptual model of hydrogeology, the runoff in the study area is an uneven isotropic 3D instantaneous flow, resulting in a mathematical model:

$$\frac{\partial}{\partial x}\left(k_x \frac{\partial h}{\partial x}\right) + \frac{\partial}{\partial y}\left(k_y \frac{\partial h}{\partial y}\right) + \frac{\partial}{\partial z}\left(k_z \frac{\partial h}{\partial z}\right) + W = S\frac{\partial h}{\partial z}t \tag{1}$$

$$h(x,y,z)|_{t=0} = h_0(x,y,z) \tag{2}$$

$$-K\frac{\partial H}{\partial n}\Big|_{A_2,A_4,A_5} = 0 \tag{3}$$

$$K\frac{\partial H}{\partial n}\Big|_{A_1,A_3} = 0 \tag{4}$$

$$H|_{A_6} = z \tag{5}$$

$$-(K+W)\frac{\partial H}{\partial n}\Big|_{A_5} = \mu\frac{\partial H}{\partial t} \tag{6}$$

H is the water level; K is the permeability coefficient; W is the recharge intensity of rainfall infiltration; μ is water supply degree; A_1 is the boundary of horizontal flow on the west side of the infiltration zone; A_2 is a zero-current interface on the north side of the infiltration zone; A_3 is the lateral flow limit on the east side of the infiltration zone; A_4 is the zero current limit in the south of the infiltration zone; A_5 is the boundary of the submerged surface; A_6 is the boundary of the diaphragm bottom plate.

4.2.3. Groundwater Solute Transport Mathematical Model

In the shallow groundwater environment in the polluted area, ion transfer begins in the wastewater storage area of the factory wastewater treatment plant. It is assumed that the pollution source continuously injects pollutants into the aquifer before treatment, and eliminates the impact of biodegradation and redox on groundwater ion transfer, as well as the preparation for dispersion and adsorption/desorption, the mathematical model is:

$$\begin{cases} n\frac{\partial C}{\partial t} = \frac{\partial}{\partial x_i}\left(nD_{ij}\frac{\partial C}{\partial x_i} - \frac{\partial}{\partial x_i}(nCV_i) - C'W\right) \\ D_{ij} = \alpha_{ijmn}\frac{V_m V_n}{|V|} \end{cases} \tag{7}$$

α_{ijmn} is the dispersion of the aquifer; V_m and V_n are components of velocity in m and n directions respectively; C' is the concentration of pollutants in the element.

The overall design framework of numerical simulation of wastewater discharge pollution is shown in Figure 3.

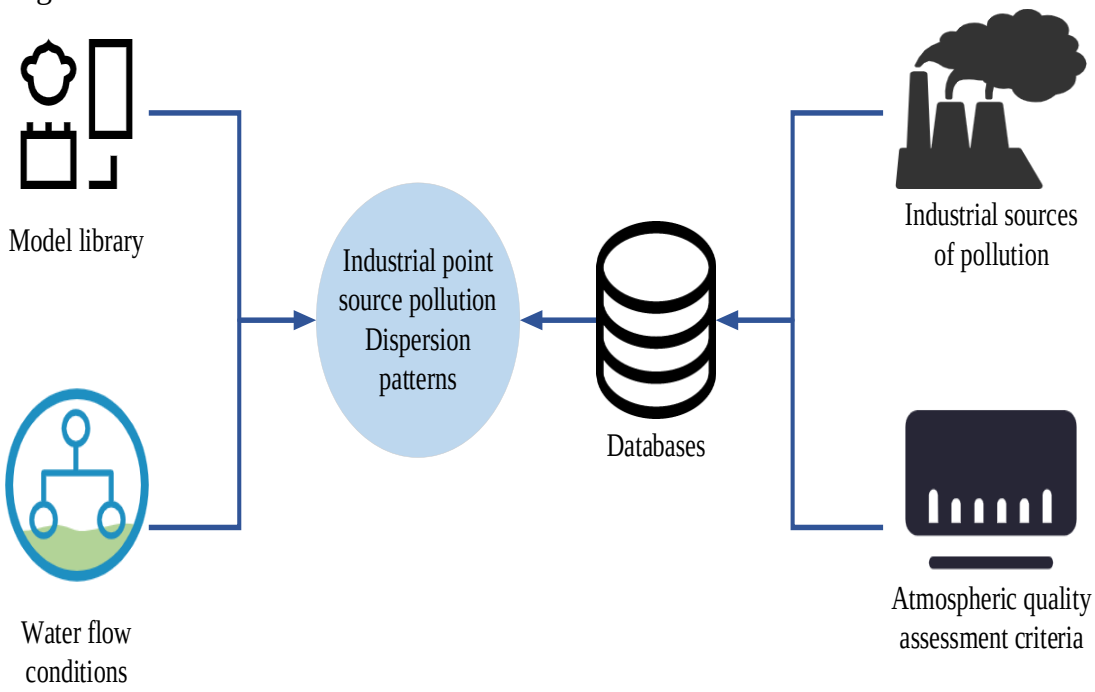


Figure 3. General design framework for numerical simulation of wastewater discharge pollution

4.3. Background and Entity Drawing

In the 3D wastewater discharge scene, the relevant scenes include undulating mountains, blue sky and the background of other wastewater pollution sources.

4.3.1. Background Drawing

The 3D rendering of terrain and sky is very complex. In fact, image-based rendering methods are used. Image-based rendering technology starts with predefined real images, and then performs some interpolation and blending. Real images are created from different angles through operations such as distortion. This technology does not need to understand the complete geometric model of a complex scene, it only needs to know some real images related to the scene, so graphics rendering

has nothing to do with the complexity of the scene. The pre-generated image can be a real image obtained when shooting a real scene, or it can be a computer-generated image. Therefore, images generated using image-based rendering technology can also be very realistic. When using image-based rendering technology, the most important point is that this method is applicable to computers, that is, because of the very low requirements, real images can easily be generated in real time on conventional computers.

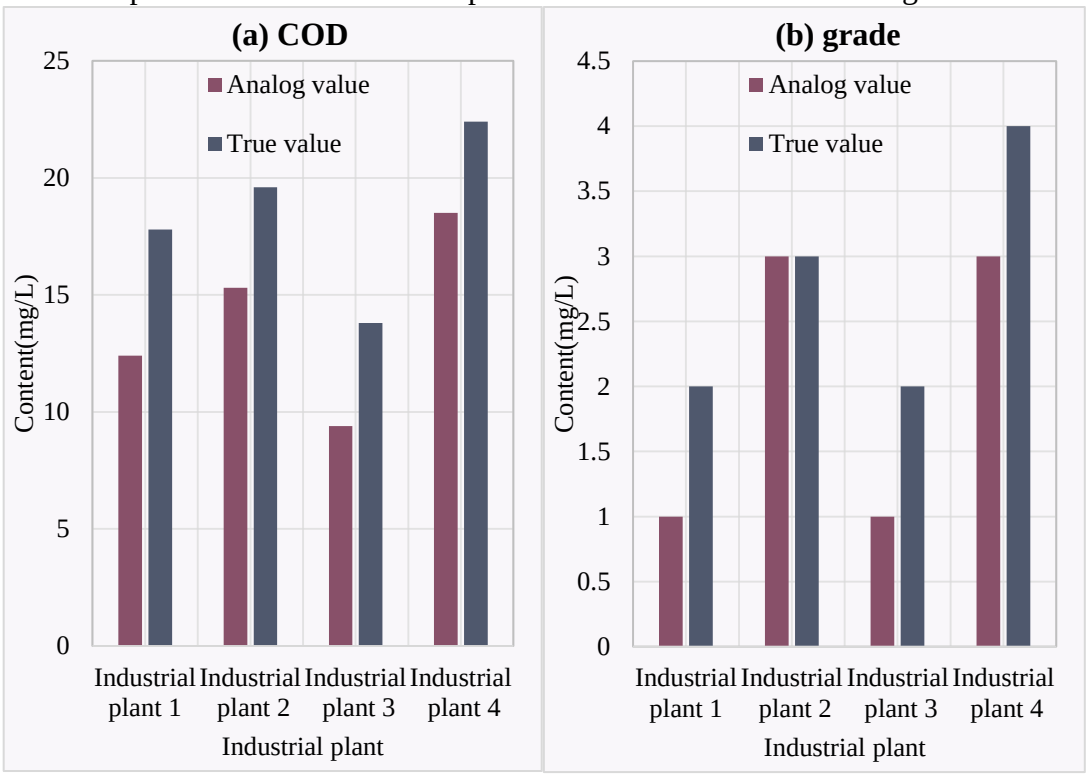
4.3.2. Entity Drawing

After creating the background image, the solids on the ground must be drawn. In order to reduce the drawing workload, only impurity sources and wastewater objects are drawn. In the wastewater discharge scenario, the pollution source is the pipeline that discharges the wastewater. Simple structure would not affect reliability and can improve real-time performance, so OpenGL library functions call pictures.

Once the above work is completed, the wastewater generated by the numerical simulation of wastewater discharge accidents can be displayed in appropriate scenarios, which can be used for dynamic simulation of the scene of environmental pollution accidents.

5. Water Pollution Accident Virtual Scene Simulation Experiment

This paper verified the effectiveness of VR technology in the treatment of water pollution accidents. In this paper, the sewage discharge of four factories was simulated by virtual scene. According to the simulated situation, the sewage treatment was carried out in time and compared with the real water pollution situation. The experimental results are shown in Figure 4.



(a) COD content in sewage
(b) Water pollution level

Figure 4. Water pollution treatment results

Figure 4 (a) shows the COD content in sewage, and Figure 4 (b) shows the water pollution level.

In Figure 4 (a), after water pollution simulation, the simulated value of COD content in wastewater of chemical plant 1 was 12.4mg/L, and the true value of COD content in wastewater of chemical plant 1 was 17.8mg/L. The simulated value of COD content in wastewater from chemical plant 2 was 15.3mg/L, and the true value of COD content in wastewater from chemical plant 2 was 19.6mg/L. The simulated value of COD content in wastewater from chemical plant 3 was 9.4mg/L, and the true value of COD content in wastewater from chemical plant 3 was 13.8mg/L. The simulated value of COD content in the sewage of chemical plant 4 was 18.5mg/L, and the true value of COD content in the sewage of chemical plant 4 was 22.4mg/L. After water pollution simulation in the chemical plant, the average value of COD content in sewage was 13.9 mg/L, and the average value of actual COD content in sewage was 18.4 mg/L.

In Figure 4 (b), after water pollution simulation, the simulation grade of chemical plant 1 sewage was Grade I, and the real grade of sewage was Grade II. The simulation grade of sewage from chemical plant 2 was Grade III, and the real grade of sewage was Grade III. The simulation grade of sewage from chemical plant 3 was Grade I, and the real grade of sewage was Grade II. The simulation grade of the sewage from chemical plant 4 was Grade III, and the real grade of the sewage was Grade IV.

It can be seen from the data that compared with the real water pollution situation, the water pollution situation has improved after using the virtual simulation of water pollution situation; the content of COD in sewage has been greatly reduced, and the quality of sewage has also been improved. In the development process of environmental pollution scenario virtual modeling, numerical simulation and 3D accident scenario modeling are mainly used as the basis, which enables managers to understand and manage pollution and accident location in time when pollution occurs, so as to take appropriate emergency measures in time to minimize damage.

6. Conclusion

In this paper, VR technology was used to study water pollution in environmental engineering. In this paper, OpenGL is used to carry out 3D modeling of virtual scene. According to the characteristics of wastewater discharge, the hydrogeological conceptual model, groundwater flow mathematical model and groundwater solute transport mathematical model were constructed, and the numerical simulation of wastewater discharge pollution accident was carried out. Finally, the background and entities in the virtual scene were drawn to get the virtual simulation scene of water pollution accident. In the experiment part, the role of virtual simulation scene in water pollution was studied. The experimental results showed that the virtual simulation scene can help people understand the dynamics of sewage in time and take effective measures; the water pollution situation has been greatly improved after the water pollution virtual scene simulation.

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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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