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# Chemical and Microbial Characteristics of Surface and Ground Water in the Areas Burying Swine Infected with African Swine Fever, An Giang Province, Vietnam

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**Abstract**

*This study assessed the surface water and groundwater quality in swine burial pits infected with African swine fever in An Giang province. Data of surface water quality were collected from the Department of Natural Resources and Environment of An Giang province with 10 monitoring positions (denoted S1 to S10) in 3 times (March, June and September) in 2020. The groundwater quality data was collected at 6 locations including S1, S3, S4, S6, S8 and S10. Parameters for surface and ground water quality including chemical oxygen demand (COD), biological oxygen demand (BOD), nitrite ($NO_2^-$-N), nitrate ($NO_3^-$-N), orthosphosphate ($PO_4^{3-}$-P), ammonium ($NH_4^+$-N), coliform and E. coli were examined. Surface water quality was evaluated using QCVN 08-MT:2015/BTNMT while groundwater quality was assessed using QCVN 09-MT:2015/BTNMT. The findings showed that all of the surface water variables exceeded the limits of QCVN 08-MT:2015/BTNMT, column B1, except $NO_3^-$-N. This indicated that surface water quality in these monitoring sites were polluted by organic matters, nutrients and microbes. It was als found that coliform and E. coli densities in ground water samples were very high. The findings of the present study revealed that water quality in swine burial pits infected with African swine fever in An Giang province was seriously polluted especially with coliform and E. Coli which could pose adverse risk to surrounding environments and health. Alternative method should be used for the treatment of swine death due to African swine fever to curb the water pollution problems.*

## 1.0 Introduction

Vietnam is a country with potentials for agricultural development, in which the livestock sector plays an important role in the agricultural economic structure of the country. Along with the socio-economic development and the increasing demand for food of the people, the livestock industry has continuously developed, especially pig raising. The Mekong River Delta is one of the largest agricultural economic regions in the country, contributing a large amount of pork production for domestic consumption and export. However, this is also a source of environmental pollution problems, especially organic and microbiological pollution on rivers [1]. Moreover, epidemic diseases not only affect the environment but also affect livestock health and people's livelihoods. Currently, pig farmers are facing African Swine Fever (ASF), a dangerous infectious disease causing severe fever and hemorrhage [2]. Infected pigs have a very high mortality rate of up to 100% [3]. In the same situation as other localities, An Giang province also faces a strong outbreak of African swine fever. With a total pig herd in the whole province of 113,091 [4], the province is facing many challenges in disease control, supporting people to stabilize their livelihoods as well as

minimizing the situation of environmental pollution during the handling of dead pigs due to the epidemic. In particular, water resource management is an issue that needs to be paid attention because water is essential for human life and for other activities [5-6]. Poor water quality is the main cause of many diseases and even death. At the same time, causing serious impacts to aquatic species. Therefore, the assessment of the quality of surface water and well water in An Giang province's African swine fever burial sites is extremely necessary. The study results would provide information on the current state of water quality in the swine burying sites with the African Swine Fever, and support the management of water resources for the locality.

## 2. Materials and methods

Surface and well water quality data around the African swine fever burial area in An Giang in 2020 were collected from the Department of Natural Resources and Environment of An Giang province. The observed parameters including chemical oxygen demand (COD), biochemical oxygen demand (BOD), nitrite ($NO_2^-$-N), nitrate ($NO_3^-$-N), orthophosphate ($PO_4^{3-}$-P), ammonium ($NH_4^+$-N), coliform and E. coli were used to evaluate the quality of surface water and underground water. Surface water quality was assessed at 10 sampling sites with diseased pig burial pits, the locations were denoted from S1 to S10 with the characteristics described in Table 1. Meanwhile, ground water quality was only assessed through 06 wells at locations S1, S3, S4, S6, S8 and S10. The remaining locations were not monitored due to no wells in the burial areas. The water samples were collected, preserved, transported and analyzed by standard methods [7] at the An Giang Provincial Center for Natural Resources and Environment Monitoring and Engineering.

**Table 1. Description of the water sample collection points**

| Code | Coordinates | Sites | Description |
|---|---|---|---|
| S1 | 539.940<br>1.211.402 | Khanh Hoa hamlet, Khanh An commune, An Phu district | Surface water of Hau river influenced by the pig burial pit (200m from the burial pit) |
| S2 | 547.054<br>1.205.235 | Vinh Xuong Commune, Tan Chau Town | Surface water of Tien river influenced by the pig burial pit (750m from the burial pit) |
| S3 | 564.003<br>1.169.057 | My Hoa 2 Hamlet, Tan Hoa Commune, Phu Tan District | Surface water of the inner field canal influenced by the pig burial pit (60m from the burial pit) |
| S4 | 577.658<br>1.153.510 | An Thi hamlet, An Thanh Trung commune, Cho Moi district | Surface water of the inner field canal influenced by the pig burial pit (30m from the burial pit) |
| S5 | 535.509<br>1.153.712 | Tan Trung hamlet, Ta Danh commune, Tri Ton district | Surface water of the inner field canal influenced by the pig burial pit (20m from the burial pit) |
| S6 | 523.338<br>1.175579 | Phu Hoa hamlet, An Phu commune, Tinh Bien district | Surface water of the inner field canal influenced by the pig burial pit (1km from the burial pit) |
| S7 | 550.839<br>1.145.424 | Trung Phu V Hamlet, Vinh Phu Commune, Thoai Son District | Surface water of Nui Choc Nang Gu canal influenced by the pig burial pit (20m from the burial pit) |
| S8 | 574.347<br>1.151.788 | My Long Hamlet 1, My Hoa Hung Commune, Long Xuyen City | Surface water of Tra Mon canal influenced by the pig burial pit (155m from the burial pit) |
| S9 | 560.604<br>1.154.752 | Phu An 1 Hamlet, Binh Hoa Commune, Chau Thanh District | Surface water of Vam Nha canal influenced by the pig burial pit (130m from the burial pit) |
| S10 | 552.301<br>1.171.158 | Vinh Hung hamlet, Vinh Thanh Trung commune, Chau Phu district | Surface water of Hau river influenced by the pig burial pit (300m from the burial pit) |

The analysis results of the above parameters were compared with the threshold values of QCVN 08-MT: 2015/BTNMT - National Technical Regulation on surface water quality (column B1) [8] and the National Technical Regulation on ground water quality QCVN 09 -MT: 2015/BTNMT [9]. Limit values of water quality parameters are shown in Table 2.

**Table 2. Limit values of surface and ground water quality parameters**

| No. | Parameters | Unit | [a]QCVN 08-MT:2015/BTNMT ($B_1$) | [b]QCVN 09-MT:2015/BTNMT |
|---|---|---|---|---|
| 1 | COD | mg/l | 30 | - |
| 2 | BOD | mg/l | 15 | - |
| 3 | Nitrite | mg/l | 0,05 | 1 |
| 4 | Nitrate | mg/l | 10 | 15 |
| 5 | Orthosphosphate | mg/l | 0,3 | - |
| 6 | Amoni | mg/l | 0,9 | 1 |
| 7 | Coliform | MPN or CFU/100 ml | 7500 | 3 |
| 8 | E. coli | MPN or CFU/100 ml | 100 | 0 |

[a]National Technical Regulation on Surface Water Quality QCVN 08-2015/BTNMT; [b]National Technical Regulation on Ground Water Quality QCVN 09-2015/BTNMT.

## 3. Results and discussion

### 3.1. Surface water quality in the areas of burial of swine infected with African Swine Fever

#### 3.1.1 Oxygenation compounds

The analytical results showed that the COD values in surface water in the study area ranged from 12-38 mg/l (Figure 1a). COD at the most of the monitoring sites met the standard (30 mg/L), except for location S3 (Hamlet My Hoa 2, Tan Hoa Commune, Phu Tan District) and S9 (Hamlet Phu An 1, Binh Hoa Commune, Chau Thanh District. ). COD values in September monitoring tended to be higher than that in March and June. Of which, in September, COD ranged from 18-32 mg/l, the lowest COD value was at S2 (Vinh Xuong commune, Tan Chau town) and the highest at location S9. COD value ranged from 12-38 mg/l and 12-35 mg/l at the March and June monitoring session, both of which had the lowest COD values at the S8 site (My Long 1 hamlet, My Hoa Hung commune, Long Xuyen city) and the highest position at S3 (My Hoa 2 hamlet, Tan Hoa commune, Phu Tan district). Compared with previous studies, COD in this study had lower value than COD observed in canals in Soc Trang province, ranging from 6.0-44.9 mg/l [10]. However, COD in the present study was higher than that in Hau river ranging 10.4 ± 1.2-16.5 ± 4.1 mg/l [6].

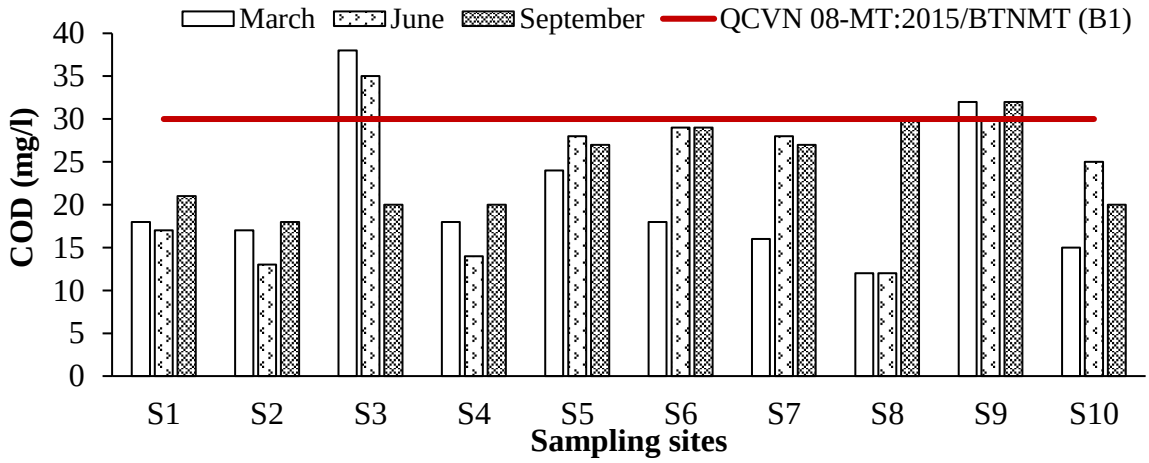


**Figure 1a. COD in surface water in the areas burying swine**

BOD values in the study area ranged from 8 to 25 mg/l (Figure 1b). In which, BOD in the monitoring phase in March, June and September were 8-25, 8-23 and 12-21 mg/l, respectively. Similar to COD, the lowest BOD values in the March and June monitoring phases were at location S8 and location S3 had the highest BOD value. Meanwhile, the locations with the lowest and highest BOD values at the September monitoring session were S2 and S9, respectively. Location S5 (Tan Trung hamlet, Ta Danh commune, Tri Ton district) and S9 (Phu An 1 hamlet, Binh Hoa commune, Chau Thanh district) had BOD value exceeding the permitted limit of QCVN 08-MT: 2015/BTNMT (column B1) [8] in all 3 monitoring phases. Besides, the value of BOD in the monitoring phase in June and September at position S6 (Phu Hoa hamlet, An Phu commune, Tinh Bien district) and S7 (Trung Phu V hamlet, Vinh Phu commune, Thoai Son district) also exceeded the standard. In particular, at location S3 (My Hoa 2 hamlet, Tan Hoa commune, Phu Tan district) during 02 monitoring times in March and June, the BOD value exceeded 1.67 times the limit specified in QCVN 08- MT: 2015/BTNMT (column B1) [8]. The analysis results showed that surface water quality near African swine fever burial holes showed signs of organic pollution and higher levels of pollution than other study areas. Specifically, the value of BOD in inland canals of An Giang province in the period 2009-2016 BOD ranged from 4.7 ± 2.3 to 12.3 ± 9.2 mg/l [11]. In Soc Trang and Vinh Long provinces, BOD values only fluctuated between 2.2-22.4 mg/l and 4.04-9.80 mg/l, respectively [10; 12].

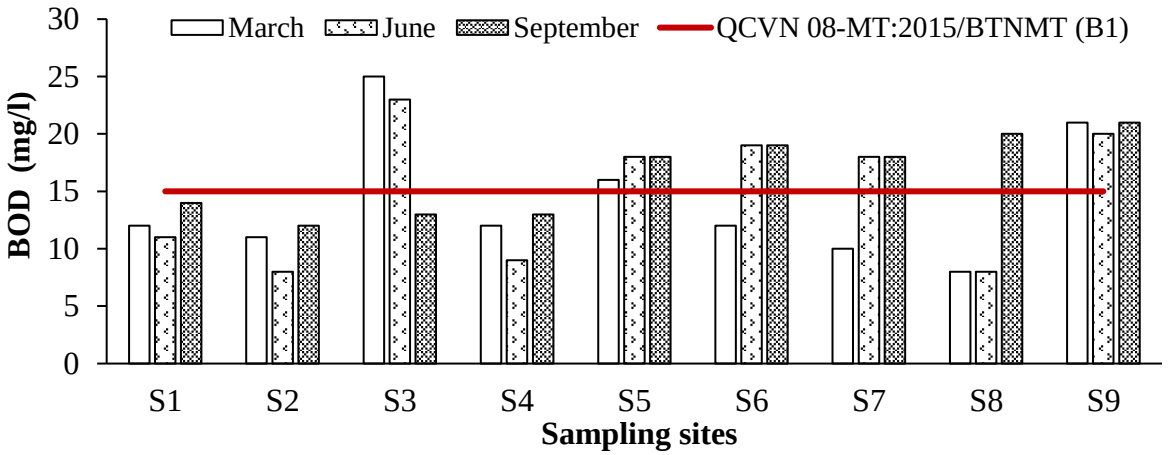


**Figure 1b. BOD in surface water in the areas burying swine**

### 3.1.2 Nutrients

The concentration of $NO_2^-$-N in the study area ranged from 0.016 to 0.515 mg/l (Figure 2a), this result was similar to the study of Tuan et al. (2019) [10] reported that $NO_2^-$-N in canals in Soc Trang province was in the range of 0.001-0.56 mg/l. However, $NO_2^-$-N concentration in the current study was much higher than $NO_2^-$-N concentrations in Bung Binh Thien - An Giang and Hau Giang province of 0.01 ± 0.01 and 0.04 ± 0.017 mg/l, respectively [13-14]. The results of the monitoring period in March and June had a range of $NO_2^-$-N values of 0.028-0.515 mg/l and 0.016-0.51 mg/l, respectively. In which, the location with the lowest $NO_2^-$-N value of the March monitoring round was in Phu An 1 hamlet, Binh Hoa commune, Chau Thanh district (S9) and in June was the location in Vinh Xuong commune, Tan Chau town (S2). Both of these two monitoring sessions had the highest $NO_2^-$-N value in My Hoa 2 hamlet, Tan Hoa commune, Phu Tan district (S3). Meanwhile, $NO_2^-$-N concentration of the September observation period fluctuated at a relatively low level only from 0.019-0.074 mg/l and there were 04 locations that did not detect $NO_2^-$-N (including S2, S3, S6 and S10). The location with the highest and lowest $NO_2^-$-N value was S7 (Trung Phu V hamlet, Vinh Phu commune, Thoai Son district) and S1 (Khanh Hoa hamlet, Khanh An commune, An Phu district). Compared with QCVN 08-MT: 2015/BTNMT (column B1) [8], the concentrations of $NO_2^-$

-N at most locations near the pig burial pits were higher than the permitted limit of the regulation. In particular, the monitoring in March and June had the value of $NO_2^-$-N 10 times higher than the standard at location S3 (Hamlet My Hoa 2, Tan Hoa commune, Phu Tan district) and 5 times exceeding the standard S5 (hamlet Tan Trung, Ta Danh commune, Tri Ton district). This indicated that the aquatic environment is deprived of oxygen and can be toxic to aquatic organisms [14].

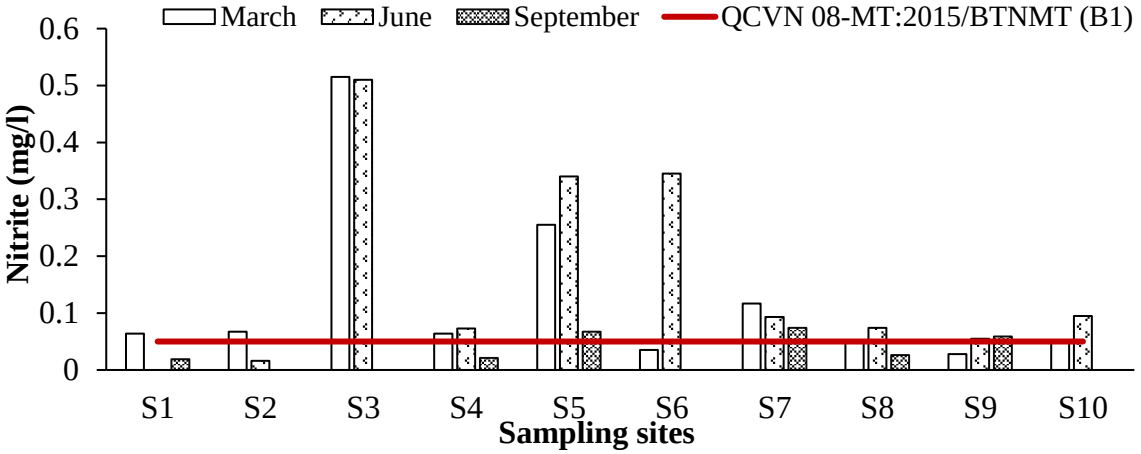


**Figure 2a. Nitrite in surface water in the areas burying swine**

The results of the monitoring surface water quality in the study area had relatively low $NO_3^-$-N, ranging from 0.012 to 1.66 mg/l (Figure 2b). The values of $NO_3^-$-N at all locations were within the allowable limit of QCVN 08-MT: 2015/BTNMT (column B1) [8]. However, the $NO_3^-$-N value in this study tended to be higher than that in the previous studies. For exampple, $NO_3^-$-N value ranged from 0.002 to 0.395 mg/l in Hau river [15]. In the period 2009-2016, $NO_3^-$-N values in the canals in An Giang were 0.31 ± 0.3-0.58 ± 0.64 mg/l [11]. In Soc Trang and Hau Giang provinces, $NO_3^-$-N values were recorded at 0.05-0.14 mg/l and 0.35 ± 0.20 mg/l, respectively [10;14]. The ranges of $NO_3^-$-N values at the monitoring phases in March, June and September were 0.012-0.343, 0.073-0.36 and 0.077-1.66 mg/l, respectively. The location S9 (Phu An 1 hamlet, Binh Hoa commune, Chau Thanh district) was the site with the lowest $NO_3^-$-N value in all 3 monitoring phases. The position with the highest $NO_3^-$-N value in the March and June monitoring period was at S3, while the September one had the highest $NO_3^-$-N value at S6.

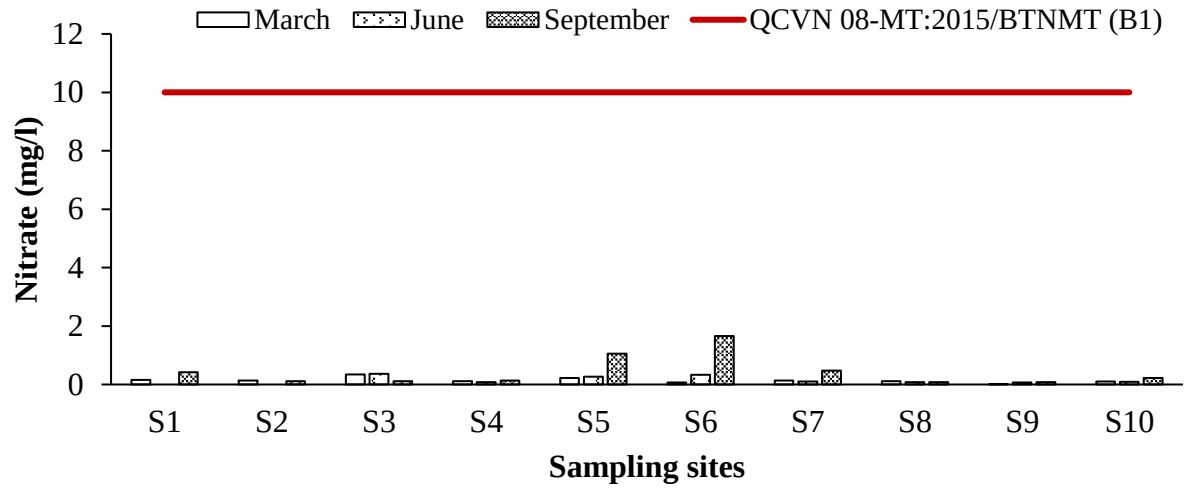


**Figure 2b. Nitrate in surface water in the areas burying swine**

In the study area, $PO_4^{3-}$-P values ranged from 0.043 to 0.586 mg/l. In which, the observed results in March and June had $PO_4^{3-}$-P values of 0.051-0.235 and 0.043-0.267 mg/l, respectively. All positions in these two monitoring phases were within the allowable limits of QCVN 08-MT: 2015/BTNMT (column B1) [8]. $PO_4^{3-}$-P values of March observation period were the highest at S1 and the lowest at S7. The highest and lowest $PO_4^{3-}$-P values were found at at S5 and S3, respectively in the monitoring time in June. Meanwhile, $PO_4^{3-}$-P value monitored in September (0.049-0.586 mg/l) was higher than that in the other months and there were 6 out of 10 positions having $PO_4^{3-}$-P exceeded the limit of QCVN 08-MT: 2015/BTNMT (column B1) [8]. The canals of Soc Trang province had $PO_4^{3-}$-P concentration in the range of 0-0.9 mg/l which was higher than $PO_4^{3-}$-P in the observed locations in the current study (Tuan et al., 2019). On the other hand, the study on surface water quality in Hau Giang province recorded $PO_4^{3-}$-P at the same level as in this study with the values ranging from 0.1 ± 0.05-0.23 ± 0.26 mg/l in Hau river [6]. However, $PO_4^{3-}$-P values in the above studies were all higher than that found in the water bodies in An Giang province in the period 2009-2016 with the average $PO_4^{3-}$-P concentration of 0.16 ± 0.12 mg/l [11].

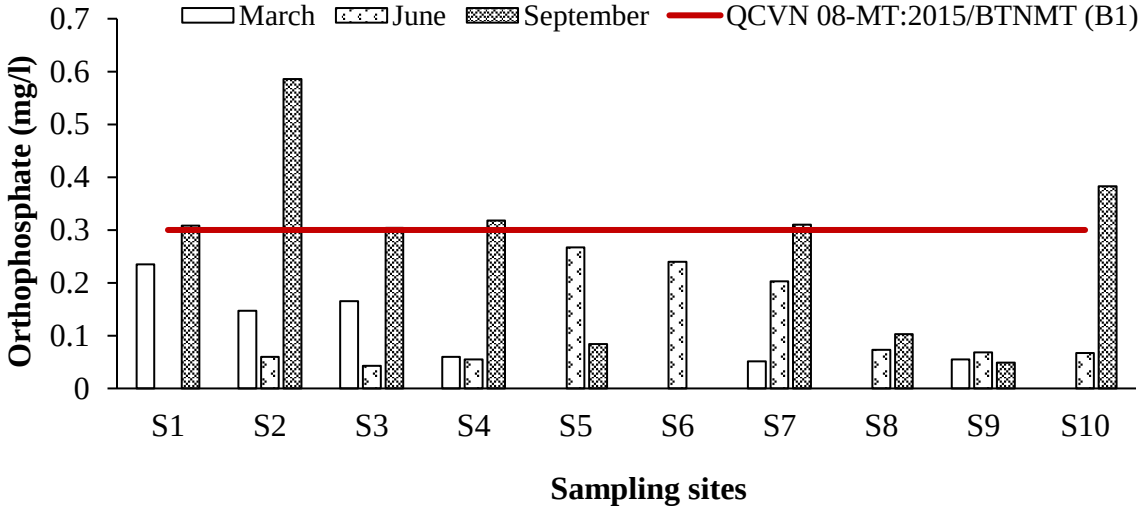


**Figure 2c. Orthophosphate in surface water in the areas burying swine**

Concentrations of $NH_4^+$-N in the study areas were in the range of 0.09-3.64 mg/l (Figure 2d). At the monitoring time in March, the lowest values of $NH_4^+$-N (0.09 mg/l) and the highest (3.64 mg/l) were recorded at position S8 and S3, respectively. Of which, there was only one position S3 having $NH_4^+$-N exceeded (4 times) the limit of QCVN 08-MT: 2015/BTNMT (column B1) [8]. The value of $NH_4^+$-N in June was relatively low, ranging from 0.1 to 1.41 mg/l. The position with the highest $NH_4^+$-N was at S6 while the position with the lowest $NH_4^+$-N value was at S10. In this monitoring phase, there were 3 positions (from S5 to S7) with $NH_4^+$-N concentrations exceeded the permitted standard. In particular, the monitoring time in September there were 7 positions having $NH_4^+$-N exceeded the value specified in QCVN 08-MT: 2015/BTNMT (column B1) [8] with the highest value of $NH_4^+$-N (3 mg/l) recorded at the location S10. The concentrations of $NH_4^+$-N in the surface water of Soc Trang province fluctuated in the range of 0.02-4.15 mg/l [10] which was higher than $NH_4^+$-N value in the current study. Meanwhile, the value of $NH_4^+$-N in the Hau river was recorded at a very low level, only ranging from 0 ± 0-0.1 ± 0 mg/l [6].

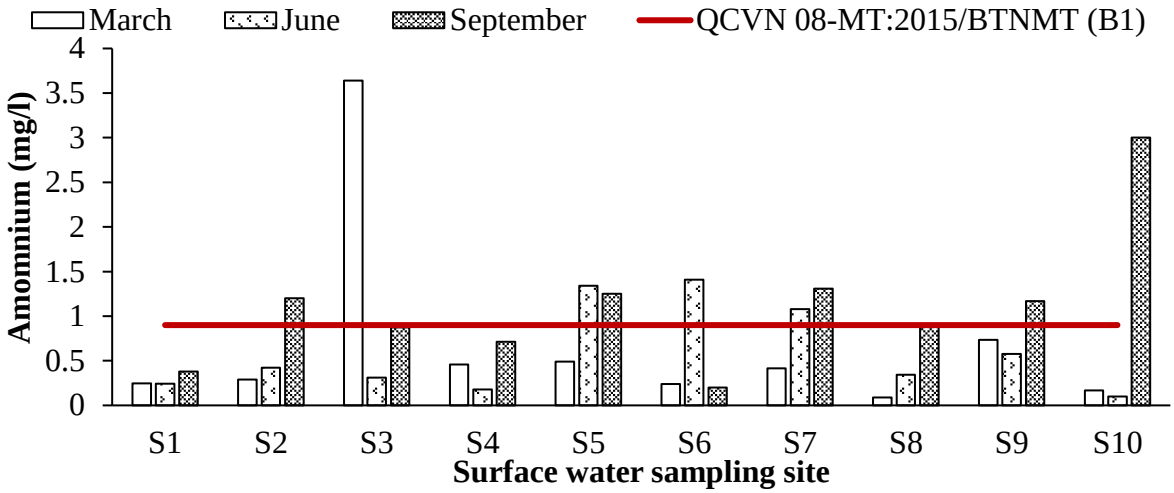


**Figure 2d. Ammonium in surface water in the areas burying swine**

### 3.1.3 Coliform and E. coli

Coliform density at the monitoring locations of the study ranged from 43-46,000 MPN/100ml (Figure 3a). Figure 3a showed that during the monitoring period in March, coliform density exceeded the standard at 5 positions including S3, S5, S6, S9 and S10. Meanwhile, in June and September monitoring times, there were 7 positions (from S3 to S8 and S10) and 5 positions (S2, S3, S7, S8 and S9) having coliform density exceeded the permitted limit in QCVN 08-MT: 2015/BTNMT (column B1) [8], respectively. In particular, the density of coliforms at the position S3 of the September monitoring period was 6.13 times higher than the standard. The locations with the lowest coliform density in the monitoring period of March, June and September were at the locations S8, S1 and S6, respectively. The highest coliform density in the monitoring period in March and September was recorded at the position S3. The monitoring period in June had the highest coliform density at the position S4. Coliform denisity in this study was lower than that in the previous studies in water bodies in Soc Trang province (2,300-89,000 MPN/100ml) [10] and rivers and canals in An Giang province (2,260-155,000 MPN/100ml) [11]. However, the density of coliform at several locations in the current study exceeded the permitted limit in QCVN 08-MT: 2015/BTNMT (column B1) [8].

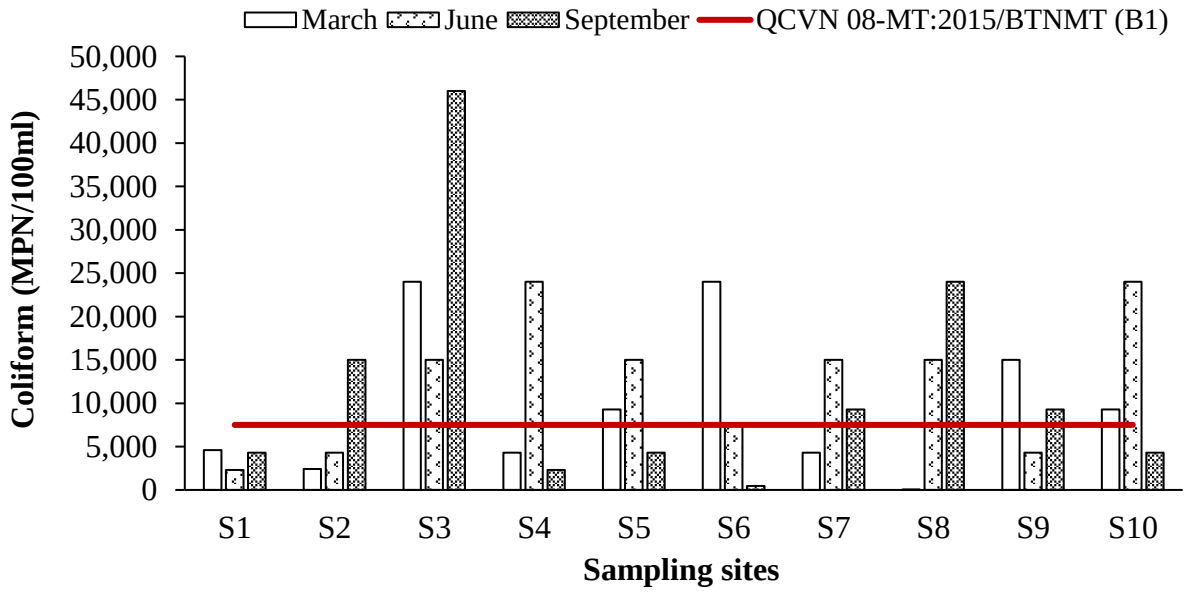


**Figure 3a. Coliform in surface water in the areas burying swine**

National technical regulations on surface water quality allows that the density of E. coli is relatively low with the permitted limit of QCVN 08-MT: 2015/BTNMT (column B1) [8] at 100 MPN/100ml. This study found that E. coli density in surface water samples in the study area was very high and there was only E. coli not foud at the monitoring location S8 in March (Figure 3b). Most of the monitoring locations had density of E. Coli surpassed the permitted standard, except for the location in Phu Hoa hamlet, An Phu commune, Tinh Bien district (S6) in September. The density of E. Coli in the March observing period ranged from 430 up to 2,300 MPN/100ml, the location with the lowest E. coli density was S2 and the highest was S6 and S9. In the June monitoring time, the S1 site had the lowest density of E. Coli with 900 MPN/100ml. The locations S3, S4, S5, S7 and S10 had the same E. coli densities of 4,300 MPN/100ml, which exceeded the permitted limit of QCVN 08-MT: 2015/BTNMT (column B1) [8] 43 times. More serious, the location S3 during September monitoring period, the denisity of E. Coli was up to 9,300 MPN/100 ml, exceeding the standard 93 times. The monitoring results in water bodies in Vinh Long province in 2019 only recorded E. Coli density at 17-92 MPN/100ml Compared to the water bodies without affected by African Swine Fever, this study ponited out that surface water quality near African swine fever burial pits in An Giang province was seriously suffering from microbiological pollution, posing highly risk on public health [6;14;16].

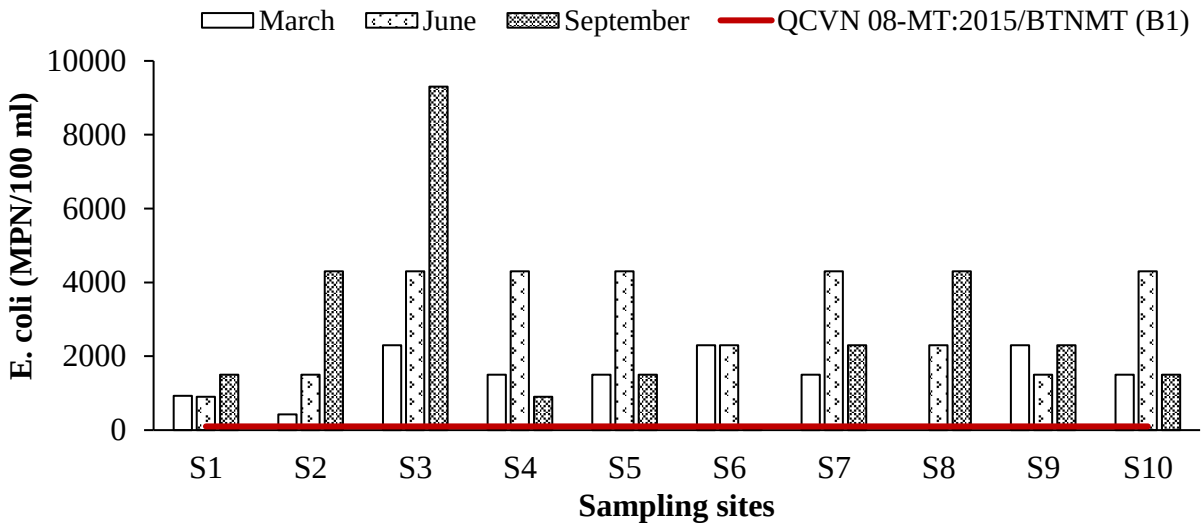


**Figure 3b. E. coli in surface water in the areas burying swine**

### 3.2. Ground water quality in the areas of burial of swine infected with African Swine Fever

3.2.1 Oxygenation compounds

The observation results of well water samples at the African swine fever burial area in An Giang province showed that the COD value ranged from 6 to 90 mg/l (Figure 4a). In which, COD values in the observations in March, June and September were 24-76, 18-90 and 6-30 mg/l, respectively. Highest COD values were recorded at position S4 in March and June. September observation had the highest COD value at position S1. Meanwhile, the positions with the lowest COD value in the monitoring sessions were S8, S10 and S4, respectively.

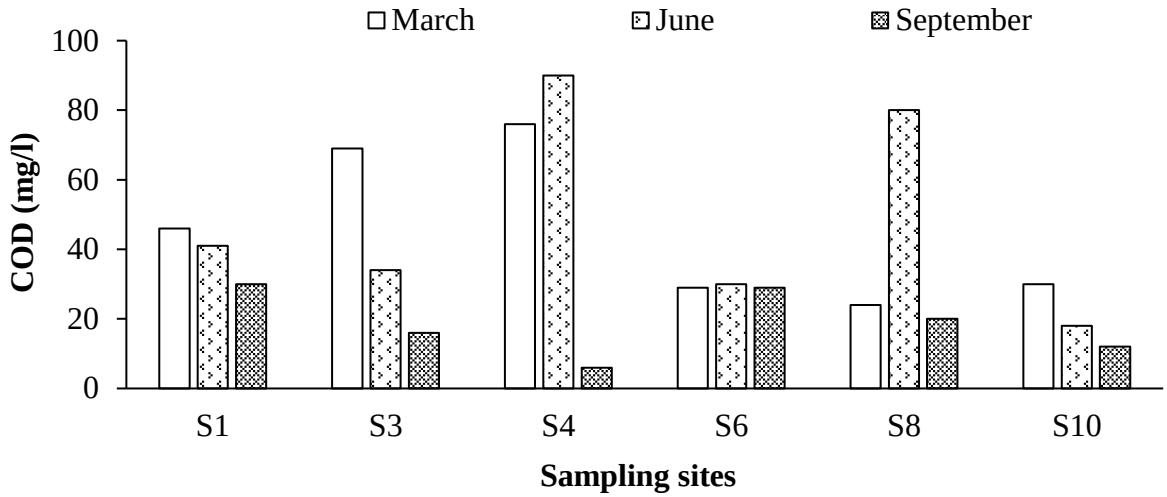


**Figure 4a. COD in groundwater in the areas burying swine**

Similar to surface water monitoring results, BOD and COD parameters have the highest and lowest values at the same locations. The value of BOD in wells ranged from 4-59 mg/l (Figure 4b). In which, the March observation period had BOD value of 16-49 mg/l, the lowest value was at S8 and highest at S4. The value of BOD in the June observation period was from 12-59 mg/l, the positions with the lowest and highest BOD values were S10 and S4, respectively. Meanwhile, the BOD value in September was much lower than the two previous observations with the lowest BOD value of 4 mg/l recorded at S4 and the highest value of 20 mg/l was recorded at S1.

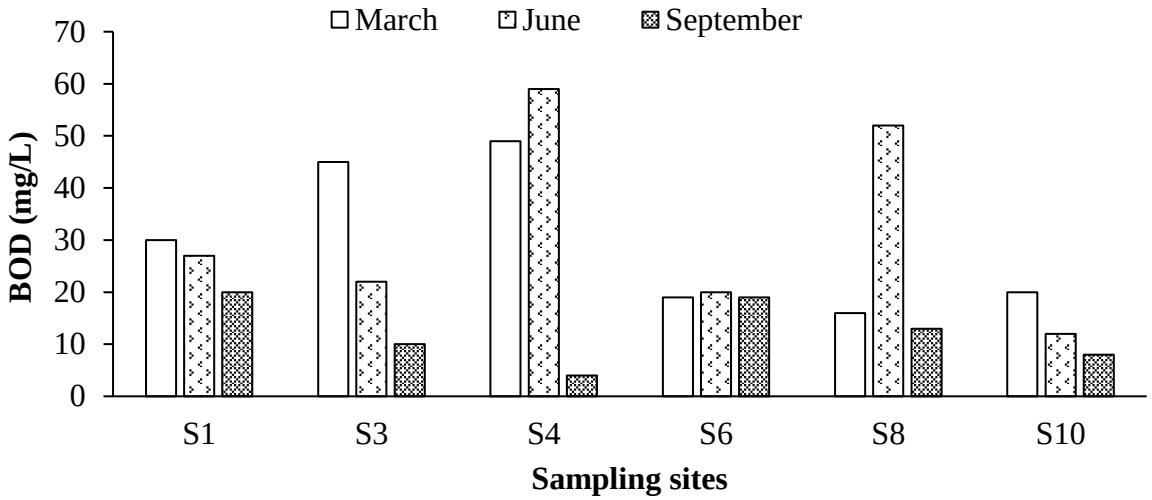


**Figure 4b. BOD in ground water in the areas burying swine**

### 3.2.3 Nutrients

The $NO_2^-$-N monitoring results in the study area were 0.011-0.465 mg/l (Figure 5a), all locations had $NO_2^-$-N values meeting the national technical regulations on ground water quality QCVN 09-MT: 2015/BTNMT (1 mg/l) [9]. The monitoring data in March and June had $NO_2^-$-N values of 0.011-0,181 and 0.032-0.465 mg/l, respectively, of which there were 03/06 locations with no nitrate detected. Both of these two monitoring sessions had the lowest $NO_2^-$-N value at position S6 and highest at location S3. Particularly, the September observation session with the lowest $NO_2^-$-N value (0.011 mg/l) was recorded at position S1 and the highest value (0.04 mg/l) at position S6.

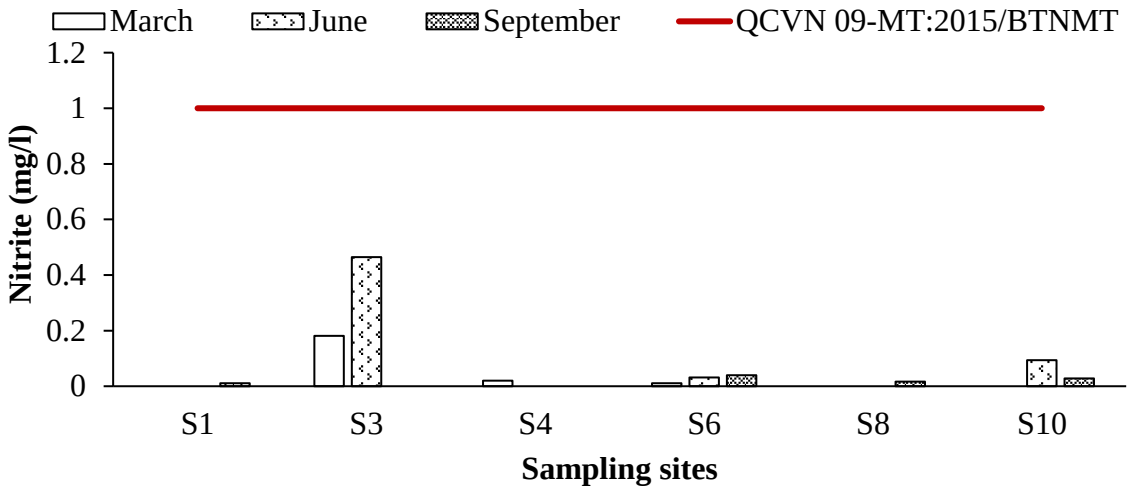


**Figure 5a. Nitrite in groundwater in the areas burying swine**

The value of $NO_3^-$-N in wells in the infected swine burial area was relatively low compared to QCVN 09-MT: 2015/BTNMT with the $NO_3^-$-N value ranging from 0.011-2.96 mg/l (Figure 5b). At the same time, the $NO_3^-$-N value in this study was also many times lower than the fluctuation of 0.09-95.96 mg/l recorded in the report in Pleiku city, Gia Lai province [5]. At the monitoring phase in March and June, there were 03 locations with no detectable nitrate value in well water samples, while in September, there were 02 undetected positions. The value of $NO_3^-$-N in 03 monitoring waves fluctuated from 0.013-0.159, 0.078-2.4 and 0.011-2.96 mg/l, respectively. The S6 position in June and September has a very high $NO_3^-$-N value compared to other positions.

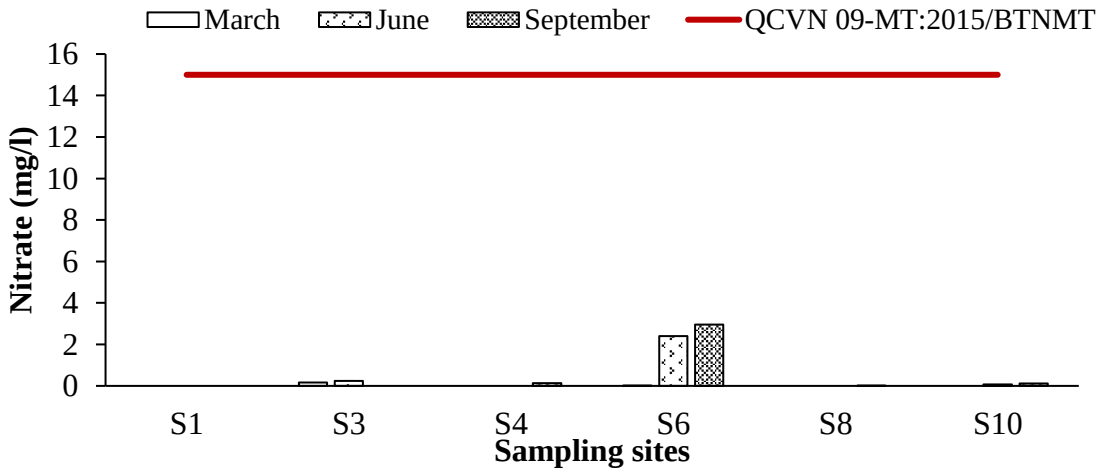


**Figure 5b. Nitrate in groundwater in the areas burying swine**

The well water monitoring positions in the study area had $PO_4^{3-}$-P values ranging from 0.032 to 3.11 mg/l (Figure 5c). In which, water samples at location S6 had the highest $PO_4^{3-}$-P values in all 03 monitoring phases with the value of 0.943, 3.11 and 1.6 mg/l, respectively. The lowest $PO_4^{3-}$-P value in March (0.213 mg/l) was recorded at position S1. Position S2 and S8 were 02 positions with the lowest $PO_4^{3-}$-P value in the June observation period (0.045 mg/l) and September (0.032 mg/l).

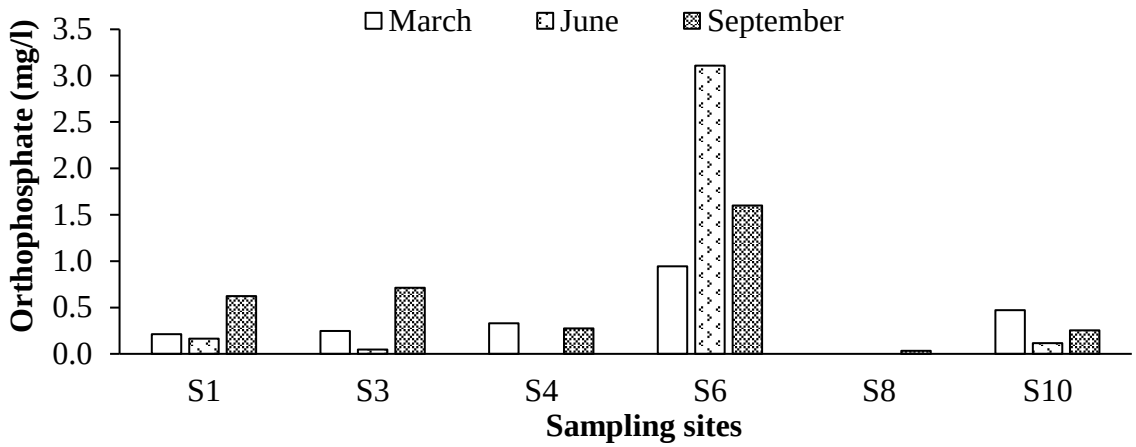


**Figure 5c. Orthophosphate in groundwater in the areas burying swine**

Ground water samples in the African swine fever burial sites of An Giang province had $NH_4^+$-N values ranging from 0.053-10.4 mg/l (Figure 5d). The value of $NH_4^+$-N at position S1 and S3 in all 03 monitoring phases exceeded the allowable limit of QCVN 09-MT: 2015/BTNMT [9]. In which, position S1 is the place with the highest value $NH_4^+$-N with values of 6.23, 4.01 and 10.4 mg/l for the monitoring phase in March, June and September, respectively. In addition, some other locations also had $NH_4^+$-N values exceeding the standard, namely positions S4 and S10 (March), position S4 and S8 in the June monitoring and S8 position in September.

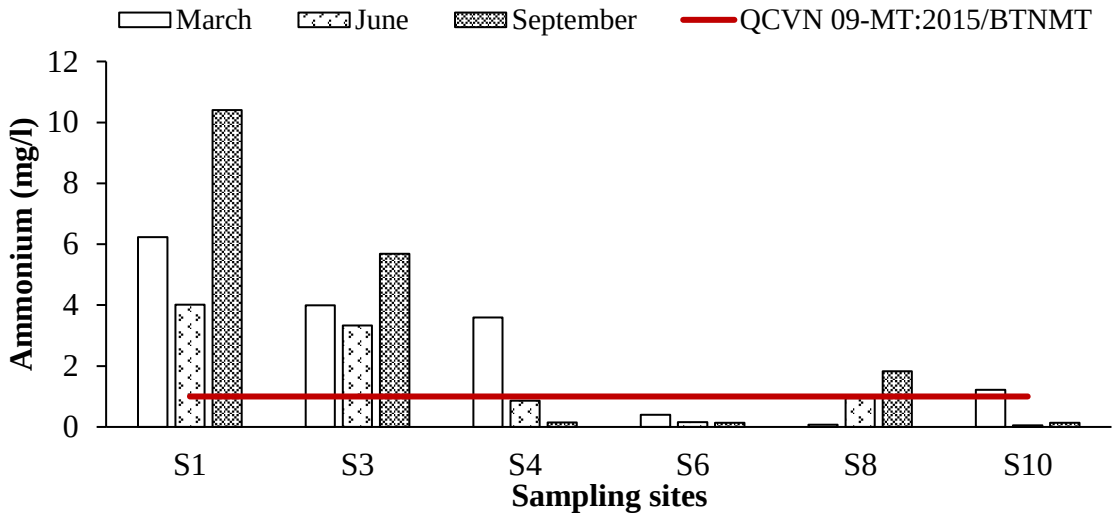


**Figure 5d. Ammonium in groundwater in the areas burying swine**

### 3.2.3 Coliform and E. coli

Coliform density in well water samples varied quite large, from 9 to 9,300 MPN/100ml (Figure 6a). In particular, the density of coliforms at the June observation period (900-9,300 MPN/100ml) was significantly higher than that in March (15-2,300 MPN/100ml) and September (9-230 MPN/100ml). Coliform density in the current study was many times higher than that of 0-1,100 MPN/100ml recorded in well water samples in 07 districts of Hanoi in 2018 [17]. This proved that coliform is an issue that needs more attention and control to minimize impacts on public health. The March observation had the lowest coliform density at position S6 and highest at position S1 and S3. Meanwhile, the locations with the lowest and highest coliform density (June and September) were S1 and S6, respectively.

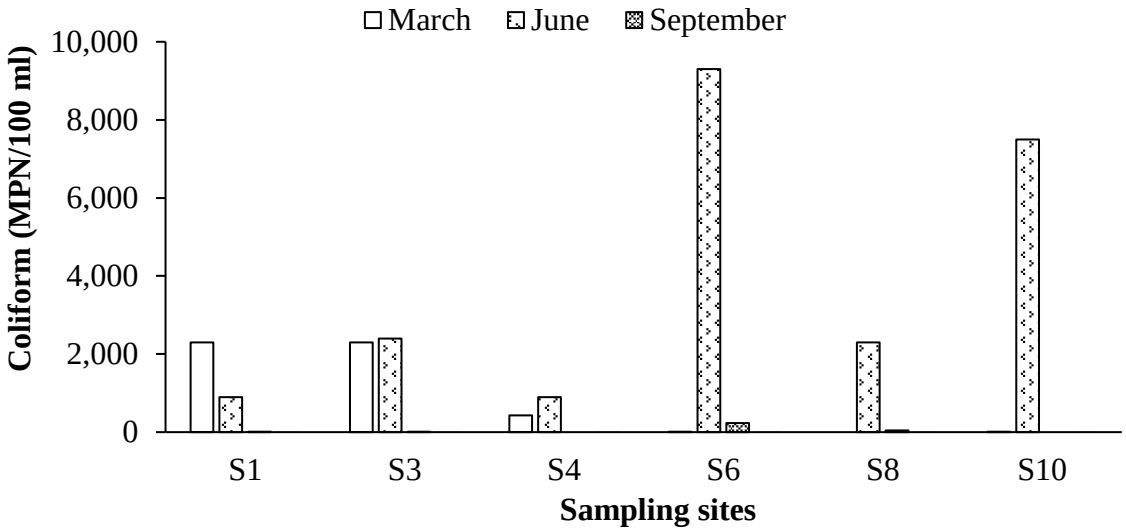


**Figure 6a. Coliform in groundwater in the areas burying swine**

E. coli was detected in all wells during the June observation period with densities between 400-9,300 MPN/100ml (Figure 6b). The location with the highest concentration of E. coli was S8 and the lowest was S1. Meanwhile, the March observation period had E. coli density ranging from 400-900 MPN/100ml. Well water samples in the September observation period did not detect E. coli, except for location S6 with a density of 9 MPN/100ml. The study results showed that the wells in the swine burial areas of African swine fever can cause impacts on the health of people due to signs of microbiological pollution. E. coli contaminated water can cause diarrhea, urinary tract infections, pneumonia for users [16].

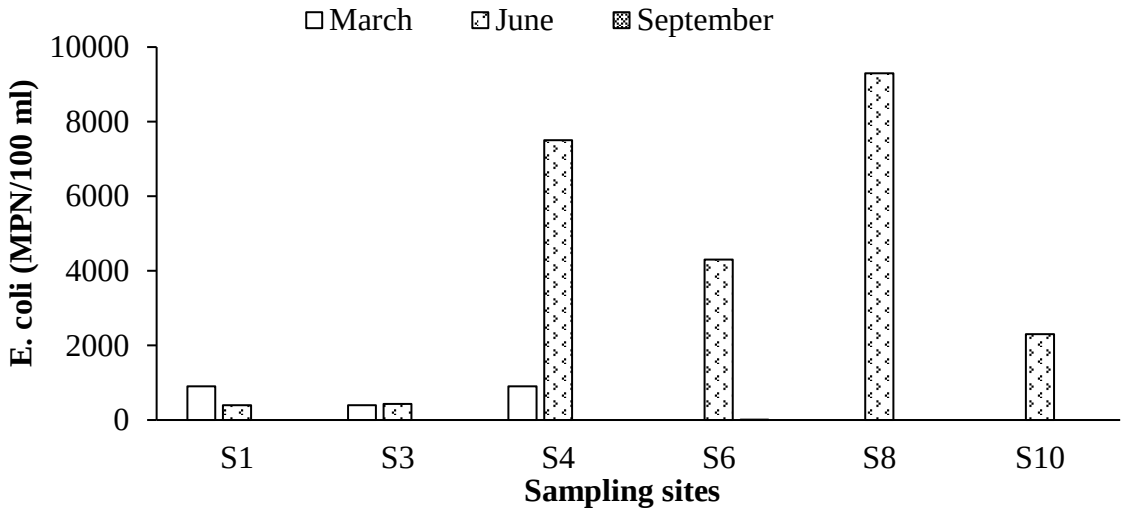


**Figure 6b. E. coli in groundwater in the areas burying swine**

## 4. Conclusion

In general, the values of surface water quality parameters observed in the study area exceed the allowable limits of QCVN 08-MT: 2015/BTNMT (column B1), except $NO_3^-$-N. This showed that surface water quality in the African swine fever burial sites of An Giang province had signs of organic pollution (COD, BOD), nutrients ($NO_2^-$-N, $PO_4^{3-}$-P, $NH_4^+$-N) and microbiological pollution (Coliform and E. coli). Besides, $NH_4^+$-N, Coliform and E. coli in ground water also exceeded the limit values in QCVN 09-MT: 2015/BTNMT. In particular, Coliform and E. coli were recorded

with very high densities in both surface water and well water samples. Thus, it can be seen that the water source in the swine burial sites was contaminated with high levels of microorganisms, potentially pose serious risks to public health. Therefore, it is necessary to have an appropriate pollution treatment method to ensure the quality of water for the people.

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