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# DIVERSITY OF PHYTOPLANKTON IN THE CANALS' WATER INFLUENCED BY LANDFILLING ACTIVITY

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**Abstract**

*The study was conducted to assess water quality in the canals influenced by the landfill activity using the diversity of phytoplankton. Water samples were used to check the evaluation of phytoplankton for water quality assessment. Four phytoplankton and water samples collected in two periods (period 1 in 4/2018 and period 2 in 10/2018). The parameters for evaluating surface water quality included pH, conductivity (EC), total suspended solids (TSS), biochemical and chemical oxygen demands (BOD, COD) and nutrients ($NH_4^+$ - N, $NO_3^-$ - N, $PO_4^{3-}$ - P). The results showed that $NH_4^+$ - N and TSS concentrations in some locations exceeded the B1 column of QCVN 08-MT:2015/BTNMT. Total 241 species of algae in five phyla (Euglenophyta, Chlorophyta, Euglenophyta, Cyanophyta, Pyrrophyta) dominated by the families of Oscillatoria, Euglena, Phacus species indicating the organically polluted water environment. The Shannon - Wiener diversity indexes (H') in the period 1 and period 2 were 1.51 - 1.62 and 1.54 - 1.69, respectively showing that the water quality was at the medium level of pollution. The water quality index (WQI) of the two-sampling periods (53 - 72) indicated water environment was only suitable for irrigation and similar purposes. This study showed that the quality of water around the landfill has been polluted, possibly due to the leachate, so it is necessary to have solutions to treat leachate and regularly monitor water quality to promptly detect and solve pollution problem.*

**Keywords:** Landfill; Leachate; Phytoplankton; Pollution; Water quality.

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## 1. Introduction

Population growth along with the socio - economic development has increasingly generated great amount of solid wastes which is complicated in composition and properties. In 2015, the country collected over 33,167 tons and only about 81 % were properly handled [11]. The improperly treated wastes could pose a serious risk on health and ecosystems. The domestic solid wastes is mainly treated by landfilling, but this technology still faces many shortcomings when landfills are not designed to meet standards. Pollution control process has not been effective since the dispersion of odors and leachate from solid waste landfills still occur [8]. Untreated leachate containing high concentrations of heavy metals is the most obvious source of pollution on surface water and underground water, soil, sediment and biota [6].

As one of the important waste receiving and treatment units of Can Tho city, Dong Thang landfill is facing overload. The amount of waste received is approximate 370 tons/day in which 70 tons are burnt and 300 tons are landfilled. Leachate has flooded landfilling compartments and leachate collection ponds with a water level of 1.5m higher than the surface of the rice - field and surrounding areas. The estimated leachate water volume inside the landfill is around 50,000 $m^3$ posing high risk of leachate overflow into surrounding paddy field and canals. The previous study reported that the soil, sediment and water quality surrounding at Dong Thang landfill have been contaminated with organic matters, nutrients and heavy metals [13]. Phytoplankton play a very important role in water bodies, they are one of the creatures that produce and synthesize organic substances, create biological productivity and clean the water environment [18]. Phytoplankton is considered as an indicator for the quality of water environment. Therefore, the distribution of phytoplankton is closely related to the chemical nature of water quality [7], water depth [9] and interaction of aquatic organisms [10]. In recent years, the use of phytoplankton to observe water quality has been increasingly concerned. This study was conducted to evaluate phytoplankton composition in canals affected by the operation of the landfill in Dong Thang commune, Co Do district, Can Tho City.

## 2. Materials and methods

### *2.1. Water sampling and analysis*

The study area is at the landfill located in Dong Thang commune, Co Do district, Can Tho city (Fig. 1). The landfill has a total area of approximate 6 ha, arranged into three landfilling compartments, four leachate - containing pond, sparse land (0.9 ha) and two incinerators. The landfill is surrounded by the rice - field where being affected by the leachate seeping. The leachate from the landfill also influences the canals including Bo Thiet and Mot Tram which are connecting to the water containing leachate to river system (Fig. 1).

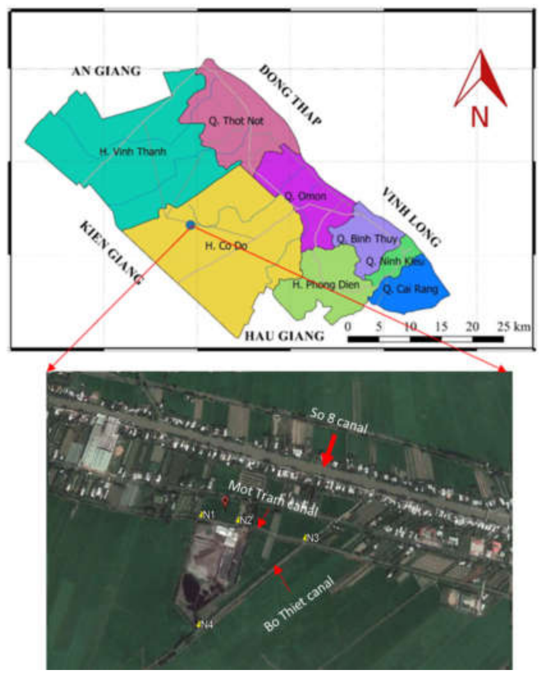


***Figure 1: Locations of phytoplankton and water sampling (Google Earth, 2019)***

Water quality index (WQI) was calculated based on Equation 1:

$$WQI = \frac{WQI_{pH}}{100}\left[\frac{1}{4}\sum_{a=1}^{4} WQI_a . WQI_b\right]^{1/2} \quad (1)$$

In which, WQIpH: WQI is calculated for pH; WQIa: WQI calculated for B

$BOD_5$, COD, $NH_4^+$ - N, $PO_4^{3-}$ - P; WQIb: WQI calculated for TSS. WQI ranges from 0 - 100 dividing water quality into five levels. Level 1 (100 > WQI> 91) is a good water quality that can be used for water supply purposes. Level 2 (90 > WQI> 76) uses water for domestic use but requires appropriate treatment. Level 3 is for irrigation and other similar purposes (75 > WQI> 51). Level 4 (50 > WQI> 26) is a water suitable for transportation and equivalent purposes. Level 5 (25 > WQI > 0) is heavily polluted and requires appropriate treatment.

***Table 1. Description of phytoplankton and water sampling locations***

| No. | Code | Coordinates | | Characteristics |
|---|---|---|---|---|
| | | Latitude | Longitude | |
| 1 | N1 | 10°5'12.15"N | 105°27'47.39"E | Canal section near the landfill. On both sides of the canal, mangoes are planted. Water flow is very slow. |
| 2 | N2 | 10°5'11.81"N | 105°27'52.71"E | Canal segment near the entrance to the landfill. The area has very slow flow of water. Lots of garbage were found at this water sampling site. |
| 3 | N3 | 10°5'9.79"N | 105°28'0.76"E | Intersection of Bo Thiet and Mot Tram where there was good flow of water. |
| 4 | N4 | 10°5'0.44"N | 105°27'48.09"E | The site was at the Mot Tram canal where it was connected to leachate collection pond. The flow of water is good. |

***2.2. Phytoplankton sampling and analysis***

Similar to water sampling, phytoplankton samples were collected over two seasons, dry season (Period 1) and rainy season (Period 2). Samples of phytoplankton were collected by filtering 200 L of water at four locations (N1, N2, N3, N4) in the canals surrounding the landfill through a 25 µm net mesh. Concentrated samples were placed in 110 mL vials and fixed with formol 4 % (4 ml formol mixed with 96 mL of distilled water). Qualitative analysis was performed using a microscope in 10 X - 40 X objective and images of phytoplankton were performed to identify morphological and structural features and classified according to Tien and Hanh (1997); Fernando (2002); Tuyen (2003); Reynold (2006) [4, 15, 16, 18]. Quantitative analysis samples were performed by counting each phytoplankton according to the method of Boyd and Tucker (1992) [2]. Density of phytoplankton is calculated by formula (2):

$$Y = \frac{X*V_c*1000}{N*A*V_t} \quad (2)$$

In which: Y is the phytoplankton density (Individuals/L); X is the number of individual phytoplankton in the cells counted; Vc is the volume of the concentrated sample (mL); N is the number of cells to be counted; A is the area of cells counted (1 $mm^2$) and $V_t$ is the volume of water collected (mL).

The diversity Shannon - Weiner diversity index was calculated by equation (3)

$$H' = -\sum_{i=1}^{n} P_i \ln P_i \quad (3)$$

In which: pi = ni/N; ni is the number of the ith individual; N is the total number of individuals in the samples. Water quality is divided based on H 'value. H '> 3 indicates good water quality or unpolluted water. 1 ≤ H' ≤ 3 indicates moderate water pollution, H '< 1 indicates highly polluted water (Wilhm and Dorris, 1968) [19].

## 3. Results and discussion

### *3.1. Surface water quality in the canals*

The results of electrical conductivity (EC) analysis in surface water showed a statistically significant difference at the water sampling positions ($p < 0.05$) with the highest value at N1 (215 ± 1.16 µS/cm) and the lowest at N4 (125 ± 1.53 µS/cm) in the first sampling period. At the second sampling period 2, EC values decreased gradually in at all the positions (except S4) with the range of 137 ± 0.06 - 183 ± 1 µS/cm, the highest at N2, the lowest at N3 (Tab. 2). The concentration of BOD and TSS tended to increase in the second sampling period with the range from 7.67 ± 0.58 - 10 ± 0 mg/L and 43 ± 0 - 78.5 ± 0.5 mg/L, respectively and both exceeded QCVN 08-MT: 2015/BTNMT (Column A1). Meanwhile, concentrations of TSS at N1 (12 mg/L) and BOD at all sampling locations (2.05 ± 0.05 - 3.58 ± 0.05 mg/L) in the first sampling period were in the allowable limits of QCVN 08-MT: 2015/BTNMT (Column A1). COD was also present with high concentration at all sampling locations (13.6 ± 0 - 19.2 ± 0.11 mg/L) in the first sampling time and all exceeded QCVN 08-MT: 2015/BTNMT (Column A1). COD decreased in the second sampling period (11.7 ± 0.58 - 15.7 ± 0.58 mg/L) except N3. The ratios of BOD/COD in the surface water were 0.15 - 0.19 and 0.55 - 0.68 in the first and second sampling period, respectively. These ratio were similar to that of the leachate in the first sampling period (Nhien and Giao, 2019) [13]. $NH_4^+$ - N concentrations at all the positions in the period 1 were higher than that in the period 2 (except for N4), especially at N1 and N2 (receiving overflowing water from the leachate pond), having the highest concentrations respectively in the sampling period 1 and 2 (Tab. 2). With the ranges from 0.437 ± 0.003 - 1.72 ± 0.01 mg/L (Period 1) and 0.19 ± 0.01 -0.94 ± 0.003 mg/L (Period 2), $NH_4^+$ - N concentrations at all the sampling positions were over than QCVN 08-MT: 2015/BTNMT (Columns A1 and A2) except N3 (Period 2). The result revealed that the water bodies surrounding the landfill continuously received a large amount of organic matter from leachate pond or agricultural areas. $NO_3^-$ - N has similar fluctuation with concentration in phase 1, higher than phase 2 from 1.74 - 5.1 times and lower than $NH_4^+$ - N due to lack of oxygen, less microorganisms or water containing toxic. At all locations, $NO_3^-$ - N concentrations were within permitted limits of QCVN 08-MT: 2015/BTNMT. At the locations far from the landfill, $PO_4^{3-}$ - P concentration was relatively low and was not detected at N4 in the period 2. At N1 at the period 1, $PO_4^{3-}$ - P was the highest and exceeded the permitted limit of QCVN 08-MT: 2015/BTNMT (Column A1).

The nutrient concentrations (except TSS and $NH_4^+$ - N) in the locations near the landfill (N1, N2) were higher than those in further areas which could be due to influences of runoff, water flow and dissolved oxygen. Runoff water could wash away wastes from the landfill or agricultural production resulting in high levels of BOD and TSS in the second sampling period. However, nutrients were diluted in the rainy season. Water quality deteriorated in the rainy season. The WQI analysis showed that the water quality was only suitable for irrigation purposes and other similar purposes with the value of the WQI in the locations in the rainy season (53 - 67) were lower than those in the dry season (63 - 72) (Tab. 3).

***Table 2. Surface water quality in the canals surrounding the landfill***

| | | EC (µS/cm) | $BOD_5$ (mg/L) | COD (mg/L) | TSS (mg/L) | $NH_4^+$-N (mg/L) | $NO_3^-$-N (mg/L) | $PO_4^{3-}$- P (mg/L) |
|---|---|---|---|---|---|---|---|---|
| Period 1 | N1 | $215^a$ ±1.16 | 3.04b ±0.05 | 18.1b ±0.11 | 12.0 | 1.72a ±0.01 | 0.139c ±0.001 | 0.105a ±0.004 |
| | N2 | 192b ±2.08 | 3.58a ±0.05 | 19.2a ±0.11 | 26.0 | 1.12b ±0.01 | 0.142c ±0.004 | 0.097b ±0.002 |
| | N3 | 148c ±0.58 | 2.51c ±0.05 | 14.1c ±0.11 | 34.0 | 0.871c ±0.02 | 0.244b ±0.01 | 0.06c ±0.003 |
| | N4 | 125d ±1.53 | 2.05d ±0.05 | 13.6d ±0 | 33.3 | 0.437d ±0.003 | 0.506a ±0.017 | 0.043d ±0.001 |
| Period 2 | N1 | 181b ±1.15 | 8.67b ±0.58 | 15.7a ±0.58 | 47c ±0 | 0.873b ±0.003 | 0.08c ±0.001 | 0.02b ±0.003 |
| | N2 | 183a ±1 | 9b ±0 | 14.7a ±0.58 | 53.5b ±0.5 | 0.94a ±0.003 | 0.08c ±0 | 0.02b ±0.003 |
| | N3 | 137d ±0.06 | 10a ±0 | 14.7a ±0.58 | 78.5a ±0.5 | 0.19d ±0.01 | 0.117a ±0.01 | 0.091a ±0.005 |
| | N4 | 160c ±0.06 | 7.67c ±0.58 | 11.7b ±0.58 | 43d ±0 | 0.687c ±0.003 | 0.1b ±0.01 | ND |
| QCVN 08-MT:2015/BTNMT (A1) | | **-** | **4** | **10** | **20** | **0,3** | **2** | **0,1** |

*Data were presented as mean ± SD, n = 3.*
*The different letters a, b, c in the same column indicate statistically different ($p < 0.05$). ND: Not detected.*

***Table 3. Water quality index in the canals surrounding the landfill***

| | Period 1 | | | | Period 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | N1 | N2 | N3 | N4 | N1 | N2 | N3 | N4 |
| WQI | 72 | 66 | 63 | 67 | 61 | 57 | 53 | 67 |
| Water quality | Water quality for irrigation purposes and other similar purposes | | | | | | | |

### *3.2. Phytoplankton*

#### *3.2.1. Diversity and composition of phytoplankton*

Over the two sampling periods, five phyla of phytoplankton with 243 species including 87 species of Euglenophyta, 62 species of Bacillariophyta, 55 species of Chlorophyta, 35 species of Cyanophyta and 4 species of Pyrrophyta were discovered. The composition of algae in the second sampling period (76 - 95 species) was more variable and more diverse than those in the first sampling time (70 - 79 species). At N1, N2 and N4, the number of algae species were richer than N3 that could be due to the impacts of leachate spillage especially in the rainy season with the development of Euglenophyta (Fig. 2). At all locations, there was an increase in the number of algae species in the second sampling period (except for N2: 76 < 79 species), especially at N1 (95 > 76 species) and N4 (89 > 79 species) due to the increase the species of Euglenophyta and Chlorophyta. At N3, due to the low influence of leachate spill, there was a decrease in the number of species of Euglenophyta và Chlorophyta but there was an increase of Cyanophyta and Bacillariophyta instead - suitable for less polluted water environment (Dan et al., 2017) [3]. Bacillariophyta decreased sharply at N4. At N2, there was an increase of Cyanophyta (5 species) and decline of Euglenophyta (8 species).

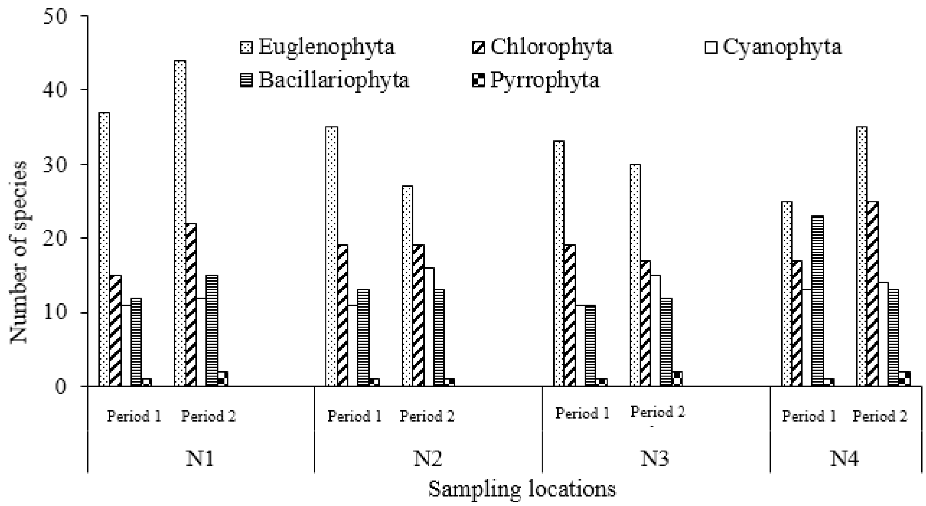


***Figure 2: Phytoplankton composition in the surveyed areas***

Survey results showed that Pyrrophyta species rarely appeared while Euglenophyta was the highest number. The diversity of phytoplankton composition at the survey sites is determined through the presence of algae that are able to tolerate pollution conditions such as Euglenophyta and Chlorophyta (Toan, 2012) [17]. Especially, the presence of species such as Oscillatoria, Euglena, Phacus showed that the quality of water was polluted with organic matters (Giao and Nhien, 2020) [5]. This result was in accordance with water quality analysis. The results of chemical and physical analysis in the water showed that BOD and TSS concentrations in the period 2 were higher than that those in the first sampling period and they both exceeded the permitted standard (Tab. 2).

*3.2.2. Density of phytoplankton*

The density of algae over the two surveys was presented in Table 4. In the first sampling period, the algae density ranged from 1,031 to 2,638 individuals/L, the highest at N1 and the lowest at N4. In the second sampling period, the highest algae density was in N2 (6,688 individuals/L) and the lowest in N3 (1,013 individuals/L). At N3, the density of algae in the period 1 was higher than the period 2 and this trend was consistent with the research of Quyen (2015) [14] that the density of the algae in the dry season was higher than in the rainy season. This difference could be related to the intensity of sunlight between the two seasons. However, under the influence of continuous leachate release, at points N1, N2 and N4, the trend was opposite. At the same time, at these locations, algae appeared with high density and fluctuated strongly over two periods from 2,638 to 4,913 individuals/L (N1); 2,063 to 6,688 individuals/L (N2) and at N4 (1,031 to 1,588 individuals/L). At N3, the density of algae was low with significant reduction of Euglenophyta, Chlorophyta and Cyanophyta. Impacts from leachate, the appearance of algae-eating fish and superior vegetation on the surface of canals such as water hyacinth, water spinach could also affect the distribution of phytoplankton.

*Table 4. Density of phytoplankton (individuals/L)*

| Phylum | Period 1 | | | | Period 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | N1 | N2 | N3 | N4 | N1 | N2 | N3 | N4 |
| Euglenophyta | 963 | 688 | 550 | 313 | 1838 | 1875 | 369 | 494 |
| Chlorophyta | 225 | 300 | 163 | 144 | 1213 | 2750 | 413 | 531 |
| Cyanophyta | 1075 | 675 | 381 | 313 | 713 | 1313 | 256 | 250 |
| Bacillariophyta | 363 | 388 | 113 | 250 | 1125 | 738 | 169 | 300 |
| Pyrrophyta | 13 | 13 | 44 | 13 | 25 | 13 | 13 | 13 |
| **Total** | **2638** | **2063** | **1250** | **1031** | **4913** | 6688 | 1219 | 1588 |

In general, through the two surveys, there was an increase in the density of Bacillariophyta and Euglenophyta, Chlorophyta at N1, N2 and N4. Pyrrophyta species was the lowest density and was not much variation since this Phyla often occur in brackish and saline water. The dominance in the density of Euglenophyta and Cyanophyta species at the survey sites indicated organic pollution of water quality possibly due to leachate. The Shannon - Wiener diversity (H') index between the sampling locations over two periods from 1.51 - 1.62 (Period 1) and 1.54 - 1.69 (Period 2) showed that water quality at the canals was polluted, especially at N4 (Fig. 3). However, the assessment of water quality based on the WQI showed that N2 and N3 sites have the highest pollution level in both rainy and dry seasons. This can be explained by the development of many phytoplankton species that are highly resistant to the environment.

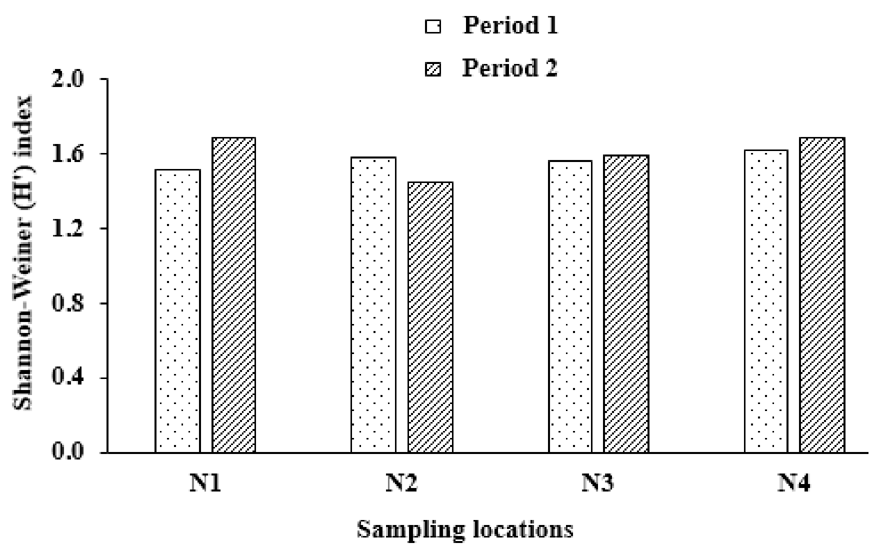


*Figure 3: Shannon - Weiner (H') indexes at the study area*

**4. Conclusion**

The water parameters of COD, TSS and $NH_4^+$ - N in the canals around the landfill exceeded the permissible limits of QCVN 08-MT: 2015/BTNMT column A1, especially TSS and $NH_4^+$ - N exceeded Column B1 in some positions. Concentration of BOD increased over the two sampling times and exceeded the permitted standard in the second period. WQI water quality index (63 - 72 and 53 - 67 in the Period 1 and 2, respectively) showed that the water was only suitable for irrigation purposes.

Results of phytoplankton analysis found five algal phyla including Euglenophyta, Chlorophyta, Euglenophyta, Cyanophyta and Pyrrophyta. The dominant species include Oscillatoria, Euglena, Phacus (Euglenophyta and Cyanophyta) indicating water environment was organically polluted. The results of calculating Shannon-Wiener diversity (H') index in the Period 1 and 2 were 1.51 - 1.62, 1.54 - 1.69 respectively, showing that water quality was at average pollution level. The cause of water pollution in this area was mainly due to leachate, so it is necessary to have the treatment measures to minimize environmental risks.

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