ON-LINE WATER QUALITY MONITORING ON BRANTAS RIVER EAST JAVA INDONESIA

Masbah R.T. Siregar *, Hiskia **, Yuyu Wahyu**, Goib Wiranto**, Imam Mashari**
*Research Centre for Physic –Indonesian Institute of Science, Komplek Puspiptek-Serpong 15314, Tangerang
**Research Centre for Electronic and Telecommunication –Indonesian Institute of Science,
Jl. Cisitu No. 21/154D Bandung 40135

Abstract **Twenty three on-line water quality monitoring stations have been built along Brantas river in East Java. The construction of these on-line stations has been aimed at providing accurate, real-time, programmed, and continuous data on the quality of the Brantas river water, such that the occurrence of a certain level of water pollution can be detected on time. The placement of these twenty three stations, as well as the types of parameters detected by the sensors inside the stations, has been based on the characteristics of the river water at each location. With this, the source of water pollution can be detected more accurately. The measured parameters include pH, temperature, conductivity, dissolved oxygen, turbidity, orthophosphate, and ammonia. The ability and effectiveness of these on-line stations in detecting water pollution in the Brantas river will be printed in this paper.**
Keywords: On-line monitoring, water quality, sensor, water pollution

I. INTRODUCTION

The Brantas River with its tributaries is the largest river in the province of East Java with a length of 320 km. The main stream of the Brantas River flows most of the way around the Butak-Arjuno Massif located in the centre of the basin. It is joined by a number of larger tributaries, e.g. the Lesti River, the Ngrowo River, the Konto River and the Widas River.

The catchments area is about 11,800 km^2 and 16 million people live within the catchments. The city of Malang (1.5 million) is situated in the upper catchments, whereas other large urban industrialized regencies of Sidoarjo, Mojokerto, Gresik and Surabaya (total population about 6 million) lie in the lower catchments.

The Long-term Development Phase II PJT 1994 - 2019 and Master Plan IV PJT (1997) emphasized on the conservation and preservation of water resource as well as on the optimization of the use of water resources. Within this framework, the Indonesian Institute of Sciences (LIPI) has had a collaborative work with Verbundplan GmbH to extent the existing Water Quantity Monitoring and Flood Forecasting and Warning System (FFWS). This extension concerns with the implementation of a Water Quality Monitoring Network along Brantas River and some of its tributaries. The On-line Water Quality Monitoring Stations have been implemented as part of Brantas river water quality and pollution management on Brantas River East Java – Indonesia [1,2,3].

For water management and water resources development, water quality and quantity monitoring is an important issue. Water quality monitoring is required to ensure the standards and criteria set by the government or regulatory agency for river water, with respect to specific use (e.g. drinking, industrial, irrigation etc.). A well planned and managed water quantity and quality measuring network can serve as a valuable tool for predicting shifts or trends. The objectives of the On-line Water Quality Monitoring have been defined in accordance to:

- water use,
- obtaining baseline data and inventories,
- regulation and guideline for development,
- law enforcement,
- water quality and quantity modeling, and
- basis for water discharge permit development.

Furthermore, the integration of this water quality monitoring network into the existing system including collection, documentation and interpretation of relevant data is one of the main objectives of the project. Modeling of hydrological events combined with a Hydrological Information System and a Decision Support System will strengthen the development of the overall water management tasks in the Brantas River Basin. It acts as a model for the conservation of the Indonesian river basins, especially in Java.

To cover the monitoring area along Brantas River, 23 On-line Water Quality Monitoring Station have been constructed [4]. They consist of 3 different types based on the measured parameters:

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- Type I (11 stations): pH, temperature, conductivity, dissolved oxygen (DO), and turbidity.
- Type II (7 stations): pH, temperature, conductivity, dissolved oxygen (DO) and nutrients (ammonia and orthophosphate)
- Type III (5 stations): pH, temperature, conductivity, dissolved oxygen (DO), turbidity, and nutrient (ammonia and orthophosphate)

The pH is a measure of the acidity or alkalinity of a sample. It functions as an indicator for chemical and biological reactions in an aquatic environment. Temperature is an influencing factor for chemical and biological reactions. Dissolved oxygen is an indicator for the river metabolism. It can be used to monitor organic as well as nutrient pollutants. The actual oxygen concentration depends on a number of factors, such as temperature, air pressure, oxygen consumption by micro organisms in a biodegradation process, oxygen production by algae, etc. The conductivity is a cumulative parameter for the ionic concentration of a solution. The higher the salt, acid or alkali contents in a solution, the greater its conductivity. It indicates the amount of dissolved material in the water column. Turbidity is an indicator for the amount of suspended solids in river water. Nutrients, ammonia and orthophosphate, are monitored to ensure the monitoring of pollution and hydrological effects as well as eutrophication. Changes in nutrient supply for autotrophic organisms are monitored. In addition, some of the stations are equipped with pressure sensor to measure the water level.

II. ON-LINE WATER QUALITY MONITORING CONCEPT

Based on the extensive studies of the Brantas River and its tributaries, the evaluation of available historical and current data (both flow and water quality). The criterion for selection of sites has been based on the reduction of pollution load, improvement of water quality and uses the on-line data for river basin management. In view of this, the location of stations should be close to problem areas, viz. population centers and industrial zones. Most stations are located around city centers like Surabaya, Kediri or Malang where the river is burdened with both untreated domestic and industrial waste load. Ideal locations for the stations are close to point sources (with the intention of controlling emissions), metropolitan areas (public health priority) and drinking water intake points (safe water for human consumption). List of the stations can be seen on the Table 1.

Table 1. List of the Online Water Quality Monitoring Station

NO.	LOCATION	COORD.	COORD.	TYPE	FREQU.
WQ-1	Upstream Pendem Bridge	07° 54,099'	112°34,544'	1 a	daily
WQ-2	Downstream Kendalpayak Bridge	08° 03,316'	112°37,697'	2	daily
WQ-3	Sengguruh Dam	08°10,970'	112°33,061'	3	hourly
WQ-4	Sutami Dam	08° 09,422'	112° 27,062'	2	daily
WQ-5	Selorejo Dam	07° 52,288'	112°21,322'	2	daily
WQ-6	Wlingi Dam	08° 08,533'	112° 14,905'	1	daily
WQ-7	Lodoyo Dam	08° 08,975'	112° 11,466'	1	daily
WQ-8	Downstream Tambangan Pakel	08° 03,637'	111° 58,735'	1 a	daily
WQ-9	Downstream Ngujang Bridge	08°00,987'	111°55,456'	3	hourly
WQ-10	Upstream Mrican Barrage	07° 45,899'	112°01,490'	1	daily
WQ-11	Downstream Cheil Jedang	07° 26,739'	112°15,429'	3	hourly
WQ-12	Downstream Ajinomoto	07° 26,957'	112°26,888'	3	hourly
WQ-13	Upstream Tambangan Canggu	07° 26,162'	112° 27,593'	1	hourly
WQ-14	Downstream Jrebeng Bridge	07° 23,229'	112° 34,650'	2	hourly
WQ-15	PDAM Krikilan	07°22,315'	112°35,590'	2	15 min.
WQ-16	Karanglo	07°22,080'	112°37,723'	1 a	hourly
WQ-17	Upstream Karangpilang Intake	07°20,902'	112°40,888'	3 a	15 min.
WQ-18	PDAM Kayoon	07° 16,059'	112° 44,965'	2 a	15 min.
WQ-19	PDAM Ngagel	07° 18,029'	112° 44,480'	2	15 min.
WQ-20	Downstream Mangetan Gate	07° 26,601'	112° 28,103'	1	hourly
WQ-21	Upstream Kertosono Old Bridge	07°36,000'	112°06,580'	1	hourly
WQ-22	Upstream Dam Porong Canal	07° 27,165'	112° 29,014'	1	hourly
WQ-23	Upstream Lesti Bridge	08° 13,836'	112° 41,080'	1	hourly
** Parameters to be measured according to the Type			a... with water level		
Type 1: pH, temperature, dissolved oxygen, conductivity and turbidity					
Type 2: pH, temperature, dissolved oxygen, conductivity and nutrients (ammonia & orthophosphate)					
Type 3: pH, temperature, dissolved oxygen, conductivity, turbidity and nutrients (ammonia & orthophosphate)					

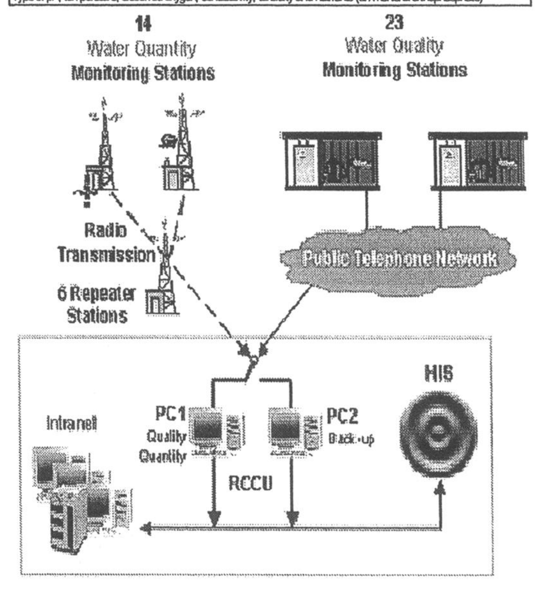


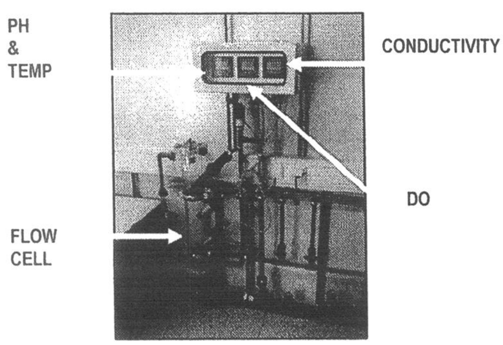
Fig.1 On-line Water Quality monitoring concept

As shown in Figure 1, after being stored locally in the monitoring stations the data are sent to a central remote control unit located at the Master Station Malang by means of a telemetric system. The remote control central unit is used to communicate with the monitoring stations, the data management, data storage and evaluation. From there the data are queried periodically by means of SQL commands and are transferred to the central database (ORACLE database) located at the Master Station Malang. This is meant for a more efficient evaluation and analysis of the data as well as in connection to the data monitoring of the existing system to allow more flexibility and reliability for decision makers. The online water quality monitoring system is controlled from the Remote Control Central Unit (RCCU) located at the Master Station Malang.

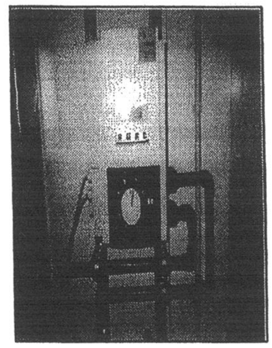
III. DESCRIPTION OF ON-LINE WATER QUALITY MONITORING STATION

The station is equipped with the steel shelter and the adjoining building. The water quality monitoring instruments are placed in the steel shelter and all other supplementary facilities e.g. power supply, electrical cabinet and telephone modem are in the adjoining building. Personnel safety requirements and appropriate ventilation systems are included. Equipment and personal safety are given by a front door access control, a security control system and a fire detection system inside the shelter as well as in the front room. According to the specific site conditions, an external submersible pump is installed within the river bed. A pipe connects the sample water intake with the water pipes within the shelter.

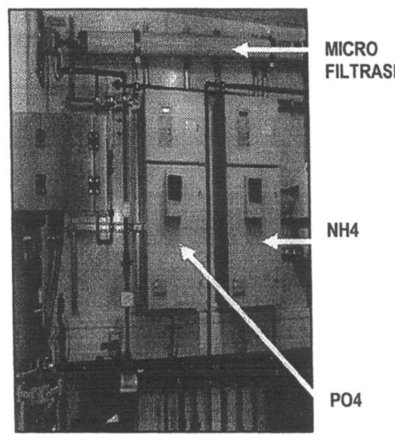
The main instrumentation is an assembly of sensors to measure pH value, temperature, conductivity and dissolved oxygen concentrations of river water which are installed in a continuous flow - trough cell. A turbidity meter is mounted on the wall. A refrigerated automatic sampler is installed for reference samples in all three types. The photographs of the instrumentation can be seen in Figure 2



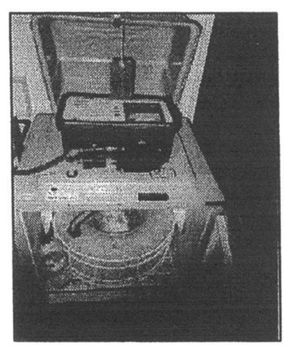
(a)
Ph, Temperature, Conductivity, Dissolved Oxygen



(b)
Turbiditymeter



(c)
Ammonia and Orthophosphate (Nutriens)



(d)
Automatic Sampler

Fig .2 Monitoring Instrument inside the Station

The external submersible pump pumps the sample water directly from the river into the water pipes installed inside the shelter. The sample water supply is controlled via the control unit CU300. After the pre-filter there is a by-pass to the continuous flow cell. Within the continuous flow cell the water passes through the pH, temperature, dissolved oxygen and conductivity sensors. These sensors monitor the water quality permanently.

A bypass after the continuous flow cell supplies the turbidity meter with sample water. The turbidity meter measures the turbidity permanently.

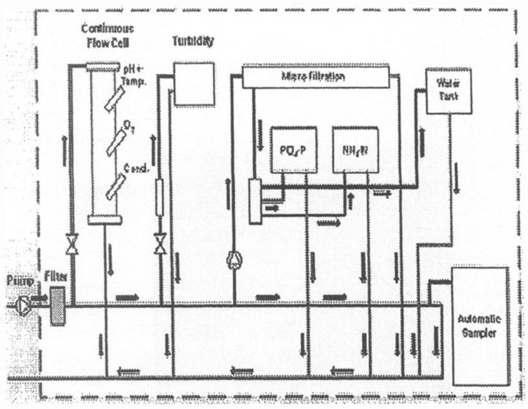


Fig.3 Schematic Overview of the Sample Water Flow in a Type 3 Station

Another bypass supplies the pump for micro filtration unit which maintains a constant flow rate through the micro filtration unit. The filtered water is used to analyze the nutrients ammonia and orthophosphate at pre-set intervals. The rest of the micro-filtered water is stored in a water tank.

At the very end of the sample water pipe in the shelter the automatic sample unit takes reference samples of the pre-filtered but not micro-filtrated water. The amount and frequency of the samples can be pre-set by the operator.

The water is drained out of the shelter after passing the equipment as described above. A schematic overview of the water flow in the station is shown in Figure 3.

IV. EVALUATIONS AND DISCUSSION

Since the beginning of the operation of the 23 stations, some river water pollution cases were detected.

There are two interesting cases, the first one is a molasses accident from sugar cane factory in the Brantas river on August 2001 and the second case is Brantas river phenomenon during Iedul Fitri Holiday on December 2002.

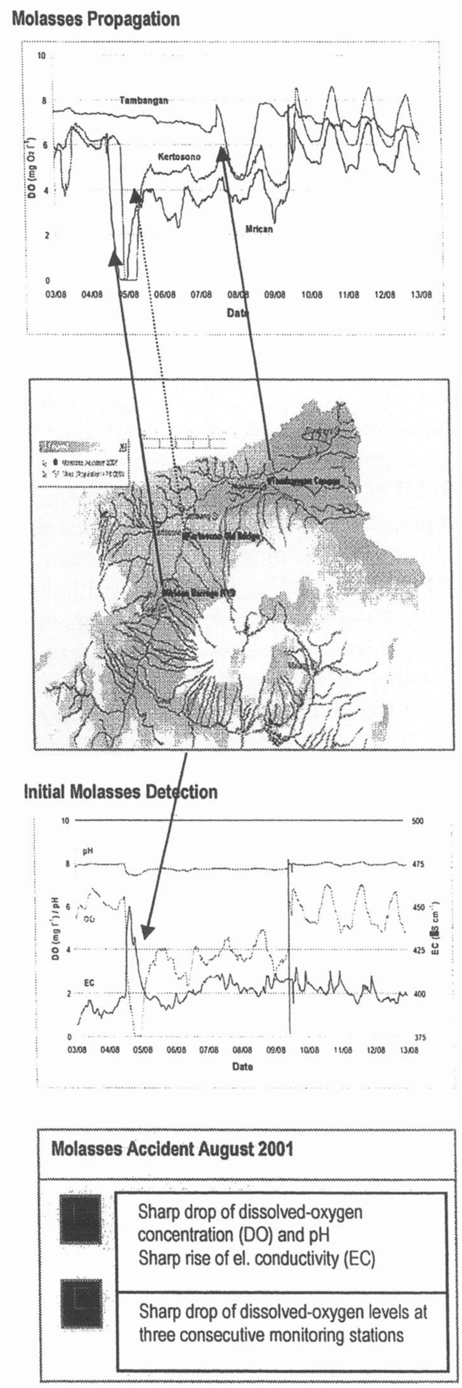


Fig. 4 Monitoring Result of Molasses Accident in August 2001

As shown in Figure 4, the nearest (WQ 10 Mrican) detected the decrease of Dissolved Oxygen and the increase of Conductivity in the location significantly. Moreover, the molasses propagation can be detected clearly in the 2 next downstream stations WQ 21 Kertosono (about 20

Km from location) and WQ 13 Tambangan Canggu (about 40 Km from location).

In general, high population and industry activity along Brantas River have caused the river water quality becomes bad as indicated by the low value of Dissolved Oxygen concentration and high turbidity value. However, this condition improved during the Iedul Fitri Holiday in December 2002. As shown in Figure 5, it is indicated by the increase in DO concentration, which was monitored by the Station WQ16 Karang Lo, WQ17 Karang Pilang, and WQ19 PDAM Ngagel in the beginning of December 2002. A simple explanation to this phenomenon is that the industry stopped the production and people activity was decreased during the Iedul Fitri holiday, therefore the waste water resulted by industry and people activity is decreased significantly.

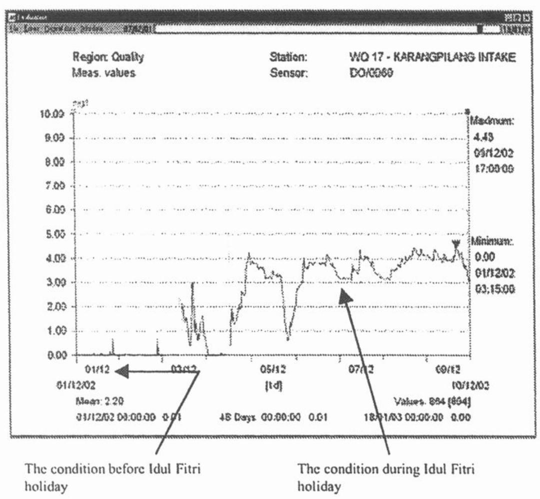


Fig. 5 DO measurement in Station WQ17 Karang Pilang during Iedul Fitri holiday in, December 2002

V. CONCLUSION

In this paper, the concept of on-line water quality monitoring system on Brantas River has been described. The monitoring network of water quality and water quantity stations for the entire Brantas River System provides the data which is needed to establish an effective decision tool for the management of the river basin. Continuous monitoring allows immediate action in case of emergency. Furthermore, long-term evaluation of the data quality results in improves in predictive capabilities based on modeling techniques and thus providing important support for decision makers.

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