Low Cost Remote Automatic Monitoring System of a Wastewater Treatment Plant

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***Abstract*—A real-time remote monitoring system for wastewater treatment plants (WWTP) has been developed to give local operators a guideline that would allow them to arrive at the optimum operational strategy in the early stage of a process disturbance. Real-time process data acquisition on WWTPs serve the key information needed for efficient operation, reducing the potential for human error, thus enabling a process to be operated in a safe and profitable manner. This paper presents a low cost automatic supervision system with real time, remote and wireless data acquisition, easily configurable and adaptable by the facilities operators and managers. The efficiency of the solution is show through the success of a wastewater treatment plant case made by an Upflow Anaerobic Sludge Blanket (UASB), connected in series with an activated sludge reactor. In this aplication, measurement values from a multi-sensor system were transmitted on-line by a telecommunication system. The developed remote monitoring system makes it possible to monitor the current plant status and to support the operation of local wastewater systems.**

***Index Terms*— Remote Aquisition, GPRS, Uasb, Real Time, Wastewater Treatment**

I. Introduction

With increasingly stringent regulations for effluent quality, the reliable and efficient operation of wastewater treatment plants (WWTPs) has become a crucial problem [1]. They are dynamic systems that are difficult to manage and require long-term expertise and constant monitoring for efficient operation. However, mainly to reduce operating costs, most domestic and industrial WWTPs are being forced to operate with fewer and less skilled operators. Especially, small-scaled WWTPs have no full-time process specialists to maintain the plant systems against large fluctuations in influent loadings and mechanical breakdown. Therefore, it becomes necessary to develop a real-time remote monitoring system to assist local operators at the small scaled WWTPs so that unskilled operators can operate and maintain the plant systems properly. The remote monitoring system collects all the operation data and measurement values from local WWTPs, extracts relevant information, and gives operational guidance to local operators [2].

This paper presents a low cost automatic remote supervision system for small wastewater treatment plants (WTTP), easily configurable and adaptable by the facilities operators and managers. The efficiency of the solution is shown through the success of a WTTP case made by an Upflow Anaerobic Sludge Blanket (UASB), connected in series with a reactor of Active Sludge. The system under study is actually working at the Hospital Geral Waldemar de Alcantara´s WTTP. The automatic monitoring system unit of a real scale enhances the current technology applied in wastewater treatment plant by improving the monitoring and management and enables tighter control techniques [3].

The monitoring system enables process engineers at the remote control center to arrive at the optimum operational strategy in real-time. Then the operational strategy is passed to local operators to maintain the plant systems against large fluctuations in influent loadings and mechanical breakdown. The measurement values from small-scaled WWTPs were transmitted to a remote control center in real-time.

II. Materials and Methods

A. *Domestic wastewater treatment plants*

The UASB reactor is a methanogenic (methane-producing) digester that uses an anaerobic process whilst forming a blanket of granular sludge which suspends in the tank. Wastewater flows upwards through the blanket and is processed (degraded) by the anaerobic microorganisms. The activated-sludge process is a biological method of wastewater treatment that is performed by a variable and mixed community of microorganisms in an aerobic aquatic environment. This consortium of microorganisms, the biological component of the process, is known collectively as activated sludge. The overall goal of the activated-sludge process is to remove substances that have a demand for oxygen from the system. The combination of the UASB reactor with activated sludge process allows the optimization of the

TABLE I.
Detailed Parameters of WWTP

Parameter	Projected	Maximum	Minimum
Equivalent Population	600 hab	1000 hab	-
Diary Input Flow	100 m³/d	150 m³/d	70m³/d
Horary Input Flow	5 m³/d	6,5 m³/d	3 m³/d
Temperature	31 ºC	36 ºC	15 ºC
pH	6,9	7,4	6,6

energy spent on the aerobic process, which makes the process very feasible from an economic point of view.

The WTTP under study is composed by an Upflow Anaerobic Sludge Blanket (UASB) reactor connected in serie with an Active Sludge reactor. The aim of this plant is the elimination of organic compounds and a significant reduction of bacteria. The WTTP posses a area of 120m² and the parameters of project are listed in table I and a block diagrams is show in figure 1.

In order to develop the automatic monitoring aiming the enhance of process efficiency, some parameters were studied and developed according to the following motivations:

1) The wastewater entrance flow (Qin): the continuous and steady feeding in the wastewater treatment systems through and anaerobic reactor brings balance to the process, avoiding disturbance and degradation of the effluent quality. Also, the hydraulic retention time is one of the main operational variables of an UASB reactor and is directly related with the entrance flow.

2) pH: Although pH is a variable that is important in all biological processes, its value is especially critical in anaerobic digestion, where important quantities of protons are released, eventually leading to acidification and process failure. This environmental factor influences significantly the degradation process of organic matter, hence, its measurement and control are important. The system also holds a pH electrode installed in the upper part of the UASB reactor

3) Temperature (°C): there are optimal temperature zones in which the bacterial growth reaches its maximum. However, the system is influenced directly by temperature. Moreover, the reactions that occur during the digestion of organic matter generate heat and can cause disturbances on the process. The system holds two temperature sensors, where one is installed in the upper part of the UASB reactor ($Temp_{INTERNAL}$) and another on the outside of reactor for measuring the environmental temperature($Temp_{ENVIROMENT}$) [4].

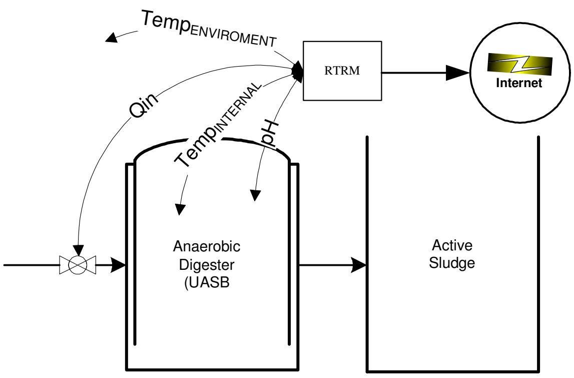

Figure 1. Block diagram of WWTP studied

B. Remote Monitoring System

Recent advances in communication and sensor technology have accelerated progress in remote monitoring capabilities for wastewater treatment plants. As a result, the ability to characterize dynamic properties at adequate temporal and spatial scales has greatly improved. They have greatly enhanced rapid (e.g., real-time) detection of hydrologic variability, recognized as a critical need for early warning systems and rapid response to harmful algal bloom events. The real time remote monitoring (RTRM) technology offer several advantages over historical monitoring techniques by streamlining the data collection process, potentially minimizing human errors and time delays, reducing overall cost of data collection, and significantly increasing the quantity and quality of data on temporal and spatial scales. [5]

The developed system consists of a sensor array, together with a software application and hardware components that enable wireless and Internet computing. Thus, can offer a wide variety of capabilities, including alarm notifications by e-mail, automatic storage of acquired data, real-time generation of HTML reports, and real-time charts and graphs visible from a web-based server.

The RTRM's architecture is hierarchical, characterized by a master-slave relationship, enabling the gradual and modular growth of a system. For the slave system, a digital microprocessed data acquisition module was used to capture data sent by the sensors, which is controlled by software developed and installed in a personal computer, the master. As a mean for the implementation of the data communication, the GPRS was chosen. As for the power source, a symmetrical power system was developed, along with a low power UPS with instantaneous momentaneous commutation, using batteries.

The block diagram of the architecture system proposed is show in figure 1. Key stages of figure 1 as follow:

1) System n: The n..esimo independent system is monitored by k sensors.

2) Ana n,k: The k..esimo analogical output of the sensor in the system n.

3) Slave n: The n..esimo slave module contains a condition block, a microcontroller and a GPRS modem that is responsible for send the digital data to the master by TCP/IP protocol.

4) Master: contains a software that has the following tasks: system's monitoring, configuration of n slaves and storage of historical data.

5) Pc j: The j..esimo personal computer have permission, through Internet, to access the historical and on line data of all systems.

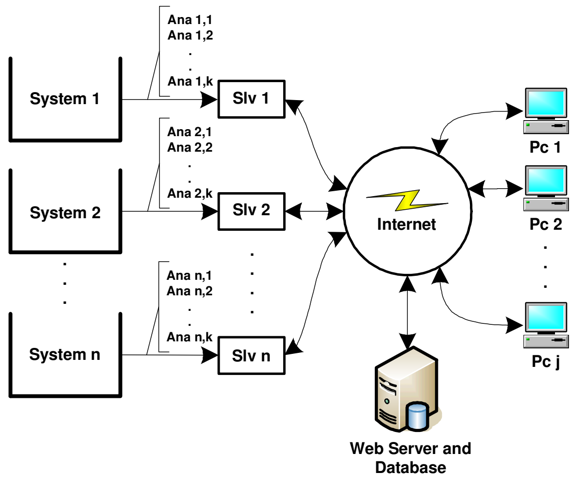

Figure 2. Block diagram of general RTMR

III. Results and Discussion

The continuous remote measurement already allows a more detailed visualization of the treatment station in a daily basis, enabling a malfunctioning detection in real time and a strategic planning of the operation and control of the system giving credibility and quickness to the decision making process[6].

Figure 3, 4 and 5, shows the traditional flow profile of the treatment system, the instantaneous values of internal pH in the UASB reactor, and the instantaneous values of internal temperature in the UASB reactor, respectively. All shown data were acquired with 15 seconds sample time during 10 hours, on December 31, 2007.

The routine operation of the WTTP requires systematic measurements of various parameters, including flow, pH and temperature. In this case, however, a flaw in this system which leads, for example, in a strong decrease in pH that exceeds the WTTP design limits, standard manual equipments may not realize the fact fast enough in order to prevents decrease of the overall WTTP efficiency or even system failure. In this way, this kind of equipment enhances the wastewater treatment plant by improving the monitoring and management and enables tighter control techniques

The instantaneous measurement shows, systematically, a sharp variation of measured values. Such variations are intrinsic to the equipment, not the process, and are considered as noise measurement.

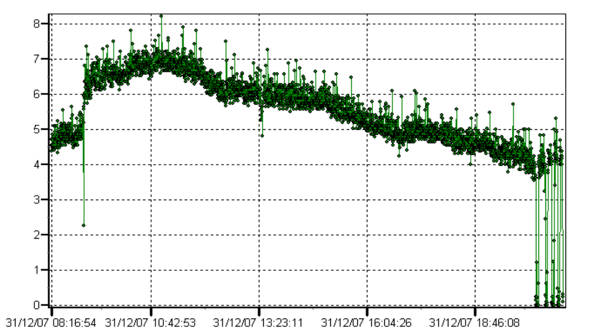

Figure 3. Instantaneous flow input of UASB reactor

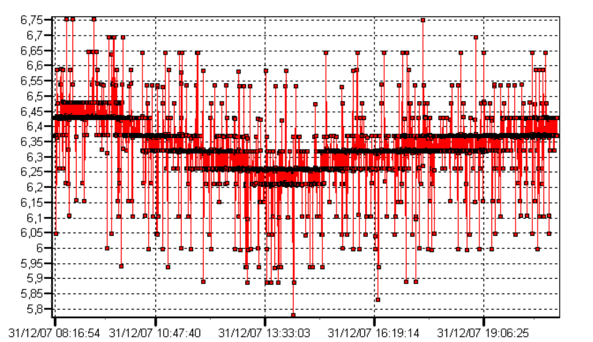

Figure 4. Internal pH of UASB reactor

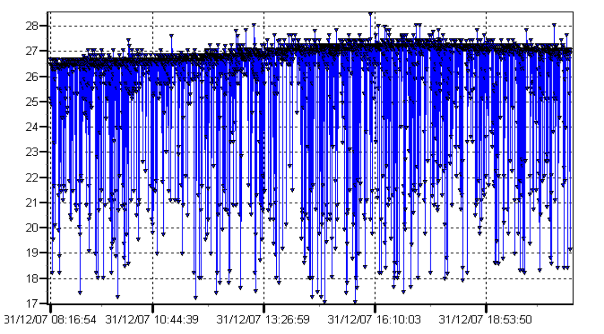

Figure 5. Internal temperature of UASB reactor

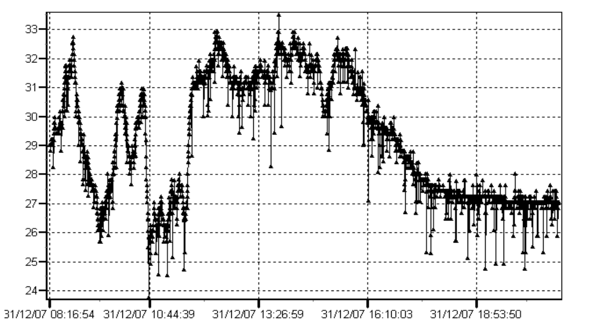

Figure 6. Environmental temperature

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