TRƯỜNG ĐẠI HỌC SÀI GÒN
TẠP CHÍ KHOA HỌC
ĐẠI HỌC SÀI GÒN
ISSN 1859 - 3208
Số 85 (02/2023)

SAIGON UNIVERSITY
SCIENTIFIC JOURNAL
OF SAIGON UNIVERSITY
No. 85 (02/2023)

Email: tcdhsg@sgu.edu.vn ; Website: http://sj.sgu.edu.vn/

DETERMINATION OF THE pH EFFECT ON DEOXYGENATION RATE IN WATER OF CAI RIVER - DONG NAI PROVINCE

Nguyen Van Son[(1)*], Phung Chi Sy[(1)], Nguyen The Tien[(1)]

[(1)]Vietnam Institute Tropical Technology & Environmental Protection

Abstract

There are many factors effecting on deoxygenation rate of river water, in which pH is one of the important parameters. This study was carried out for a composite water sample of Cai River - Dong Nai province which is mixed from 90 water amounts taken vertically (from the top to the bottom of the river) and horizontally (from the right bank to the left bank), at 5 locations along Cai River in two tide conditions. The sample was separated in to five parts to analyzed BOD by EZ-Oxyro 4R Respirometer for 20 consecutive days in five pH values including pH=5, pH=6, pH=7, pH=8 and pH=9. During this experiment, the deoxygenation rate was determined using the Phelps Law and Slope method. The results showed that the deoxygenation rate increased during the pH ranging between 5 and 7 and decreased when the pH raises from 7 to 9. In addition, the correlation between deoxygenation rate and pH by Slope method is determined with correlation factor $R^2 = 0.8965$.

***Keywords**: Cai River, Deoxygenation rate, pH*

1. Introduction

One of the most important problems of our planet is how to use water resource sustainingly and protect it effectively. In order to ensure the exploitation of water resources in a sustainable way, the impact of socio-economic development activities on the quality of water resources should be concerned to study more extensively. In river water resource protection, the ability of river self-cleaning is considered as a significant factor [1]. The river self-cleaning process is contented several natural procedures which make the concentrations of pollutants return to the initial state in the river [2], [3], [4]. The mechanism of river self-cleaning is based on various processes including physical, chemical as well as biological ones. During natural biological process, micro-organism is considered as the main factor which decompose and consume dissolve organic matters to transfer them to inorganic compounds. The decomposition of organic matters in water is caused by heterotrophic micro-organism, especially aerobic bacteria [5]. The speed of the decomposition of organic matters in water is highly depended on the deoxygenation rate which is mainly influenced by temperature, pH, salinity, and dissolve oxygen (DO) [6]. Normally, the deoxygenation rate is based on math model which has high uncertainly accuracy. However, the study about deoxygenation rate of organic matter in river water or the factors affecting on them is not common in Vietnam [1].

*Corresponding author: sonvittep@gmail.com

Cai River, a branch of Dong Nai River, plays an important role for surrounding area in many fields such as agriculture, drainage, micro-climate control, water transportation, silt transfer, as well as pollutants treatment. The self-cleaning ability of water in Cai River, as known in every other rivers, depend on organic matter biodegradation. This study aims to estimate the influence of pH on deoxygenation rate of organic matter in Cai River.

2. Materials and methods

2.1. Materials

Table 1. The details of materials in this study

Material	Description
River water sample	The composite sample of 90 water amounts (9 water amounts/location * 5 locations * 2 different tide conditions). 5 locations: see Fig. 1. 9 water amounts/location: see Fig. 2. The composite sample is set up in 5 different pH level samples including pH=5, pH=6, pH=7, pH=8 and pH=9.
Pure oxygen	Purity: 99.999%; Qingdao/China. Pure oxygen is used for pumping to the reactor to keep the pressure constant.
Pure KOH	Purity: 85% Scharlau/Spain. Pure KOH is used for reacting with CO_2 to form K_2CO_3.
Pure NaOH	Purity: 99.9% Merck/Germany. Pure NaOH is used for pH adjustment of water samples.
Pure H_3PO_4	Purity: 85% Merck/Germany. Pure H_3PO_4 is used for pH adjustment of water samples.
Pure Allylthiourea	Purity: 98% Acros/United State. Pure Allylthiourea is used for inhibition of nitrification bateria of water samples.

2.2. Methods

a. River water collecting and preserving methods

River water sample is collected and preserved following the standard TCVN 6663-6:2018 “Water quality - Sampling - Part 6: Guidance on sampling of rivers and streams” which equivalent to ISO 5667-6:2014 [7].

The composite sample is well mixed of 90 water amounts which is collected at 5 locations along Cai River (Fig. 1) during two different tide conditions. Each location, water at 9 positions (Fig. 2) is taken using bathometer (Wildco, United State). The composite sample of 90 water

amounts: 9 water amounts/location * 5 locations * 2 different tide conditions. The sample is stored in 1-5^{o}C until being analyzed.



Fig. 1. *Sampling locations along Cai River*

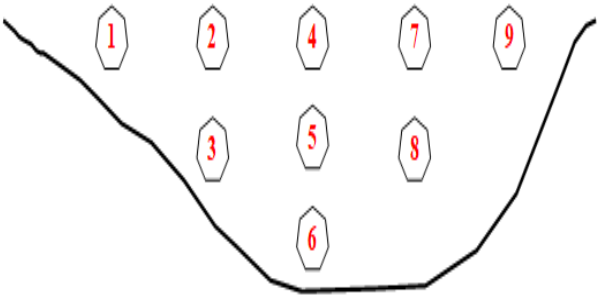


Fig. 2. *Sampling points distribution in one cross-section at each location*

b. pH values in the experiment

According to the monitoring results at Cai River during 2019 and 2020, the pH value ranged from 5.1 to 8.2. Therefore, the pH values in this experiment are set up in five different levels including pH=5, pH=6, pH=7, pH=8 and pH=9.

Pure NaOH and pure H_3PO_4 are used for pH adjustment of water samples. Pure Allylthiourea is used for inhibition of nitrification bateria of water samples.

c. BOD analysis method



Fig. 3. *BOD EZ-Oxyro 4R Respirometer*

The composite water sample in this study is analyzed BOD using EZ-Oxyro 4R Respirometer (Korea) (Fig. 3). This machine determine BOD based on the difference of pressure values and oxygen amounts at the beginning point and later periods of time. In details, inside the reactor, the respiratory process of micro-organism discharge CO_2 which react with KOH to form K_2CO_3. Then, an amount of oxygen is pumped to the reactor to keep the pressure constant. Finally, the BOD is calculated based on the oxygen consumption [8].

d. Deoxygenation rate calculation method

The Thomas' Slope method is used to calculate deoxygenation rate and estimated the influence of pH. This method is used in this study because it is the most popular method in calculating the deoxygenation rate in organic matter river water studies. It has been developed to base on the least squares of the first order reaction equation. The summary of equations in Thomas' Slope method is presented below [2]:

$$\frac{dy}{dt} = K_1(L_a - y) = K_1 L_a - K_1 y \quad (1)$$

$$na + b\sum y - \sum y' = 0 \quad (2)$$

$$a\sum y + b\sum y^2 - \sum yy' = 0 \quad (3)$$

$$\frac{dy_i}{dt} = y_i' = \frac{(y_i - y_{i-1})\left(\frac{t_{i+1} - t_i}{t_i - t_{i-1}}\right) + (y_{i+1} - y_i)\left(\frac{t_i - t_{i-1}}{t_{i+1} - t_i}\right)}{t_{i+1} - t_{i-1}} \quad (4)$$

$$K_1 = -b \text{ và } L_a = -a/b \quad (5)$$

$$k_1 = 0.4343K_1 \quad (6)$$

Where,

- d_y is the increase of BOD per a unit of time.
- K_1 is deoxygenation rate, based on e (day^{-1}).
- k_1 is deoxygenation rate, based on 10 (day^{-1}).
- L_a is ultimate BOD for first-stage (mg/l).
- y is BOD (mg/l).
- y'= dy/dt presents the change of BOD.
- t is time (day).
- n is the number of BOD calculation minus 1 (n must be greater than 6).

3. Results and discussions

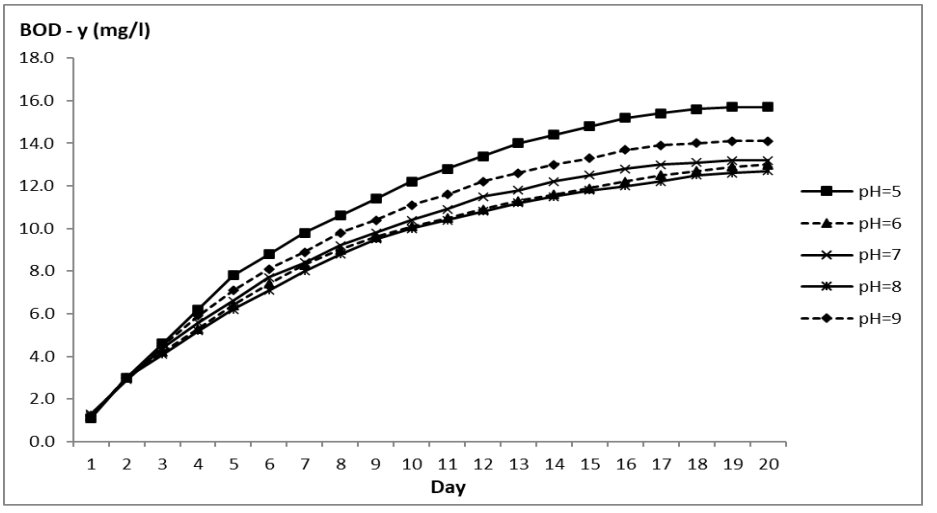


Fig. 4. *BOD results in different pH conditions of Cai River water sample*

The BOD values in this study are showed in Fig. 4. According to the results, in the pH=5, the BOD_5, BOD_{10}, BOD_{15}, BOD_{20} is 7.8 mg/l, 12.2 mg/l, 14.8 mg/l, and 15.7 mg/l, respectively. When the pH change to 6, the BOD_5, BOD_{10}, BOD_{15}, BOD_{20} is 6.4 mg/l, 10.1 mg/l, 11.9 mg/l, and 13.0 mg/l, respectively. At pH=7, the BOD_5, BOD_{10}, BOD_{15}, BOD_{20} is 6.6 mg/l, 10.4 mg/l, 12.5 mg/l and 13.2 mg/l, respectively. In case of pH=8, the BOD values at day 5, 10, 15, 20 range from 6.2 mg/l to 10.0 mg/l, 11.8 mg/l and 12.7 mg/l. Finally, at pH=9, the BOD results in the day number 5, 10, 15 and 20 is 7.1 mg/l, 11.1 mg/l, 13.3 mg/l, and 14.1 mg/l, respectively.

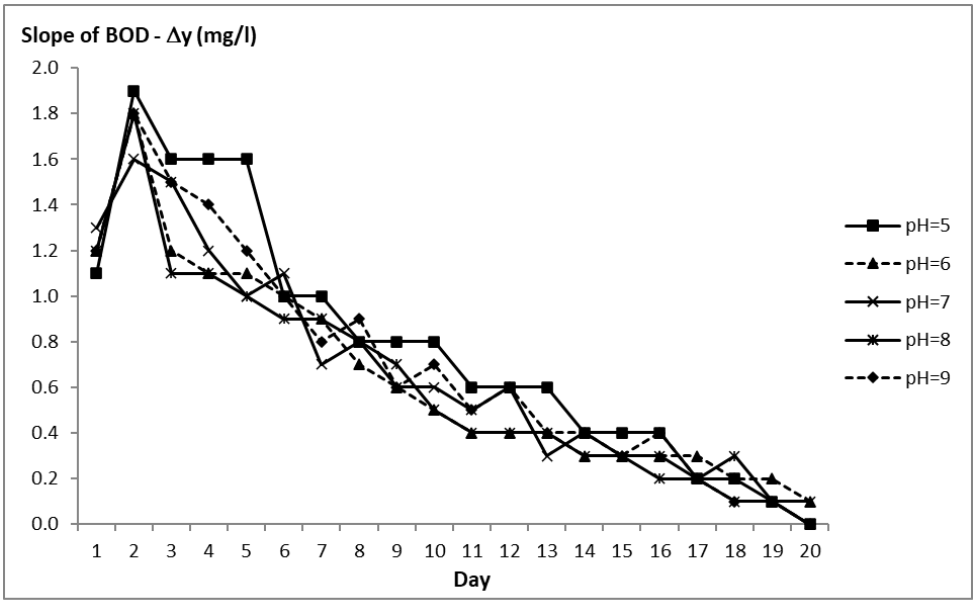


Fig. 5. *The BOD slopes in different pH values of Cai River water sample*

Fig. 5 shows the slopes of BOD in different pH values. The maximum slopes present in the 6 first days. The BOD slopes become stable from the 19th day of experiment.

Table 2. The deoxygenation rates of Cai River water sample at different pH values

The deoxygenation rate	**Value (day^{-1})**				
	pH=5	**pH=6**	**pH=7**	**pH=8**	**pH=9**
K_1 (based on e)	0.113	0.123	0.124	0.122	0.121
k_1 (based on 10)	0.049	0.053	0.054	0.053	0.053

The deoxygenation rates of Cai River water sample at different pH values are showed in Table 2. The deoxygenation rate increased during the pH ranging between 5 and 7 and decreased when the pH raises from 7 to 9. The result of this study is suitable with [6]. It meant that, in the neutral condition of water, the organic matter is decomposed faster than in the alkaline or acid conditions.

- K_1 (based on e) for Cai River at pH = 5, 6, 7, 8, 9 is 0.113 day^{-1}, 0.123 day^{-1}, 0.124

day^{-1}, 0.122 day^{-1}, 0.121 day^{-1}, respectively.

- k_1 (based on 10) for Cai River at pH = 5, 6, 7, 8, 9 is 0.049 day^{-1}, 0.053 day^{-1}, 0.054 day^{-1}, 0.053 day^{-1}, 0.053 day^{-1}…

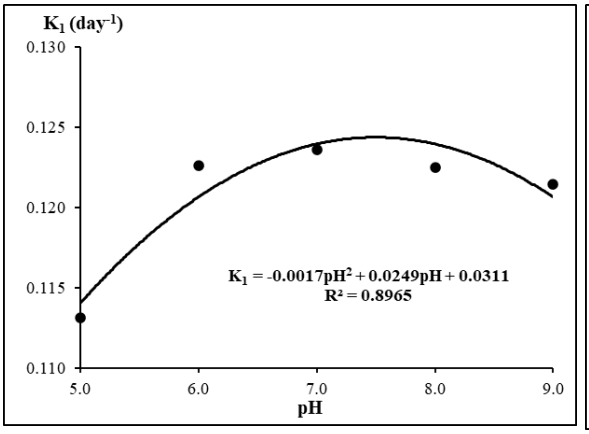


Fig. 6. *Correlation between K_1 and pH*

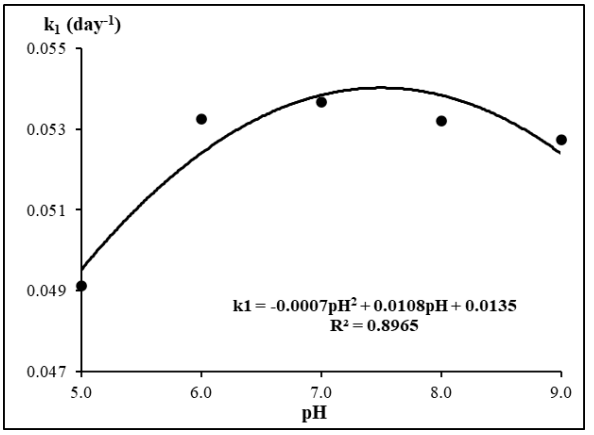


Fig. 7. *Correlation between k_1 and pH*

Based on the results, the correlation equations between (1) K_1 and pH; and (2) k_1 and pH are showed below:

(1) $K_1 = -0.0017pH^2 + 0.0249pH + 0.0311$ with correlation coefficient $R^2 = 0.8965$.

(2) $k_1 = -0.0007pH^2 + 0.0108pH + 0.0135$ with correlation coefficient $R^2 = 0.8965$.

4. Conclusions

The results showed that the deoxygenation rate increased during the pH ranging between 5 and 7 and decreased when the pH raises from 7 to 9. In details, when the pH values change from 5 to 6, 7, 8 and 9, the deoxygenation rate K_1 (based on e) are 0.113 day^{-1}, 0.123 day^{-1}, 0.124 day^{-1}, 0.122 day^{-1}, and 0.121 day^{-1}, respectively, while the deoxygenation rate k_1 (based on 10) presents 0.049 day^{-1}, 0.053 day^{-1}, 0.054 day^{-1}, 0.053 day^{-1}, and 0.053 day^{-1}, correspondingly. The correlation equations between pH and deoxygenation rates of Cai River water sample are also proposed in this study as (1) $K_1 = -0.0017pH^2 + 0.0249pH + 0.0311$ with correlation coefficient $R^2 = 0.8965$; and (2) $k_1 = -0.0007pH^2 + 0.0108pH + 0.0135$ with correlation coefficient $R^2 = 0.8965$.

REFERENCES

[1] Nguyen Van Son, *Research on the influences of social-economic development on water quality of Vam Bung Canal and propose the integrated management method for water resource protection*, Binh Duong province, 2023.

[2] C. C. Lee and Shun Dar Lin, *Handbook of Environmental Engineering Calculations*, Mc Graw Hill, Second Edition, 2007.

[3] Benoit R.J., *Self-purification in natural waters*. Water and Water Pollution Handbook, Vol, 1. Marcel Dekker, New York, 1971.

[4] Penrug Phangsombut, *Self-purification capacity of the Rangtubtap canal, Samutsongkram province*. Faculty of Graduate Studies, Mahido University, Thailand, 2005.

[5] Luong Duc Pham, *Wastewater treatment technology using biological method*. Education Press, 2007.

[6] P.G. Whitehead and T. Lack, *Dispersion and self-purification of polluants in surface water systems: a contribution to the international hydrological programme*, Paris: UNESCO, Technical Papers in Hydrology 23, 1982.

[7] TCVN 6663-6:2018, *Water quality - Sampling - Part 6: Guidance on sampling of rivers and streams*, 2018.

[8] Dream Bios, *Operation Manual for EZ-Oxyro 4R Respirometer*, Seoul Korea, 2015.

Ngày nhận bài: 01/10/2022 Biên tập xong: 14/11/2022 Duyệt đăng: 14/12/2022