Investigation on the Relationship between Seasonal Climate Variables and Water Quality near Aquaculture Farms

การตรวจสอบความสัมพันธ์ของตัวแปรทางสภาพอากาศตามฤดูกาลและคุณภาพน้ำใกล้กับฟาร์มเพาะเลี้ยงสัตว์น้ำ

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Abstract

Water is essential requisite for human being, aquatic organisms, and aquaculture production. In aquaculture sector especially for shrimp farming, water is common factor because it is water intensive enterprise and required daily water exchange. Physical, chemical, and biological characteristic can determine to ensure water quality for the species alive. In addition, anthropogenic activities and natural processes such as seasonal and annual variation of climate can cause water quality change. This research studied the relationship between climatic and water quality parameters based on secondary data from 2016-2018 at the canal near aquaculture farms in Bangkok and Samut Prakan province. Rainfall and air temperature used for climatic parameters, and pH, water temperature, dissolved oxygen (DO), biochemical oxygen demand (BOD), ammonia (NH_3-N), nitrate (NO_3^--N) and total phosphorus (TP) used for water quality parameters. Pearson's correlation used as an analysis tool for this study. Results revealed that significantly negative correlation observed between rainfall and pH (r= -0.67) in winter season. Same results were found between air temperature and BOD (r=-0.50), and NH_3-N(r= -0.65), and TP (r= -0.50). In rainy season, water temperature (r= 0.67) and DO (r= 0.56) were significantly positive correlated with air temperature. In summer, positive correlation occurred between air temperature and water temperature (r= 0.60), and rainfall and NO_3^- -N (r= 0.54). This study suggests that good water quality condition occurred in winter season because less variations of temperature and rainfall. In addition, less BOD, NH_3-N, NO_3^--N and TP values as less effect of surface runoff from the land.

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Keywords: Climatic parameters, water quality, aquaculture, Pearson's correlation

บทคัดย่อ

น้ำเป็นสิ่งจำเป็นสำหรับชีวิตของมนุษย์ สัตว์น้ำ และการผลิตสัตว์น้ำ ในส่วนของการผลิตสัตว์น้ำ โดยเฉพาะการทำฟาร์มกุ้งน้ำจะเป็นปัจจัยที่สำคัญเนื่องจากจะต้องใช้ในปริมาณมาก และต้องมีการถ่ายเทน้ำในแต่ละวัน คุณภาพน้ำทางกายภาพ เคมี และชีวภาพ เป็นตัวบ่งบอกว่าน้ำนั้นเหมาะสมต่อการดำรงชีวิต นอกจากนี้กิจกรรมของมนุษย์ และกระบวนการทางธรรมชาติเช่นความแปรปรวนของสภาพอากาศตาม ฤดูกาลและปีสามารถมีผลต่อคุณภาพน้ำได้ งานวิจัยนี้ได้ศึกษาความสัมพันธ์ของสภาพอากาศและ คุณภาพ น้ำตามฤดูกาลในช่วงปี พ.ศ. 2559-2561 ในคลองใกล้กับฟาร์มเพาะเลี้ยงสัตว์น้ำในจังหวัดกรุงเทพมหานคร และสมุทรปราการ โดยใช้ข้อมูลสภาพอากาศด้านปริมาณน้ำฝนและอุณหภูมิอากาศ ใช้ข้อมูลคุณภาพน้ำ ได้แก่ ค่าความเป็นกรด-ด่าง อุณหภูมิน้ำ ออกซิเจนละลาย ความต้องการออกซิเจน ทางชีววิทยา แอมโมเนีย ไนเตรท และฟอสฟอรัสทั้งหมด และใช้ความสัมพันธ์ของเพียร์สัน ในการวิเคราะห์หาค่าความสัมพันธ์ ผลการศึกษาพบว่าปริมาณน้ำฝนมีความสัมพันธ์เชิงลบ กับค่าความเป็นกรด-ด่าง (r=-0.67) ในฤดูหนาว และให้ผล ในทำนองเดียวกับ อุณหภูมิอากาศ ได้แก่ ความต้องการออกซิเจนทางชีววิทยา (r=-0.50) แอมโมเนีย (r= -0.65) และฟอสฟอรัสทั้งหมด (r= -0.50) ในฤดูฝนพบอุณหภูมิน้ำ และค่าออกซิเจนละลายมี ความสัมพันธ์ เชิงบวกกับค่าอุณหภูมิอากาศ ในฤดูร้อนพบค่าความสัมพันธ์เชิงบวกกับอุณหภูมิอากาศ และอุณหภูมิน้ำ (r= 0.60) และปริมาณน้ำฝนกับไนเตรท (r= 0.54) ผลการศึกษานี้สามารถชี้แนะได้ว่า คุณภาพน้ำในฤดู หนาวมีสภาวะที่เหมาะสมกว่าฤดูอื่น เนื่องจากมี ความแปรปรวนจากอุณหภูมิ และปริมาณ น้ำฝนต่ำ นอกจากนี้ยังมีค่าความต้องการออกซิเจนทางชีววิทยา แอมโมเนีย ไนเตรท และ ฟอสฟอรัสทั้งหมดต่ำ เนื่องจากได้รับผลกระทบจากน้ำบ่าจากผิวดินน้อย

คำสำคัญ : ตัวแปรสภาพอากาศ คุณภาพน้ำ การเพาะเลี้ยงสัตว์น้ำ ความสัมพันธ์ของเพียร์สัน

Introduction

Water is the basic important resource and essential for human beings, living organisms, aquatic fauna and flora, aquaculture, agriculture, and navigation (Sarker et al., 2015). Water quality related with physical, chemical, and biological characteristic and hydrological properties. Water is supporting system for aquatic life and in the case of animal such as shrimp farming - water is a common factor because it is one of the water-intensive enterprises, and needs daily water exchange (Ataguba et al., 2012; Apud 1985; Islam et al., 2015). Therefore, water quality determination requires for sustainable aquaculture particularly for shrimp farming.

Anthropogenic activities such as urbanization, population growth, industrialization, land use change, climate change (altering weather pattern - drought and flood) and natural processes - air temperature and precipitation causes water quality degradation or deterioration (Barakat et al., 2016; Qian et al., 2007). In addition, seasonal and annual variation may influence the availability of water and may lead to water quality degradation (Islam et al., 2015). The extreme seasonal variations such as increasing of ambient air temperature, extreme hydrological events, drying-wetting cycles of soil, raising solar radiation are also the climate change determinants which affected on water quality (Delpla et al., 2009). Increasing air temperature decreases the surface water volume due to the increasing evapotranspiration rate. Besides, dissolved oxygen in water bodies can be reduced by rising ambient air temperature because warm water has less holding capacity for dissolved oxygen. It will affect on the growth rate of aquatic organisms (Shrestha and Kazama, 2007; Khanom et al., 2014). Moreover, many transportation pathways such as wastewater discharge from household, industries, storm water runoff from agriculture and aquaculture farming and some atmospheric deposition are one of the pollutants entering source of water bodies that are also dependent on seasonal variation (Quyang et al., 2006). Bordalo et al. (2001) presented that the concentration of ammonia increases in wet season due to surface runoff. It can cause increasing oxygen consumption of tissue, damaging gill and decreasing blood ability for transporting oxygen (Carbajal- Hernandez et al., 2012). Therefore, water quality degradation can cause species communities changing and reducing the health of aquatic communities (Shrestha and Kazama, 2007). Hence, aquaculture practices need good water quality condition particularly for coastal area (Ataguba et al., 2013). Because coastal area are more vulnerable area than inland, and coastal water is regarded as limitless absorbers of waste and contaminated by pollutants derived from different sources (Eng et al., 1989).

In Thailand, mostly aquaculture farming especially extensive and semi-intensive farm can be found along the coastal line. These farms directly use surface water from the associated canal. Then, water quality of the canal can affect on pond water under seasonal variation. Besides, those farms culture the whole year because of low density. Moreover, there is less report on the relation of seasonal climate variability and water quality in the coastal area. Therefore, the aim of the present study is to investigate the relationship between seasonal climate variability and water quality near aquaculture farms.

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Methodology

The study area is located in Bangkok and Samut Prakan province where coastal aquaculture farming particularly shrimp and fish ponds can be found. The extensive and semi-intensive farm use water from Hua Krabue canal which is located near aquaculture farm, and far from around 16 km of gulf of Thailand. In this study, the secondary climate data was taken from two meteorological stations in Bangkok province and water quality data was collected from one station. The meteorological data (rainfall and mean air temperature) was derived from Meteorological Department of Thailand and water quality parameters were derived from Bangkok Metropolitan Administration (BMA). The changes of climate parameters and water quality data during 10 years period (2008-2018) were determined and Pearson's correlation coefficient was used to investigate the relationship between two variables - seasonally climate data and water quality parameters using the data within the period of 2016-2018. For seasonal analysis, water quality data and climate data were divided into 3 categories- summer (middle February- middle May), rainy (middle May- Middle October), and winter (middle October-Middle February). Seven water quality parameters – water temperature, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), ammonia (NH_3-N), nitrate (NO_3^--N), and total phosphorus (TP) were used in this study. The following equation was used for correlation between two variables, and r-value mentions for determination of positive correlation and negative correlation.

$$r = \frac{\sum(X-\bar{X})(Y-\bar{Y})}{\sqrt{\sum(X-\bar{X})^2(Y-\bar{Y})^2}}$$

where, r= simple correlation of x and y variables,

X= seasonally climatic parameters

$\bar{X}$= mean climatic parameters for the season

Y= seasonally climatic parameters

$\bar{Y}$= mean climatic parameters for the season

In this study, the levels of r-values were considered as follows: r= weak correlation (0.10-0.33), r= fair correlation (0.34 -0.66), and r= strong correlation (0.67 -0.99).

Results and Discussion

Yearly and seasonally climate data variables

Time series data of yearly total rainfall from 2008-2018 and seasonally total rainfall from (2016-2018) were shown in Fig. 1. Fig. 2 showed yearly mean temperature during the period 2008- 2018, and seasonally means temperature within the period 2016- 2018.

Annual rainfall was fluctuated but steadily increasing rainfall could be seen from 2015- 2017 (Fig. 1a). According to Fig. 1b, total rainfalls were high in rainy season which leading to low salinity in coastal area due to dilution effects and increase nutrients loads in the water by runoff from residential area and agricultural area (Qian et al., 2007). Khalil et al. (2018) reported that higher amount of rainfall was found in wet season than dry season. Ahmed and Diana (2015) observed that white spot syndrome virus occurs in shrimp during low water salinity. Higher amount of nutrients encourage algal bloom and eutrophication process (Khanom et al., 2014; Wyk et al., 1999). It is assumed that higher amount of rainfall can affect on water quality and aquatic organisms especially for shrimp farming.

According to Fig. 2a, the average temperature of the study area was also fluctuated, however it was gradually increased over the period 2008-2018 except in 2008 and 2011 because weak la Nina happened in 2008 and flooding caused in 2011. Marks, D (2011) also forecasted that daily maximum temperature will increase to 1.2 – 1.9 by 2050 in Thailand. Although, a lower average temperature was found in theses 2 years, a higher amount of rainfall was observed. Singhrattna et al. (2005) mentioned that increasing temperature could be resulted in the decreasing rainfall. In Fig. 2b, although air temperature was highest in summer compared with rainy and winter seasons over the period 2016-2018, the range was suitable for shrimp farming because the optimum range of water temperature is 28- 32°C. Thuong (2017) also mentioned that higher temperature can affect on developing shrimp such as the rate of shrimp growth, feeding, and outbreak of disease. In addition, higher temperature can decrease DO value in water bodies because aquatic plants and organisms need more oxygen for their respiration and metabolism process (Marlina, and Melyta, 2019). Decreasing DO value can affect the growth rate of aquatic organism (Khanom et al., 2014). Moreover, increase temperature can raise the microbial decomposition rate because they favor warm temperature and depend on temperature (Bandyopadhyay S. 2008). Then ammonia (NH_3-N) can increase in water. It can swell shrimp’s gill, which leads to reduce the shrimps’ ability for taking the oxygen from water bodies. Therefore, deterioration of water quality and low oxygen in water may be caused by increasing water temperature that is direct relation with air temperature (Rahaman et al., 2015; Islam A. M., 2016). In addition, higher temperature can lead to

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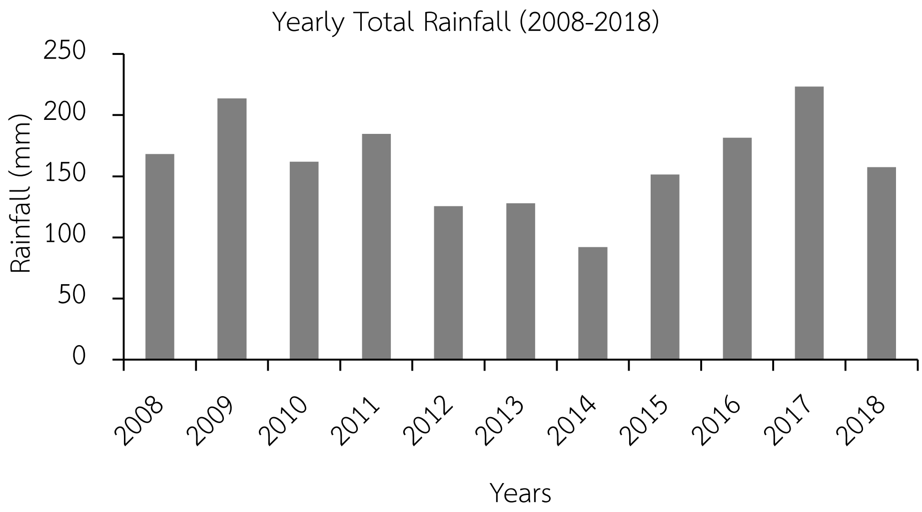
prolonged drought in the coastal, consequently to increase the evapotranspiration rate of shrimp's ponds and lakes. As a result, frequency of shrimp mortality and diseases such as disfigures and discolors may be increased (Ahmed, and Diana, 2015). Thus, higher temperature has negative impacts on water quality and coastal aquaculture sectors, particularly for shrimp farming.



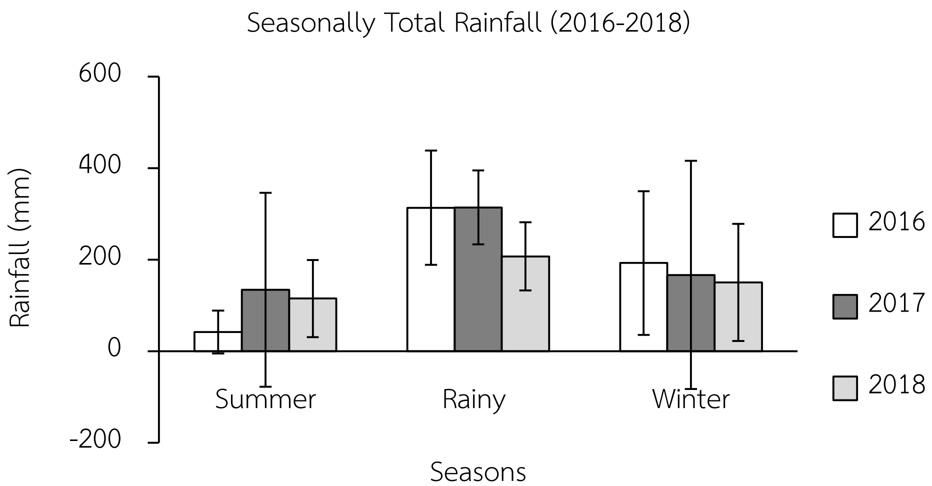


Fig. 1. (a) Yearly total rainfall during 2008- 2018 and (b) seasonally total rainfall during 2016-2018.

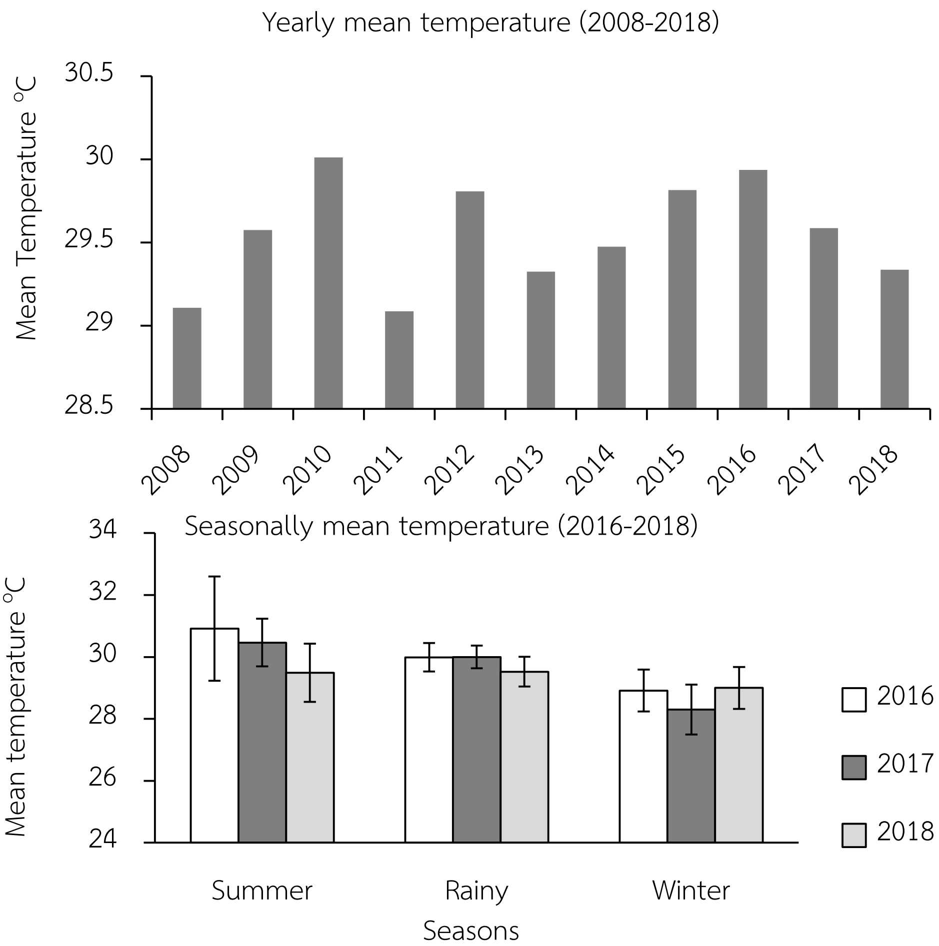


Fig. 2. (a) Yearly mean temperature during 2008- 2018 and (b) seasonally mean temperature during 2016-2018.

Yearly and seasonally water quality variables

According to Fig. 3a, yearly water temperature trend was fluctuated, and the trend was high in 2010 and 2012, while higher air temperature was observing. Therefore, water temperature is consistent with air temperature. Similar findings can be seen which supported by Rahaman et al. (2015). In Fig. 3b, rise in water temperature was occurred in summer and it was gradually decreased in rainy and winter season. Similar result found in the study of (Islam et al., 2015; Gadhia et al., 2012). However, yearly and seasonally water temperature do not affect on shrimp farming because the optimum temperature for shrimp ranges 28-32 °C (National Environmental Board, 2007).

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As detailed in Fig. 4a, pH value was not significantly changed within 10 years except in 2008 and it was still suitable for coastal shrimp farming practices. In Fig. 4b, the value of pH was fluctuated in all seasons and it was within the optimum range (7.0-8.5) (National Environmental Board, 2007). Islam et al. (2015) and Sarker et al. (2015) also reported that higher amount of pH value was found in wet season.

As shown in Fig. 5a, DO value was fluctuated, and it concentration was below the suitable range (DO ≥ 4 mg/l) during 10 years expect in 2016 because this canal is located near the inner city. In seasonally, the higher amount of DO was observed in summer (Fig. 5b). However, DO value was below the suitable range except in 2016 summer, and 2016 and 2017 rainy season.

As detailed in Fig. 6a, BOD value was fluctuated within 10 years. In seasonally, BOD was also high in summer season compared with rainy and winter season (Fig. 6b). It is interesting that, the trend of DO and BOD was same in yearly and seasonally. Therefore, in this study BOD may depend on not only climate parameters but also land use because BOD depend an organic contamination from upstream in the study area. Sarker et al. (2015) also mentioned that the reason of higher amount of BOD is the presence of some industries and increased urbanization in study area.

According to Fig. 7a, the trend of NH_3-N was increased in 2007 and 2008, and then it was gradually decreased and finally immediately increasing was occurred from 2015. The same trend was also found in NO_3^--N (Fig. 8a). In seasonally, NH_3-N concentration in winter season was lower than summer and rainy season due to fair seasonal variation (Fig. 7b). Higher amount of NO_3^--N concentration could be seen in summer and winter because of summer storm and late monsoon period (Fig. 8b). However, the concentration of NH_3-N and NO_3^--N exceed the optimum ranges in both yearly and seasonally.

TP value was fluctuated from 2008-2014 and immediately decreased from 2014-2018 (Fig. 9a). In seasonally, TP was not significantly changed in three seasons (Fig. 9b), but slightly high TP concentration was found in rainy season compared with other season because of runoff by rainfall.

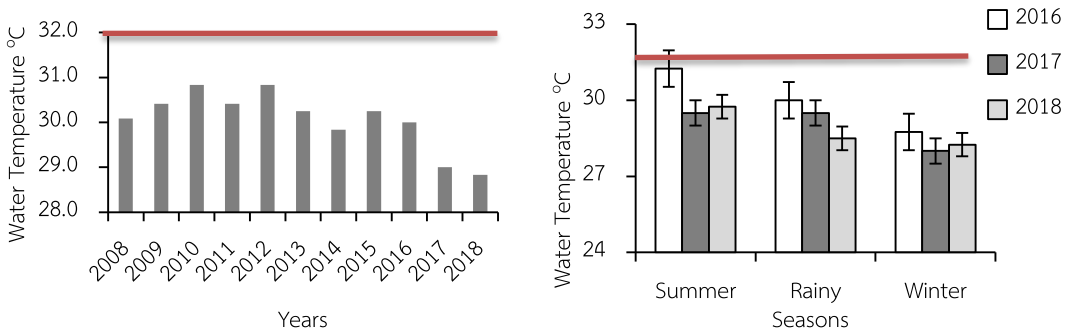
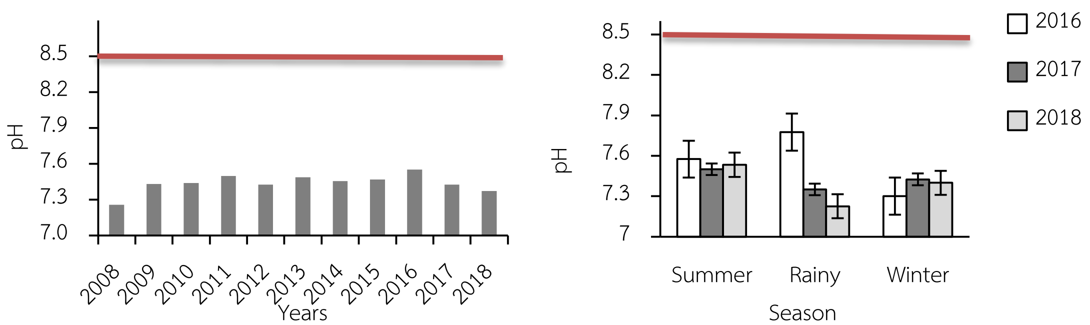
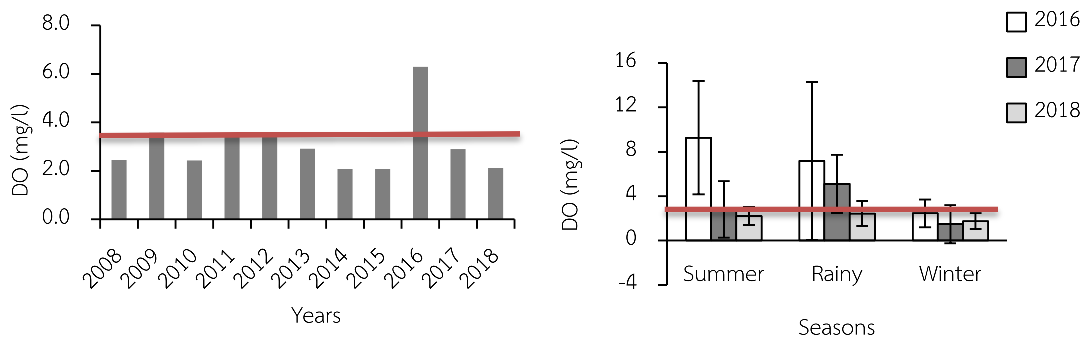


Figure 3. (a) Yearly water temperature during 2008-2018; (b) seasonally water temperature during 2016-2018



(a) (b)

Figure 4. (a) Yearly pH value from 2008- 2018; (b) seasonally pH value from 2016-2018



(a) (b)

Figure 5. (a) Yearly DO value from 2008-2018; (b) seasonally DO value from 2016-2018

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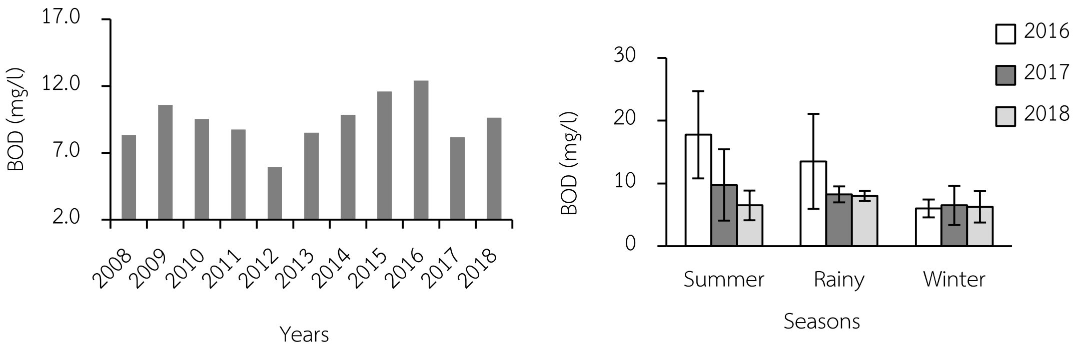
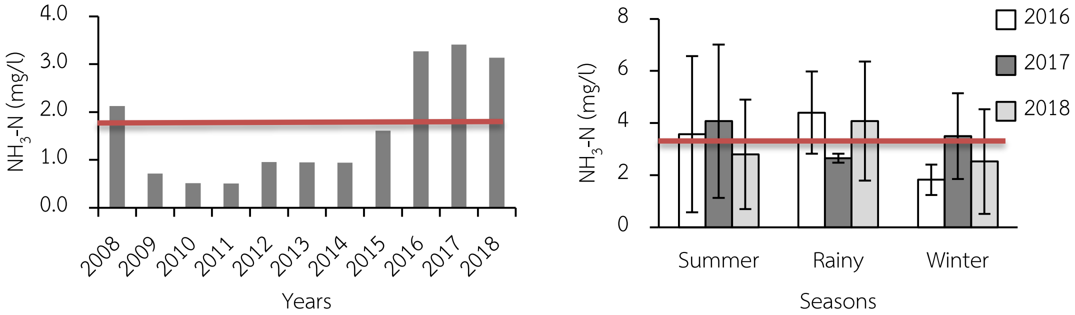


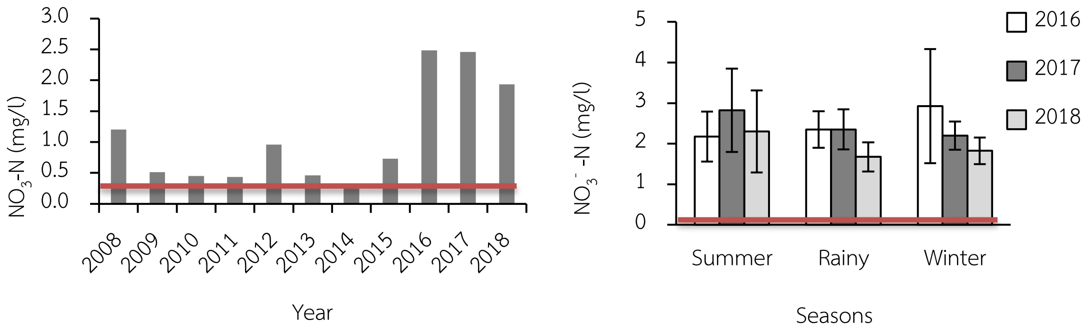
(a) (b)

Figure 6. (a) Yearly BOD value from 2008-2018; (b) Seasonally BOD value from 2016-2018



(a) (b)

Figure 7. (a) Yearly NH_3-N concentration from 2008-2018; (b) Seasonally NH_3-N concentration from 2016-2018



(a) (b)

Figure 8. (a) Yearly NO_3^--N concentration from 2008-2018; (b) Seasonally NO_3^--N concentration from 2016-2018

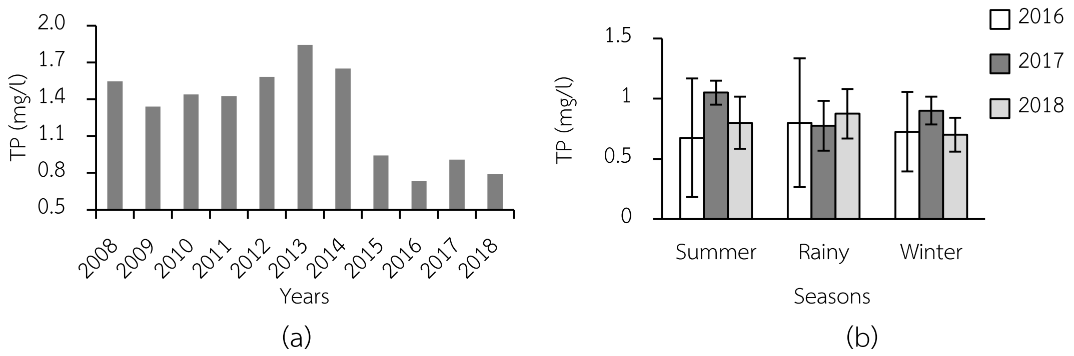


Figure 9. (a) Yearly TP value from 2008-2018; (b) Seasonally TP value from 2016-2018

Analysis of correlation between climate data and water quality parameters

Table 1 presents the correlation between seasonal climate variability and water quality parameters.

Temperature influences the biological activities of fauna and flora of aquatic farm. Rise in temperature force to increase the chemical reaction in water bodies (Rahman et al., 2015). In this study, water temperature was fair positive correlated with air temperature in summer (r= 0.60) and was strong positive correlated with air temperature rainy season (r= 0.67). Weak to fair positive correlation was found between water temperature and rainfall in rainy (r= 0.21) and summer (r= 0.52). Rahaman et al. (2015) mentioned that direct relation was occurred between water temperature and climate parameters such as air temperature and precipitation. Because heavy rainfall causes reducing turbidity and thus sunlight can reach to deeper region of water bodies, consequently to increase the water temperature.

Water pH shows the reciprocal relationship between hydrogen ion activity and given water temperature in water bodies (Rahman et al., 2015). pH has fair positive correlation with air temperature in rainy (r= 0.35) and in winter (r= 0.45) , whereas weak negative correlation was found in summer (r= -0.31). However, rainfall and pH has weak negative correlation in summer (r=-0.23) and strong negative correlation in winter (r= -0.67). This finding was correspondence to the work of Prathumratana et al. (2008) that negatively correlation was observed between pH and precipitation.

DO is one of the essential parameters for aquatic organisms and use as a common parameter to investigate the water quality (Barakat et al., 2016). According to Table 1, DO was fair to weak positive correlated with air temperature in rainy (r= 0.56) and in winter (r= 0.20). Weak negative correlation was found between DO and rainfall in summer (r= -0.33) and winter (r= -0.30). DO shows inverse relationship with rainfall, mean water flow and level which was

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supported by (MRC, 2005). However, Gadhia et al. (2012) also reported that DO concentrations may be improved in wet season due to high water flow, water exchange, and low resident time. Therefore, it can be assumed that seasonally climate variability influences on DO concentration. Similar finding was also recorded by Rahman et al. (2015).

As detail in Table 1, BOD was weak positive correlated with rainfall (r= 0.24) in rainy season. The results showed that the value of BOD was higher in rainy season (average BOD = 10.5 mg/l) because it may come from different land use. Bordalo et al. (2001) mentioned that the greater amount of BOD concentration was observed in wet season due to surrounding land use. It was interesting that fair positive correlation was occurred between BOD (r= 0.45) and air temperature in rainy season while DO value was also direct correlated with air temperature. Marlina, and Melyta, (2019) mentioned that higher temperature accelerates chemical reaction, as a result it cause increasing DO and reaction rate of BOD degradation through microbes. On the other hand, BOD value (r= -0.50) was fair negative correlation with air temperature in winter because lower temperature occurred in winter season which was compared with rainy season. In summer, BOD was weak positive correlated (r= 0.22) with air temperature because warm water has less holding capacity of dissolved oxygen in water. Similar result was observed in the study by Shrestha and Kazama, (2007) and Khnaom et al. (2014). Therefore, air temperature variation due to seasonally climate variables influences on BOD value in water bodies.

NH_3-N comes from the microbial decomposition of organic nitrogen such as protein and, particulate matters, fertilizer and excrement of aquatic organism. In present study, NH_3-N has fair negative correlation (r= -0.65) with air temperature in winter season. Weak positive correlation was found between NH_3-N (r = 0.30) and air temperature in summer because higher air temperature speed up the decomposition rate of organic matters. Similar findings was also found in Thuong (2017) that raising air temperature could cause increasing NH_3-N concentration in water which affected on developing of shrimp. Bandyopadhyay S. (2008) mentioned that microbial decomposition rate could accelerate 2-3 folds depend on temperature. On the other hand, NH_3-N was weak negative correlated with rainfall in rainy (r= -0.33) and summer (r= -0.30) season.

As detail in Table 1, nutrient parameters (NO_3^--N and TP) have positively fair to weak correlation with rainfall amount, respectively, (r= 0.54) and (r= 0.39) in summer, (r=0. 39) in rainy, and (r=0.34) and (r= 0.16) in winter. In summer season, direct correlation was observed between rainfall and nutrient parameters because of summer storm. Prathumratana et al. (2008) mentioned that nutrient parameters were direct relationship with rainfall due to water flow. Beside higher amount of rainfall could increase pollutant loads – TP and NO_3^--N in water bodies by runoff from residential and agriculture area, as a result it affected on water quality (Qian et al., 2007; MRC, 2005). In winter season, NO_3^--N (r= -0.11) and TP (r= -0.50) were weak to fair negative correlated with air temperature. Similar result showed by Barakat et al. (2016) that NO_3^--N was negative correlated with temperature.

Table1. Correlation between Seasonal Climatic Parameters and Water Quality Parameters

Parameters	Air Temperature			Rainfall		
	Summer	Rainy	Winter	Summer	Rainy	Winter
Water Temperature	**0.60***	**0.67***			0.21	0.52
pH	0.31	0.35	0.45	-0.23		**-0.67***
DO		**0.56****	0.20	-0.33		-0.30
BOD	0.22	0.45	**-0.50****		0.24	
NH_3-N	0.30		**-0.65***	-0.3	-0.33	
NO_3^--N			-0.11	**0.54****	0.39	0.34
TP			**-0.50****	0.39		0.16

(Pearson's correlation coefficients (r))

Note - *Correlation is significant at ≤ 0.05. **Correlation is significant at ≤ 0.1

Application for aquaculture practices

In the present study, it was revealed that temperature and rainfall was gradually increased during study period 2008 - 2018. As the frequency of extreme weather events, high temperature and rainfall, is increasing, therefore it could influence on water quality. Higher air temperature caused increasing water temperature, NH_3-N and pH level in water, consequently to fish dead if the culture pond is not proper management. Large amount of rainfall could also be affected on water quality in term of increasing NO_3^--N and TP which polluted from land run-off. The preparedness to cope with climate change should be implemented by farmers to protect against damage to aquaculture products. These water quality parameters are difficult to notice, therefore, farmers should test water before taking water from canal into the pond or has pretreatment such as aeration, adsorption and plant uptake to prevent water pollutants go into the ponds. To prevent high water temperature, farmers should add more water in the pond, excavate wider and deeper canal at the edge of the pond. Murakidhar et al. (2013) mentioned that calcium carbonated application is possible way to raise the pH level and so on farmers should add calcium carbonate while low level pH occurred in water bodies because of high temperature. To prevent water pollution from runoff pathway, farmers should reduce soil erosion by infield grass strip and build embankment. The other possible way to prevent seasonally water quality variation and degradation is that farmer should adjust harvestable time and use mix culture (for example- polyculture of fish and shrimp) to promote production. Finally, farmers and policy makers can be use this data to forecast the impact of climate change on the water quality and the consequent to aquatic animals for find out the solutions for sustainable water quality management, particularly for coastal aquaculture farming.

Conclusion

The result indicated that long-term investigation of mean temperature was gradually increased and rainfall was fluctuated over the period 2008-2018. Yearly water temperature, pH, DO and BOD value were fluctuated within 10 years periods. NH_3-N and NO_3^--N increased during the period 2008-2018. TP value was also fluctuated and decreased in the study period. According to short-term observation (seasonally), the variation of rainfall was not high in rainy season compared with other season. The high variation of rainfall was occurred in summer season due to summer storms. Same result also found in winter because of late monsoon period. In addition, Pearson's correlation analysis indicated that significantly negative correlation was occurred between rainfall and pH, and between air temperature and BOD, NH_3-N, and TP in winter season. In rainy season, air temperature has significantly positive correlation with DO and water temperature. In summer, air temperature was significantly positive correlated with water temperature, and rainfall was significantly positive correlated with NO_3^--N. Thus, in this study, good water quality condition observed in winter season compared with other season because increase DO value and decrease BOD, NH_3-N, NO_3^--N and TP values were found due to low biological degradation. In addition, the variation of mean temperature and total rainfall is moderate in winter season. Hence, winter season is more suitable for aquaculture farming especially for shrimp farming than summer and rainy season. If shrimp farmers culture in summer and rainy, they should integrate the water quality by using closed system and keep storage pond for adjusting water. Therefore, water quality variation under seasonal variation should be considered for water quality management of aquaculture farming in coastal area. However, there are also needed to consider multiple factors such as loading nutrient, tidal effects, and farm activities along the canal.

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References

Ahmed, N. D. and Diana, J. S. (2015). Threatening “white gold”: Impacts of climate change on shrimp in coastal Bangaladesh. Journal of Ocean & Coastal Management, 114, 42-52.

Apud, F. D. (1985). Extensive and semi-intensive culture of prawn and shrimp in the Philippines. Proceedings of the First International Conference on the Culture of Penaeid Prawns/ Shrim*ps* (pp. 105-113). Iloilo City: Southeast Asian Fisheries Development Center.

Ataguba, G. A., Ogbe, F, G., Solomon, S. G., Ameh, M. I., and Okomoda, V. T. (2013). Synthesis of climate change effects on water sources for aquaculture. Proceedings of the 28th Annual Conference of Fisheries Society of Nigeria. Fisheries Society of Nigeria. pp 104-108. Abuja: Fisheries Society of Nigeria.

Bandyopadhyay, S. (2008). Water quality management for coastal aquaculture.Delhi: Daya Publishing House.

Barakat, A., Bagdadi, M. E., Rais, J. M., Aghezzaf, B., and Slassi, M. (2016). Assessment of spatial and seasonal water quality variation of Oum Er Rbia (Morocco) using multivariate statistical techniques. International Soil and Water Conservation Research, 4 (4), 284-292.

Bordalo, A. A., Nilsumeanchit, W., Chalermwat, K. (2001). Water quality and uses of the Bangpakong river (Eastern Thailand). Journal of Water Resource, 35 (15), 3635- 3642.

Carbajal- Hernandez, J., Sanchez- Fernandez, L., Carrasco- Ochoa, A., Martinez- Trinidad, J. (2012). Immediate water quality assessment in shrimp culture using fuzzy inference systems. Journal of Expert System with Application, 39 (12), 10571-10582.

Delpla, I., Jung, A-V., Baures, E., Clement, M. and Thomas, O. (2009). Impacts of climate change on surface water quality in relation to drinking water production. Environment International, 35 (8)**,** 1225 - 1233.

Eng, C. T., Paw, J. N., and Guarin, F. Y. (1989). The environmental impact of aquaculture and the effects of pollution on coastal aquaculture development in Southeast Asia. Marine Pollution Bulletin, 20 (7), 335-343.

Gadhia, M., Surana, R., and Ansari, E. (2012). Seasonal variation in physical- chemical characteristics of Tapi estuary in Hazira industrial area. Journal of Our Nature, 10, 249-257.

Islam, M. S., Ferdous, J., Nasmi, S., and Kabir, H. (2015). Seasonal variation in water quality and its effects on fish production in the Brahmaputra River at Mymensingh of Bangladesh. Journal of Environmental Science, 29, 18- 24.

Islam, A. Md., Islam, S. Md., and Wahab, A. Md. (2016). Impacts of climate change on shrimp farming in the South-West coastal region of Bangladesh. Research in Agriculture, Livestock, and Fisheries, 3 (1), 227-239.

Islam, A. Md., Akber, A. Md., Ahmed, M., Rahman, M. Md. and Rezaur, M. (2018). Climate change adaptations of shrimp farmers: A case study from Southwest coastal Bangladesh. Journal Climate and Development, 11 (6), 459-468.

Khanom, U. S., Sharmeen, S., Ferdouse, J., Shumi, W., Abdu, A., Hamid, H. A. and Hossain, M. A. (2014). Determination of pond water quality for aquaculture and ecosystem management. Journal of Food, Agriculture and Environment, 12 (3), 389- 394.

Khalil, K., Rittima, A., and Phanknmolsil, Y. (2018). Seasonal and annual trend of rainfall and stream flow in Mae Khlong Basin, Thailand. Journal of Applied Environmental Research, 40 (3), 77-90.

Marks, D. (2011). Climate change and Thailand: Impacts and response. Journal of International and Strategic Affair, 33 (2), 229-258.

Marlina, N., and Melyta, D. (2019). Analysis effect of cloud cover, wind speed, and water temperature to BOD and DO concentration using QUAL2Kw Model (Case Study in Winongo River, Yogyakarta), MATEC web of Conference *280*. Indonesia: EDP Science.

Mekong River Commission (MRC). Overview of the hydrology of the Mekong Basin; 2005.

Muralidhar, H. K., Kumaran, M., Kumar, J. A., Dayal, J. S., Jayanthi, M., Saraswathy, R., Lalitha, N., Panigrahi,A., Rao, A. S., Muniyandi, B. and Murugan, P. 2013. Climate Change and Coastal Aquaculture in West Godavari District, Andhra Pradesh: Impacts, Vulnerability, Adaptations and Mitigation for Resilienc. Journal of Agrometerology, **15**, 116-122.

Notification of the National Environmental Board No. 27, B.E. 2547 (2006) dated December 26, B. E. 2549 (2006), and published in the Royal Government Gazette, Vol. 124, Part 11 D dated February 1, B. E. 2550 (2007).

Prathumratana, L., Sthiannopkao, S. and Kim, W. K. (2008). The relationship of climatic and hydrological parameters to surface water quality in the lower Mekong River. Journal of Environmental International, 34 (6), 860-866.

Qian, Y., Migliaccio, K. W., Wan, Y., and Li, Y. (2007). Trend analysis of nutrient concentration and loads in selected canal for the southern Indian River lagoon, Florida. Journal of Water, Air and Soil Pollution, 186 (1-4), 195-208.

Quyang, Y., Nkedi-kizza, P., Wu, Q. T., Shinde, D., and Huong, C. H. (2006). Assessment of seasonal variation in surface water quality. Journal of Water Research, 40 (20), 3800-3810.

Rahman, Md. Z., Zaman, Md. F. U., Khondoker, S., Hasan-Uj-Jaman, Md., Lokman H. M., and Bappa, S. B. (2015). Water quality assessment of a shrimp farm: A study in a salinity prone area of Bangladesh. International Journal of Fisheries and Aquatic Studies, 2 (5), 9-19.

Sarker, Md. R. H., Islam, A., Islam, A., Hoque, Md. M., and Roy S. (2015). Seasonal variations in quality of Louhajang River water, Tangail. Journal of Science Research, 28 (1), 9- 16.

Singhrattna, N., Rajagopalan, B., Kumar, K. K., and Clark, M. (2005). Interannual and interdecadal variability of Thailand summer monsoon season. Journal of Climate, 18 (11), 1697-1708.

Shrestha, S., and Kazama, F., S. (2007). Assessment of surface water quality using multivariate statistical techniques: A case study of the Fuji river basin, Japan. Journal of Environmental Modelling and Software, 22 (4), 464- 475.

Thuong, I. C. (2017). Assessing the impact of climate change and sea level rise on shrimp farming in Can Gio district, Ho Chi Minh City. Journal of Science, 14 (9), 187-199.

Wyk, V. P., and Scarpa, J. (1999). Water quality and management. In: VanWyk, P. (Ed.), Farming marine shrimp in recirculating freshwater systems. Florida. Department of Agriculture and Consumer Services, Tallahassee, pp. 128–138.