Design and Application of Monitoring Station of Black and Odorous Water Body Based on Industrial Computer and Remote Computer

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Abstract. Monitoring station of black and odorous water body (BOWD) based on industrial computer and remote computer control was designed and built to resolve the time-consuming problem about manual monitoring in the course of supervise of BOWD. Hardware configuration, technological process and software design were researched according to the demand analysis of monitoring station of BOWD. The results indicate that the monitoring station of BOWD can get real-time monitoring data of classification evaluation indexes of BOWD with a good stability, the relative error is below 7.14% between real-time monitoring data and manual monitoring date.

1. Introduction
In 2015, guidelines for the treatment of urban black and odorous water body was jointly published by ministry of housing and urban-rural development and ministry of environmental protection in China[1,2]. BOWD refers to the water body with unpleasant color and/or unpleasant odor in the built-up area[3,4]. This phenomenon also exists in other developing countries[5-7]. Dissolved oxygen (DO), ammonia nitrogen (NH3-N), water transparency and oxidation-reduction potential (ORP) are the classification evaluation indexes of BOWD[8]. Four indexes are analyzed every 1-7 days in every monitoring section which is set every 200-600 m along BOWD, all indexes must be analyzed more than three cycles[9]. It is time-consuming to get monitoring results in the way of manual work. Some researches about obtaining date from monitoring stations are carried out[10, 11], but there is no report on monitoring station of BOWD. The main objective of this research is to design monitoring station of BOWD which can be controlled by industrial computer and remote computer. The finding may be helpful for future study about monitoring station about BOWD.

2. Demand analysis
The monitoring station of BOWD should have detecting units of DO, NH3-N, water transparency and ORP, all real-time monitoring data about them can be got. The station should be controlled by industrial computer and remote computer, and all date or information including real-time monitoring data, historical data, supplementary data, station introduction, startup log, monitor message and so on can be got in the industrial computer and remote computer. All water pumps and water valves can be
controlled by software. The monitoring station should have stutter stop switch, warning notices, washing function, and some stand-by facility.

3. Hardware configuration
Detecting units of DO, water transparency and ORP are in the form of probe, three probes are in the same detection pool. Detecting unit of NH$_3$-N is in the form of analysis meter. All detecting units have RS485 protocol. Water pumps, water valves, water tanks are connected to the water pipe. Camera is used for getting monitor message. Communication module, 4G/5G router and serve are necessary for connecting industrial computer and remote computer or all detecting units.

4. Technological process
The technological process of monitoring station of BOWD is shown is Fig. 1. The raw water can flow into the sampling device set in the appropriate monitoring section and some rubbish is prevented. The raw water in water tank 2 is pumped into detection pool by pump 2. The pump 1 will work if there is something wrong with pump 2 or water tank 2. Probes of DO, water transparency and ORP detect the three classification evaluation indexes. The date can be seen on the screen of universal controller. The raw water in detection pool is pumped into sampling cup by lift pump 1. Sediment, silt and some other impurities in the raw water are filtered before it is pimped into sampling cup. The filtered raw water is pumped into NH$_3$-N analysis meter by lift pump 2 and the NH$_3$-N concentration can be got. The date of four classification evaluation indexes is output through RS485 protocol, it also can be got from the industrial computer. A certain amount of tap water is used for washing the water tank, detection pool and sampling cup when the course of detection is over. Valve 1 and valve 4 are used for inflow, valve 2 and valve 3 are used for outflow. All pumps, valves and cameras are connected to the industrial computer through electric switch module. The industrial computer can be controlled by the remote computer because they are connected through server, internet and 4G/5G router and they have the same control function for the monitoring station.

5. Software design
5.1. software module
Detecting parameter, condition monitoring, operating state, data information warning notices and some other modules are all can be controlled in the main interface of control software which is shown in Figure2. Line charts of four classification evaluation indexes are shown in the left and each chart includes the last twenty-four date and their average value. The last six date is shown in the table. The light on the right of warning module can turn red if there is something wrong with the monitoring station. And then stutter stop module should be clicked. Detection cycle, starting time, rate of inflow, configuration information, station information, administrator adjustment and so on can be set in the parameter module. All pumps, valves, universal controller, NH$_3$-N analysis meter and monitoring screen can be turn on or off by clicking respective module. More surveillance video can be got in the backstage management system. The control software can be used in both industrial computer and remote computer.
Figure 1. The technological process of monitoring station of BOWD

Figure 2. The main interface of control software
5.2. Main program flow
The main program flowchart is shown in Figure3. Process of self-check is necessary after starting the station. The station will be in initialization state after manual control and trouble clearing. Then the station will enter the next established process. The station will enter standby state when the course of washing is over and it is ready for the next starting.

![Figure 3. The main program flowchart of monitoring station of BOWD](image)

6. Testing experiment

6.1. Hardware test
The main detecting units of classification evaluation indexes were brought from HACH. The rest hardware used in the station was purchased from formal manufacturer. All hardware has passed electrostatic discharge test, aging test, high-low temperature test and some other test before delivery, so the station can meet application requirements.

6.2. Stability test
Some real BOWD was got and detected in the way of both manual detecting and station detecting. Triplicate detection was carried out for each test, and the relative standard deviation was generally less than 10%. The manual detection data (MDD) was determined as true value, the station detection data (SDD) was determined as test value, relative error (R) was calculated between MDD and SDD. The result is shown in table 1. R of NH$_3$-N, DO, ORP and transparency is less than 1.71%, 4.55%, 5.71% and 7.14%, which indicates that the monitoring station of BOWD can get real-time monitoring data of classification evaluation indexes of BOWD with a good stability.

| NO. | NH$_3$-N (mg/L) | DO (mg/L) | ORP (mV) | Transparency (cm) |
|-----|----------------|-----------|----------|------------------|
| 1   | 3.45           | 0.23      | -177     | 62               |
| 2   | 6.78           | 0.53      | -158     | 47               |
| 3   | 8.32           | 0.98      | -134     | 55               |
| 4   | 10.67          | 1.56      | -87      | 43               |
| 5   | 12.67          | 1.96      | -84      | 44               |
| 6   | 15.37          | 1.53      | 3.57     | 43               |
| 7   | 18.22          | 2.45      | 5.17     | 37               |
| 8   | 21.32          | 2.42      | 5.14     | 35               |
| 9   | 25.76          | 1.02      | 3.58     | 15               |
| 10  | 28.65          | 6.39      | 2.68     | 13               |

7. Epilogue
The monitoring station of BOWD in this research can be controlled by industrial computer and remote computer. The station can get real-time monitoring data of DO, NH$_3$-N, water transparency and ORP. R of NH$_3$-N, DO, ORP and transparency between MDD and SDD is less than 1.71%, 4.55%, 5.71% and 7.14%, the station has a good stability.
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