Journal of Hydrology (2007) 334, 347–358

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journal homepage: www.elsevier.com/locate/jhydrol

Experimental investigation and modelling approach of the impact of urban wastewater on a tropical river; a case study of the Nhue River, Hanoi, Viet Nam

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Received 28 June 2006; received in revised form 3 October 2006; accepted 12 October 2006

KEYWORDS
RWQM1;
To Lich River;
Nhue River;
Hanoi;
Pollution;
Urbanisation

Summary Analyses of water quality and flow regime in combination with laboratory studies and ecological modelling were used to assess the water quality impact of pollution from to To Lich River that drains through Hanoi City and greatly contaminates the Nhue River. With an average discharge of 26.2 m^3/s, the Nhue River receives about 5.8 m^3/s of untreated domestic water from the city's main open-air-sewer — the To Lich River. The studies during 2002–2003 showed high concentrations of BOD (70 mg O_2/l), DOC (15 mg C/l), coliform (2.4e^6 MNP/100 ml), total phosphorus (3.5 mg P/l), and total nitrogen (31.6 mg N/l) in the To Lich, while DO level was less than 1 mg O_2/l. Such high loads of untreated wastewater impacted water quality in the Nhue River where DO decreased at times to as low as 1 mg O_2/l. The accumulation of particulate organic matter and micro-organisms in the sediments of the Nhue represented substantial sources of nutrients and sinks for DO. They are also considerable production of dissolved carbon dioxide at concentrations up to two orders of magnitude higher than pressure. Such pressures (***Ep***CO_2) are expected in polluted environments, but the results presented here are new for Vietnam and much of developing countries. A number of factors linked to field monitoring and laboratory measurements clearly indicate the importance of autotrophic over heterotrophic biological processes and sediments. An ecological model for management purposes has been developed that reliably estimates of the pollutant loads. An opportunity was taken to examine the changing impacts and processes when the To Lich was diverted from the Nhue. The monitoring and modelling of this opportunity showed

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0022-1694/$ - see front matter
doi:10.1016/j.jhydrol.2006.10.022

low dissolved oxygen levels even if the impact from the To Lich was lessened. Alternatives are proposed to alleviate problems of water quality in the Nhue. It is concluded that the treatment of the To Lich River's water is highly recommended; otherwise a reduction to one third of current wastewater discharge is needed to bring water quality back to the environmental standard.

Introduction

Rapid urbanisation and major economic development in Vietnam has led to dramatic degradation of the environment and increased health risks due to inefficient processing of the increased burden of effluent and solid wastes (Bolay et al., 1997). A major example of this is the Nhue River, a tributary of The Red River, which is polluted by Hanoi City (Fig. 1). With a population of more than three million and no wastewater treatment facility (JICA, 1995), the city's domestic wastewater has resulted in severe environmental issues for the Nhue downstream its confluence with the city's main sewer, the To Lich River (JICA, 1995).

This paper examines the water quality issues and remediation strategies for the Nhue based on the efforts of a multidisciplinary scientific program[1] launched in 2001 to assess the environmental state of the river, especially around Hanoi, and to develop suitable treatment methods for the polluted water. For this, the water quality and flow regime was used in combination with a 1-D physico-biochemical model (Trinh et al., 2006a). This was done to (1) investigate the ecological state of the Nhue River, (2) quantify the impact of wastewater rejected into the river (both point and non-point sources) and (3) evaluate several practicable management alternatives.

To our knowledge, very few modelling attempts have been made to quantify and predict the ecological interactions in a similar highly polluted subtropical river in Vietnam and other countries in south East Asia (Quynh et al., 2005; Trinh et al., 2006a; McAvoy et al., 2003). Therefore, in terms of ecological modelling, this work is one preliminary for ecological modellers to work on highly polluted subtropical river systems, an issue of fundamental importance to the development of environmental management tools and remediation strategies for such an important region of the world.

The studied area and the experimental surveys

The river basin studied comprises of two subcatchments, the Nhue and the To Lich (Fig. 1) with respective catchment areas of 1070 km^2 (Cu et al., 2005) and 77.5 km^2 (JICA, 1995). The To Lich River stems from West Lake in the northern part of Hanoi city and it flows southward through Hanoi to join the Nhue River downstream. Domestic and industrial wastewater from Hanoi mainly discharges to the To Lich River without prior treatment and the river is effectively the principal open-air-sewer of the city. The Nhue River, as a branch of The Red River, takes its source from the Red River about 11 km to the north west of Hanoi and is joined with the To Lich some 20 km downstream of Hanoi. The mean inflow to the Nhue River from the Red River is 26 m^3/s and it typically receives around 5.8 m^3/s of untreated wastewater from the To Lich River.

Monthly water quality surveys were conducted from January 2002 to October 2003 at seven key locations (Fig. 1). Five of these monitoring points (N1, N2, N3, NT1 and NT2) are on the Nhue River at 0 km, 8 km, 15.2 km, 25.2 km, and 33 km from its source, the Red river. There is also one monitoring point for the Red river 4 km upstream of the Nhue's source and one monitoring point (TL) in the To Lich River at 800 m upstream of its confluence with the Nhue. The information collected during these surveys included topographic, hydrodynamic, physico-chemical, chemical and biological conditions (Table 1). Water flow

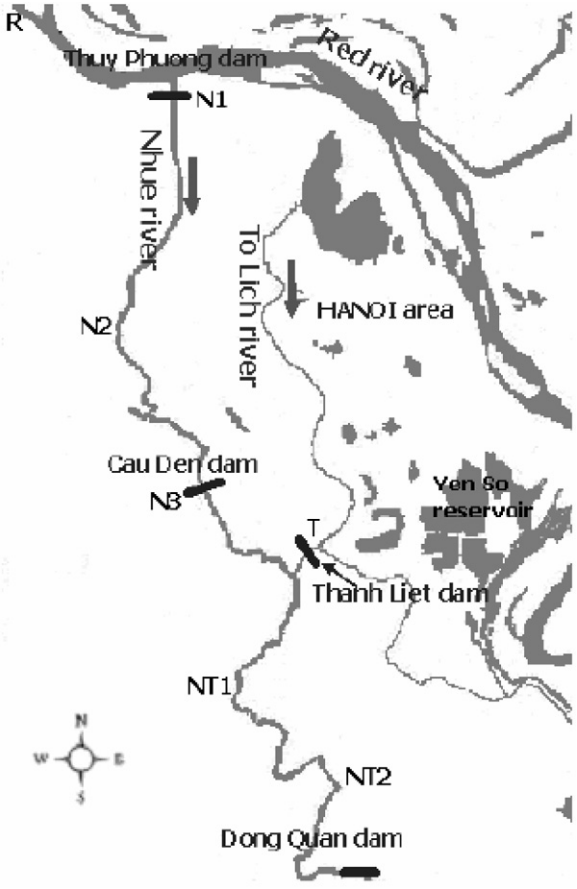

Figure 1 Map of the studied area.

[1] ''Programme de recherches Franco Vietnamien sur la pollution des eaux en zone urbaine'' between Centre National de Recherches Scientifiques, CNRS, France and Vietnamese Academy of Science and Technology, with the support of French Ministry of Foreign Affairs and Vietnamese Ministry of Science and Technology; http://www.waterprog-frvn.org.vn.