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Bacterial Quality Assessment of Lake Nasser Sediments During the Drought and Flooding Seasons

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IN EGYPT, Lake Nasser is an important water resource. So, this study was concerned with evaluating the quality of the lake via determination of bacterial load in sediment samples collected from fifteen sites along the lake, and ten sites of Dahmit and Tushka Khors before and after flooding in the years 2016 and 2019. Results indicated that the highest bacterial density was recorded during drought season and lowest in flooding seasons of both years. Statistically, the highest bacterial load was recorded in the middle stream compared to the other two sides. The northern part of Lake Nasser recorded higher bacterial density in 2019, while the southern part recorded higher bacterial density in 2016. *Salmonella* spp. were detected in about 56% of Lake Nasser samples in 2016, compared to 33% in 2019. Also, year 2016 recorded higher bacterial densities than in 2019, this may be due to the difference in flood strength, lake level, and sedimentation capacity from year to another. Finally, it is important to constantly monitor the quality of Lake Nasser to avoid any alteration of its natural characteristics.

Keywords: Bacterial quality, Khors, Lake Nasser, Sediments.

Introduction

Lake Nasser is the main source of fresh water in Egypt. Lake Nasser extends between latitudes 22° 31′ to 23° 45′ N and longitudes 31° 30′ to 33° 15′ E (El-Shabrawy & Dumont, 2003). The lake is man-made and it lies behind the High Dam, where the High Dam stores flood waters. The flood permanently begins at the end of July to the end of November (Abd Ellah, 2020). The construction of the High Dam began in 1960, and ended in 1970 (Awulachew et al., 2012). It has been built in southern Egypt to protect Egypt from floods, and to save water in all times. The High Dam Lake extends southwards for about 480km; 300km lie in Egyptian land, called Lake Nasser, and 180 km in Sudanese land, called Lake Nubia (El-Shabrawy & Dumont, 2003). Lake Nasser has a number of flooded side valleys (dendritic side extensions) known as Khors. There are 85 khors, 48 are located on the eastern side and 37 on the western side (Entz, 1973). These khors represent about 55% of the total lake volume and 79% of the total lake surface (El-Shabrawy, 2009). All khors are U-shaped in cross section. Some of them are wide, with a gentle slope and a sandy bottom, such as Kalabsha and Tushka, while others are steep, relatively narrow with a rocky bottom, such as Korosko (Latif, 1984). Khors are affected by changes in the lake Nasser water levels (Halls et al., 2015). Due to the importance of Lake Nasser to Egyptians, many governmental and research organizations are concerned with preserving the quality of the lake and protecting it from pollution. Lake Nasser extends in Egypt for about 300km, its morphometric features and khors differ from one site to the other in length, shoreline length, surface area, volume, width, and depth. This led to changes in limnological properties such as biological, chemical, physical, and geological properties (Gharib & Abdel Halim, 2006).

In general, the aquatic environment is exposed to pollution. The pollution increases with increasing human activity. Domestic, agricultural, and industrial wastewaters are the major sources of pollution, along with other human activities such as mining, fishing, oil from ships, etc.

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Water quality is not only determined through the determination of heavy metals or physical and chemical parameters, but also through the determination of microbial load. Determination of the total number of bacteria has been widely used in the assessment of microbial water quality (Ali, 2022), where the bacterial load reveals the source and amount of water pollution. Contamination of water samples is not only attributed to the bacterial load but also to the differential temperature ratio test (total number of bacteria at 22°C: total number of bacteria at 37°C), it indicates the level of contamination, where an increase over the recommended ratio of 10:1 means increase in the level of contamination (Ministry of Health, 1939; Van der Merwe & Britz, 1993). Also, bacterial indicators of pollution (total coliforms, faecal coliforms and faecal streptococci) indicate contamination by sewage. Furthermore, the ratio of faecal coliforms to faecal streptococci is used to differentiate between human (domestic) and animal (agriculture) wastes. As mentioned by Geldreich (1970), the ratio FC:FS lower than 0.7 points to pollution originating from animals, the ratio 0.7- 4.0 indicates people and animal pollution while the ratio is higher than 4.0 points concerning people pollution.

Many studies determined the microbial quality of water by measuring certain bacteriological parameters in water, but few studies measured it in sediments. Measurement in the sediments gives a strong indication of the occurrence of water pollution, because the formation of the sediment protects microbes, whether native or invasive, from phages and toxic microbial substances (Weiss, 1951; Roper & Marshall, 1979), which increases the survival rate of microbes, it is longer in sediment than in water (Goyal & Adams, 1984).

In this study, Lake Nasser was assessed by estimating the microbial load for sediments collected from eastern and western sides beside midstream of five sites (Aswan High Dam, Wadi Abyed, El Madiq, Tushka and Abu Simbel); as well as five sites of Dahmit Khor (located at the northeast of the lake) and five sites of Tushka Khor (located at the southwest of the lake), during dry and flood seasons for the years 2016 and 2019.

Materials and Methods

The study area

Sediment samples were collected from eastern and western sides, the midstream of five sites along Lake Nasser (Aswan High Dam, Wadi Abyed, El Madiq, Tushka and Abu Simbel), five sites of Dahmit Khor (located at the northeast of the lake) and five sites of Tushka Khor (located at the southwest of the lake). This is illustrated in Fig. 1 and Table 1 for the years 2016 and 2019 before and after flooding.

Sediment samples

Approximately one kilogram of sediment samples were collected using Ekman grab from each of the study sites. In the laboratory, ten grams of each sample were transferred aseptically to 90 ml of 0.85% sterile saline solution, and shaken for one hour, then serial dilutions (tenfold) from the original suspension were performed up to 10^7.

Enumeration of various bacterial groups

Various groups of bacteria were enumerated in sediment samples.

Total bacteria count

Determination of viable bacteria numbers at incubation temperatures of 22°C and 37°C was performed using nutrient agar medium (Atlas, 1946) and pour plate technique (APHA, 1999). This estimate is notably useful in determining bacterial load, and it is also useful in indicating changes in the source of water pollution by comparing changes in the total number of bacteria incubated at 22°C (autochthonous bacteria) and 37°C (allochthonous bacteria).

Total spore-forming bacteria

Successive dilutions were pasteurized, for 15 min at 80°C, before plating using nutrient agar and incubation at 30°C (APHA, 1999).

Total thermophilic bacteria

Nutrient agar plates of total thermophilic bacteria were incubated at 55°C (APHA, 1999).

Enumeration of various bacterial indicators of pollution

Total coliforms: MacConkey broth medium (Atlas, 1946) and multiple-tube technique, most probable number MPN (APHA, 1999) were used, then tubes were observed for acid and gas production after incubation at 37°C for 24 hours.

Faecal coliforms: MacConkey broth medium (Atlas, 1946) and MPN technique (APHA, 1999) were used, then tubes were observed for acid and gas production after incubation at 44.5°C in a water bath for 24h.

Faecal streptococci: Azide-dextrose broth medium (Atlas, 1946) and MPN technique (APHA, 1999) were used, then tubes were observed for turbidity after incubation at 37°C for 48 hours.

Total Enterobacteriaceae count: A suspension of 0.5mL was spread over eosin methylene blue agar medium (Atlas, 1946) and incubated at 37°C for 24h (APHA, 1999).

Detection of Salmonella spp. as pathogenic bacteria: Using spread plate technique and S-S agar (*Salmonella Shigella* agar) medium at 37°C incubation temperatures for 24h. Black colonies refer to a positive result (APHA, 1999).

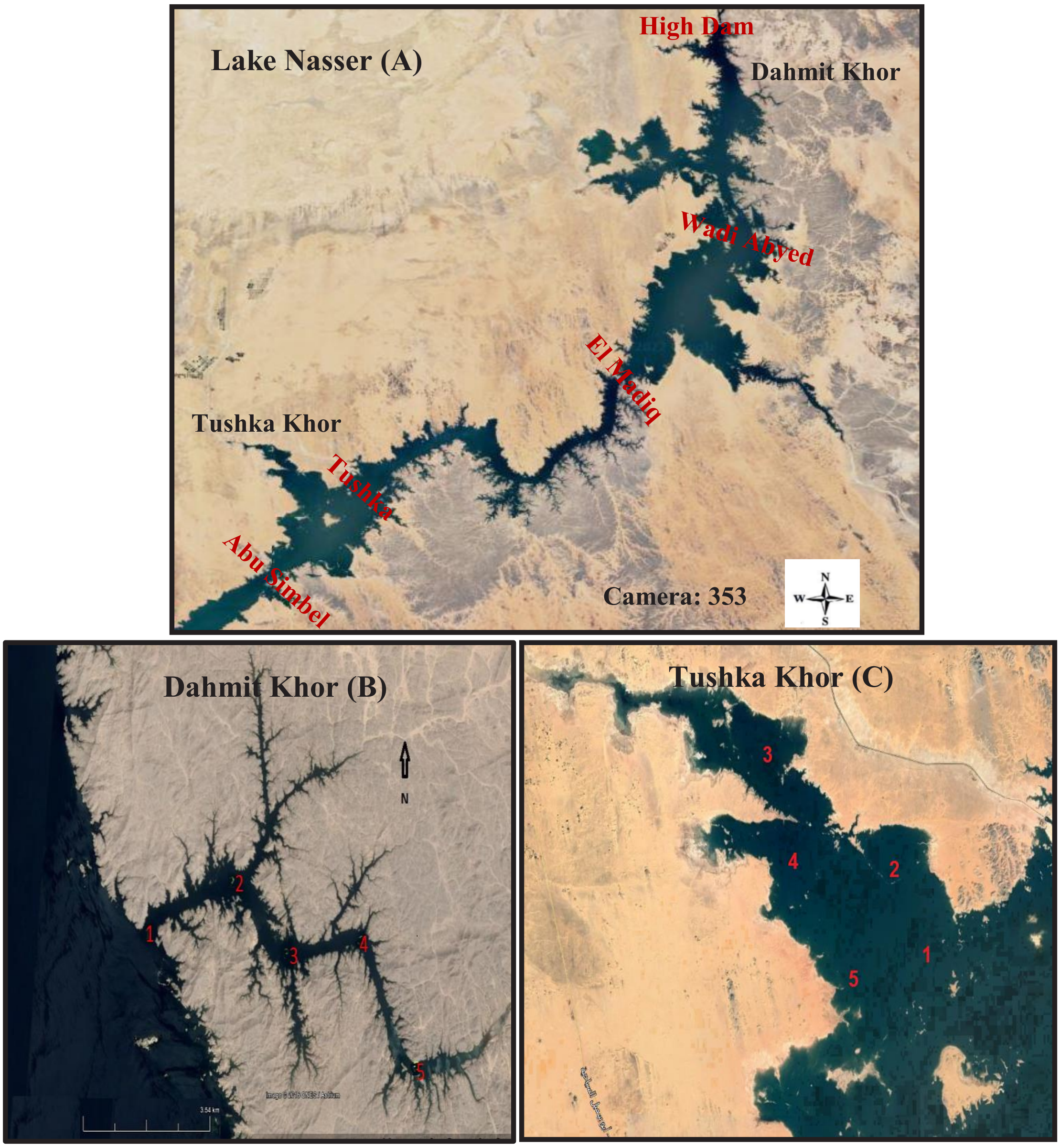

Fig. 1. A satellite image identifies sampling sites of five locations (A) along main channel of Lake Nasser (Aswan High Dam, Wadi Abyed, El Madiq, Tushka and Abu Simbel) as well as five locations of Dahmit (B) and Tushka (C) Khors of Lake Nasser (https://earth.google.com/web/search/high+dam,+aswan/@23.06213554,32.32294319,341.02856194a,352570.07629238d,35y,359.63506326h,0t,0r/data=CigiJgokCdUPKV1V4ChAEVNmM_yDbyfAGRy5827-vVBAIfifpyrDPCZA).

TABLE 1. Descriptions of the sampling sites and GPS data of five locations along main channel of Lake Nasser (Aswan High Dam, Wadi Abyed, El Madiq, Tushka and Abu Simbel) as well as five locations of Dahmit and Tushka Khors of Lake Nasser

Location	Site	GPS data
Main channel of Lake Nasser		
Aswan High Dam (2.9km from High Dam)	East	N: 23° 57' 38.34"; E: 32° 53' 53.14"
	Middle	N: 23° 57' 39.40"; E: 32° 52' 59.84"
	West	N: 23° 57' 57.24"; E: 32° 51' 45.25"
Wadi Abyed (74.3km from High Dam)	East	N: 23° 22' 39.27"; E: 32° 57' 21.50"
	Middle	N: 23° 22' 17.93"; E: 32° 56' 02.10"
	West	N: 23° 22' 41.22"; E: 32° 55' 13.30"
El Madiq (138.6km from High Dam)	East	N: 22° 54' 55.41"; E: 32°37'14.70"
	Middle	N: 22° 55' 21.23"; E: 32° 36' 43.69"
	West	N: 22° 55' 51.28"; E: 32° 36' 04.35"
Tushka (240km from High Dam)	East	N: 22° 34' 39.42"; E: 31° 55' 38.27"
	Middle	N: 22° 35' 28.23"; E: 31° 55' 33.98"
	West	N: 22° 35' 58.79"; E: 31° 52' 00.53"
Abu Simbel (268.8km from High Dam)	East	N: 22° 20' 11.31"; E: 31° 40' 50.66"
	Middle	N: 22° 20' 47.88"; E: 31° 39' 31.38"
	West	N: 22° 21' 10.13"; E: 31° 37' 57.75"
Dahmit Khor		
Dahmit Khor located at the northeast of the lake	1	N: 23° 45' 03.12"; E: 32° 57' 37.22"
	2	N: 23° 45' 29.31"; E: 32° 59' 02.32"
	3	N: 23° 44' 51.30"; E: 32° 59' 52.12"
	4	N: 23° 45' 04.39"; E: 33° 01' 06.49"
	5	N: 23° 43' 51.66"; E: 33° 02' 0.44"
Tushka Khor		
Tushka Khor located at the southwest of the lake	1	N: 22° 33' 44.15"; E: 31° 46' 26.31"
	2	N: 22° 37' 20.90"; E: 31° 44' 50.51"
	3	N: 22° 40' 55.05"; E: 31° 38' 37.59"
	4	N: 22° 36' 41.49"; E: 31° 40' 01.22"
	5	N: 22° 32' 55.23"; E: 31° 42' 53.80"

Statistical analysis

Data obtained were statistically analysed using STATISTICA 10 (StatSoft, Inc., Tulsa, USA). Analysis of variance (ANOVA) was used to examine the independent effects.

Results

Bacterial load in sediments of Lake Nasser during drought and flooding seasons in the years 2016 and 2019

Results of bacterial load in sediments obtained from different locations of Lake Nasser during the drought and flood seasons in 2016 and 2019 varied depending on the year, season and the site.

Bacterial load in sediments obtained from different locations of Lake Nasser during drought and flooding seasons 2016

Total bacterial numbers ranged from 4.8 to 9.5 Log No. g^{-1}. The highest significant numbers were recorded before flooding at the western side of Abu Simbel (9.5 Log No. g^{-1}) and the lowest numbers were recorded after flooding at the eastern side of Tushka site (4.8 Log No. g^{-1}) as shown in Fig. 2.

The same observation was recorded in case of the Enterobacteriaceae group, which recorded the highest significant numbers before flooding at the western side of Abu Simbel (8.2 Log No. g^{-1}) and the lowest numbers were recorded after flooding at the eastern side of Tushka site and western side of El Madiq (4.6 Log No. g^{-1}) as shown in Fig. 2.

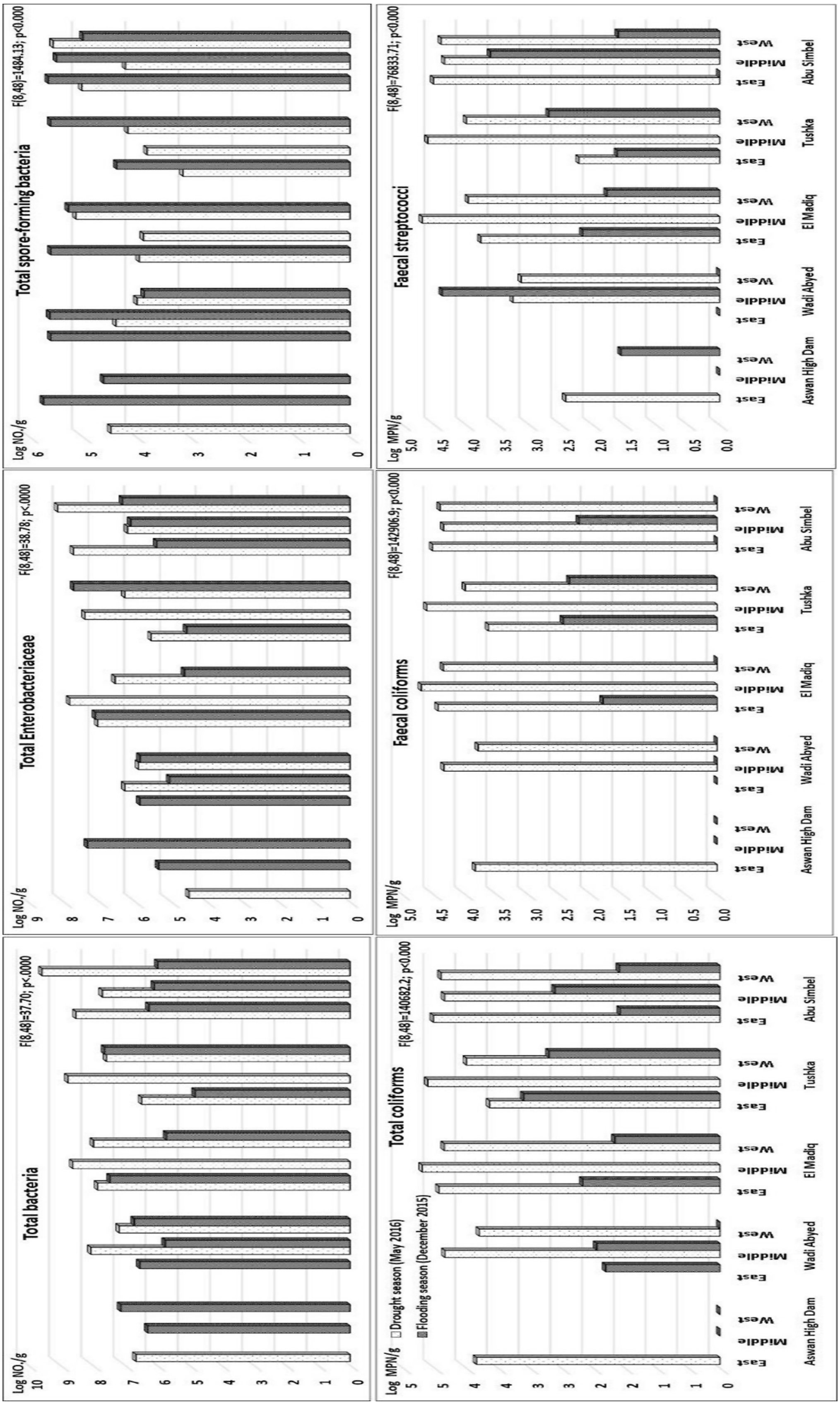

Fig. 2. Microbial population in sediments obtained from different locations of Lake Nasser during drought and flooding seasons of 2016

Total numbers of spore-forming bacteria ranged from 3.1 to 5.7 Log No. g^{-1}. The highest counts recorded after flooding compared to before flooding (Figs. 2, 3).

It is clear that the drought season recorded higher bacterial indicators of pollution compared to flooding season except the midstream of Wadi Abyed site which recorded the highest faecal streptococci during flooding season (4.4 Log MPN g^{-1}) compared to drought season (3.3 Log MPN g^{-1}).

In general, during drought season, the highest total bacterial numbers were recorded at the southern part of Lake Nasser (Abu Simbel) and progressively decreased downstream (decreased from 8.6 to 6.6 Log No. g^{-1}) except for the Tushka site; while during flooding season, numbers increased slightly downstream (from 6.1 to 6.7 Log No. g^{-1}). Furthermore, bacterial indicators of pollution progressively decreased downstream as shown in Fig. 3.

Statistical analysis (Table 2) showed that the southern part of Lake Nasser (Abu Simbel) recorded highest numbers for total Enterobacteriaceae and total spore-forming bacteria, while the midstream of Nasser Lake (El Madiq) recorded highest numbers for total bacteria, total Enterobacteriaceae and faecal streptococci. Northern part of Lake Nasser (Aswan High Dam) recorded lowest bacterial load for all the studied bacterial groups except for total spore-forming bacteria. Regardless of sites and seasons, the western side of Lake Nasser recorded highest numbers for total Enterobacteriaceae and total spore-forming bacteria; with lowest numbers for total and faecal coliforms. While midstream Lake Nasser recorded highest numbers of total bacteria and various bacterial indicators of pollution. Regardless of the sides and sites effects, drought season recorded highest bacterial load for all the studied bacterial groups except for total spore-forming bacteria as shown in Table 2.

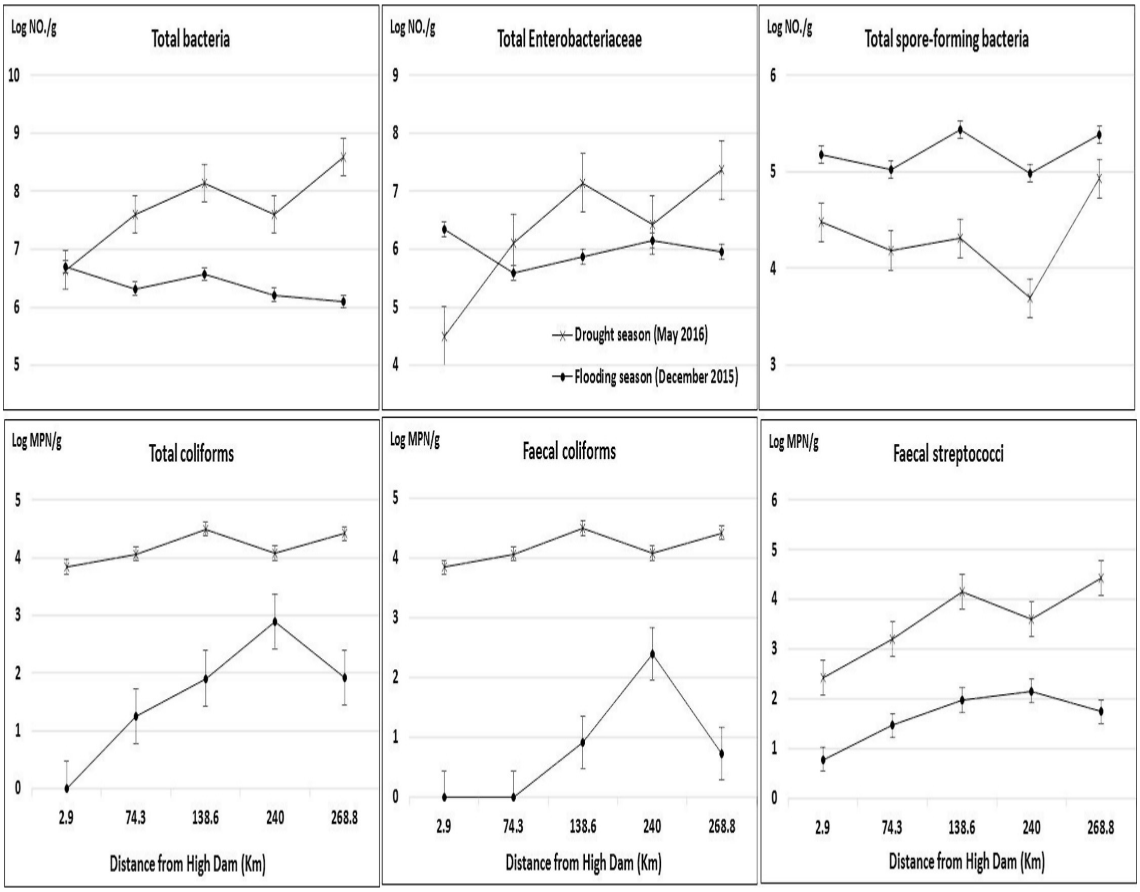

Fig. 3. Changes in microbial load in sediments obtained from different locations of Lake Nasser during drought and flooding seasons (2016)

TABLE 2. Statistical analysis (ANOVA analysis) of the bacterial load for Lake Nasser during the drought and flooding seasons in 2016 as affected by seasons (drought and flood), sites (Aswan High Dam, Wadi Abyed, El Madiq, Tushka and Abu Simbel) and the sides (east, middle and west)

	TBC	TE	TSFB	TC	FC	FS
Sites effect						
Aswan High Dam	6.68 d	5.73 c	4.94 b	1.28 e	1.28 e	1.33 e
Wadi Abyed	6.84 d	5.80 c	4.69 d	2.37 d	1.63 d	2.16 d
El Madiq	7.51 a	6.64 a	4.76 c	3.46 b	3.06 b	3.28 a
Tushka	7.04 c	6.31 b	4.21 e	3.60 a	3.40 a	3.03 c
Abu Simbel	7.34 b	6.67 a	5.16 a	3.17 c	2.58 c	3.10 b
In the same column, means followed by the differ letter are significantly different (P ≤ 0.05).						
Sides effect						
East	6.81 b	5.97 c	4.73 b	3.13 b	2.58 b	2.09 c
Middle	7.31 a	6.32 b	4.73 b	3.22 a	2.88 a	3.56 a
West	7.26 a	6.54 a	4.80 a	2.50 c	2.10 c	2.57 b
In the same column, means followed by the differ letter are significantly different (P ≤ 0.05).						
Seasons effect						
Drought	7.90 a	6.63 a	4.31 b	4.25 a	4.25 a	3.78 a
Flood	6.35 b	5.95 b	5.20 a	1.59 b	.73 b	1.62 b
In the same column, means followed by the differ letter are significantly different (P ≤ 0.05).						

TBC, total bacteria count; TE, total Enterobacteriaceae; TSFB, total spore-forming bacteria; TC, total coliforms; FC, faecal coliforms; FS, faecal streptococci.

Bacterial load in sediments obtained from different locations of Lake Nasser during drought and flooding season 2019

Total bacterial loads of various bacterial groups were statistically highest in drought season and lowest in flooding season, except total thermophilic bacteria (Figs. 4, 5). Total bacteria count at 22°C ranged from 4.6 to 9.5 Log No. g^{-1}. The highest numbers were recorded before flooding at the midstream of Wadi Abyed site, and the lowest numbers were recorded after flooding at the western side of Tushka (Fig. 4). Total bacteria count at 37°C ranged from 4.5 to 9.2 Log No. g^{-1}. The highest numbers were recorded before flooding at the western side of Wadi Abyed and the lowest numbers were recorded after flooding at the eastern side of Tushka site. The numbers of total bacteria at 22°C and 37°C were almost comparable, where the ratios between total bacterial count at 22°C: at 37°C ranged from 0.8-1.2 in the drought season and 1.0-1.1 in the flood season.

Total numbers of spore-forming bacteria ranged from 3.1-5.5 Log No. g^{-1}, and the highest numbers were recorded before flooding at the midstream of Abu Simbel site, and the lowest numbers were recorded after flooding at the western side of El Madiq (Fig. 4).

Means numbers of thermophilic bacteria were almost comparable, except Aswan High Dam and Tushka sites, as shown in Fig. 5.

Total coliforms ranged from 0.0 to 5.0 Log MPN g^{-1}. It is important to mention that no total coliforms were found in the midstream after flooding for most of the sites (Fig. 4).

Faecal streptococci numbers ranged from 0.3 to 4.8 Log MPN g^{-1}. The highest numbers were recorded before flooding at the midstream of El Madiq site, and the lowest numbers were recorded after flooding at the midstream of Aswan High Dam site (Fig. 4).

Statistical analysis (Fig. 6) showed that the highest numbers of total bacteria at 22°C and 37°C were recorded in Wadi Abyed site, and the lowest numbers were recorded in Tushka site. While Abu Simbel site recorded highest numbers of spore-forming bacteria, thermophilic bacteria and faecal streptococci (Fig. 6). In general, midstream of Lake Nasser recorded highest numbers of all the studied bacterial groups except for total coliforms. Drought seasons, in general, recorded highest bacterial load for all the studied bacterial groups except for total thermophilic bacteria as shown in Fig. 6.

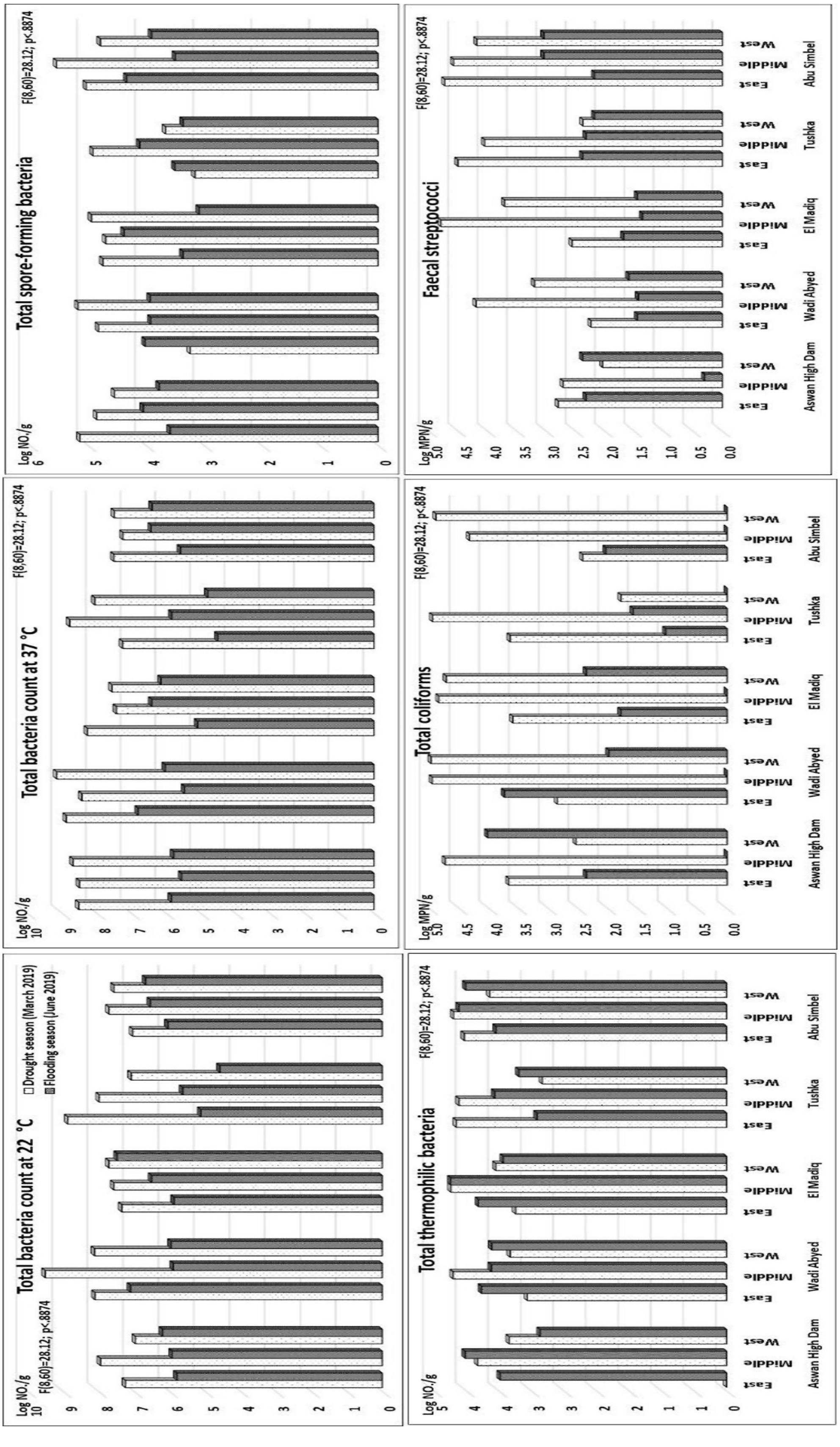

Fig. 4. Microbial population in sediments obtained from different locations of Lake Nasser during drought and flooding seasons of 2019

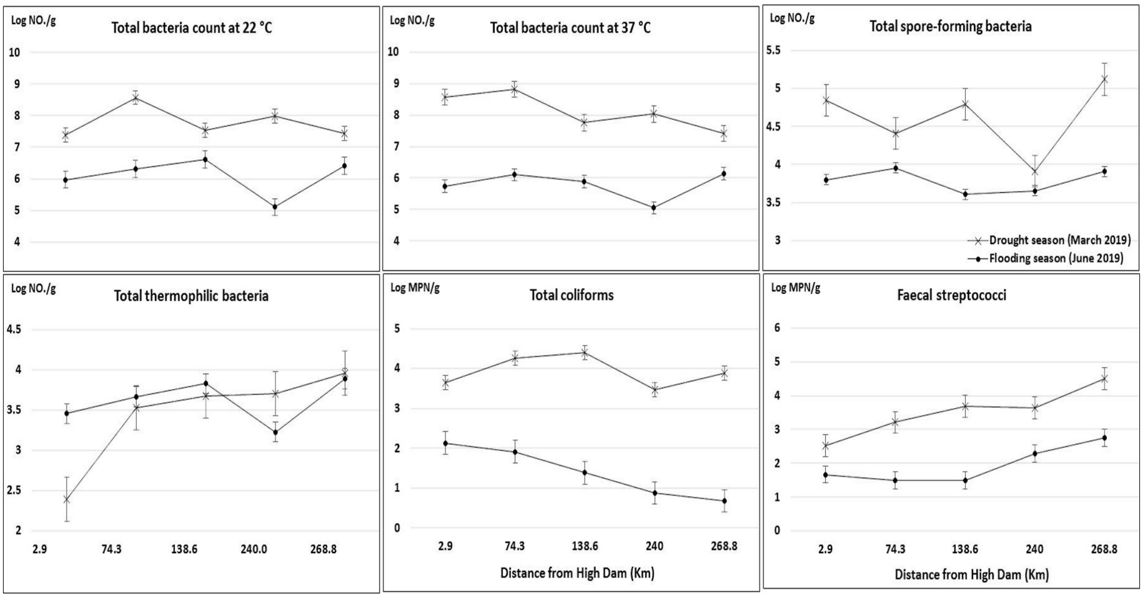

Fig. 5. Changes in microbial load in sediments obtained from different locations of Lake Nasser during drought and flooding seasons (2019)

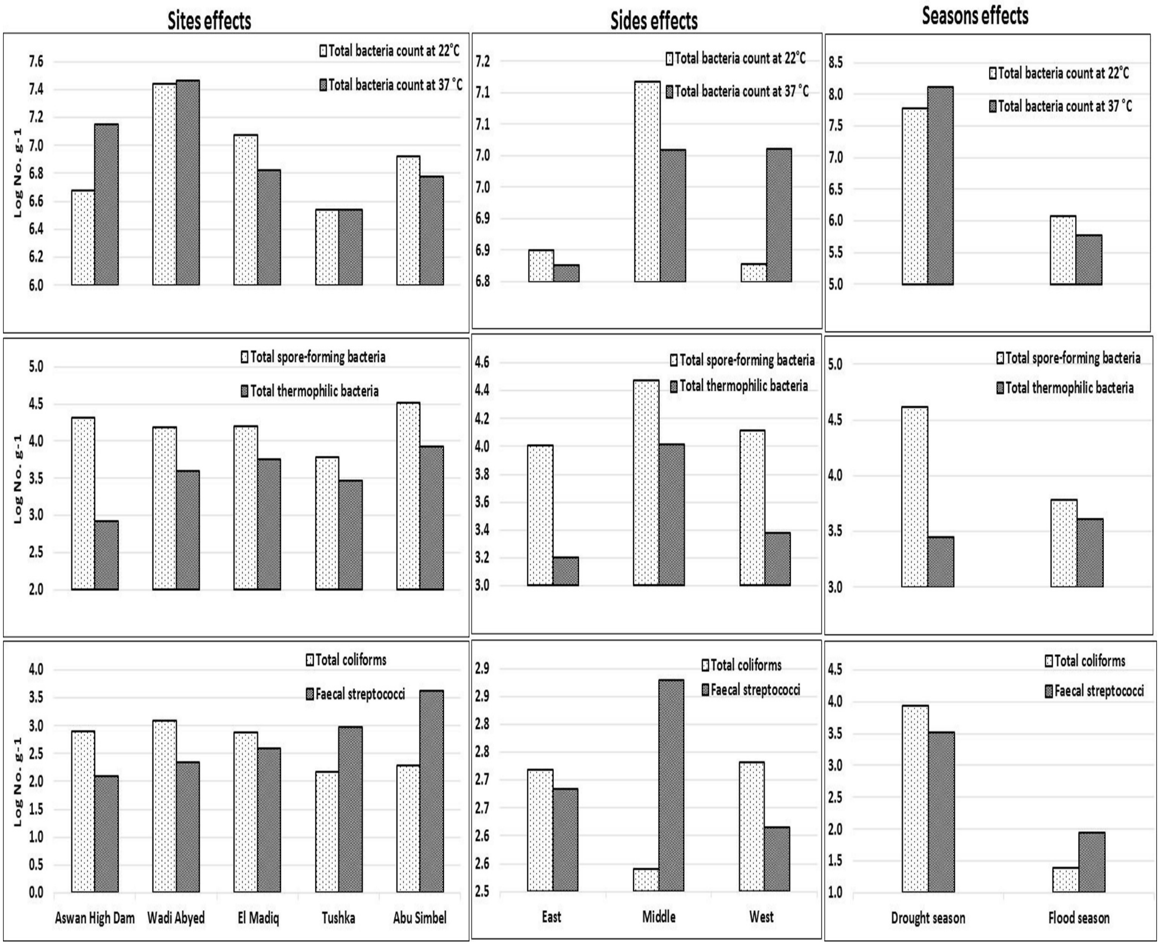

Fig. 6. Statistical analysis (ANOVA analysis) of the bacterial load for Lake Nasser during the drought and flooding seasons in 2019 as affected by seasons (drought and flood), sites (Aswan High Dam, Wadi Abyed, El Madiq, Tushka and Abu Simbel) and sides (east, middle and west)

Differentiation of the bacterial Load of Lake Nasser sediments in 2016 and 2019

Comparison of the bacterial load of Lake Nasser sediments in 2016 and 2019 are illustrated in Fig. 7. The means of bacterial loads were almost comparable in 2016 and 2019 (total bacteria, spore-forming bacteria, total coliforms and faecal streptococci were 7.1, 4.8, 2.8, and 2.6 Log MPN g^{-1} respectively in 2016, and 7.0, 4.2, 2.7, and 2.7 Log MPN g^{-1} respectively in 2019). El Madiq site and the southern part of Lake Nasser recorded higher numbers of total bacteria and total coliforms in 2016 than in 2019. In contrast, northern part of Lake Nasser (Aswan High Dam and Wadi Abyed) recorded higher numbers of total bacteria and total coliforms in 2019 than in 2016. Higher numbers of spore-forming bacteria were recorded in 2016 compared to 2019. There were more numbers of faecal streptococci in 2016 than in 2019 in the sites El Madiq and Tushka, and vice versa in other sites. *Salmonella* spp. were detected in about 56% of Lake Nasser samples in 2016, compared to 33% in 2019.

Bacterial loads in sediments of Dahmit and Tushka Khors

Bacterial loads in sediments obtained from different locations of Dahmit and Tushka Khors during drought and flooding of season 2016

Results of bacterial loads in sediments obtained from different locations of Dahmit and Tushka Khors during drought and flooding of season 2016 are illustrated in Fig. 8. Middle of Dahmit Khor (side 3) recorded highest numbers of total bacteria in drought and flooding seasons (8.7 and 8.5 Log No. g^{-1} respectively), followed by (side 5) ending khor (8.1 and 7.5 Log No. g^{-1} respectively). While the ending of Tushka Khor (side 3) recorded highest numbers for total bacteria in drought season (8.4 Log No. g^{-1}), the beginning of khor (side 1) recorded highest numbers in flooding season (7.4 Log No. g^{-1}). In general, drought season recorded higher total bacteria numbers than flooding seasons either in Dahmit or Tushka Khors (means 7.9 and 7.5 Log No. g^{-1} for drought and flooding seasons respectively in Dahmit Khor, and means 7.9 and 6.9 Log No. g^{-1} for drought and flooding seasons respectively in Tushka Khor).

Also, middle of Dahmit Khor recorded the highest numbers for total spore-forming bacteria either in drought season (side 4) or in flooding seasons (side 3). And middle of Tushka Khor (side 4) recorded highest numbers either in drought or flooding seasons (4.7 and 5.4 Log No. g^{-1} respectively). In general, higher numbers of total spore-forming bacteria were recorded in the flooding season compared to drought season either in Dahmit or Tushka Khors.

Also, higher numbers of Enterobacteriaceae group were recorded in the middle of Dahmit Khor (8.0 and 7.7 Log No. g^{-1} for drought and flooding seasons respectively), while ending of Tushka Khor (side 3) recorded higher numbers of Enterobacteriaceae group (7.5 and 7.0 Log No. g^{-1} for drought and flooding seasons respectively). In Dahmit Khor, highest numbers of Enterobacteriaceae were recorded in drought than flooding seasons (means 6.9 and 6.5 Log No. g^{-1} respectively), while in Tushka Khor there are no differences between drought and flooding seasons (means of 6.4 Log No. g^{-1}).

The same observation was recorded for bacterial indicators of pollution. In Dahmit Khor, the highest numbers were recorded in the middle of khor either in drought or flooding seasons (4.6 and 4.5 Log No. g^{-1} respectively). In Tushka Khor, highest numbers were recorded in the ending of khor (4.6 Log MPN g^{-1}) in the drought season, and in the beginning of the Khor in the flooding season (Fig. 8).

Bacterial loads in sediments obtained from different locations of Dahmit and Tushka Khors during drought and flooding season of 2019

Numbers of total bacteria at 22°C and 37°C were almost comparable, where the ratio between total bacterial counts at 22°C: 37°C ranged from 0.9 to 1.3 in Dahmit khor and 0.8 to 1.3 in Tushka khor. Drought season recorded highest numbers at 22°C or 37°C than flooding season either in Dahmit or Tushka Khors as illustrated in Fig. 9. The beginning of Dahmit Khors (site 2) recorded higher bacterial numbers (9.1 and 8.7 Log No. g^{-1} of total bacteria at 22°C and 37°C respectively) in drought season, while ending of Dahmit Khors (site 5) recorded higher numbers (6.0 and 5.9 Log No. g^{-1} of total bacteria at 22 and 37°C respectively) in flooding season. The Beginning of Tushka khor (site 2 and site 5) recorded higher numbers. Site 2 recorded 7.0 and 7.1 Log No. g^{-1} of total bacteria at 22°C and 37°C respectively in drought season, while site 5 recorded 7.5 and 5.9 Log No. g^{-1} at 22 and 37°C respectively in the flooding season.

Higher numbers of total spore-forming bacteria were recorded in the drought season compared to flooding season either in Dahmit or Tushka Khors (Fig. 9). While higher numbers for thermophilic bacteria recorded in the flooding season compared to drought season.

Bacterial indicators of pollution (total coliforms and faecal streptococci) are illustrated in Fig. 9. Drought season recorded higher total coliform numbers than flooding season in all studied sites except ending of Dahmit Khor (site 5), and beginning of Tushka Khor (site 5) as shown in Fig. 9. There are little differences between drought and flooding seasons for faecal streptococci in Dahmit Khor (means 3.2 and 3.1 Log MPN g^{-1} respectively). In Tushka Khor drought season recorded higher numbers than flooding season (means of 3.4 and 2.1 Log MPN g^{-1} respectively).

Comparison of the bacterial loads in sediments of Dahmit and Tushka Khors in 2016 and 2019

Comparison of the bacterial loads of Lake Nasser sediments in 2016 and 2019 are illustrated in Fig. 10. In general, drought season recorded higher population for the various bacterial groups studied than flooding season either in Dahmit or Tushka Khors. Year 2016 recorded a higher population than year 2019 except for faecal streptococci.

In fact, there is a similarity in the density of *Salmonella* spp. in 2016 and 2019. This was detected in about 30% of Khors samples in both years.

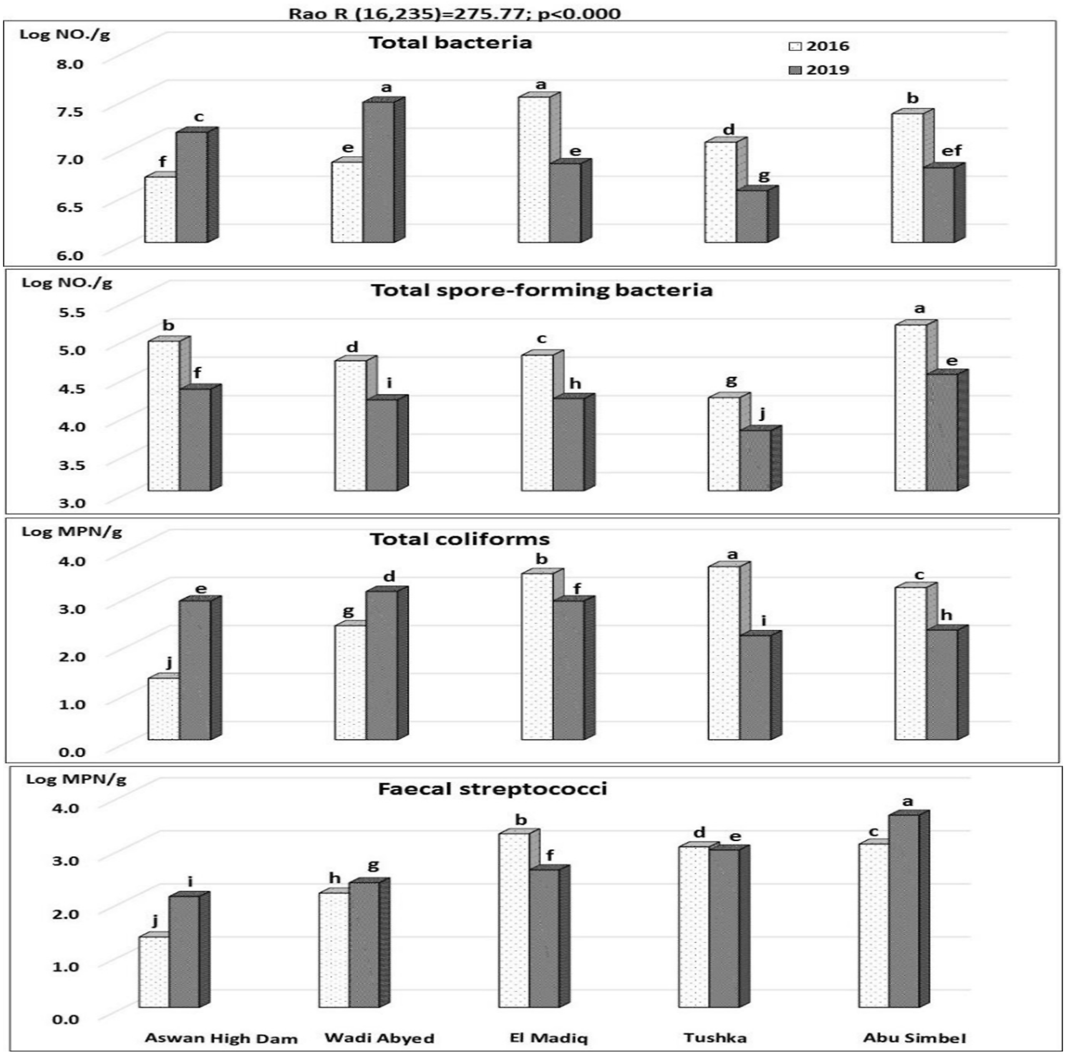

Fig. 7. Bacterial load at the experimental sites of Lake Nasser as affected by years 2016 and 2019 [The differ letter are significantly different (P ≤ 0.05)]

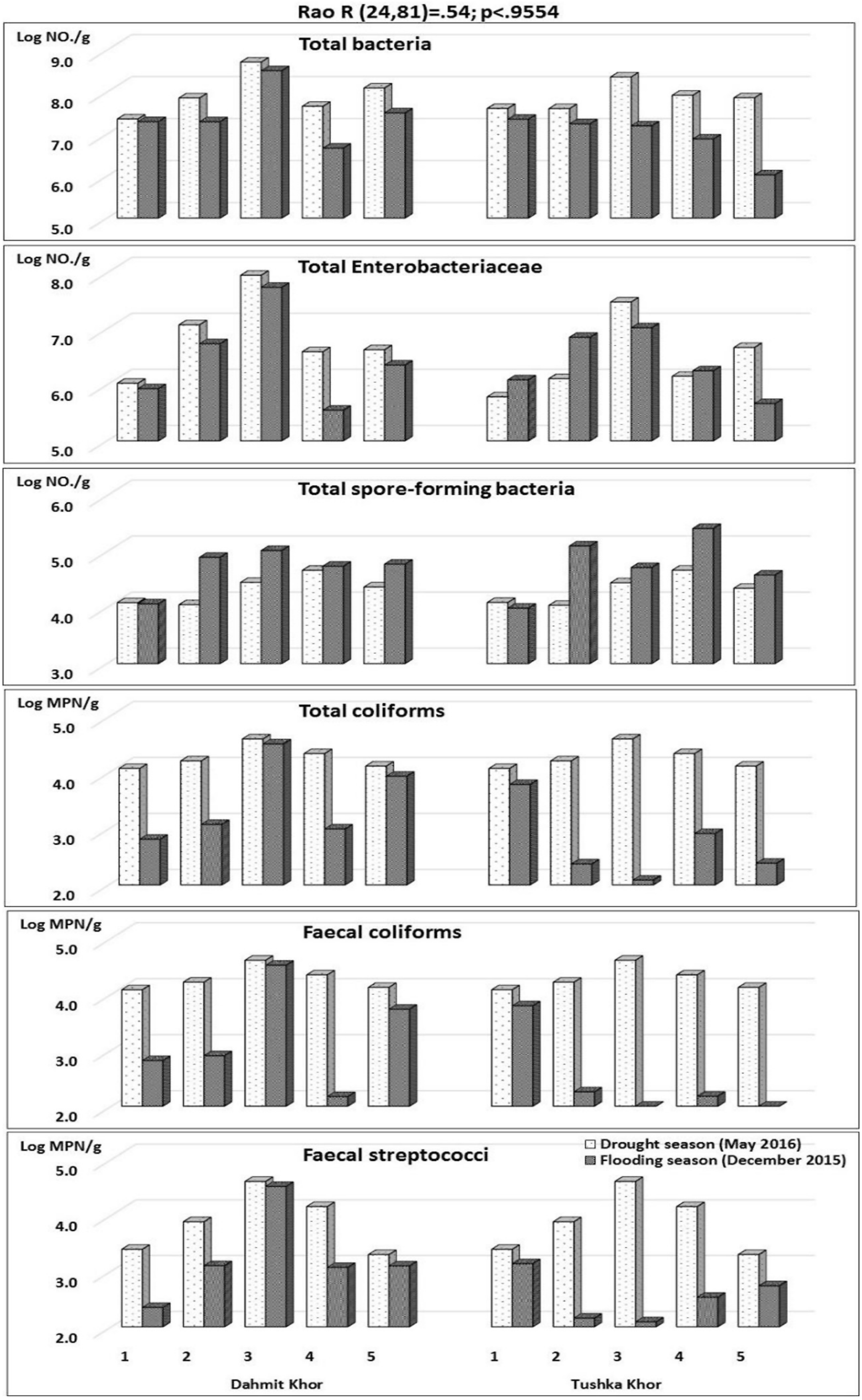

Fig. 8. Microbial population in sediments obtained from different sites of Dahmit and Tushka Khors during drought and flooding seasons of 2016

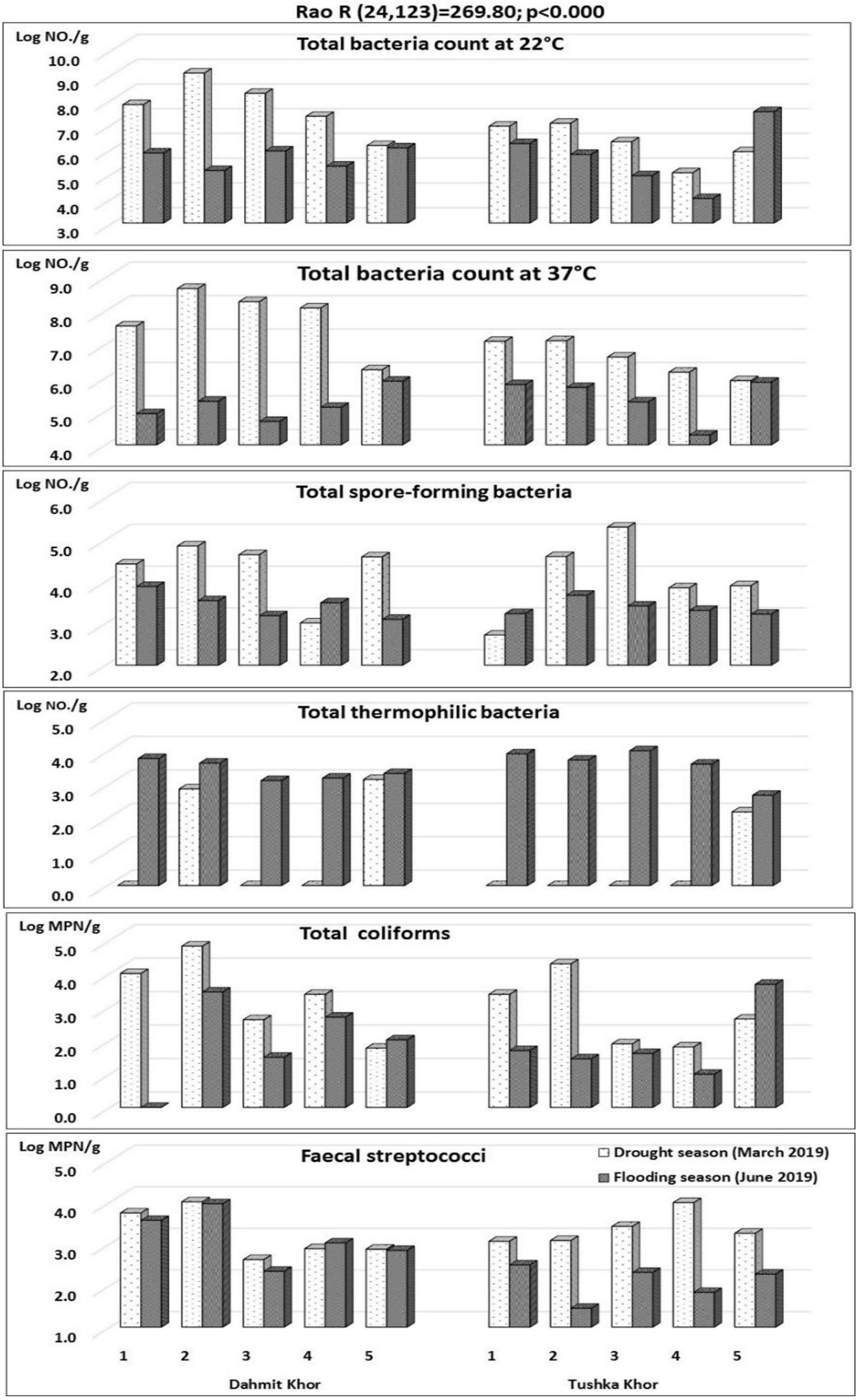

Fig. 9. Microbial population in sediments obtained from different sites of Dahmit and Tushka Khors during drought and flooding seasons of 2019

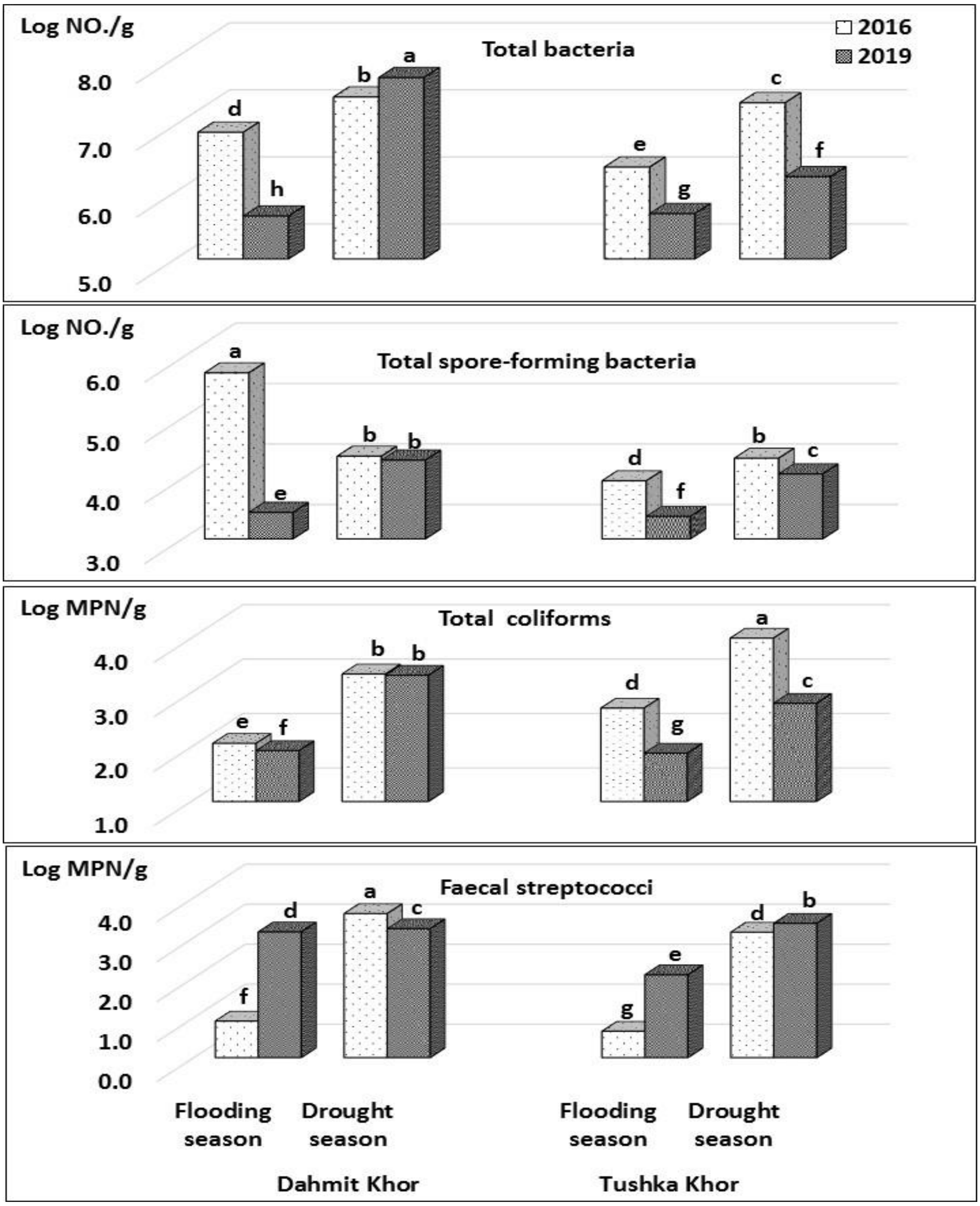

Fig. 10. Bacterial load at the experimental site of Dahmit and Tushka Khors as affected by years 2016 and 2019 [The differ letter are significantly different ($P \leq 0.05$)]

Discussion

Microbial community density is used to assess the overall health of an ecosystem. Such as the benthic invertebrates populations (EI-Tantawy et al., 2003), and the bacterial community (Othman et al., 2016; Ali, 2022), because they are sensitive to environmental pollutants. Lake Nasser is the main source of fresh water in Egypt. Hence, this study evaluates the quality of the lake water through determination of bacterial loads in sediments. The results showed that the bacterial load decreased downstream in the dry season, while it increased downstream in the flood season, this may be due to the effects of flooding, which carries a large amount of nutrients and silt (Toufeek & Korium, 2009). Also, the distribution of fauna and flora in the lake is affected by the current speed (ranged from 0 to 3cm/sec in Lake Nasser), where it affects the sedimentation of organic matter (Nicholas, 1970). Besides, depth of sediments has effects on the distribution of grain size, where the clay size increased with depth (El Dardir, 1994), this also affects the distribution of fauna and flora in the lake (Iskaros & El Dardir, 2010). Midstream of Lake Nasser recorded highest numbers of all the studied bacterial groups except total coliforms comparing other two sides. This demonstrates the influence of both sediment type and sediment organic content, where Farhat & Salem (2015) recorded that sediment types in Lake Nasser differ from silty clay or clayey silt, in addition to that the eastern and western sides of the lake contains more sand. The bacterial load being statistically highest in drought season and lowest in flooding season either in 2016 or 2019, this may be due to that sedimentation led to increasing nutrients in drought season than in flooding season.

Moreover, the bacterial indicators of pollution gradually decreased downstream, this may be due to the increase of tourism activity in the south of Abu Simbel Temple, where the western side of Abu Simbel at drought season 2016 recorded highest significant numbers of the total bacteria, and total Enterobacteriaceae group. In general, southern part of Lake Nasser recorded higher bacterial loads. El Madiq recorded higher numbers of bacteria, Abu Simbel recorded higher numbers of Enterobacteriaceae group, and Tushka recorded higher numbers of total coliforms. These results agree with Ali (2022), who reported that higher microbial load was recorded in southern part of Lake Nasser compared to the northern part. And agree with Rabeh (2003), who reported that the fishing and grazing activities around the lake are the main source of Lake Nasser pollution.

Comparing bacterial load in the year 2016 and 2019, northern part of Lake Nasser recorded higher bacterial density (total bacteria and total coliforms) in year 2019, while the southern part recorded higher bacterial density in year 2016. Also, the bacterial load being highest in the middle stream either in 2016 or in 2019 compared to the other two sides, this may be due to the impact of human activity lesser than the impact of the passage of cruise ships to Sudan, and to Abu Simbel temple in the south. Season 2016 recorded higher bacterial density than 2019 except faecal streptococci, this may be due to the difference in flood strength, lake level, and sedimentation capacity from year to year (Elsahabi et al., 2018).

Conclusions

The quality of the lake can be determined by estimating the microbial load in the sediments. The results show that there is an improvement in the microbial quality of the lake in 2019 compared to 2016, especially in the southern part of it.

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تقييم الجودة البكتيرية لرواسب بحيرة ناصر أثناء موسمى الجفاف والفيضان

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تعد بحيرة ناصر مصدرًا مائيًا مهمًا في مصر، لذا فقد اهتمت هذه الدراسة بتقييم جودة البحيرة من خلال تحديد الحمولة البكتيرية في عينات الرواسب التي تم جمعها من خمسة عشر موقعاً على طول البحيرة، وعشرة مواقع في خور دهميت وخور توشكي قبل وبعد الفيضان في عامي 2016 و2019.

أوضحت النتائج أن أعلى كثافة بكتيرية سجلت خلال موسم الجفاف وأدنى كثافة في موسم الفيضان في كلا العامين .إحصائيا، كما سجل مجرى البحيرة الأوسط أعلى حمل بكتيري مقارنة بالجانبين الآخرين. كذلك سجل الجزء الشمالي من بحيرة ناصر كثافة بكتيرية أعلى في عام 2019 ، بينما سجل الجزء الجنوبي كثافة بكتيرية أعلى في عام 2016 . أيضاً تم اكتشاف % *Salmonella* sp. في حوالى56% من عينات بحيرة ناصر عام 2016 مقارنة ب 33% عام 2019. كما سجل عام 2016 كثافات بكتيرية أعلى من عام 2019 ، وقد يرجع ذلك إلى اختلاف قوة الفيضان واختلاف مستوى البحيرة ومعدل الترسيب من عام لآخر. وأخيرا، من المهم مراقبة جودة بحيرة ناصر بشكل مستمر لتجنب أي تغيير في خصائصها الطبيعية.