

Continuous Monitoring of Turbidity in Ohio Rivers Using Modified Sidestream Method

In a collaboration between YSI Inc. and the Miami Conservancy District in Southwest Ohio, the water quality of the Mad and Stillwater Rivers in the Dayton, Ohio, area is continuously monitored at gage stations (Figures 1a and 1b) using a sidestream method. The general measurement of turbidity in this “process-type” application correlates turbidity with conductivity during rainfall events.

Gage houses have been fitted with a vessel into which river water is pumped continuously and then discharged back into the river (Figure 2). The vessel is not sealed; instead it uses a drain stem which assures that river water is not discharged until the vessel is full. This method allows the insertion of both the sampling filter of an automatic sampler and a multiparameter sonde, which contains sensors for temperature, conductivity, pH, dissolved oxygen, chlorophyll, blue-green algae, and turbidity.

Equipment

YSI 6-Series multiparameter monitoring platforms (sondes), with above sensors, acquire the data. For the turbidity studies, the sondes were equipped with YSI 6136 turbidity sensors, which are automatically cleaned with an attached wiper to remove bubbles and fouling prior to logging a data point (Figures 3 and 4). The wiper is activated within approximately one minute of recording data. The turbidity sensor is characterized by an optical system in which the angle between the emitted and detected radiation is approximately 90 degrees. In addition, the sensor

uses an 860 nm near-infrared LED light source. These features (90 degree scatter and 860 nm radiation) are consistent with the recommendations of the International Standards Organization (ISO) 7027 method.



Figure 1a. Typical gage station for sidestream monitoring of rivers, during normal flow.



Figure 1b. Gage station at high flow/high turbidity. Sidestream methodology prevents the water quality sensors from getting damaged during flood events.

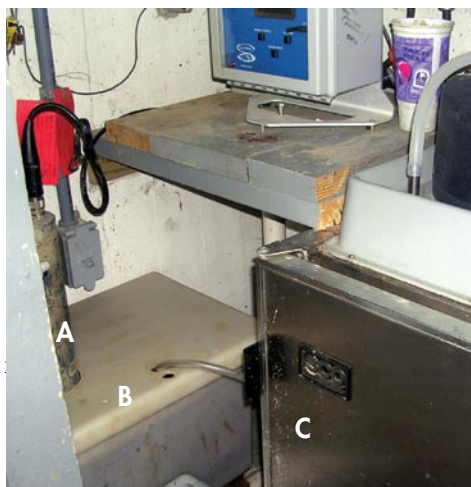


Figure 2. Contents of gage station, including A) sonde, B) sidestream vessel, C) auto sampler, and web-based data collection platform (not shown).

The sondes are attached to YSI EcoNet web-based data collection platforms that are powered from AC outlets available in the gage houses. The sondes are in turn powered by the DCPs via an SDI-12 interface. The DCPs are set up to trigger sonde acquisition of data every one or two hours, depending on the site.

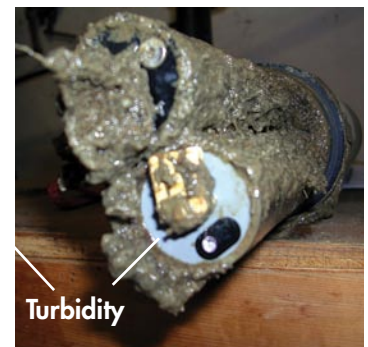


Figure 3. Sensors in sonde Figure 4. Sediment fouling on sensors

Typical Data

The data for the Stillwater River from the winter 2006-2007 (Figure 5) are typical of that obtained during rainfall events. The data were acquired at a two-hour sample interval over about six months. Turbidity measured with the ISO 7027-type sensor correlates well with specific conductance. The correlation occurs because rainwater is effectively free of ions and lowers the conductivity of the overall river while it also washes sediment from fields contiguous to the river.

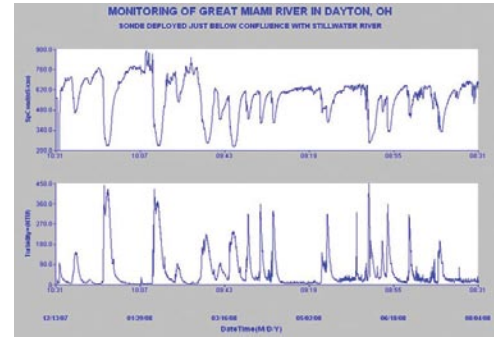
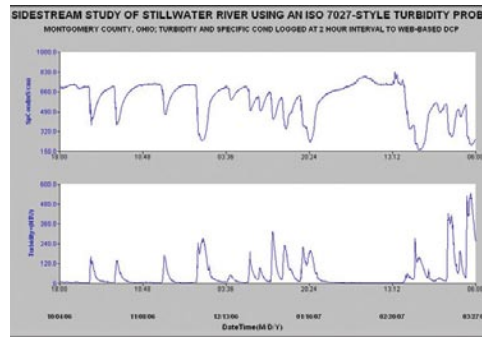
Because there is also continuous flow measurement (ft³/sec) at the site, the turbidity data could be combined with flow to estimate sediment transport, particularly during rainfall events. To do this, a turbidity reading in NTU is correlated to the amount of local sediment in mg/L present for that value of turbidity. Usually a good estimate for this geographic area is 1 NTU corresponds to about 1 mg/L, but clearly this value will vary depending on the ground conditions. The sediment transport calculation has not been finalized at this time.

Sidestream methodology is likely reflective of the actual conditions in the river since the data for a sonde directly immersed in the river about five miles downstream from the gage station (Figure 6) have a very similar relationship of turbidity to conductivity. The entire multiparameter data file for one year of downstream monitoring is shown (Figure 7) for general reference, and is reflective of the ability of these sensors to function for long periods of time with minimal maintenance.

Turbidity data for a rainfall event in 2009 compares the intensity and temporal pattern of turbidity at different sites on the same river system. Both rivers flow into the Great Miami in downtown Dayton and together account for half the total flow of the Great Miami after the confluence. The sharper turbidity pattern for the Mad River (Figure 8) is typical of most rainfall events in the region. The Mad is a smaller, more canalized river with high overall velocity. However, the additional turbidity events in the Stillwater after day 2 are likely due to localized rainfall in the watershed of this river, but not in that of the Mad. The main rivers are 20-30 miles apart in the upper regions of their respective watersheds.

Summary

Turbidity sensors of the ISO 7027-type design can provide high quality data in long-term studies when used in a process-style, sidestream application in which river water is pumped to a vessel which contains the turbidity sensor and then discharged back into the river.



Figures 5 and 6. Turbidity data from Stillwater and Mad Rivers

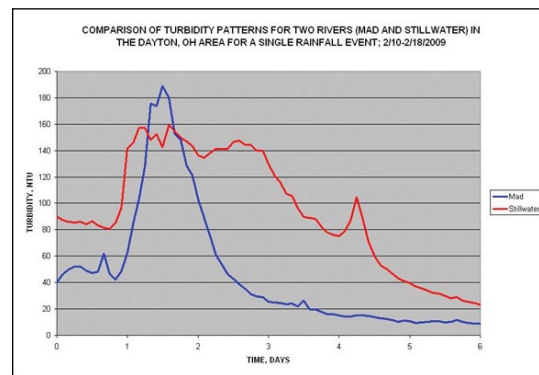
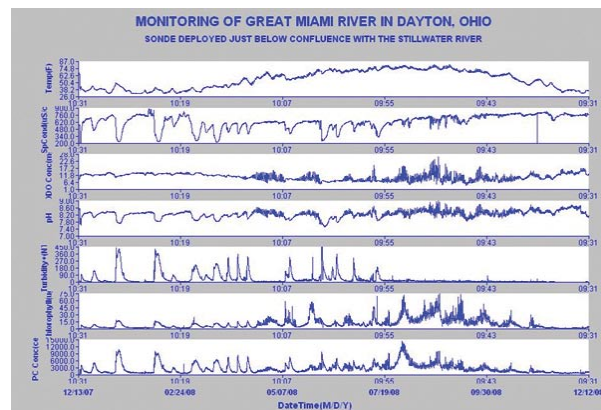


Figure 8. Turbidity comparison

Below, Figure 7. Long-term data with YSI 6600V2-4 sonde



When the turbidity sensor is attached to the proper data collection platform, the data are available in real-time. A mechanically cleaned turbidity sensor may be necessary to obtain this type of continuous data, since fouling is a common issue in river systems characterized by high turbidity events. As expected, the turbidity data show a good inverse correlation with the conductivity of the water because the rainwater which generates the high turbidity events has effectively zero ion content. Continuous logging of turbidity allows semi-quantitative comparison of patterns of sediment transport for different watersheds and, with the proper correlation of turbidity to suspended sediment concentration, will allow fairly accurate calculations of the total sediment transported.