Water Pollution in Asia – A Brief Review of Monitoring Technologies

The pressure on water resources is increasing rapidly. Nowhere is this more felt than in Asia, home to 60% of the world's population. Safeguarding and managing these precious water resources is receiving increasing priority. As part of this drive, increasing numbers of water quality monitoring instruments are being deployed. This paper presents an overview of the various types of technologies used for the monitoring of surface waters in Asia.

"A great number of technologies and systems are available for water quality monitoring."

Author Details:
Joep van den Broeke
Benten Water Solutions
Emails: jvandenbroeke@benten-water.com
Tel: +31 (0) 85 877 0386

Asia faces a serious and growing water quality challenge. Rapid population growth, urbanisation and industrialisation in the region threaten to limit the freshwater supply. Strong seasonal variations in precipitation due to monsoons and inadequate water and wastewater treatment facilities compound these issues even further. For example, one third of China's main river systems have water of quality with very limited or no functional use, and in the water-scarce northern provinces 40 to 60% are permanently classified as non-functional.[1] In countries such as Japan and South Korea, which have comprehensive sanitary facilities and wastewater treatment, pollution is less severe. Nevertheless, their water resources are under pressure from elevated nutrient levels and trace contaminants, such as pesticides and pharmaceuticals. The only river systems that remain largely untouched are the upper reaches of rivers in Indochina, such as the Mekong. However, increasing development in countries such as Cambodia and Laos is now starting to compromise water quality even in those few remaining pristine rivers.

Effective management of the water sources requires information and understanding. Water quality monitoring networks are in place across the entire region; for example, both India and China maintain networks with thousands of monitoring sites. Despite the impressive numbers, however, spatial coverage remains sparse due to the size of the continent. Furthermore, monitoring consists primarily of infrequent manual analysis of a few physical-chemical parameters suited neither to map out the dynamics of water quality variability nor to properly assess chemical and biological quality. This is becoming increasingly apparent, and both China and India are investing in setting up networks of stations for continuous water quality monitoring. For example, in its 11th Five Year Plan, the Chinese government intends to establish an advanced environmental monitoring system, equipping all key sources of pollution with automatic monitoring instruments. More recently, the World Bank has awarded the River Ganges Improvement Contract to set up a network of online monitoring stations along India's River Ganges, and the Taiwanese EPA initiated the installation of real-time monitoring systems at 114 large-scale enterprises around the country to monitor violations of its Water Pollution Control Act.

Figure 1: Floating monitoring station, Yangtze River, China.

Traditional Monitoring Parameters

The measurement of basic physical-chemical parameters is by far the most widespread application of on-site water quality instrumentation. Parameters such as pH, EC, DO, ORP and temperature can be measured using handheld meters or with online sensors. A trend can be observed towards the use of multiparameter probes, which combine small sensors into a single submersible instrument. Another development is the arrival of the optical DO sensor. The advantage of all these systems is their long-term stability and low sensitivity to fouling, thus reducing maintenance, bringing down lifecycle costs while at the same time increasing up-time and reliability.

High levels of precipitation during monsoons as well as erosion from the Himalayas result in high levels of suspended solids in many of Asia's rivers. Variable levels of suspended particles can be detected by turbidity and TSS sensors, which typically use an optical transmitter with a red or NIR light source, and measure the light absorption of the particles in the sample. Alternatively, sensors which measure light scattering (e.g. at a 90° angle) can be used for lower concentrations of solids and turbidity.

All these instruments are available from any of the major water monitoring instrument manufacturers. Also, instruments for these traditional monitoring parameters are widely available from local manufacturers, who have a substantial share of this market. In contrast, the market for more advanced systems (see below) remains dominated by US and European manufacturers.[2]

Nutrients

Elevated levels of nutrients, mainly as a result of fertiliser use, pose a serious problem for water quality. For the monitoring of the nitrogen levels in river water, ion selective electrodes (ISEs) are currently the preferred option. Both ammonium and nitrate, the primary contributors to the nitrogen load in river water, can be measured using ISEs. These have matured into a stable and robust sensor technology which can be used under rough field conditions, with an average maintenance period of between 3 – 6 months. The main issue of concern, especially for ammonium, is cross-sensitivity of the electrodes to interfering substances. Advanced sensors use additional electrodes to measure and compensate for this interference. Alternatively, UV spectrometers can be used to monitor nitrate. Both the advanced generation of ISEs as well as the optical instruments are available from manufacturers such as Hach, s::can and WTW.

Cabinet Analysers

Currently, the other important nutrient, orthophosphate, can only be measured using online analysers. An analyser is an automated and/or miniaturised system to perform a classical laboratory analysis, such as a titration. The reagents dosed to the sample react with the substance of interest and the analyser measures the reaction products or the disappearance of the reagent, often electrochemically or using a photometer. Apart from phosphate, analysers offer the ability to detect contaminants, such as metals and arsenic, which cannot easily be measured in-line with other technologies. The disadvantage of analysers is the maintenance required, which includes the replenishment of reagents, tubing and pumps on a regular basis. This requires skilled personnel and easy site access, confining the applicability of analysers to centrally located monitoring stations with well-trained staff.

Figure 2: Cabinet analysers at a monitoring station in China.

Organic Parameters

The measurement of organic load, especially useful as an indicator of municipal and industrial wastewater discharges, has traditionally been dominated by analyser-type instruments; a typical TOC/COD analyser uses a reagent to oxidise the organic material in a sample and measures the reaction products, e.g. CO_2. These analysers, however, suffer from the same restrictions as those for phosphate, metals, etc. A low-maintenance, more robust alternative has recently appeared in the form of UV spectrometer instruments. UV absorption, most notably at 254nm, has long been used as an indicator of the concentration of organic materials in water. Such optical instruments, devoid of moving and replaceable parts, are highly robust and easy to use. With the increasing penetration of multi-wavelength and full-spectral instruments, performance has increased to a level at which they can be used for reliable measurement of TOC/DOC/COD/BOD as well as nitrate, nitrite and suspended solids, all in a single multiparameter instrument. Spectrometer instruments for in-situ measurement are available from manufacturers such as s::can, WTW, Trios and SAtlantic.

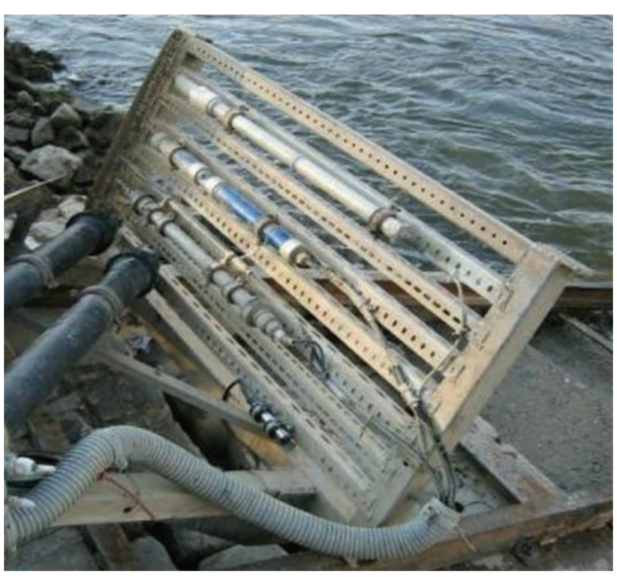

Figure 3: Submersible probes, including ISEs and a UV/Vis spectrometer, on a movable platform.

Since mineral oils are also mixtures of organic substances, their analysis is a different challenge. Although part of the mineral oil absorbs light, and is therefore visible to a UV spectrometer, it is fluorescence that is most frequently used for oil-in-water measurement. Fluorescence measurement is a highly sensitive method, and allows optimisation of an instrument for a specific fraction of the oil (BTX, PAH, etc.) by selection of the excitation/emission wavelengths. However, these instruments suffer from the problem that oil does not dissolve well in water and may therefore be missed or incorrectly quantified, even during a significant contamination event. Widely used instruments include those from e.g. Turner Designs, YSI, Hach and Trios.

Many components of oil float on water. In such a case they can be detected by measuring the reflectivity of the water surface. Solutions for oil-on-water monitoring are available from e.g. GE, Trios, MultiSensor Systems and Partech. However, even with a combination of an oil-on-water and oil-in-water sensor, it remains impossible to guarantee detection of all oil contaminations due to their inhomogeneous character.

Ecological Status Monitoring

An interesting development in water quality assessment in Asia is the focus on the evaluation of its ecological as well as chemical status. Whereas ecological status was a latecomer in Western countries, the involvement of institutions such as the World Bank and European Union in the development of monitoring strategies in Asia means ecological status has been a key element from the start. The assessment of ecological status of water requires an inventory of the living organisms found there. Most small organisms are analysed and classified using a microscope. One exception is planktonic (free floating) algae, which can be measured using spectrofluorometry. The basic parameter measured in fluorometry is the total concentration of chlorophyll-a, which indicates total algal biomass, but does not provide any information on the various algal classes and their abundance. More advanced instruments measure a fluorescence fingerprint used to calculate concentrations of individual algal classes, such as green algae and cyanobacteria. Instruments for chlorophyll-a measurement are available from major instrument suppliers as well as many smaller producers. Instruments allowing algal classification are available from e.g. YSI, Turner Designs, Chelsea, WetLabs (green algae and/or cyanobacteria) and bbe Moldaenke (up to 5 algal classes simultaneously).

Toxicity Measurement

The quality of water is not linearly dependant on the sum of all the substances dissolved in it. When substances are present in a mixture, their (toxic) effect can be amplified or diminished. Currently, the only method of evaluating the effect of such a mixture on living organisms is by exposing those organisms to the water sample. Toximeters, also called online biomonitors, make use of this approach; an online biomonitor is an instrument that continuously records an organism's behavioural and/or physiological response, and evaluates changes that could indicate pollution in the environment. Although these systems do not identify what triggers the response, the direct measurement of the toxic effects provides complementary information to that obtained from chemical monitoring. Known sites at which biomonitors have detected occurrences of a pollutant not detected by conventional, analytical systems have demonstrated the usefulness of these biomonitors in river water monitoring.[3] China and South Korea are heavily investing in the use of biomonitors, especially in rivers affected by industrial activities. The leading manufacturers of these types of instruments are bbe Moldaenke, microLAN and Seiko.

Figure 4: Daphnia Toximeter.

Since biomonitors contain living organisms, their operation is often more critical than that of simple physico-chemical sensors; climate control, culturing and replacement of the organisms, maintenance of pumps, feeding systems, etc are all necessary. As with the cabinet analysers, this restricts their use to locations which have the necessary infrastructure and skilled personnel.

Discussion

A great number of technologies and systems are available for water quality monitoring. Increasingly, instruments can be deployed in-situ and can measure continuously and in real-time. Although most systems have reached a stage of maturity allowing deployment in the field, some have limited applicability due to their complex nature and the need for an advanced infrastructure. The less complex systems, however, allow autonomous operation for extended periods. Solar powered instruments with automatic cleaning systems and wireless communications interfaces for remote access and real-time data collection are becoming commonplace and enable deployment at remote, unmanned stations and in buoys. As more and more data is collected, handling and interpreting this information for management procedures is becoming the next challenge in water quality monitoring.

Figure 5: Example of a stand-alone solar powered monitoring station with wireless data transmission to a web-based data collection system as deployed in Singapore.

References:

1) World Bank, Environment and Social Development Department (2006): China Water Quality Management.

2) D. Liu, W. Yi, U.S. Commercial Service(2008): China: Water Monitoring Technologies and Instruments.

3) C.J. de Hoogh, A.J. Wagenvoort, F. Jonker, J.A. van Leerdam, A.C. Hogenboom (2006). HPLC-DAD and Q-TOF-MS Techniques Identify Cause of Daphnia Biomonitor Alarms in the River Meuse in Environ. Sci. Technol. Vol. 40, pp. 2678-2685.

Photos courtesy of s::can Messtechnik (Figures 1, 2, 3 and 5) and bbe Moldaenke (Figure 4).

Read, Print, Share or **Comment** on this Article at: **Envirotech-Online.com/Articles**