Remote monitoring of turbidity in water conduits

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Abstract
We have developed a turbidity sensor for monitoring water quality in water conduits at different regions. The sensor had good stability, that it could be used in fields. Turbidity monitoring data has been sent toa server via realtime remote monitoring system (AUREMS), and water quality has been controlled in real time. The water quality management in water conduits help understand the migration of organic or inorganic matter due to leakage or damage of conduits.

Key-Words: Turbidity; Remote monitoring; Water quality control

1 Introduction

It is important to monitor the water quality in conduits continuously and in real time. Among many monitoring parameters for water quality, water turbidity is one of the most important parameters. It is an expression of the optical properties of water which cause light to be scattered and absorbed. Turbidity is mainly caused by the presence of suspended matters. It shows a wide range in spatial and temperal variability in waters[4]. Therefore, changes in turbidity help understand the distribution of suspended matters or sediment in water.

Many optical measurement techniques have been used to measure the turbidity in waters such as fluorescence, light scattering and absorption et al[5-6]. In this work a turbidity sensor based on light scattering has been used to monitor turbidity of water in water conduits. To monitor turbidity at distant sites in real time an automatic remote monitoring system for water quality (AUREMS) has been employed, which was developed by Dong-Yang Hi-Tech Co.

This paper describes an approach to monitor turbidity in water conduits using a home-made turbidity sensor and field turbidity monitoring with a remote monitoring system, AUREMS..

2 Performance of a turbidity sensor

2.1 Turbidity measurement

Optical turbidity sensors can be classified as either attenuance or nephelometric instruments. Sediment particles absorb or scatter light as it passes through the sampling medium. When sediment particles absorb light, turbidity can be measured by attenuance[7-8]. Turbidity may be quantified by measuring the reduction in intenbsity of a light beam, after passing through the sampling medium, between an emitting and detecting lens. The beam intensity and inter-lens path length can be altered to control the operational range. Turbidity measurement by attenuance is usually applied to media of faily high turbidity. Turbidity measurement by nephelometry is based on the principles that suspend particles scatter light[9]. The detectiing lens of nephelometric devices is usually set perpendicular to emitting lens to collect only scattered light[10]. Turbidity can be quantified by measuring the amount of scattered light detected, and this technique is most often applied to media of relatively low turbidity.

In this work we have employed an nephelometric turbidity sensor made by our laboratory. The home-made turbidity sensor uses a near infrared light sources which is preferable to a visible source for turbidity monitoring. It also gives good resolution, turbidities in the range of 0-40 NTU. This range can encompass all of sediment concentrations encountered in water conduits.

2.2 Temperature changes

Turbidity sensor can be tested at laboratory under almost constant temperature conditions and temperature fluctuation may be small. But real-time monitoring of turbidity is exposed during all seasons, and is therefore subjected to a wide temperature range. So, temperature dependent output change is a common problem and was identified by Clune (1986) as the main source of potential error in logged data[11].

The electronic components of a turbidity sensor are inherently temperature sensitive. For example, in an investigation into the effect of temperature change on on turbidity sensor used to monitor sediment transport in an Australian forested catchment, Gippel (1989) identified a 0.42 % change in turbidity for 1 ºC change in temperature. To reduce this potential source of error, some turbidity sensors incorporate a temperature sensor to compensate readings (Gippel, 1989)[12]. Similarly, Lawler (1995) reports that, in some turbidity sensors, the influence of temperature change may be partially compensated by having an opposite affect on the efficiency of emitting and detecting photocells[13].

Within the temperature range of 4-40 ºC, our sensor output was monitored in the laboratory, as shown in Fig. 1.

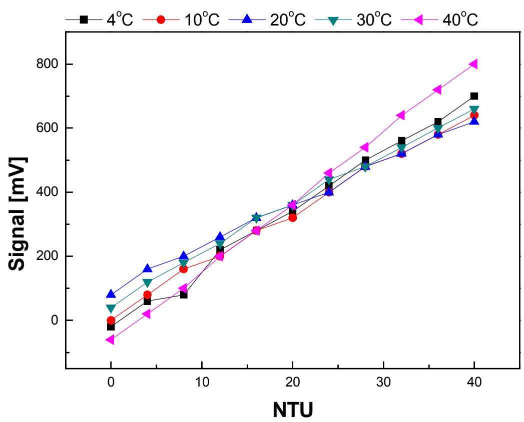

Fig.1 Effects of temperature on sensor signal at different NTUs

As water temperature is continuously monitored by sensor output, water temperature records can be easily combined with turbidity output in the field.

2.3 Stability

Stability of a turbidity sensor is important, that turbidity measurement of a sample should be consistent. One of the greates causes of inconsistency associated with turbidity measurement is the variation in turbidity of the same sample recorded by different sensors. This can be explained by variation in the response of different types of turbidity sensor to the specific properties of the sampling medium and suspended material[14].

Formazin is normally used to calibrate turbidity, because it has high absorbance capacity, as highly efficient scatter. Using formazin the stability of a turbidity sensor can be tested by measuring turbidity for a period. Fig. 2 shows stability testing of turbidity by a home-made sensor. The repeated testing of the sensor was satisfactory for use in the field.

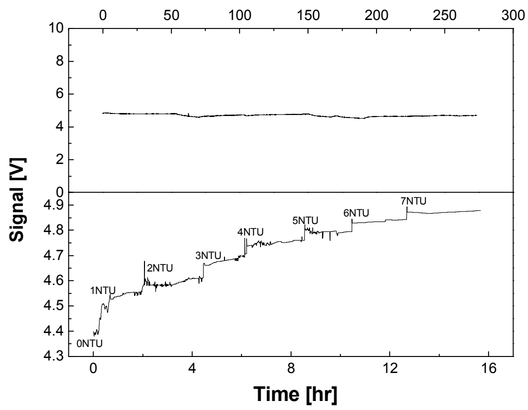

Fig.2 Stability tesing of turbidity sensor

3 Remote turbidity monitoring

3.1 Calibration

To show a unique response of the sensor to turbidity the voltage output from the sensor has been calibrated into standard reproducible nephelometric units (NTU). Formazin is adopted as the standard refernce material for turbidity calibration. It combines neutral buoyancy with constant particle size. Fig. 3 shows typical calibration curve for turbidity sensor. Th calibration plot shows linear relationship between sensor output and turbidity.

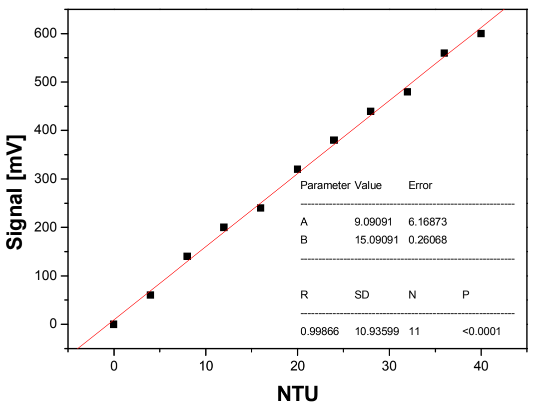

Fig. 3 Typical calibration curve for home-made turbidity sensor.

3.2 Errors in turbidity measurement

The deployment of monitoring instrument in the field introduces greater potential for errors, relative to laboratory measurement. Turbidity monitoring in the field is sensitive not only to the compex influences of sediment particle transport processes, but also significant climatological and biological factors. Some of the errors which have become apparaent during the acquisition of representative field turbidities are errors due to sensor placement and change in water colour.

3.3 Remote monitoring

Remotely monitoring data have some major advantages over conventional data sets. For example it provides information over large areas on turbidity quickly. But disadvantages are that hydrologically meaningful parameters usually have to be estimated from the remotely sensed data using either empirical relationships, or by deriving relationships through intermediate parameters.

The data acquisition of turbidity has been carried out by an automatic remote monitoring system for water quality (AUREMS) of Dong-Yang Hi-Tech Co. It is equipped with several sensors for water quality monitoring, such as chlorine sensor, turbidity sensor, pH, dissolved oxygen sensor etc. The data from turbidity sensor are first sent to data collector and then to a server system. This system is shown schematically in Fig. 4.

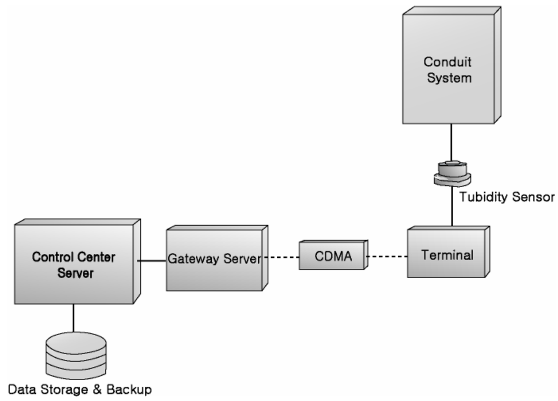

Fig. 4 Schematic of AUREMS

The objective of using data from turbidity sensor in AUREMS is to provide information on water quality parameters, such as suspended sediment concentrations. After laboratory measurements of a remote monitoring system were carried out by using formazin as standard solutions for turbidity, the turbididy in water conduits are monitored by the remote monitoring system. The results of one such data set of remote turbidity monitoring are shown in Fig. 5.

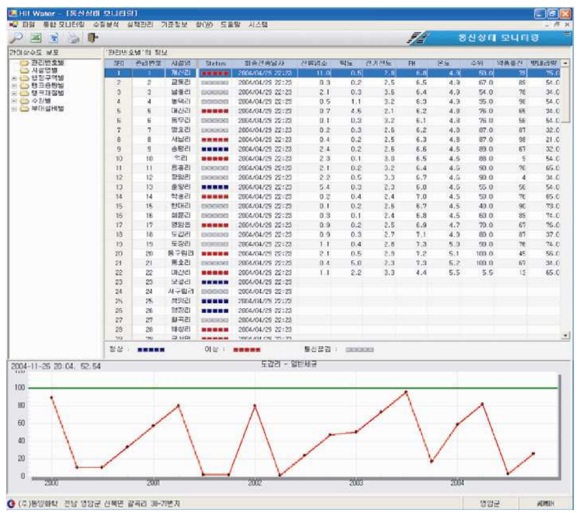

Fig. 5 Variation of turbidity in a water conduits by a remote monitoring system

4 Conclusion

In this study, we presented the remote monitoring of turbidity using AUREMS. Remote monitoring of turbidity makes possible to control the water quality in water conduits in real time. Water qualitry management of water conduits should focus on control of several critical parameters, i.e. not simply on nutrient input control but also on understanding and migrating the inputs of coloured dissolved organic matter and total sediment load from various sources.

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