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# Cloud System Structure Pre-Warning System and Method for Canal type Reservoir Tributary Bay Water Bloom

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**Abstract**
This research proposes a cloud system structure pre-warning system and method for canal type reservoir tributary bay water bloom. The system consists of five modules: monitoring cloud module, information cloud module, application supporting module, water bloom pre-warning module, and discussion decision-making module. The system achieves seamless linkage and operation control based on a cloud system structure, carrying out all-weather monitoring, cloud storage, and water bloom risk pre-warning. The water bloom pre-warning module consists of a risk analysis unit and a pre-warning and forecasting unit. The discussion decision-making module is used for achieving decision-making discussion and information sharing communication in a cloud environment. This study provides a new measure based on the cloud system structure for preventing and reducing water bloom events.

**Keywords-** cloud system structure, pre-warning system, canal type reservoir, tributary bay, water bloom, risk analysis, pre-warning and forecasting, decision-making discussion, information sharing communication.

## Introduction

Water bloom events in canal type reservoir tributary bays have become a major environmental problem worldwide. These events not only have a severe impact on the ecological environment but also on the safety of drinking water. In this context, the development of a pre-warning system and method for water bloom events is of great significance. The traditional pre-warning system lacks real-time monitoring, comprehensive data analysis, and decision-making support capabilities. Therefore, a cloud system structure pre-warning system and method for canal type reservoir tributary bay water bloom is proposed to achieve seamless linkage and operation control over the modules based on a cloud system structure, carrying out all-weather monitoring, cloud storage, and water bloom risk pre-warning.

## Related work

Water bloom is a common phenomenon that occurs in slow eutrophication water bodies when environmental baseline conditions are suitable for the fast propagation of algae. After the retention of river-like reservoirs, the self-purification ability of the water body significantly declines, and this, coupled with suitable environmental conditions, leads to the occurrence of water bloom in responsive waters, such as tributary Ku Wan. The Three Gorges Reservoir is an example of this phenomenon, where the formation of gulf, storehouse, and tributary water bloom during spring and summer seasons can cause significant damage to ecological diversity, water supply security, fish protection, and tourism.[1]

The management and control of water bloom in gulf, storehouse, and river-like reservoir tributaries are crucial as they often account for a significant portion of the total reservoir area. However, the outburst of water bloom in these areas often occurs without warning, and the current technology for improving water quality after an algal bloom is still immature. Therefore, an optimal strategy for water bloom management and control is to accurately forecast and respond to the early stages of the phenomenon.[2]

Currently, there is a significant gap in research and practical reports on water bloom pre-alarming practices for gulf, storehouse, and river-like reservoir tributaries. Existing water bloom monitoring is primarily based on three methods: the bloom pre-alarming based oninformationificial sample, the bloom pre-alarming based on automatic monitor stations, and the bloom pre-alarming based on remote

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sensing image. However, these methods have significant deficiencies and defects.[4,5]

The bloom pre-alarming method based oninformationificial sample requires the collection of water samples from the worksite, followed by offline hydrochemical analysis in a laboratory to obtain water quality information. This method has several drawbacks, such as long monitoring periods, high labor intensity, poor specificity, slow data acquisition, and difficulty in finding early pollution sources.

The bloom pre-alarming method based on automatic monitor stations involves the formation of an automatic water quality monitoring system by monitoring centers and several fixed monitoring stations. However, the territorial scope of gulf, storehouse, and river-like reservoir tributaries is vast, making it difficult to comprehensively monitor the target waters using stationary monitoring websites. Additionally, the remote monitoring generates a large amount of data, which makes data storage, transmission, and mining challenging. Furthermore, the computing power, storage capacity, and application service ability of hardware devices are generally insufficient to meet current demands.

The bloom pre-alarming method based on remote sensing image uses satellite remote-sensing images or radar technology to extract water quality and water bloom information. However, remote sensing satellite measuring periods are long, which results in lower temporal resolution, and in-situ measurement data is needed to calibrate the remote sensing technology, which increases the complexity of the process.

The development of cloud computing provides new opportunities for water environment and ecology protection. However, the existing cloud computing theory does not fully address the characteristics of gulf, storehouse, and river-like reservoir tributary water bloom disasters, such as their randomness, nonlinearity, and strong man's activity. Thus, a new cloud architectural framework is needed to carry out bloom pre-alarming and effectively overcome the obstacles posed by river-like reservoir tributary gulf, storehouse, and algal bloom space-time randomness.

In summary, the management and control of water bloom in gulf, storehouse, and river-like reservoir tributaries are crucial for the protection of ecological diversity, water supply security, fish protection, and tourism. The existing methods of water bloom pre-alarming have significant deficiencies and defects, making it necessary to develop a new cloud architectural framework to effectively monitor and predict water bloom.

**Research Objective**

The objective of this research is to propose a cloud system structure pre-warning system and method for canal type reservoir tributary bay water bloom. The system comprises five modules: monitoring cloud module, information cloud module, application supporting module, water bloom pre-warning module, and discussion decision-making module. The study aims to achieve seamless linkage and operation control over the modules based on a cloud system structure, carry out all-weather monitoring, cloud storage, and water bloom risk pre-warning, and provide a new measure for preventing and reducing water bloom events.

**Research**

The increasing prevalence of water bloom, a phenomenon where bodies of water turn green due to the rapid growth of algae, has become a significant concern for the health and environmental risks it poses. Existing technologies for monitoring water blooms have some shortcomings and limitations in providing real-time data and early warning of potential risks. In response, a cloud-based early warning system for water blooms has been developed to address the deficiencies of existing technologies and provide a reliable and complete tool for preventing and reducing the harm caused by water blooms.

The technical solution used in this cloud-based early warning system is the cloud architectural framework, which includes the monitoring cloud module, information cloud module, application supporting module, bloom pre-alarming module, and decision-making module of holding a conference or consultation. The monitoring cloud module is composed of terminal collecting units and operational communication units, with the former comprising on-site bloom pre-alarming multi-parameter sampling equipment that collects key parameter real-time data relevant to water bloom risks. The operational communications unit is responsible for controlling the terminal collecting units and transmitting data by using wireless communication devices, temporary storage, remote controllers, power supply, and solar panels.

The information cloud module serves as a storage medium that accepts and stores the large datasets collected by the monitoring cloud module. It is structured on self-starting type data Intranet, which enables data transmission and call between each memory node of storage sites net simultaneously. The application supporting module comprises four units: shoring of foundation unit, applied customization unit, collaboration data unit, and emergency disposal unit. This module is structured on a SOA component model+service bus+component framework and

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allows for interoperability reciprocal exchange of business information and call business function between each unit, thus meeting the demand of system users terminal, monitoring field, memory node, mobile car and boat, watershed management layer, for initialization system running environment and execution module cooperation.

The bloom pre-alarming module, which is composed of venture analysis unit and early-warning and predicting unit, receives information real-time collection information data from the cloud module. Using main cause dynamic test, data-driven risk profile and event class, coupling technique reappearing, and other techniques, it analyzes the risk and potential order of severity of different meteorologies, the hydrology, and the outburst of water environment Water Under China. The output of the venture analysis unit is then transmitted to the early-warning and predicting unit, which differentiates and distributes different alarm commands to the decision-making module of holding a conference or consultation according to the water bloom risk threshold value.

The decision-making module of holding a conference or consultation comprises a display device, sound amplifier, synchronous communication equipment, and monitoring worktable. It adopts the hold a conference or consultation parallel communication interactive model of chamber of scenario and supports synchronous communication of voice, word, and video shows. This module receives the final instruction from the emergency disposal unit and provides a potential order of severity criterion of water bloom. It starts the emergency pre-plan that pre-stores targetedly, deploys and implements the emergency pre-plan, and synchronously feeds back the implementation result to the decision-making module of holding a conference or consultation, thereby synchronizing the decision-making process.

The monitoring cloud module is implemented by combining the terminal collecting unit and operational communications unit. The terminal collecting unit obtains key parameter real-time data that is relevant to water bloom risks. This unit comprises some on-site bloom pre-alarming multi-parameter sampling equipment that is set on the distributed laying mode using secure bond to move. The littoral fixed station mode is adopted as the main mode, while buoy mode is used in waterborne regions where littoral fixed stations cannot be constructed. The move mode of locomotive/boat-carrying collecting devices is used regularly to walk the boat and monitor fixed equipment for data check.

Here are the steps to apply the cloud architectural framework method for early warning of water bloom:

Monitoring Cloud Module:

a. Apply the supporting module using the operational communications unit of the monitoring cloud module.

b. Use the on-the-spot bloom prealarming multi-parameters sampling equipment to collect environmental factors and biochemical characterization parameters of water bloom on a large scale in waters.

c. Each field apparatus of the terminal collecting unit receives operating instructions from the center applications system and automatically replies with its geographic position of living in longitude and latitude, elevation, and unique identity code.

d. Each field apparatus of the terminal original position information acquisition unit regularly accepts video enabled instructions and carries out waterborne, underwater video monitoring.

Large Data Transmission:

a. Store the relevant large data transmission of the water bloom gathering in step (1) into the information cloud module using the large digital camera datamation pattern.

b. Use the following transmission models depending on the situation:

i. Straight transmission model
ii. Middle rotary-die type
iii. Rotary-die type continues
iv. Standby pattern of depositing

Venture Analysis Unit:

a. Analyze the target water bloom of water body related data and the video data that have collected using the venture analysis unit of the bloom prealarming module.

b. Adopt main cause dynamic testing method to analyze size and the scope of the percentage contribution of varying environment factor pair algal grown under varying environment condition.

c. Adopt data-driven Risk Forecast Method and event class replay method to predict the outcome and potential order of severity of breakout of water bloom.

Early-Warning and Predicting Unit:

a. Accept the output results of the venture analysis unit.

b. Distribute different alarm commands to the decision-making module of holding a conference or consultation according to different breakout of water bloom risks.

Decision-Making Module of Holding a Conference or Consultation:

a. Call out different application terminals.

b. Carry out decision-making holds a conference or consultation according to the potential order of severity of water bloom of venture analysis unit feedback.

c. Form emergency disposal decision-making and send instructions to the emergency disposal unit.

d. Start specific aim emergency preplan, emergency preplan deployment and implementation result synchronous feedback give the decision-making module of holding a conference or consultation for its decision-making of holding a conference or consultation.

**Conclusion**

This research proposes a cloud system structure pre-warning system and method for canal type reservoir tributary bay water bloom. The system consists of five modules: monitoring cloud module, information cloud module, application supporting module, water bloom pre-warning module, and discussion decision-making module. The system achieves seamless linkage and operation control based on a cloud system structure, carrying out all-weather monitoring, cloud storage, and water bloom risk pre-warning. The water bloom pre-warning module consists of a risk analysis unit and a pre-warning and forecasting unit. The discussion decision-making module is used for achieving decision-making discussion and information sharing communication in a cloud environment. This study provides a new measure based on the cloud system structure for preventing and reducing water bloom events, which can effectively improve the ecological environment and the safety of drinking water.

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