A Preliminary Trend Analysis of DO and BOD Records in Kathmandu, Nepal: Towards Improving Urban Water Environment in Developing Asian Countries

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Abstract

Deterioration of urban water quality has been recognized as one of the critical environmental issues in rapidly developing Asian cities. Rapid population growth and economic development but in haphzard manner are considered to be main reasons for the critical urban water degradation. United Nations University - Institute for the Advanced Study of Sustainability (UNU-IAS) with funding from Ministry of the Environment, Japan has recently launched Water and Urban Initiative (WUI) for enhancing urban water environment in rapidly developing Asian cities. Initially, Hanoi, Jakarta, Kathmandu and Manila have been considered as study areas for this Initiative. Towards this, this study aims to analyse the water quality deterioration trend in the Kathmandu valley in terms of dissolved oxygen (DO) and biochemical oxygen demand (BOD) to ascertain water quality problems. Water quality data of three stations; Gaurighat, Teku (Kalopul) and Sundarighat; located along the Bagmati River of Kathmandu valley was used to examine the water quality deterioration trend. The results indicated that the DO is significantly decreasing as the river flows down towards the city core and BOD is increasing as the river flows down towards the city core. The quality of river water is extremely poor and not suitable enough for the purpose of agriculture. To protect the water quality and maintain ecologically and economically healthy land development of the Kathmandu Valley, it is essential to integrate the water quality management with land use planning, industrial and other developments.

Keywords: Water quality, Water and Urban Initiative, Dissolved oxygen, Biochemical oxygen demand, Land use planning, Community awareness

1. Introduction

In recent years, urban water quality in developing country cities are found to be critically deteriorated. Rapid population growth and economic development in unplanned way mainly constitute the urban water degradation. Installation of adequate sanitation systems and implementation of effective legal land use frameworks are largely lacking in comparison to rapid urbanization and economic growth. Pollutants affecting water quality come from point or non-point sources. Point pollution can be relatively easily monitored by measured discharge and chemical concentrations periodically. However, non-point source pollution presents greater challenges because of their dispersed origins and the fact that they vary with

season and weather. Additionally, non-point source pollutants are often overlooked by human beings. Water quality is highly influenced by land use pattern as it determines the type and quantity of non-point source pollutants.

In recent years, deteriorating trend of water quality parameters has received considerable attention globally (Tsanis and El-Shaarawi, 1992; Evans and Jenkins, 2000; and Raike et al., 2003). These studies found increasing trends in nutrients in rivers passing through Agricultural areas, while a decline in chlorophyll was observed. Variability of the water quality variables may be cyclical with the seasons, steadily trend, abruptly or some other established variation over time (Kannel et al., 2007; Chang, 2008; Bouza-Deano et al., 2008; and Tabari et al., 2011).

Considering the significance of further research in the field of water quality management, United Nations University - Institute for the Advanced Study of Sustainability (UNU-IAS) with funding from Ministry of the Environment, Japan has launched Water and Urban Initiative (WUI) project for enhancing urban water quality in rapidly developing Asian cities. In this research, existing water quality management frameworks and spatial relationships between land uses and urban water quality measured with biological, water chemistry and habitat indicators will be reviewed in some of the representative urban watersheds. Initially, the study is planned in Hanoi, Jakarta, Kathmandu and Manila (Figure 1). Later, the study will be extended to some other JCM (Joint Crediting Mechanisms) countries.

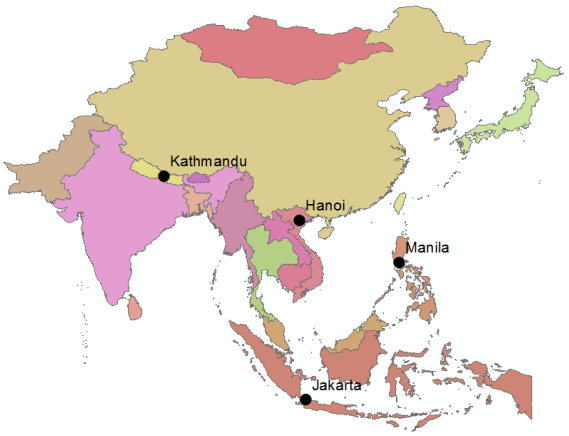

Fig.1 Map showing the location of the selected four representative urban areas for WUI project.

In this paper, Kathmandu valley was selected for the preliminary study of urban water quality. This study aims to analyse the water quality deterioration trend in terms of dissolved oxygen (DO) and biochemical oxygen demand (BOD) to ascertain potential water quality problems. The results of this study will be helpful to figure out an effective management plan for the sustainable urban water environment of the Kathmandu valley.

2. Materials and methods

The purpose of water quality management of WUI project is to maintain and improve water quality which requires designation of water usage, establishment of criteria to protect designated uses, and development of water quality management plans. The overall objective

of this research programme is to enhance urban water quality by identifying drawbacks in existing water quality management frameworks and developing policy tools in developing Asian cities and, also carry out water quality modeling for alternative urban land use development scenarios that meets both socio-economic and ecological needs.

WUI project aims to analyze existing water quality management frameworks, hydrographic, land uses and commonly available water quality parameters from various sources to establish impacts on urban water quality. The common water quality parameters include dissolved oxygen (DO), pH, total suspended solids (TS), total dissolved solids (TDS), Nitrogen (NH_3, NO_3 and NO_2), total organic carbon (TOC), hardness, pathogens etc. These water quality variables have been selected from commonly used indicators based on the data availability in the study areas. The high resolution satellite imageries of past few decades will be compared to examine the changes of land use and establish the relationship between land use types and water quality variables, and give the technical support which can help propose the appropriate strategy that will permit the sustainable regional development and protection of ecological environment, and understand how it is important to assess the potential impacts of land use types on water quality changes in the urban watershed scale.

Water quality data collected by the Department of Hydrology and Meteorology, Government of Nepal over a period of 15 years (1992 - 2006) from three stations; namely Gaurighat, Teku (Kalopul) and Sundarighat; located along the Bagmati River of Kathmandu valley was used to examine the trends in water quality parameters (DHM,2008). Figure 2 shows the location of these three stations in the Kathmandu Valley Watershed Map.

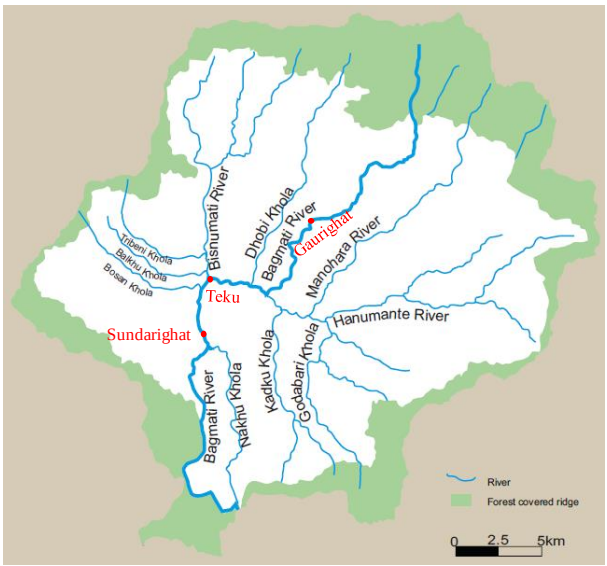

Fig. 2 Map showing river systems in Kathmandu Valley.

The Kathmandu Valley lies between the latitudes 27°32’13” and 27°49’10” north and longitudes 85°11’31” and 85°31’38” east. Over the period between 1984 and 1990, the urban area has increased by 7% of its total surface area (Halcrow Fox and Associates, 1991). KAPRIMO (2007) has indicated that the situation of water-flow and water quality of rivers within the valley is very alarming and excessively polluted in most of the parts. The pollution of these rivers has deeper impacts on overall urban environment and human health. Figure 3 presents some pictures of the polluted river sites.

a) Children bathing at a polluted site of Bagmati River b) Dhobhi Khola polluted

(Photo Courtesy: Kathmandu Valley Environment Outlook, 2007)

Fig. 3 Pictures of the polluted river sites.

3. Results and discussion

DO and BOD are two internationally recognized indicators for water quality. The oxygen contained in water is necessary for the survival of animals and plant organisms as well as for the degradation of chemical and biological contaminations. The BOD shows the amount of oxygen necessary for biological oxidation of decomposable or biodegradable organic components (pollution) under defined conditions (usually 5 days at 20°c). The minimum value of DO for good water quality is 5 mg/lit (KAPRIMO, 2007). Maximum desirable BOD level for drinking and aquatic life is 4 mg/lit, bathing is 6 mg/lit and agriculture is 10 mg/lit (BBWMSIP, 1994). Water quality presumed to be better as the level of DO increases, and worst as the level of BOD increases.

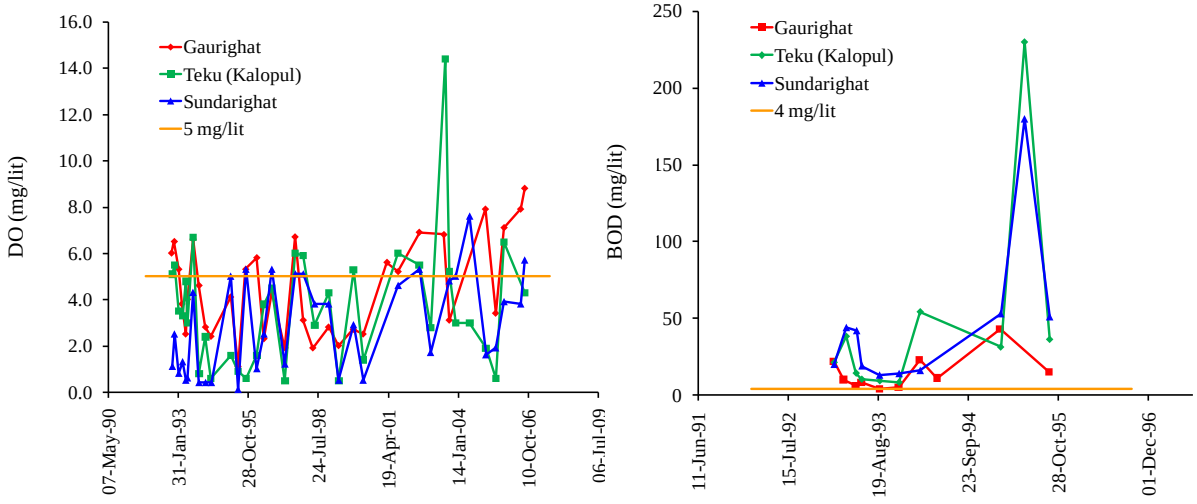

Fig. 4 Trends of DO and BOD measured at stations Gaurighat, Teku (Kalopul) and Sundarighat.

Trends of DO and BOD measured at stations Gaurighat, Teku (Kalopul) and Sundarighat are presented in Figure 4. The trends show that the DO is decreasing as the river flows down towards the city core and BOD is increasing as the river flows down towards the city core. In most of the measured samples the value of DO is found less than 5 mg/lit. Similarly, no measured samples have the value of BOD less than 4 mg/lit; even observed more than 10

mg/lit in most of the samples. It indicates that the quality of river water is extremely poor and not desirable even for the purpose of agriculture.

Rivers in Kathmandu Valley are degrading significantly as they flow down towards densely populated city core. River segments in highly urbanized area have extremely poor water quality. Poor sanitation situation of settlements, open defecation practice, disposing household solid waste into the river banks, waste generated by tourists and picnickers, chemicals fertilizers and pesticides used for farming starts polluting river water in the surrounding hills of the valley and adjoining areas are the important settlements situated in the area.

Outer reaches of the city core areas are highly urbanizing and constructions are increasing haphazardly. Increasing trend of industries such as concrete, dying, paper mills, piggery, poultry, saw mills, etc. are very common in these areas. There is no any systematic sewerage treatment system. Huge volume of waste water generated from the households and industries are directly discharged into the rivers. Even municipal wastes are also commonly disposed in the river banks. Dumping of solid waste and sewerage connection is more acute as it goes down towards city core. A rampant use of river for bathing; washing clothes, utensils, vegetables and vehicles; domestic animals; and disposing remains after rituals have also contributed in degrading the water quality in outer reach of the city core.

Hence it is essential to integrate the water quality management and land use planning to protect the water quality and to maintain ecologically and economically healthy land development of the Kathmandu Valley. To address these issues, strong regulatory mechanism, and community awareness and mobilization are other key factors to be taken into considerations.

4. Conclusions

In this study, Kathmandu valley was selected for the preliminary study of WUI project to analyse the trend of the water quality deterioration. Water quality data of three stations; namely Gaurighat, Teku (Kalopul) and Sundarighat; located along the Bagmati River was used to examine the the water quality deterioration trend. The results indicated that the DO is decreasing as the river flows down towards the city core and BOD is increasing as the river flows down towards the city core. The quality of river water is extremely poor and not desirable even for the purpose of agriculture. Hence it is essential to integrate the water quality management and land use planning to protect the water quality and to maintain ecologically and economically healthy land development of the Kathmandu Valley. To address these issues, strong regulatory mechanism, and community awareness and mobilization are other key factors to be taken into considerations.

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