AUTOMATIC FLUID MONITORING AND SAMPLING APPARATUS AND METHOD

This is a continuation-in-part of application Ser. No. 612,832 filed Nov. 13, 1990, which issued as U.S. Pat. No. 5,172,332, and which is in turn a continuation-in-part of application Ser. No. 455,981 filed Dec. 22, 1989 which issued as U.S. Pat. No. 5,091,863. This is also a continuation-in-part of application Ser. No. 846,602 filed Mar. 5, 1992.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to an integrated automatic sampling and monitoring apparatus capable of automatically performing fluid sampling operations in conjunction with real-time, in situ monitoring of at least one analyte by means of at least one fiber optic sensor.

More particularly, the invention relates to a compact unitary fluid sampling apparatus having a computer control system operably connected with a fiber optic sensor so as to provide a user with various unique modes of operation. One unique mode of operation is the capability of triggering sampling operations on the basis of critical values of a given analyte, as measured by the fiber optic sensor. By thus limiting sample collection to upset conditions only, i.e., where a given analyte exceeds a predetermined critical value, the number of samples collected for subsequent laboratory analysis may be reduced so as to minimize analytical costs.

Other modes of automatic operation provided by the apparatus include sampling on the basis of time, and/or flow-proportional sampling based on flow rate. The apparatus also automatically stores sample collection data and measured values of an analyte(s) of interest. Real-time values of the analyte as measured by the fiber optic sensor can be viewed on an alphanumeric display of the apparatus, transferred to a remote computer, and/or retrieved from memory for transfer to an external output device such as a computer and/or a printer for producing a hard copy record.

The invention provides continuous in situ measurement of an analyte of interest, as measured by the fiber optic sensor, in a fluid discharge or stream. The output from the fiber optic sensor provides real-time values of the analyte, so that the collection of samples for later lab analysis may serve primarily as a back-up monitoring technique and may even be dispensed with entirely. The undesirable time lags necessitated by lab analysis of collected samples may thus be eliminated, with real-time measured values of an analyte serving to immediately alert a technician or other user to an upset condition.

The apparatus according to the invention also provides the unique capability of providing actual loading data, i.e., of measuring the actual quantity of an analyte in the form of a target pollutant discharged into a receiving channel or body of water. Quantitative assessment of actual loadings is performed by the computer control means on the basis of input from the fluid flow assembly of the apparatus and from the fiber optic sensor or any other type of sensor capable of providing in situ real-time measurement of an analyte. The resulting loading data is stored in memory. In addition, the apparatus is capable of averaging the values of a given analyte over time, with averaging data also being stored in memory.

The terminology "analyte" as used herein refers to any one of various physical and/or chemical properties of a fluid which may be measured by a fiber optic sensor for monitoring purposes and/or for triggering sampling operations. Such analytes include, but are not limited to, total suspended solids, total dissolved solids, total organic carbon, chloride, chemical oxygen demand, biochemical oxygen demand, nitrate, total phosphorus, ammonia nitrogen, nitrate, total Kjeldahl nitrogen, dissolved oxygen, oil and grease, total hydrocarbons, pressure, and a variety of other analytes of interest, such as various target pollutants including heavy metals.

The terminology "fiber optic sensor" as used herein refers to a sensor of the type having a fiber optic element which transmits light from a photoemitter to a photodetector, the fiber optic element comprising a fiber optic core made of highly light-transmissive optical fiber. Typically, the photoemitter takes the form of a light-emitting diode (LED). Light input to the fiber optic core by the LED traverses the core and becomes incident on the photodetector, which converts the modulated light into an electrical output signal which may be amplified for displaying or recording data. A sensing element, which is responsive to an analyte of interest, modifies the transmission properties of the fiber optic element, which in turn alters the output signals from the photodetector. Any one of a variety of types of fiber optic sensors may be employed with the invention, such as one in which the sensing element constitutes part of the fiber optic element itself, in the form of a clad surrounding the fiber optic core. The clad is made of material having a lower refractive index than that of the core, while at least a portion of the clad is made of a material responsive to an analyte of interest. The clad material is responsive to a given chemical(s) or other analyte, such that its refractive index changes in the presence of such analyte(s) to thereby alter the light-transmitting properties of the sensor. The analyte-sensitive clad material may be sensitive to a group of analytes, such as total heavy metals, total petroleum, or the like.

2. Description of the Relevant Art

In today's climate of deep concern over environmental pollution, municipal agencies and private companies alike are faced with the responsibility of carefully monitoring fluid waste, particularly in order to comply with stringent statutory and regulatory pollution limits or to conduct pollution research. To this end, an automatic fluid sampling apparatus is commonly used to repeatedly collect samples for subsequent laboratory analysis. In addition, a separate analytical meter may be used for on-site monitoring of a critical fluid parameter, such as pH level, to alert the user to an upset in the process stream. A separate flow meter may also be used for monitoring the volume of fluid flow and for pacing sampling operations in proportion to flow rate. The sampler, analytical meter and/or flowmeter are regularly transported for positioning in municipal or industrial manholes to monitor sewer lines containing fluid waste, or to remote field sites for monitoring, research purposes, or the like.

Various problems arise in using separate sampler, flowmeter and analytical devices at a remote field site or in a sewer manhole. Transporting a number of separate devices to a sampling site is cumbersome and inconvenient, while mounting of the separate devices in a