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Influence of Hydraulic Characteristics to Water Quality in Lamtakong River, Thailand

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1. Introduction

The Water resource problems today, on both quantity and quality, have arisen in many places around over the world. More water is required and more polluted water has been discharged since human activities nearby the river have increased. As a result, water quality problems which harm ecosystem, social, economy especially on the downstream would be expected.

The temporal and spatial distribution of water quality constituents are controlled by complex physical-biological-chemical interaction processes. In the last decades, several studies and tools for the water quality prediction have been developed (James, 1993; Chapra, 1997). Each model has its own level of complexity and applicability and new models appear regularly that further enhance understanding of those processes (Cox, 2003; Brown and Barnwell, 1987; Whitehead et al., 1997; DHI Water & Environment, 2003). However, the applicability of more advanced models are limited due to the quality and quantity of data available (Eatherall et al., 1998). Hence, for some cases, especially for the remote area, other compromised tools could be more applicable.

The influence of hydraulic parameter to water quality parameters is analyzed in order to provide a simple analytical tool which could be applied to area where the set of data measurement is scarce. Both Froude number (*Fr*) and Reynolds number (*Re*) are easy to obtained parameters and directly relate to flow characteristics in terms of strength of flow and its turbulence which could lead to the change of dissolved oxygen level. The study shows the numerical relationship between *Fr*, *Re* and water quality based on the Lamtakong River and Mae Klong River in Thailand.

2. Water Quality Model

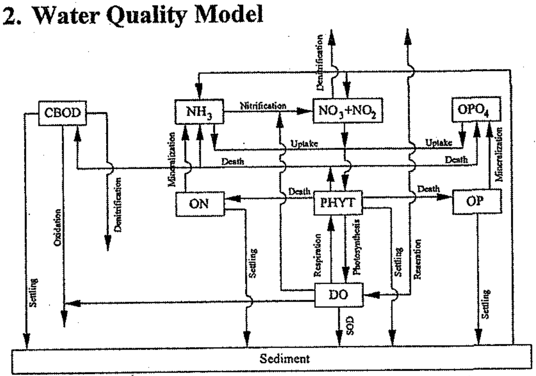

Fig.1 Schematic of water quality model (Zheng et al., 2004)

In this study, the water quality model constitutes a complex of four interacting systems: dissolved oxygen, nitrogen cycle, phosphorus cycle, and phytoplankton dynamics. Eight water quality components are included: dissolved oxygen (DO), phytoplankton as carbon (PHYT), carbonaceous biochemical oxygen demand (CBOD, BOD), ammonium nitrogen (NH4), nitrite and nitrate nitrogen (NO3), ortho-phosphorus (OPO4), organic nitrogen (ON), and organic phosphorus (OP). The conceptual framework for the water quality model is illustrated in Figure 1.

3. Simulation cases setup

Three typical numerical cases (boundary conditions), are based on three from five classes categorized by Pollution Control Department (PCD, Thailand). In this study, Class 1 refers to good water quality level of water resource for fisheries, swimming, and water sports, Class 2 for agricultures and Class 3 for industrial uses. Each case is set up to evaluate the relationship between local (Froude number), temporal (Reynolds number) hydraulics characteristic and water quality parameters. The water quality in terms of DO and BOD are considered at 1 kilometer downstream. The Froude number is set to vary from 0.10 to 0.99 while Reynolds number varies from 100,000 to 1,000,000 for each case and changes due to chemo-biological processes during the flow period are in compared in percent. The water quality characteristic for each case is shown in Table 1 while other required efficiencies are set based on default values for tropical climate.

Table1. Parameters setting for the typical numerical cases

	Class 1	Class 2	Class 3
DO [mg/l]	6.0	4.0	2.0
PHYT [mg/l]	0.5	1.0	1.5
BOD [mg/l]	1.5	2.0	4.0
NH4 [mg/l]	0.5	0.5	0.5
NO3 [mg/l]	5.0	5.0	5.0
OPO4 [mg/l]	3.0	3.0	3.0
ON [mg/l]	1.0	1.0	1.0
OP [mg/l]	0.5	0.5	0.5

4. Results & Discussion

From the numerical model, relationship of DO change to *Fr* and *Re* can be illustrated as shown in Figure 2. Degree of DO change along the channel increases with proportional to *Fr* while decreases exponentially to *Re*. Increase of *Fr* promote the reaeration while turbulence which identified by *Re* leads additional benthic oxygen demand. Concurrently, reaeration rate for each class is varied due to the gap between the existing DO and saturation concentration. As for the first class, DO concentration is already near saturated level, therefore less reaeration has taken place.

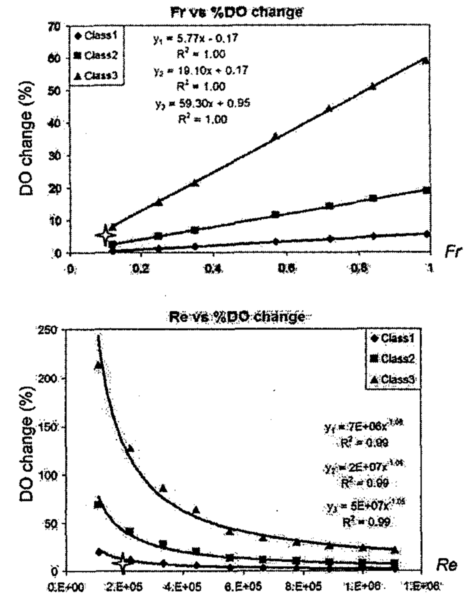

Fig.2 Effects of *Fr* and *Re* to % change of DO level at 1.0km downstream

However, there is no notable difference among those three cases for degradation of BOD and the rates decrease at higher *Fr* and *Re* (Fig.3). The reason is that, from the expression of *Fr* and *Re*, those 2 unitless parameters become higher at high velocity and the period which water body moves to the considering point at 1 kilometer downstream or the detention time then becomes shorter.

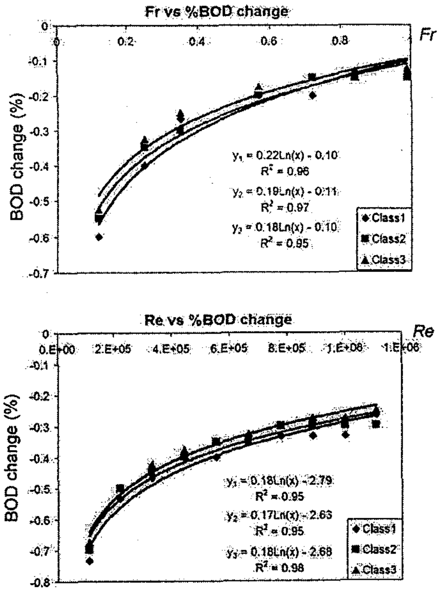

Fig.3 Effects of *Fr* and *Re* to % change of CBOD at 1.0km downstream

Considering the agreement to observation data from two rivers in Thailand, the model cannot well illustrates water quality behavior. In Fig.2, the star mark shows the only 1 from 7 observation points (five points located in the Lamtakong River and two more points from the Mae Klong River) matches to the graphs. The reason is that the model does not take an account of lateral flows, which mostly refer to wastewater discharges. BOD from wastewater depletes oxygen and defers river self-purification (negative value in Fig.2 and positive value in Fig.3).

5. Summary

Water quality can be roughly estimated by simple hydraulics parameters. *Fr* can be considered as local channel characteristics which affected by slope, roughness, etc. While, *Re* is calculated by flow depth and velocity, change of *Re* can represent to temporal change of flow for each location. These two simple hydraulics parameters have relationship to water quality in both direct and indirect ways. With higher *Fr* number and low *Re*, the better water quality, in term of increasing of DO, would be expected downstream. However, an agreement between the value from observed fields and the numerical river cases in this study is still insufficient, since rivers still have different boundary conditions. Therefore, more typical cases and local climate are needed to generate a variety of conditions which will fit to each specific river type.

Acknowledgements

A part of this study was supported by a Grant-in-Aid for Scientific Research from the Ministry of Education, Science and Culture of Japan.

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