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THE EFFECTS OF AERATION PRESSUREON THE TREATMENT OF ORGANIC SUBTRACTSIN TO LICH RIVER

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ABSTRACT

The river located in inner areas of Hanoi are seriously polluted day by day, especially To Lich River. To Lich River is mainly polluted by the type of domestic wastewater of Hanoi. This study was conducted to assess the water quality of To Lich River and the effects of pressure of forced aeration method obtained by enhancement of hydrostatic pressure (aerating at 0.25, 2.00 and 4.00 meters of depth) on the ability to dissolve oxygen into water and digestion of organic subtracts in To Lich River. When aerating at 4.00 m of depth, approximately 0.4 atm of enhanced pressure, the performance of organic waste treatment for the upper layer and lower layer are 66% and 58% respectively. This study approach towards sustainable development in order to minimize the use of materials and the generation of waste from treatment, simultaneously enhance the self-cleaning capacity of Inner River, thereby to exploit the natural resources in rational and economical ways.

Keywords: pollution, water quality, forced aeration, To Lich River.

INTRODUCTION

In the period that the industrialization and modernization are taking place faster day by day along with the urbanization in the whole of Vietnam's territory in general and expanding the development of Hanoi in particular, the demand for water for households, organizations, enterprises, production facilities has been increasing, leading to the discharge of daily-life wastewater, production wastewater and other service wastewater also increased. Therefore, the quality of the water sources is increasingly degraded, especially the surface water sources where directly receives the discharge of pollutants pour into. The polluted sources with the diverse origin of characteristic are increasing and difficult to control [3].

Located in the center of Hanoi, the four rivers considered to play a role in being the channel for drainage systems include: To Lich, Lu, Set and Kim Nguu Rivers. According to general assessment, all these rivers are heavily polluted due to the large loading of organic subtracts, inorganic subtracts, microbiological, etc. These rivers are solid black of color (due to the high concentration of organic subtracts), having stinky smell (smell of H_2S) and directly affect the urban landscape as well as health of people living around the areas. [1; 2; 4]

The treatment of wastewater characterized with organic pollutants by biological methods is considered to be environmentally friendliness and widely applied in many countries around the world. The bacteria play an important role in the water treatment via consumption of organic subtracts as a nutrient source, typically aerobic and anaerobic bacteria. Because aerobic bacteria use dissolved oxygen to degrade organic compounds into inorganic forms, therefore ensuring an abundant source of oxygen in the water to facilitate the growth of microorganisms is considered to be very important.

The concentration of dissolved oxygen in water is governed by several factors such as temperature, pressure and salinity in which the temperature factor is hardly difficult to control in open systems. Therefore, in order to improve the efficiency of the dissolution of oxygen into water, the options that modify the aeration pressure is possible to be selected. This can be obtained when conducting aeration at different depths.

Based on the background, this study was implemented to investigate the effects of pressure on both of the dissolved ability of oxygen into water and the performance of organic compounds treatment.

MATERIAL AND METHODS

Research materials

Three sets of pilot-scale aeration module were installed at the laboratory of Faculty of Environmental Sciences, VNU University of Science. All modules had a reactor made of transparent acrylic resin with a cylinder shape. The dimension of each reactor is 4.00 m of height, 90 mm of diameter and 3 mm of thickness. An air diffuser made of porous ceramic and an air blower (XU125D6, Germany) is also included in each of reactors; the air flow was controlled by an air flow meter (DK 800-6, Taiwan) with 50 - 500 L/h of measuring range. A ball valve for discharging wastewater is attached at the bottom of each reactor. All the porous ceramic with spherical shape was fixed inside the reactors at different position for each module. The distances from the surface of water column (when fully loaded the wastewater into reactor), at which the porous ceramic was attached, for three experimental modules are 0.25 m, 2.00 m and 4.00 m respectively (M1, M2 and M3).

The wastewater used in experiment was obtained from the To Lich River and the sampling location is Lu Bridge in Hanoi, Vietnam. Wastewater sample was kept to be fresh in the whole time of transportation from the sampling site to experimental site. The analysed results of physical and chemical parameters of surface water are shown in Table-1.

Table-1. Several parameters of the surface water quality.

No	Parameters	Unit	Results	QCVN 08-MT:2015/BTNMT (B1) (*)
1	pH	-	7.27	5.5÷9.0
2	DO	mg/l	0.1	≥ 4
3	COD	mg/l	127.41	30
4	$N\text{-}NH_4^+$	mg/l	41.08	0.9
5	$N\text{-}NO_3^-$	mg/l	2.45	10
6	$P\text{-}PO_4^{3-}$	mg/l	2.41	0.3

(*) Vietnam National Technical Regulation on surface water quality

Research methods

- Operating conditions

Wastewater was manually loaded into all the reactors until the water column similarly reached 4.00 m of height. The same air flow rate (50 L/h) was imposed on each reactor. As mentioned above, when changing the aerating position, the corresponding enhancement of pressure caused by hydrostatic pressure would be obtained. Based on the Henry's law, at a constant temperature, the amount of a given gas that dissolves in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid. In general, the formula for Henry's law can be expressed by Equation 1.

$$S_i = H \times P_i \qquad \text{(Equation. 1)}$$

In which:

H: Henry's law constant (often in units of M/atm)

P_i: Partial pressure of the gas (often in units of atm)

S_i: Solubility of a gas at a fixed temperature in a particular solvent (in units of M/L)

With respect to these assumptions, M3 is considered to achieve the highest aerating pressure when comparing with those of M1 and M2 respectively.

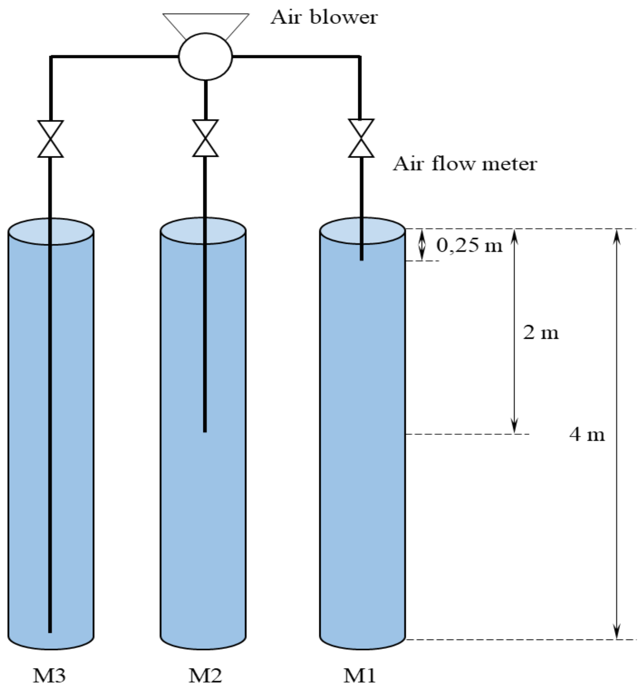

Figure-1. Schematic diagram of aeration module.

The wastewater had been being continuously aerated in 2 days to measure the fluctuation of DO concentration, organic compounds concentrations which were represented by COD parameter. The measurement was conducted for both of upper layer and lower layer of wastewater column. The time for sampling are respectively 0h, 2h, 4h, 6h, 8h, 12h, 16h, 20h, 30h and 48 hours from the beginning of aeration process. Since the DO concentration of wastewater was measured on-site by using DO meter (Adwa AD111, Hungary), the aeration would be paused in 15 minutes before conducting the analysis. In addition, after collecting sample for measurement, the reactors would be loaded with supplemental sample to reach the initial height of water column contained inside.

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- Analysis and data processing methods

The DO concentration was measured by using DO meter which were standardized and the simple COD was measured by following the schedule expressed by current Vietnam Standard (TCVN 6491:1999).

All the measured data were gathered and processed with the Microsoft Excel.

RESULT AND DISCUSSIONS

The effects of pressure on the ability to dissolve oxygen into water

The fluctuation of DO concentrations along with time of upper layer were shown on Figure-2a, 2b and 2c and these datasets are also summarized and shown on Figure 2d to make a comparison. At the starting time (8h00), the DO concentrations of samples in all reactors were approximately 0.1 mg/L. After being aerated for 2h, DO concentrations had significantly increased, it was 3.7 mg/L, 5.2 mg/L and6.0 mg/L for M1, M2 and M3 module respectively. For M2 and M3, the higher DO concentrations were obtained than one of M1. This can be attributed to the higher in disturbance of wastewater when conducting aeration at greater depth, through which the air bubble would have more chance to interact with the water body and it directly resulted in the enhancement of dissolution of oxygen into water.

For the next 4 hours of aeration, DO concentrations of wastewater in all reactors tend to slightly increase? The corresponding average values of M1, M2 and M3 are4.3 mg/L, 5.3 mg/L and 5.7 mg/L. The higher results were still obtained from M2 and M3 than the result of M1, the explanation for this has been mentioned above. The final DO concentrations which were obtained after finishing the 48 hours of aeration were 5.5 mg/L, 6.2 mg/L and 6.2 mg/L (corresponding to M1, M2 and M3).

In overall, the DO concentrations of wastewater have the trend that getting the higher values in the early morning as well as the late afternoon and those would be lower in the mid afternoon as well as the night. To explain for these fluctuations, in the early morning when the sunlight gradually appeared, this is the time for the photosynthesis of plants and algae species living in water, therefore the amount of enhanced oxygen had been generating. Due to the field experiment was conducted in the late autumn; the ambient temperature regularly reaches its peak value in the period from 12h00 to 16h00. Theoretically, an increase in temperature would has the effect on oxygen saturation and it would be used to explain for the decrease of DO concentrations of wastewater during the mid to late afternoon.

In the evening, the ambient temperature decreased and this slightly affected to oxygen saturation, specifically to increase the DO concentrations. Although the temperature still decreased in the midnight, the obtained results would be slightly different to those of evening. During this time, when the sunlight did not absolutely appear, the plants and algae living in water began to conduct the respiration which consumes oxygen, thus generating a decrease in DO concentration.

Based on the analytical data, the corresponding logarithmic trendlines, which express the fluctuation of DO along with time, were obtained and simultaneously shown on the Figures 2a, 2b and 2c. The highest coefficient of trendlines obtained from data analysis belonged to M3 experiment ($a = 0.6897$) and the lowest coefficient belonged to M1 experiment ($a = 0.5833$).Obviously, the higher coefficient of trendline is equivalent to the faster increment of DO concentration as well as the better performance of dissolving oxygen into water. Although the reliability of all trendlines did not reach the very high level (the correlation coefficients were not in the range of reasonable values), this obtained results partly clarified the effects of pressure on the water solubility of oxygen. The trendlines also predicted that if the wastewater were continuously aerated longer, the obtained DO concentrations would slowly increase.

Similarly, the fluctuation of DO concentrations along with time of lower layer were shown on Figure-3a, 3b and 3c which represented for M1, M2 and M3 module respectively, Figure-3d was created from the summarize of datasets to make a comparison. Although the DO concentrations of samples in all reactors were identical to those of upper layer (≈0.1 mg/L), these had significantly increased after applied aeration on wastewater for 2h. The corresponding values were 0.2 mg/L (M1), 1.4 mg/L (M2) and 4.5 mg/L (M3). For M1 and M2, it could be clearly realized that there is a clear difference between upper layer and lower layer of the obtained DO concentration at the same period. Because of conducting aeration at the 0.25 m (M1) and 2.00 m (M2) of depth, the lower water bodies were not directly aerated and an amount of oxygen, which had been dissolved into these water bodies, obtained from the diffusion of dissolved oxygen contained in the upper water bodies. Due to the whole water body in M3 reactor was directly aerated, the rate of increment of DO concentration is the highest when comparing with those of M2 and M1. After finishing the 48 hours of aeration, the final DO concentrations were 4.6 mg/L, 5.2 mg/L and 5.2 mg/L (corresponding to M1, M2 and M3) and these results still were lower than those of upper layer.

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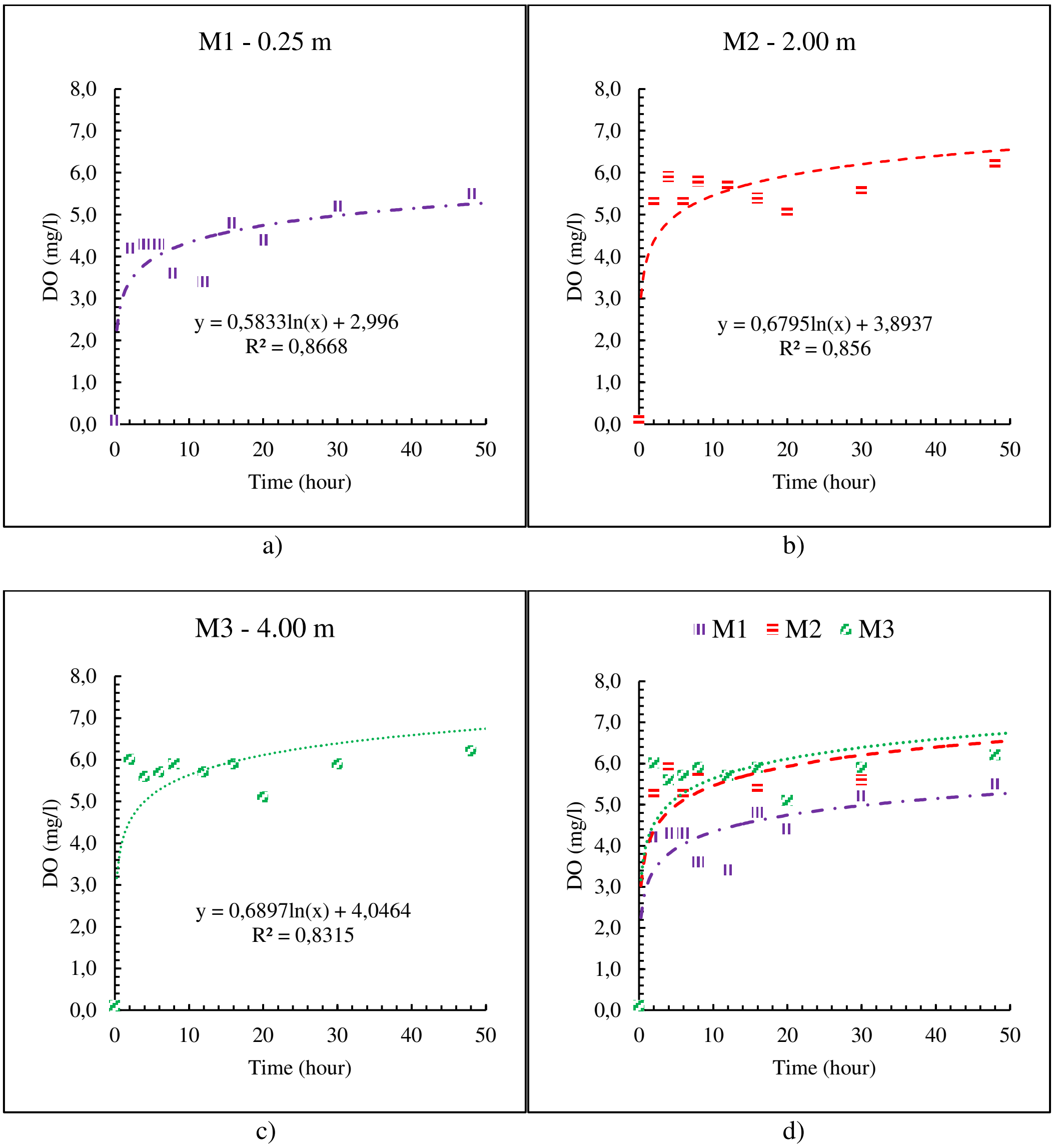
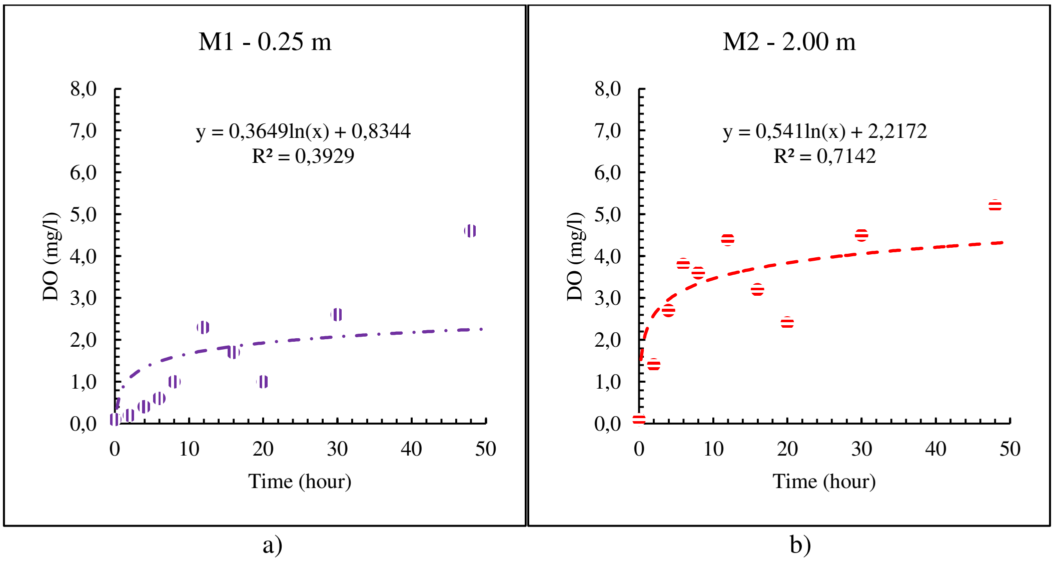


Figure-2. The fluctuation of DO concentration of upper layer.



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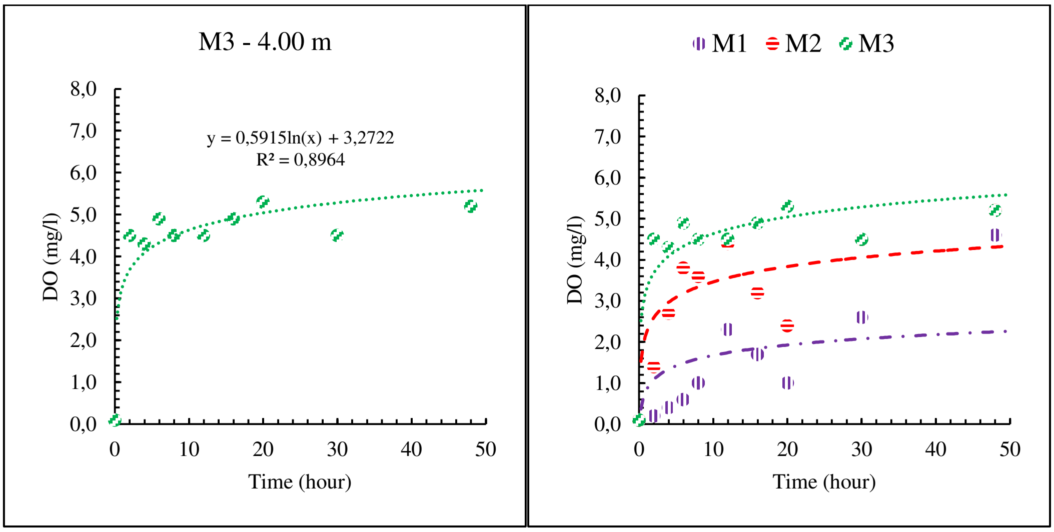

c) d)

Figure-3. The fluctuation of DO concentration of lower layer.

The DO concentrations of wastewater sample at lower layer still have the trend that getting the higher values in the early morning as well as the late afternoon and those would be lower in the mid afternoon as well as the night. The explanation for these fluctuations have been already mentioned above.

The corresponding logarithmic trendlines were also created by using the analytical data of each module. The highest coefficient of trendlines obtained from data analysis belonged to M3 experiment (a = 0.5915) and the lowest coefficient belonged to M1 experiment (a = 0.3649). The correlation coefficients of all trendlines were not in the range of reasonable value, especially the one of M1. For M1 experiment, the aeration was conducted at 0.25 m, therefore the diffusion of oxygen was applied on almost water body. In the same manner, the trendlines also predicted that if the wastewater were continuously aerated longer, the obtained DO concentrations would slowly increase.

The performance of organic compounds treatment

In similar manner, to research the effect of aeration depth on the performance of organic compounds, a comparison of fluctuation of COD between upper and lower layer as well as between the experimental modules were conducted. The changes of COD of upper layer-wastewater in M1, M2 and M3 reactor were respectively shown on Figures 4a, 4b and 4c. At the beginning, the COD value of wastewater in all the reactors is quite low (90 mg/L). After being aerated for 6h, the COD value of wastewater had significantly decreased, they were 46 mg/L for M1, 46 mg/L for M2 and 62 mg/L for M3.Obviously, the COD value of wastewater in M3 reactor was higher than the other (at the same period) and this can be attributed to the more heavily in treatment process which was caused by aeration at greater depth. In general, the COD of wastewater tended to decrease rapidly in the early stage (from 0h to 8h) and slowly in later stage. At the end of process, wastewater in all of reactors had obtained the same value of COD which was 32 mg/L. This resulted in the same COD removal efficiency (64.4%) for all experimental modules.

To compare the corresponding trendlines of all experimental modules together, the highest coefficient obtained from analyzed datasets was -7.357 (the minus denoted the decrease of COD over time) which belonged to M3 module, and the lowest coefficient was -6.426 which belonged to M1 module. Although the trendlines did not reach the very high level in confidence (the correlation coefficients did not reach the high values enough), these were supposed to contribute to clarification the effects of pressure on the water solubility of oxygen as well as COD removal efficiency. Besides that, the trendlines also provided a prediction that if the wastewater were continuously aerated longer, the obtained COD would slowly decrease.

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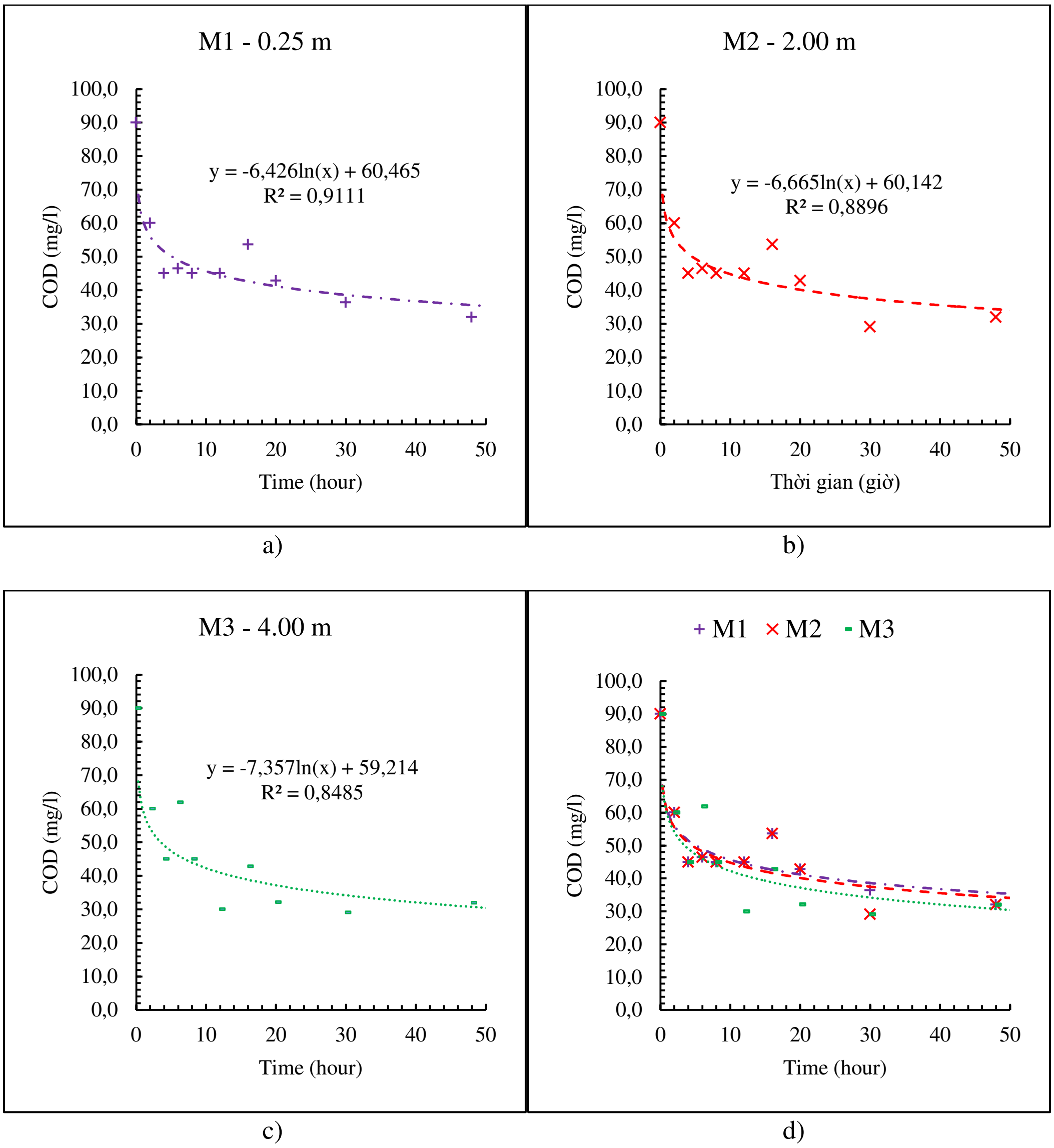

Figure-4. Changes of COD in wastewater of upper layer.

In the same manner, the COD fluctuation over time of lower layer were shown on Figure-5a, 5b and 5c corresponding to M1, M2 and M3 module. To make a generally comparison, Figure-5d also was created from the datasets of each module. At the beginning, the COD value of wastewater in all the reactors was identical to those of upper layer (90 mg/L). After being aerated for 6h, the COD value of wastewater had significantly decreased which were 54 mg/L for M1, 62 mg/L for M2 and 62 mg/L for M3. Obviously, obviously, the values from M1 and M2 were higher when compare to those of upper layer (at the same period) and this can be explained that the oxygen uptake of lower layer were not direct from aeration (as the upper layer) but from the oxygen diffusion. The COD values of wastewater in M2 and M3 reactor was higher than M1 (at the same period) and this can be attributed to the more heavily in treatment process which was caused by aeration at greater depth.

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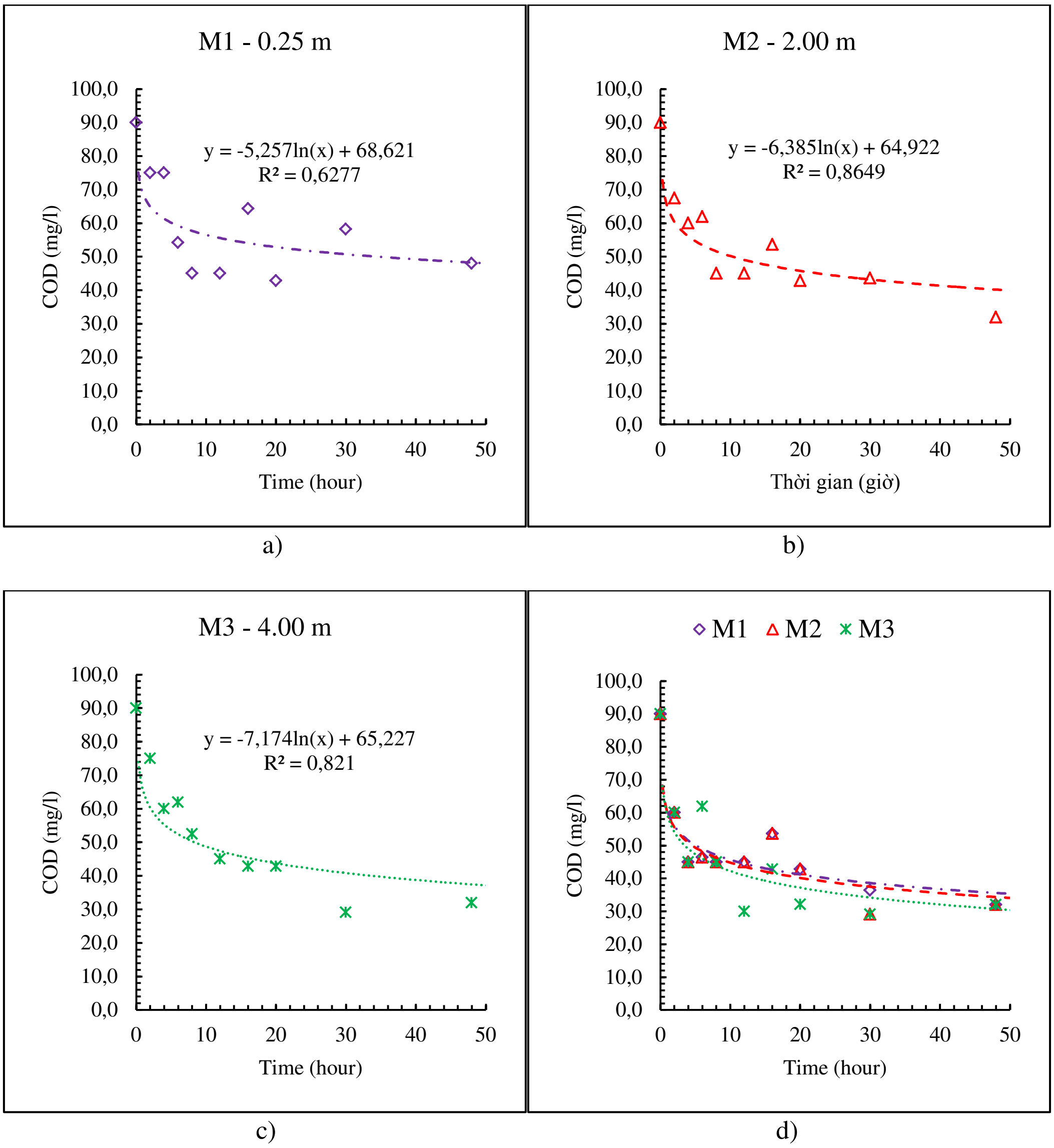

Figure-5. Changes of COD in wastewater of lower layer.

Generally, the COD of wastewater tended to decrease rapidly in the early stage (from 0h to 8h) and slowly in later stage. At the end of process, wastewater in M2 and M3 reactor had obtained the same value of COD which was 32 mg/L whilst it was 48 mg/L from M1. The corresponding COD removal efficiency was 46.7% for M1 and 64.4% for M2 and M3 module.

To compare the corresponding trendlines of all experimental modules together, the highest coefficient obtained from analyzed datasets was -7.174which belonged to M3 module and the lowest coefficient was -5.257 which belonged to M1 module. In addition, all of coefficients obtained from trendlines of lower layer were quite lower when compared to those of upper layer. Although all the trendlines did not reach the very high level in confidence, these were supposed to contribute to clarification the effects of pressure on the water solubility of oxygen as well as COD removal efficiency. Furthermore, the trendlines also provided a prediction that if the wastewater were continuously aerated longer, the obtained COD would slowly decrease.

CONCLUSIONS

A. The pressure had the effect on the solubility of oxygen into water as well as oxygen saturation. The wastewater sample from M2 and M3 module was aerated at 2.00 m and 4.00 m of depth respectively, that is equivalent to 0.2 and 0.4 atm of enhancing pressure, had the optimal result of DO concentration (0.1 - 6.2 mg/L for upper layer and 0.1 - 5.2 mg/L for lower layer)when compared to M1 and M2 module (0.1 - 5.5 mg/L for upper layer and 0.1 - 4.6 mg/L for lower layer)with the same flow rate conditions of air supply and aeration time.

B. The pressure also had the effect on the digestion of organic compounds in wastewater; the higher removal efficiency was obtained when conducting aeration at greater depth. The optimal result of COD removal efficiency was obtained from M3 module at which the wastewater sample had been aerating at 4.00 m of depth.

C. The obtained efficiency of oxygen solubility into water as well as COD removal were greater at upper layer when compare to those of lower layer. At the end of 48-hours aeration, the highest DO concentration was 6.2 mg/L for upper layer and 5.2 mg/L for lower layer, the highest COD removal efficiency was 64.4% and these results were simultaneously obtained from M3 experimental module.

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