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Microbial contamination in the surface water in the Ba Vi National Park, Ha Noi

Ô nhiễm vi sinh vật trong môi trường nước mặt Vườn Quốc gia Ba Vì, Hà Nội

Research article

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Ba Vi National Park, one of 28 Vietnam National parks, is currently preserved and exploited for a variety of purposes, including the preservation of intact natural forest ecosystems and genetic resources of rare plants and animals. This paper presents the monitoring results of microbial contamination in surface water environment of the Ba Vi National Park (Ha Noi) in the period 2013-2014 and 2018. The results showed that total coliform (TC) density varied from 23 to 11,000 MPN/100ml in bimonthly observation in 2013-2014 which was lower than that one of sampling campaign in 2018, from 900 MPN/100ml to 8,100 MPN/ml. Fecal coliform (FC) densities vaired from 0 to 110 MPN/100ml in 2013 -2014 were lower than that in 2018, from 0 MPN/100ml to 600 MPN/100ml. At several observation time, both TC and FC were higher than the allowable values of the Vietnam national technical regulation QCVN 08-MT: 2015/BTNMT column A1 for surface water quality. The exceeded values of TC and FC than the allowable values and the increase trend from the 2013 to 2018 periods indicated the potential risks to the public health in this region when people use water for domestic and agricultural purposes. Our results provide dataset for environmental management in the Ba Vi National Park in order to protect the eco-environment in parallel with economical-social development.

Vườn Quốc gia Ba Vì, một trong 28 vườn quốc gia của Việt Nam hiện đang được bảo tồn và khai thác cho nhiều mục đích, trong đó có bảo tồn nguyên vẹn các hệ sinh thái rừng tự nhiên, các nguồn gen động, thực vật quý hiếm, các đặc sản rừng và các di tích lịch sử, cảnh quan tự nhiên trong vùng. Bài báo trình bày kết quả quan trắc, đánh giá mức độ ô nhiễm vi sinh vật trong môi trường nước mặt tại Vườn Quốc Gia Ba Vì, Hà Nội giai đoạn 2013-2014 và 2018. Kết quả cho thấy mật độ coliform tổng số (TC) biến đổi trong khoảng từ 23 – 11.000 MPN/100ml trong các đợt quan trắc định kỳ 2 tháng/lần trong hai năm 2013 - 2014 và trong khoảng từ 900 – 8.100 MPN/100ml trong một đợt quan trắc năm 2018. Mật độ fecal coliform (FC) biến đổi trong khoảng từ 0 - 110 MPN/100ml năm 2013 -2014 và từ 0 - 600 MPN/100ml vào năm 2018. Vào một số thời điểm quan trắc, mật độ FC và TC vượt giá trị cho phép của quy chuẩn kỹ thuật Quốc Gia QCVN 08-MT:2015/BTNMT cột A1 về chất lượng nước mặt. Các giá trị TC và FC vượt quá giá trị cho phép và xu hướng gia tăng TC và FC từ 2013 -2018 cho thấy nguy cơ tiềm tàng khi người dân sử dụng nguồn nước này cho các mục đích sinh hoạt và nông nghiệp. Như vậy, kết quả của nghiên cứu này nhấn mạnh nhu cầu giám sát thường xuyên chất lượng nước và cần thực hiện các giải pháp hiệu quả để xử lý và quản lý nguồn gây ô nhiễm trong khu vực nhằm bảo vệ môi trường sinh thái song song với phát triển kinh tế - xã hội của khu vực.

Keywords: Ba Vi National Park (Ba Vi NTP), fecal coliform (FC), sustainable development, total coliform (TC), water environment

1. Introduction

Coliform is an important indicator in assessing the quality of water environment. Because it is easy to be detected and quantified, coliforms are suitable indicator bacteria for assessing the microorganism contamination level in water environment, including drinking, domestic and aquacultural water. Coliform group is widespread in nature, infecting the human body primarily through the

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consumption of contaminated food and water. Almost coliforms are non-pathogenic coliform, but some strains can cause some illness such as diarrhea, dysentery, urinary tract infections, hepatitis, bronchitis, pleurisy ... Some strains can produce foreign toxins, effecting on nerve cells. *Escherichia coli* (*E. coli*) can cause diarrhea, blood disorders and kidney failure, even lead to death. In the world (mainly especially in developing countries), toxic strain *E.coli* is responsible for about 2.5 million infant deaths per year (Kosek et al., 2003). Consequently, the study of bacteria, especially coliform (total coliform and fecal coliform) in soil and water environment was carried out in many countries in the world (Mendes et al., 2012; Dias et al., 2010; Sá et al., 2014; Nguyen et al., 2014...).

In Vietnam, the TC and FC contamination in some rivers and lakes was observed. For example, TC and/or FC contamination of some urban rivers in Ha Noi (Lich, Lu, Set, Kim Nguu), the Day- Nhue river (ICEM, 2007), the upstream of the Red River (Nguyen et al, 2014), the Red River section flowing through the Hanoi city (Nguyen et al., 2015; 2016) was evaluated.

The Ba Vi National Park is famous for its rich and variety of fauna and flora. There are many rare animals and plants that need to be protected, preserved and developed (Dang Huy Huynh, 2016). This park is also an important ecotourism point in North Vietnam. However, along with the development of ecotourism, there is a deterioration in the environmental quality in the Ba Vi National Park, especially for the surface water environment (Bui, 2012). Limitted information on the water environment quality, especially on microbial contamination in the Ba Vi National Park was published (Bui, 2012).

In this study, we presented the observation results of microbial contamination in surface water of the Ba Vi National Park, Ha Noi in the period 2013-2014 and 2018. The results may help for environmental management of the Ba Vi National Park.

2. Methodology

2.1. Study site description

Ba Vi National Park is located in Ba Vi district (Ha Noi) and Luong Son, Ky Son district (Hoa Binh province) with a total area of 10,815 ha; 50 km far from Ha Noi center, toward the West. The core zone includes a strict protection zone (2,069 ha), an ecological rehabilitation zone and an administrative and service area (8,714 ha) whereas the buffer zone covers more than 35,000 ha in 16 mountainous communes.

The rainy season lasts from April to October and the dry season occurs from November to next March. Higher temperature and rainfall was observed in rainy season (23^0C and 100 mm respectively) than in dry season (20^0C and 15.0 đến 64.4mm respectively) (People's Committee of Ba Vi district, 2014). The Da River (one main tributary of the Red River) and some small artificial reservoirs/lakes such as Suoi Hai lake, Dong Mo lake ... are responsible for water storage and regular water supply for production and for the local human demand in buffer zone (Ba Vi NTP, 2009).

Surface water in the Ba Vi has been used for different purposes such as domestic and agricultural activity (Pham Thi Tram, 2015; Nguyen Manh Hung, 2014).

There are no inhabitants in the forbidden forest of the Ba Vi National Park, but the population was relatively high in the buffer zone (89,928 inhabitants in 2008) and rapidly increased in the period 2013 - 2017 (Hanoi statistic Yearbook, 2017). Tourism activities are developing strongly with many tourist destinations, attracting approximately 80 thousand visitors per year in the period before 2010 (Bui, 2012). However, the numbers of tourist have been increased rapidly from 139,610 passengers in 2013 to 347,437 passengers in 2016 (Center for Ecotourism and Environmental Education of the Ba Vi National Park, 2017).

The main land occupation is agriculture (wet rice and cash crops, afforestation and fruit trees) in this area. Livestock is the second important agricultural production in this area. According to the Hanoi Statistical Office (2017), livestock in 2015 at Ba Vi were 34,520 cattles (buffaloes, cows); 181,112 pigs and 2,209 poultries and an increase trend was observed during the study period.

2.2. Method

Table 1: Sampling sites for observation of water quality in the Ba Vi National Park

No	Site name	Site position	Site description
1	NR1	21°04'48.7"N 105°22'10.8"E	Small stream in forest, core zone
2	NR2	21°04'30.7"N 105°21'53.3"E	Small stream in forest, core zone
3	NR3	21°04'08.2"N 105°22'55.7"E	Tien Stream, buffer zone
4	NR4	21°06'08.2"N 105°22'55.7"E	Small stream near communs, buffer zone
5	NR5	21°05'15.1"N 105°23'20.4"E	Tien Sa Lake buffer zone
6	NR6	21°05'39.1"N 105°23'22.3"E	Vua Pond, buffer zone

Sampling campaigns: Water samples were bimonthly taken during the period from August 2013 to July 2014 and one sampling campaign in March 2018 at six sites located in the Ba Vi National Park region (Table 1 and Figure 1). The samples were taken by the Vietnam Standard method TCVN 6663-6: 2008.

Sample preservation: Water samples were preserved by the Vietnam Standard method TCVN 5993: 1995.

Coliform determination: Total coliforms (TC) and fecal coliform (FC) densities are determined by the most probable number method according to the Vietnamese standard TCVN 6187-2: 1996 which is presented in detail in (Nguyen et al., 2014).

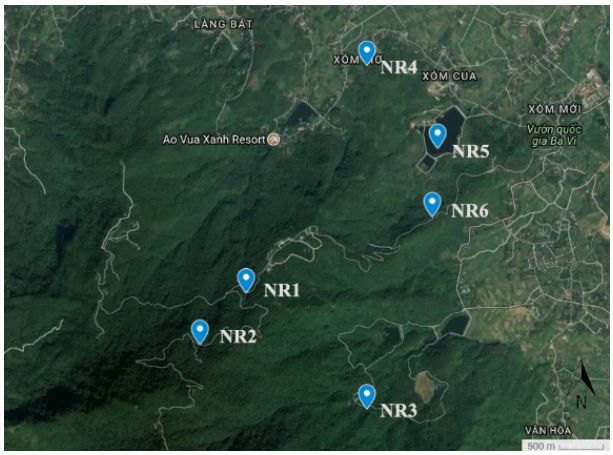

Figure 1. Map of sampling sites

3. Results and discussion

3.1 Total coliform (TC) and fecal coliform (FC) in water environment of the Ba Vi National Park

The results showed that TC density varied widely, from 23 to 110,000 MPN/100 ml in 2013-2014 and from 900 to 8,100 MPN/100ml in 2018. FC density ranged from 0 to 110 MPN/100 ml in 2013-2014 and from 0 to 600 MPN/100ml in 2018 (Table 2).

The median values of TC density of 6 sites in 2013-2014 (67 MPN/100ml) was within the allowable values of the Vietnam national technical regulation QCVN 08-MT:2015/BTNMT column A1 (2,500 MPN/100 ml) but the one in 2018 (4,050 MPN/100ml) was 1.6 times higher than the allowable value. However, during the period 2013-2014, many values of TC and FC at some sites increased dramatically. Notably, very high values, up to 11,000 MPN/100ml were observed at NR2 in April and June 2014 and at NR6 in June 2014. For the sampling campaign in 2018, the TC values at almost sites (NR1, NR4, NR5 and NR6) exceeded from 1.3 to 2.3 times higher than the permissible limits.

Similary to TC density, the median values of FC density of 6 sites in 2013-2014 (4 MPN/100ml) and 2018 (50 MPN/100ml) were within and 2.5 times higher than the allowable values of the Vietnam national technical regulation QCVN 08-MT:2015/BTNMT column A1 (50 MPN/100 ml). However, at several time observed, FC reached to a high value, e.g. at the NR1 site (100 MPN/100 ml), at NR2 site (300 MPN/100 ml) in July 2014 and in March 2018 and at NR5 site (600 MPN/100 ml) in March 2018.

The TC and FC densities at some time exceeded the allowable values, indicating the potential risks to the public health in this region when people use water for domestic and agricultural activity purposes (Pham Thi Tram, 2015; Nguyen Manh Hung, 2014). Due to the possibility of its pathogens and the spread of infection such as intestinal diseases, urinary tract infections, hepatitis, bronchitis….by harmful coliform group presented in water, effective sollutions should be applied for ameliorating water environment of this area.

Table 2. TC and FC (100 MPN/100ml) in surface water of the Ba Vi National Park

Sample Name	TC Median Min ÷ Max		FC Median Min ÷ Max	
	2013-2014	**2018**	**2013-2014**	**2018**
NR1	93 (23-430)	8,100	0 (0-36)	100
NR2	75 (23-11,000)	900	4 (0-10)	300
NR3	46 (43-230)	1,500	0 (0-23)	0
NR4	58 (23-11,000)	3,300	4 (0-110)	0
NR5	38 (36-93)	5,800	4 (0-43)	600
NR6	75 (63-93)	4,800	36 (0- 63)	0
All 6 sites	***67 38 ÷ 93***	***4,050 900÷8,100***	***4 0 ÷ 36***	***50 0 ÷ 600***
QCVN 08-MT: 2015	A1: 2,500; A2: 5,000; B1: 7,500; B2: 10,000		A1: 20; A2: 50 B1: 100; B2: 200	

Note: QCVN 08-MT: 2015/BTNMT column A1 - Used for domestic water supply (after normal treatment), aquatic animal and plant conservation and other purposes such as A2, B1 and B2; A2 - Used for domestic water supply but suitable treatment technology or use purposes such as B1 and B2; B1- For irrigation or other uses with similar water quality requirements or uses such as B2; B2- Navigation and other purposes with low quality water requirements.

In this study, the TC density of 6 sites in 2013-2014 varied in very large range, from 23 to 110,000 MPN/100 ml, with a median of 67 MPN/100 ml. Even very high values at some time were observed in the Ba Vi National Park, the median value was close with that of some lakes and streams in the world such as Kodaikanal and Yercaud tourist lakes in India (Rajakuman et al., 2006) (*Table 3*). However, much higher TC value in one sampling campaign in March 2018 was closed with that of the surface water in the Cat Ba National Park (Ngo, 2015), in the mangrove ecosystems of the Xuan Thuy National Park (Nguyen et al., 2008). These values were however, much still lower than the values of some urban rivers e.g, the To Lich River, Nhue River, Lu River and Cam River (Hai Phong) (Nguyen et al., 2014), where the domestic wastewater is the main cause of pollution.

Similar trend of FC densities in the water environment of the Ba Vi National Park which ranged from 0 to 110 MPN/100 ml during the whole period 2013 and 2018, with a median value of 4 MPN/100ml. The median value was far lower than the FC values of the Red River (Nguyen et al., 2014); the Pichhola lake, India (Dangi et al., 2017); the Kengeri lake, India (Latha et al., 2013); and in the surface water at livestock grazing region in Stanislaus National Forest, USA (CSERC, 2018). However, this value was close with the FC densities at the two Koda-

ikanal and Yercaud tourist lakes in Tamilnadu province, India (Rajakuman et al., 2006) (Table 3).

Table 3. TC and FC densitites (MPN/100ml) in surface water in the World

Location	TC Average Min ÷ Max	*FC* Average Min ÷ Max	*Reference*
Ba Be NTP[(a)]	650, 470, 586, 430	-	Nguyen et al., 2015
Cat Ba tourist area	1,200	-	Ngo, 2015
Xuan Thuy NTP	2,254	-	Nguyen et al., 2008
Red River	1,765 23 ÷ 11,000	191 0-1,600	Nguyen et al., 2014
To Lich River[(b)]	570.10^3 24.10^6	-	Nguyen et al., 2014
Nhue River	106,600 (at Thanh Tri)	-	Nguyen et al., 2014
Lu River	160.10^3	-	Nguyen et al., 2014
Cam River (Hai Phong province)	$405\text{-}24.10^3$	$310\text{-}19.10^3$	Nguyen et al., 2014
99 Florida Lakes (USA)	1,670 251 ÷ 5025	-	Hoyer et al., 2006
Kengeri lake (India)	640 (Sept) ÷ 1,500 (May)	210 (April) ÷ 510 (July)	Latha et al., 2013
Pichhola lake (India)	1,959	129	Dangi et al., 2017
Kodaikanal Lake (India)	46÷50[(c)] 46÷60[(d)] 33÷40[(e)]	27÷33[(c)] 33÷46[(d)] 17÷27[(e)]	Rajakuman et al., 2006
Yercaud Lake (India)	94÷140[(c)] 110÷180[(d)] 79÷110[(e)]	63÷94[(c)] 70÷110[(d)] 63÷79[(e)]	Rajakuman et al., 2006
Stanislaus National Forest (USA)	-	900[(f)] >1,600[(g)]	CSERC, 2018

Note: [(a)]in stream, Ba Be lake 1, 2 and 3; [(b)]at Thanh Liet dam and To pond; [(c)]summer; [(d)]monsoon, [(e)]winter, [(f)]at Herring, Jordan, Niagara and Rose Creek, [(g)] at Bell, Herring, and Rose Creek.

3.2 Factors affecting on TC and FC densities

As known, many environmental factors such as temperature, pH, nutrient contents, turbidity, salinity, hydrology and climate could control TC and FC presence in the water environment. In addition, TC and FC densities are directly affected by a wide range of human activities, such as domestic and industrial wastewater (point sources) and runoff from agricultural land... (non-point sources).

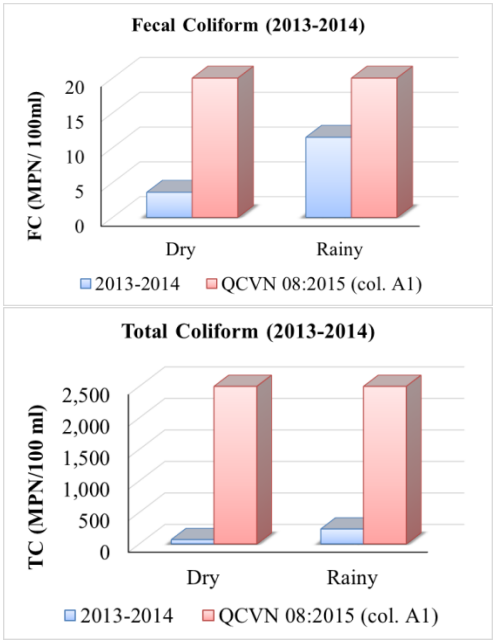

Figure 2. Median value of TC and FC in water surface of 6 sites of the Ba Vi National Park in dry and wet seasons during the period 2013-2014

Figure 2 shows the median values of TC and FC densities in dry (in the range 23 - 8,100 MPN/100ml; FC: 0 - 10 MPN/100 ml) and wet seasons (in the range TC: 23 - 11,000 MPN/100ml; FC: 0 - 600 MPN/100 ml) in the period 2013-2014. The results show that the median TC and FC densities in the rainy season were 3.5 and 3.0 times higher than the ones in the dry season. The study of (Rajakuman et al., 2006) also showed the difference between the TC and FC densities in rainy (summer) season compared to dry season (winter) in the Kodaikanal and Yercaud tourist lakes in Tamilnadu, India *(Table 3)*. Higher values of TC from 402 ÷ 46,110 MPN/100 ml in the rainy (summer) season than in the dry (winter) season 103 ÷ 4,920 MPN/100 ml, were also observed for the Xuan Thuy National Park in Vietnam (Haneji, 2014).

Land cover is an important factor in controlling TC and FC values. The study for the Seine river basin (France) showed that the FC in streams which flow through grassland grazing (FC: 1,000 MPN/100 ml) was much higher than the ones in streams flowing through the forest land and the cultivable land (FC: 100 MPN/100 ml) (Servais et al., 2007). These authors demonstrated that there was no significant difference between the average FC densities in streams which flow through forest land and cultivable land.

When comparing the values of TC and FC in March 2014 and 2018 (Figure 3), much higher values in 2018 (4,050 and 50 MPN/100 ml respectively) were found than the ones in in the period 2013-2014 (68 and 0 MPN/100 ml respectively).

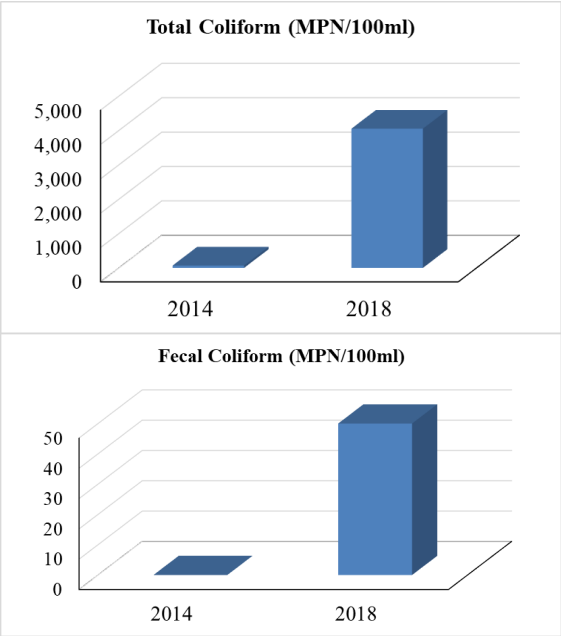

Figure 3. Median values of TC and FC densities in water surface of 6 sites in the Ba Vi NTP in March 2014 and March 2018 (dry season)

As known, FC is only presented in human and animal warm-blooded feces, the presence of FC in water environment indicates the human and animal (including warm-blooded wildlife) faecal inputs to natural waters in this region. Thus, the increased FC densities in water environment in March 2018 compared to March 2014 indicate the increase of human and animal warm-blooded feces toward water effluent (streams and lakes) in the Ba Vi National Park. As presented above, from the year 2013 to 2018, rapid changes in the economic and social conditions in this region were observed. The numbers of tourist increased three times from 2013 to 2016 (Center for Ecotourism and Environmental Education of the Ba Vi National Park, 2017). In this period, inhabitants and livestocks in the buffer zone have clearly increased (Hanoi Statistical Office, 2017). However, no information concerning wastewater collection or treatment for this area exists. We suggested that the increase of different point sources and non-point sources probably gave favorit for the increase of coliform during our study period. Our study emphrasises effective measures should be taken to treat and prevent the polluted sources in this area.

4. Conclusions

Total coliform and fecal coliform densities were observed in the water environment of the Ba Vi National Park in the periods 2013-2014 and 2018. The results showed that TC density varied widely, from 23 to 110,000 MPN/100 ml in 2013-2014 and from 900 to 8,100 MPN/100ml in 2018. FC density ranged from 0 to 110 MPN/100 ml in 2013-2014 and from 0 to 600 MPN/100ml in 2018. Notably at some time observed, both TC and FC values were much higher than than allowable values of the Vietnam national technical regulation QCVN 08-MT: 2015/BTNMT column A1.

The seasonal variation of both TC and FC was observed, probably due to higher temperature in rainy season than in dry season. The increase of TC and FC was found when comparing the values in March 2014 and March 2018. The median values of TC and FC during the period 2013-2014 were within the allowable values whereas both median TC and FC dendsities in 2018 were 1.6 and 2.5 times respectively higher than the allowable values. The increase trend of TC and FC in 2018 *vs.* 2013-2014 may reflect the increase of point and non-point sources in this region.

The TC and FC exceeded the allowable values, are the potential risk to public health in this area, especially when water in stream/lakes is used for agricultural activities. Thus, our results emphasizes the need for regular monitoring of water quality as well as for implementing effective solutions to treat and manage pollution sources in the area in order to protect the eco-environment and in parallel with economical-social development of the Ba Vi National Park region.

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