EVALUATION OF BIODEGRADATION RATE CONSTANT (K_1) AND BOD POLLUTION IN THE LAKE SYSTEM OF HANOI

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ABSTRACT

The long-term BOD research of 8 lakes by using B.O.D sensor set (Italia) has gained stable and reliable results. It can be concluded that the level of BOD pollution of Hanoi' lakes is considerable; the biodegradation rate constant of BOD kinetics varying from $0.27d^{-1}$ to $0.43d^{-1}$ (base e, at 20°C) shows a high capacity for BOD degradation of the lake system in Hanoi.

Introduction

Lakes in Hanoi form a holistic system, which play many important environmental roles in the life of Hanoi city. The system can be served as a part of water drainage and purification system, fish farming, regulating microclimate, supplementing groundwater, recreational and sport areas, biodiversity conservation, etc. In recent years, because of many reasons, their environmental state is becoming worse. A better understanding of the system's physico-biochemical behavior will be helpful in establishing proper strategies, policies, planning, and regulations for effective and economical management of these ecosystems. This report will present the most recent results in evaluation of BOD degradation kinetic's rate constant and organic pollution of typical lakes in Hanoi.

Research methods

Theoretical Basis and Calculation Method

The biodegradation of organic matters by bacteria follows first-order kinetics, which is expressed through the following equation:

$$y = L_0[1 - \exp(-k_1 t)] \quad \text{Or} \quad y = L_0[1 - 10^{-K_1 t}] \qquad (1)$$

Where

y : The BOD satisfied at any time of t
t : Time (d)
k_1 and K_1 : Rate constant for BOD removal; k_1 (base e) = 2.3 K_1 (base 10); (d^{-1})
Lo : Ultimate BOD (= initial amount of organic matter); mg/L

Lo and k_1 are two important parameters; in which the value of Lo (or ultimate BOD) tells us the "true" level of BOD pollution and k_1 points out the velocity at which biodegradation process takes place in a water body. However, in determining these values from actual data, there is sometimes a serious difficulty. In case where the value of Lo is unknown, the form of BOD equation makes the determination of the values of k1 and Lo from original data impossible. Those values are only obtained by using long-term BOD test, in which data of BOD is recorded everyday in an eligible time for fully decomposing, normally is greater than 10 days.

There exist many methods for estimating the values of ultimate BOD (BOD_u) and k_1. In this study to solve the BOD first-order kinetics equation, we have applied the least-squares method [2], which is programmed on Turbo Pascal programming language 7.0.

Long-term BOD Tests

To carry out experiences, we use a set of B.O.D Sensor VELP (Made in Italia). The operation of this device is based on the principle that the internal pressure transducer controlled by a microprocessor translates the values of pressure directly into BOD value, which are

memorized automatically every 24 hours, for a total of five values during the standard five days period.

The precision of method was evaluated by using solutions with a known content of glucose and glutamic acid, pure grade and previously dried at 105°C during 1 hour. The solution was prepared by using high quality distilled water, added with nutrients and seeded with bacteria. The results through this test were reasonable.

All samples were incubated at 20°C during 21 days. Nitrification was suppressed by adding 1mg/L ATU-Allyl Thiourea ($C_4H_8N_2S$) due to the high concentration of nitrogen in lake waters.

Results and discussion

BOD pollution of lakes in Hanoi

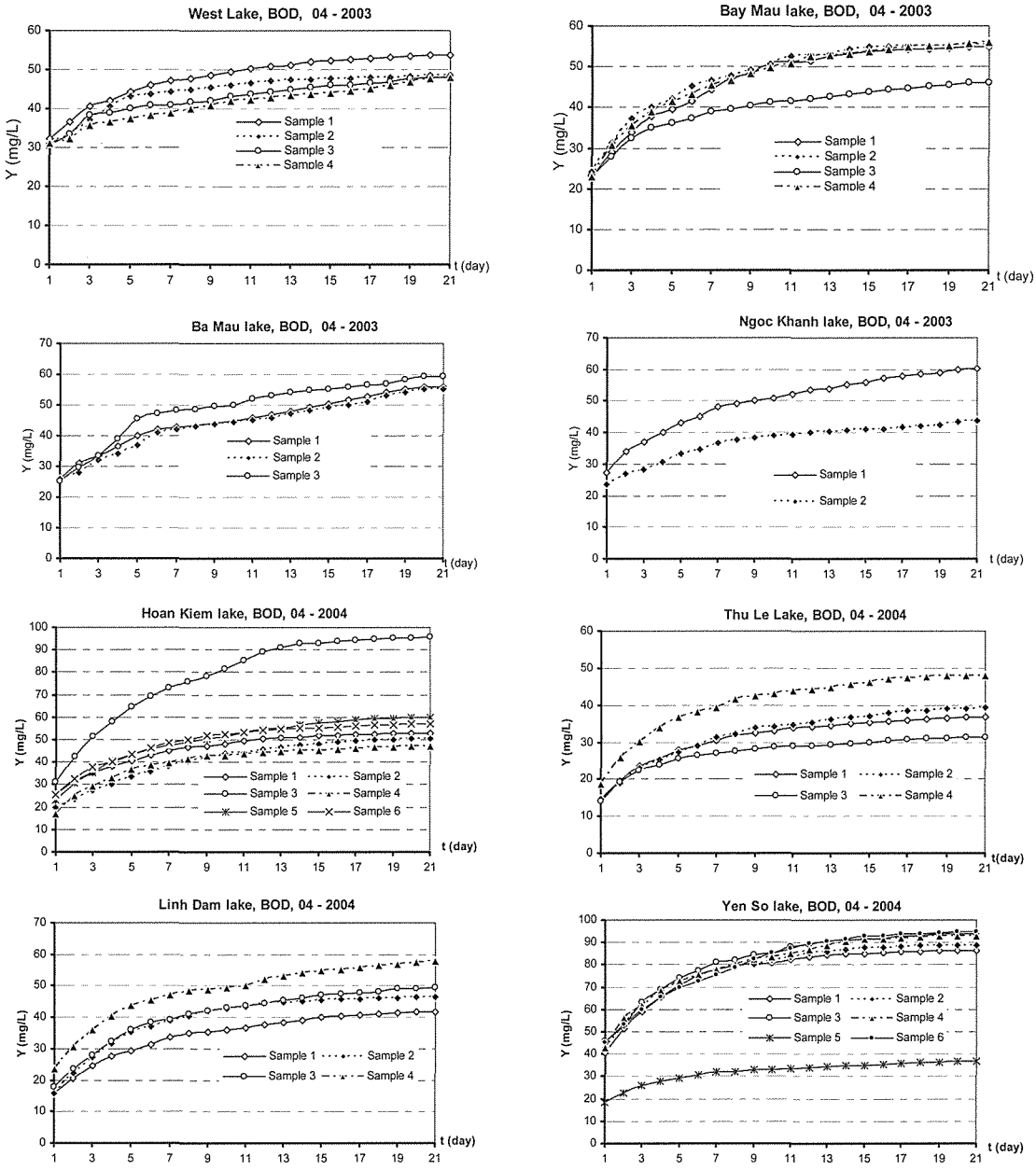

Figure 1. Long-term BOD values of Hanoi lake's water

The data from long-term BOD tests of water samples taking from 8 studied lakes are displayed in Figure 1 and the estimated values of Lo and k_1 by using least-squares method are on tables below.

Table 1. k_1 (base e, 20^0C) and L_o values estimated by least-squares method

Lakes		Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Hoan Kiem	k_1 (d^{-1})	0.38	0.22	0.23	0.35	0.30	0.36
	L_0 (mg/l)	53.2	51.5	**96.0**	47.4	60.5	57.3
Yen So	k_1 (d^{-1})	0.42	0.43	0.36	0.39	0.45	0.31
	L_0 (mg/l)	87.1	89.0	94.1	93.5	37.4	**95.4**
Thu Le	k_1 (d^{-1})	0.34	0.28	0.47	0.34	-	-
	L_0 (mg/l)	37.4	39.5	31.5	48.1	-	-
Linh Dam	k_1 (d^{-1})	0.28	0.30	0.27	0.34	-	-
	L_0 (mg/l)	42.4	47.1	50.0	58.2	-	-
Ho Tay	k_1 (d^{-1})	0.52	0.59	0.58	0.43	-	-
	L_0 (mg/l)	55.12	48.30	48.00	44.77	-	-
Bay Mau	k_1 (d^{-1})	0.30	0.36	0.43	0.33	-	-
	L_0 (mg/l)	55.00	55.10	45.70	55.80	-	-
Ba Mau	k_1 (d^{-1})	0.29	0.23	0.28	-	-	-
	L_0 (mg/l)	56.00	56.50	58.70	-	-	-
Ngoc Khanh	k_1 (d^{-1})	0.32	0.41	-	-	-	-
	L_0 (mg/l)	66.64	41.44	-	-	-	-

After 21 days, the process of organic matter oxidation is almost completed. More than 95% of organic matters are oxidized to carbon dioxide and water, thus the recorded BOD at that time is approximate to Lo (BOD_u). The average estimated BOD_u values, varying from 39.1 mg/L (Thu Le lake) to 82.8 mg/L (Yen So lake), show that organic pollution of these lakes in Hanoi are quite high.

Comparing to national standard for surface water with respect to permissible BOD_5 lower than 25 mg/L (TCVN 5942-1995), it is apparently that all studied lakes are polluted in BOD but at different extend. Yen So lake, which has the function as a regulating factor of drainage and sewer system of Hanoi, is the most heavily-polluted with the average BOD_5 concentration of 64.8 mg/L while this value of Thu Le lake is only 29.4 mg/L making it the least polluted water body

Le Hien Thao (1995) in the research on pollution level of lakes in Hanoi had reported that the value of BOD_5 in Hoan Kiem Lake' water was 26mg/L ÷168 mg/L, average 74.3mg/L [3]. Another survey of Luu Minh Loan on the quality of water in Hoan Kiem Lake during 1998-1999 also indicated that BOD_5 (4/1999) changed from 20mg/L to 24.4 mg/L. The most recently data in the "State of the Environment of Hanoi, 2003" report showed a BOD_5 value of 16 ÷ 35.2 mg/L.

The average value of BOD_5 in Hoan Kiem lake obtained in the dry season 2003-2004 is 37.1 mg/L (31÷39.2 mg/L). In the case of Hoan Kiem lake, we have seen a significant change in BOD_5 since 1995. The water quality of Hoan Kiem Lake at present is less polluted when comparing to the year 1995, but has a degrading trend in the period from 1998 until now, although a lot of improvements have been made.

Yen So lake, which is constructed to control flood and waterlogged, is another typical case. Average BOD_5 concentration of Yen So in 2004 is 64.8 mg/L and Linh Dam lake is 38.1mg/L. These values are much higher than that in the investigation carried out by the Department of Science, Technology and Environment (DOSTE) of Hanoi (1993) were 21.4 mg/l and 17.3 mg/L, respectively [4]. As a regulating reservoir of Hanoi drainage system, it can be explained that Yen So lake's water quality is rapidly decreased because it is receiving more and more polluted untreated wastewater from the city. This trend will threaten the function of ecological Yen So Park, which is built around the lake.

Rate constant of BOD removal (k_1)

Each type of water body, such as treatment and drainage sewer system or waste stabilization ponds, etc... is characterized by a typical k_1 value, for example, the k_1 value (base e) of domestic water is 0.23 d^{-1}, of Chao Phaya - Thailand river water is 0.14÷0.23 d^{-1}, of drainage canals in Bangkok (Thailand) is 0.16÷0.44 d^{-1} (at 30°C) [5].

Table 2. Average estimated Lo, k_1 of lake's water in Hanoi, dry season 2003-04

	Hoan Kiem	Thu Le	West Lake	Bay Mau	Ba Mau	Ngoc Khanh	Linh Dam	Yen So
BOD_5 (mg/L)	37.1	**29.4**	41.2	39.8	40.8	38.3	38.1	**64.8**
Lo (mg/L)	61	**39.1**	49.1	52.9	57.1	54.1	49.4	**82.8**
k_1 (d^{-1})	0.31	0.36	**0.53**	0.36	**0.27**	0.37	0.3	0.39

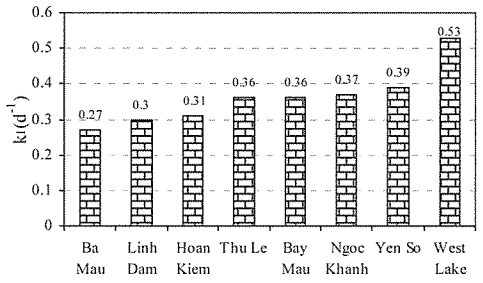

Figure 2. Rate constant of BOD removal

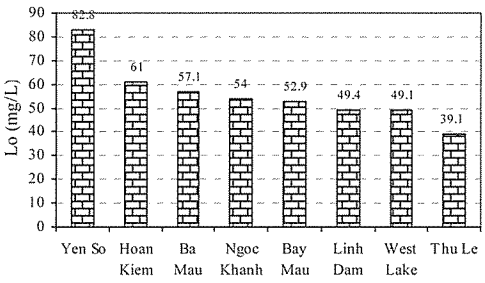

Figure 3. BOD_u (L_0) in Hanoi's lakes

The calculated k_1 (at 20°C) in Hanoi' lakes (Fig.2) varies from 0.27 d^{-1} to 0.53d^{-1}, in which the highest is of West lake (0.53d^{-1}) and Yen So lake (0.39d^{-1}), and Ba Mau lake has the lowest k_1 value (0.27d^{-1}). These values seem to be higher than that obtained by the author from Thailand.

The capacity of self-purification process in a lake is influenced by the magnitude of photosynthesis, natural re-aeration process, and potential of decomposing organic matter by bacteria etc., which strongly depends on numerous local factors such as climate (temperature, sunlight, wind), lake's hydrology (degree of turbulence, natural mixing in the water), morphology (shoreline, depth) and biology (the density of bacteria, algae, etc). With high BOD biodegradation velocity, Hanoi lakes are wetland ecosystems which could be applied for treatment of domestic organic wastewater, recycling and recovering nutrients.

CONCLUSION

The lakes in Hanoi have been polluting by highly biodegradable organic matters, this trend has seemed to be worse in recent years. The estimated the rate constant degradation values k_1 with an average of 0.39 d^{-1}, shows that the capacity in biodegradation of organic matters of these lakes is extremely good. In order to properly manage the aquatic ecosystems and maintain a pleasant environment, controlling of organic matter loading into lakes, properly design and improve the purification capacity by technological measures are needed.

References

1. Phelps, E.B., 1909. U.S. Geological Survey Water Supply Paper, No229, p 74-88.

2. Duncan Mara, 1975. Sewage Treatment in Hot Climates, University of Dundee, Scotland.

3. Le Hien Thao. Research the process of bio-treatment and water pollution in some lakes in Hanoi. Doctoral thesis, Ministry of Education and Training. 1999.

4. Department of Science, Technology and Environment (DOSTE) of Hanoi. Environmental state in Hanoi 2003.

5. Vu Quyet Thang, 1984. Evaluation of k_1 for BOD in Tropical Rivers, Asian Institute of Technology, Bangkok, Thailand.