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The Influence of Discharge Effluents on the River Nile Water Quality at Aswan Governorate, Egypt

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ABSTRACT

The disposal of El-Sail drain, Kom Ombo drain, Edfu ferroalloys factory, and Edfu sugar cane factory around Aswan city poses a serious threat to the River Nile waters, especially El-Sail and Kom Ombo drains which recorded higher microbial load. Kom Ombo drain recorded higher total bacterial counts (TBC) at 22 °C (1800 $x10^3$ cfu/ml), thermophilic bacteria (259 cfu/ml) and spore-forming bacteria (15.8 $x10^3$ cfu/ml). While El-Sail drain recorded higher TBC at 37 °C (137 $x10^3$ cfu/ml) and higher values for indicator bacteria (total coliforms, faecal coliforms, and faecal streptococci). In addition, warmer seasons (spring and summer) showed higher counts of indicator bacteria *Salmonella* sp. and *Shigella* sp. in 22 and 30 % of samples, respectively, whereas *Escherichia coli* was detected in all sites, recording the highest values at El-Sail drain samples. Furthermore, El-Sail drain samples recorded the highest values for electrical conductivity, total dissolved solids, biochemical oxygen demand, NH_3, NO_2^- and PO_4^{3-}, while Kom Ombo drain samples recorded the highest values for water temperature and NO_3^-. Ranks of water quality index (WQI) were good in all sites, except for the disposal sites which ranged from fair to marginal. In conclusion, the River Nile water at Aswan governorate is heavily polluted, especially at El-Sail drain and Kom Ombo drain. Consequently, treatment and safe disposal of different industrial and domestic wastes are recommended.

INTRODUCTION

Pumped pollutants (undesirable substances) change the natural properties of water and damage the aquatic system, and hence, it is dangerous for aquatic organisms **(Canli & Kalay, 1988; Nda *et al.*, 2018)**. The River Nile is the main source of freshwater in Egypt, therefore it must be maintained with good quality. In this context, many studies have been conducted to monitor and control freshwater, through addressing microbiological, physical, and chemical measurements **(Soltan, 1991; Awadallah *et al.*, 1993; Ismail & Ramadan, 1995; Abdel-Satar & Elewa, 2001; Ali *et al.*, 2015; Rawway *et al.*, 2016; El-Sheekh *et al.*, 2018; Elbadry, 2019)**. It is worth mentioning that, microbial contamination is one of the most important factors of water pollution, especially pathogenic microorganisms **(Rawway *et al.*, 2016)**. Faecal coliform and streptococcus bacteria have also been used to indicate contamination of water with feces, and this is a risk to human health because this means that the water source receives large amounts of domestic and agricultural waste, and there is also a high possibility of a large number of pathogenic bacteria **(Ali *et al.*, 2000)**.

The quality of the Nile water varies with regard to place and time. It is affected by human activities (e.g. population, industry, fishing, and agriculture) and seasonal change (e.g. floods and cold or hot seasons). Additionally, the quantities and qualities of wastewater effluents are major influences on water quality **(Ali *et al.*, 2011)**. There is no significant pollution at the beginning of the Nile flow in the far south of Egypt **(Othman *et al.*, 2016)**. But, with the beginning of human activities, and at every point of discharge, contaminated water has been observed **(Ali *et al.*, 2011; Ali *et al.*, 2016)**.

Many indexes have been used to determine water quality and pollution rate. For example, the contamination index (CI) measures the relative contamination of different metals in the separated and combined state **(Backman *et al.*, 1998)**. The heavy metal pollution index (*HPI*) is an effective estimating method to evaluate water quality with respect to heavy metals **(Zakhem & Hafez, 2015)**. Aquatic toxicity index (ATI) was developed by **Wepener *et al.* (1992)** to estimate the health of aquatic ecosystems based on the effects of water parameters on fish health. The water quality index (WQI) is the most important index for the evaluation of water quality. The calculation of WQ1 is based on the number of physicochemical and bacteriological parameters **(Poonam *et al.*, 2013)**. Water quality index displays the grade of water quality in rivers, lakes, and streams and addresses the water quality data in simple expressions as excellent, good, and bad **(Al-Shujairi, 2013)**.

Four visible drains were detected in Aswan Governorate, namely; 1) El-Sail drain, which receives domestic and industrial wastewater from Egyptian chemical industries (KIMA), and factories that produce nitrogenous fertilizers and chemical materials. The drainage rate is about 56-70 km^3/day released into the River Nile **(Ahmed, 2015 & Ali *et al.*, 2015)**, 2) Kom Ombo drain, which receives agricultural and industrial wastewater from Kom Ombo sugar cane factory. The drainage rate is about 143.9 km^3/day released into the River Nile **(APRP, 2002)**, 3) Edfu ferroalloys company drain, which receives the industrial wastewater which is directly discharged into the River Nile, and 4) Edfu sugar cane factory drain, which receives the industrial wastewater. The drainage rate is about 268.9 km^3/day released into the River Nile **(APRP, 2002)**.

The present study was conducted to examine the effect of visible drainage effluents on the River Nile water quality in Aswan Governorate, through microbiological and chemical analysis and water quality index WQI calculations.

MATERIALS AND METHODS

1. Study Area

Water samples were collected seasonally (from April 2017 to January 2018) from five sectors with three samples from each sector (east, west and middle), four sectors represented main visible discharge drains in the governorate of Aswan (El-Sail, Kom Ombo, Edfu ferroalloys and Edfu sugar cane factory) and one sector represented invisible discharge effluents (Gabal Taqouq) (Figure 1).

2. Collection of water sampling

Water samples were aseptically collected in sterilized 500 ml glass bottles for bacteriological determinations and in 1000 ml bottles for physicochemical analyses.

3. Analyses of water sampling

3.1. Bacteriological analyses

3.1.1. Major bacterial groups

Bacteriological analyses of water samples included counting of total viable bacterial counts (TBC) at 22^{o}C and at 37^{o}C, in addition to the total spore-forming bacteria (SFB) (after pasteurization of samples for 15 min at 80°C, and incubation at 32^{o}C), and total thermophilic bacteria (ThB) (incubation at 55^{o}C), using pour plate technique with plate count agar medium **(APHA, 1998)**.

3.1.2. Bacterial indicators of sewage pollution

Bacterial indicators of sewage pollution included counting of total coliforms (TC) and faecal coliforms (FC) in MacConkey broth medium, and faecal streptococci (FS) in azide-dextrose broth medium using MPN method **(APHA, 1998)**.

3.1.3. Pathogenic bacteria

Salmonella sp., *Shigella* sp. and *E. coli* were enumerated and isolated using surface plate technique and salmonella-shigella agar medium and incubated at 35ºC for 24 and 48 hours **(APHA, 1998)**. Automated identification for these bacterial isolates was determined using the Biomerieux Vitek 2 System (at the Central Laboratories, Ain Sham University Hospitals).

3.2. Physicochemical properties

3.2.1. pH, electrical conductivity, total dissolved solids and temperature

The pH of water, electrical conductivity (EC), total dissolved solids (TDS) and water temperature (Temp.) were measured using a pH-meter, Crison Multimeter MM40^{+} **(APHA, 1998)**.

3.2.2. Dissolved oxygen (DO)

DO was estimated according to **APHA (1998)**.

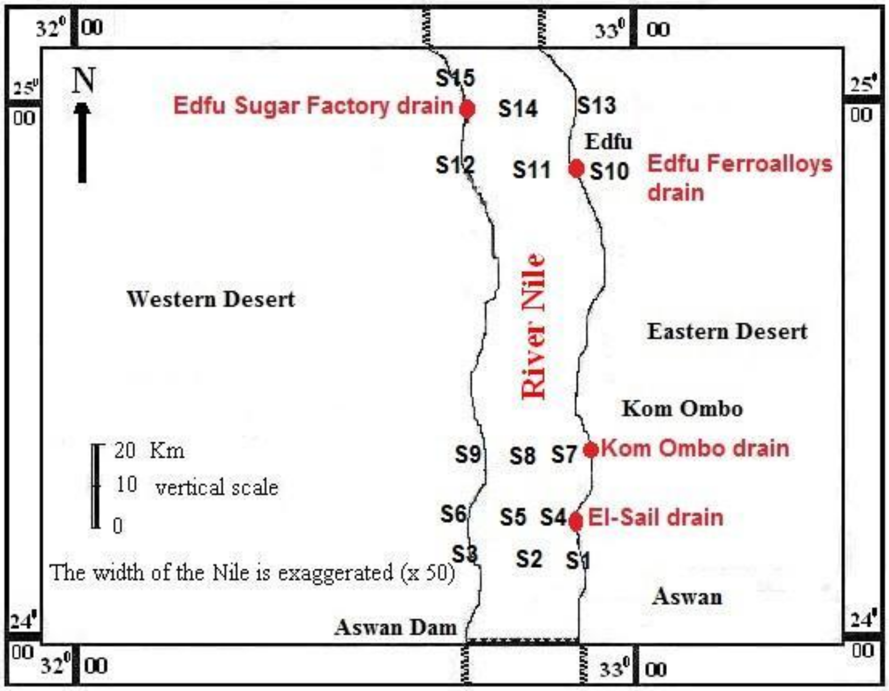

Fig. 1. Sampling sites from the River Nile in Aswan, Egypt; following are further descriptions of the sampling sites and GPS data:

Code	Sector	Site	GPS data	Description
S_1		East	24º 4`56.32874” / 32º 53`10.33356”	In front of OLD CATARACT Hotel
S_2	Gabal Taqouq	Middle	24º 4`58.78693” / 32º 53`10.13251”	Main channel of the River Nile
S_3	(Sector 1)	West	24º 5`4.70581” / 32º 52`55.09003”	In front of AMON Hotel
S_4	El-Sail drain	East	24º 6`59.79446” / 32º 53`56.79199”	In front of El-Sail drain
S_5	(Sector 2)	Middle	24º 7`7.45056” / 32º 53`44.10278”	Main channel of the River Nile
S_6		West	24º 7`2.52731” / 32º 53`34.69574”	On the other side of El-Sail drain
S_7	Kom Ombo drain	East	24º 27`22.51785” / 32º 55`33.60901”	In front of Kom Ombo drain
S_8	(Sector 3)	Middle	24º 27`21.62521” / 32º 55`21.70258”	Main channel of the River Nile
S_9		West	24º 27`11.45599” / 32º 55`9.86481”	On the other side of Kom Ombo drain
S_{10}	Edfu Ferroalloys	East	25º 0`47.46804” / 32º 52`19.43052”	In front of Edfu ferroalloys factory drain
S_{11}	drain (Sector 4)	Middle	25º 0`45.00961” / 32º 52`45.07874”	Main channel of the River Nile
S_{12}		West	25º 0`44.47403” / 32º 52`30.67291”	On the other side of Edfu ferroalloys factory
S_{13}	Edfu sugar	East	25º 2`44.32121” / 32º 52`3.38562”	On the other side of Edfu sugar factory drain
S_{14}	factory drain	Middle	25º 2`47.00592” / 32º 51`50.50415”	Main channel of the River Nile
S_{15}	(Sector 5)	West	25º 2`39.41162” / 32º 51`41.12457”	In front of Edfu sugar cane factory drain

3.2.3. Biochemical oxygen demand (BOD)

BOD was calculated from the difference between initial and final DO **(APHA, 1998)**.

3.2.4. Nitrate measurement

It was measured by using the method of **Mullin and Riley (1955)**.

3.2.5. Nitrite measurement

It was carried out in 25 ml water sample using colorimetric method **(APHA, 1998)**.

3.2.6. Estimation of Ammonia

Ammonia was estimated colorimetrically using phenate method **(APHA, 1998)**.

3.2.7. Estimation of Orthophosphate

It was estimated by using stannous chloride method **(APHA, 1998)**.

4. Water quality index (WQI)

The WQI is identified according to the Canadian Water Quality Index (CWQI) endorsed by the Canadian Council of Ministers of the Environment **(CCME, 2001)**. The WQI was calculated using the following equation:

$$WQI = 100 - \left[\frac{\sqrt{F1^2 + F2^2 + F3^2}}{1.732} \right]$$

F_1 (Scope): The % of variable that exceeds the permissible value.

$$F1 = \left[\frac{Number\ of\ failed\ variables}{Total\ number\ of\ variables} \right] x\ 100$$

F_2 (Frequency): The % of separate tests for each variable that exceeds the permissible value.

$$F2 = \left[\frac{Number\ of\ failed\ tests}{Total\ number\ of\ tests} \right] x\ 100$$

F_3 (Amplitude): The extent (excursion) to which the failed test reaches when it exceeds the permissible value.

$$F3 = \left[\frac{nse}{0.01\ nse + 0.01} \right]$$

Where $nse = \left[\frac{\sum excursion}{Total\ number\ of\ tests} \right]$

And $excursion = \left[\frac{Failed\ tests}{Guidline\ value} \right] - 1$

Two sets of guidelines were used to determine the suitability of the Nile water for drinking **(EWQS, 2007**; **WHO, 2011)**. Rating of water quality is classified as poor (0 – 44), marginal (45 – 64), fair (65 – 79), good (80 – 94) or excellent (95 – 100).

5. Statistical analysis

All statistical calculations were achieved using SPSS **(STATISTICA, 2007)** statistical program version 20. In addition, the correlation coefficient (*r*) between the measured parameters was examined.

RESULTS

1. Major bacterial groups

The total microbial load in the water samples obtained from the different sites of the River Nile in the governorate of Aswan, which is affected by different sources of wastewater are illustrated in Fig. (2). Remarkably, the disposal sites are affected by wastewater discharging, where the highest bacterial load of various bacterial groups under study are recorded at the disposal sites.

The highest total viable bacteria count (TBC) which grows at 22 ºC (TBC at 22 ^{o}C) recorded higher counts at disposal site of Kom Ombo drain, followed by the disposal site of Edfu sugar cane factory drain, El-Sail drain and Edfu ferroalloys factory drain (average 1800, 732, 325, 91 cfu x10^3/ml respectively). Additionally, TBC at 22^{o}C showed their highest values during winter season, while the lowest values were recorded during summer season (Fig. 2).

The highest values for TBC at 37 ºC were recorded at El-Sail drain (137 x10^3 cfu/ml), followed by Kom Ombo drain (89 x10^3 cfu/ml), then Edfu ferroalloys factory drain (48 x10^3 cfu/ml), and Edfu sugar cane factory drain (26 x10^3 cfu/ml). In Fig. (2), the TBC at 37°C is arranged seasonally in the following order: spring > winter > autumn > summer.

Significant value of $p<0.05$ recorded from Kom Ombo drain reveals a high exposure to thermal pollution, as it recorded higher value for thermophilic bacteria (average 259 cfu/ml), followed by El-Sail drain (average 172 cfu/ml). In addition**,** summer season recorded the highest thermophiles, followed by winter then spring and autumn **(**average 60, 40, 23 and 19 cfu/ml, respectively) (Fig. 2).

Spore forms bacteria (SFB) showed higher values during winter and spring (average 4 cfu/ml), and the polluted sites at Kom Ombo drain and Edfu sugar drain showed the highest spore forming bacterial load (average 15 cfu/ml) (Fig. 2).

In addition, the percentage increases in microbial load comparing to the main channel at the same sector, and values ranged from 649 to16668, 533 to 1172, 426 to 43792 and 2855 to13434 for total bacteria developed at 22°C, total bacteria developed at 37°C, spore forms bacteria and thermophilic bacteria, respectively (Fig. 3). Obviously, thermophilic bacteria and spore forms bacteria recorded higher percentage increases, and the same took place in Edfu sugar cane factory drain followed by Kom Ombo sugar cane factory drain, while the increase of the minimum percentage was recorded at Edfu ferroalloys factory drain (Fig. 3).

2. Bacterial indicators of sewage pollution

Similar results were obtained in the case of bacteria indicators of pollution (total coliforms, TC, faecal coliforms, FC and faecal streptococci, FS), where they are distinguished at all disposal sites (Fig. 4). The highest values were recorded at the disposal sites, particularly, El-Sail drain, which showed the highest values of total coliforms, faecal coliforms and faecal streptococci (average 1173, 550 and 17 MPN/100 ml, respectively). In addition, the highest bacterial indicators of pollution (TC, FC, and

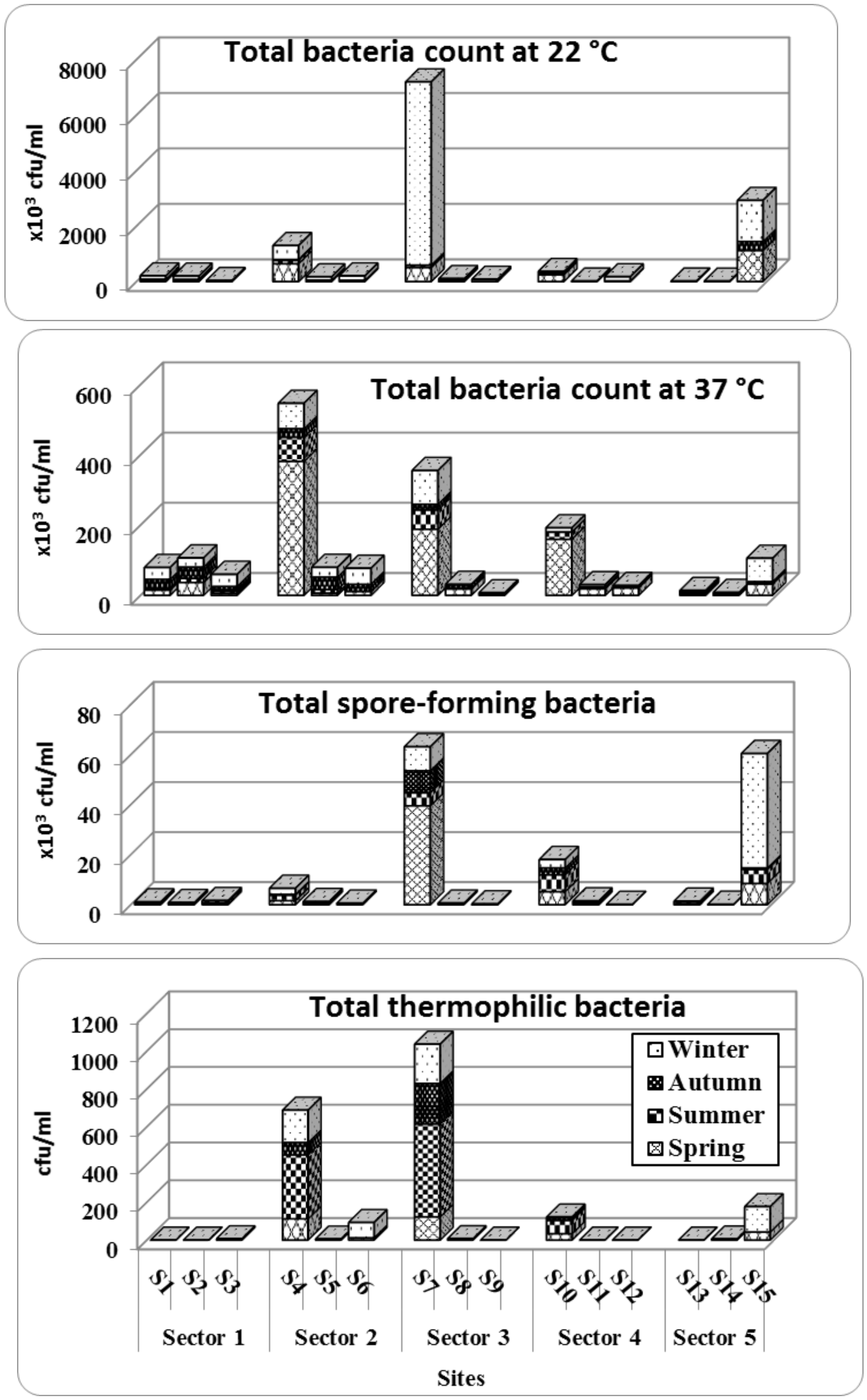

Fig. 2. Cumulative total microbial load in water samples obtained along the different sites of Aswan governorate affected by different sources of wastewater (for S_1 to S_{15} refer to Fig. 1).

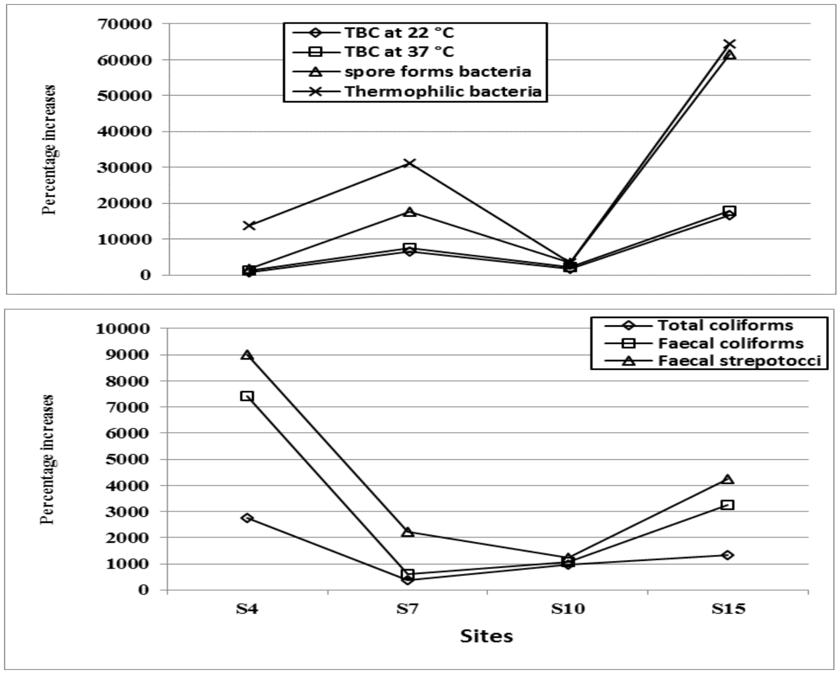

Fig. 3. Increase of microbial load percentages compared to the main channel in the same sector. (For S_4, S_7, S_{10} and S_{15} refer to Fig. 1).

FS) values were detected in the warmer seasons; spring and summer. In general, both TC, FC and FS of the River Nile water samples exceeded the permissible limits of **EWQS (2007)**; which recommended 2/100ml, 0/100ml, 0/100ml, respectively as maximum permissible limits.

Additionally, Fig. (3) shows that the increases in the highest percentage (comparing to the main channel at the same sector) were recorded at El-Sail drain (2760, 4648 and 1583% for total coliforms, faecal coliforms and faecal streptococci, respectively), while the increases in the lowest percentage were recorded at Edfu ferroalloys factory drain (975, 89 and 158% for total coliforms, faecal coliforms and faecal streptococci, respectively).

3. Pathogenic bacteria

Unfortunately, investigative pathogenic bacteria, such as *Salmonella* sp., *Shigella* sp. and *E. coli* recorded that *E. coli* was detected in all samples but *Salmonella* sp. and *Shigella* sp. were detected in 22 and 30% of the samples, respectively (Fig. 5). The polluted sites (El-Sail drain, Edfu ferroalloys drain and Kom Ombo drain) recorded the highest values of *E. coli* (average 5.5, 3.6 and 3.4 x10^3 cfu/ ml, respectively). Seasonally, the season of summer recorded higher values of *Salmonella* sp. and *E. coli* (average 0.1 and 4.0 cfu x10^3/ml, respectively), while *Shigella* sp. recorded higher values in winter (1.6 x10^3 cfu/ml).

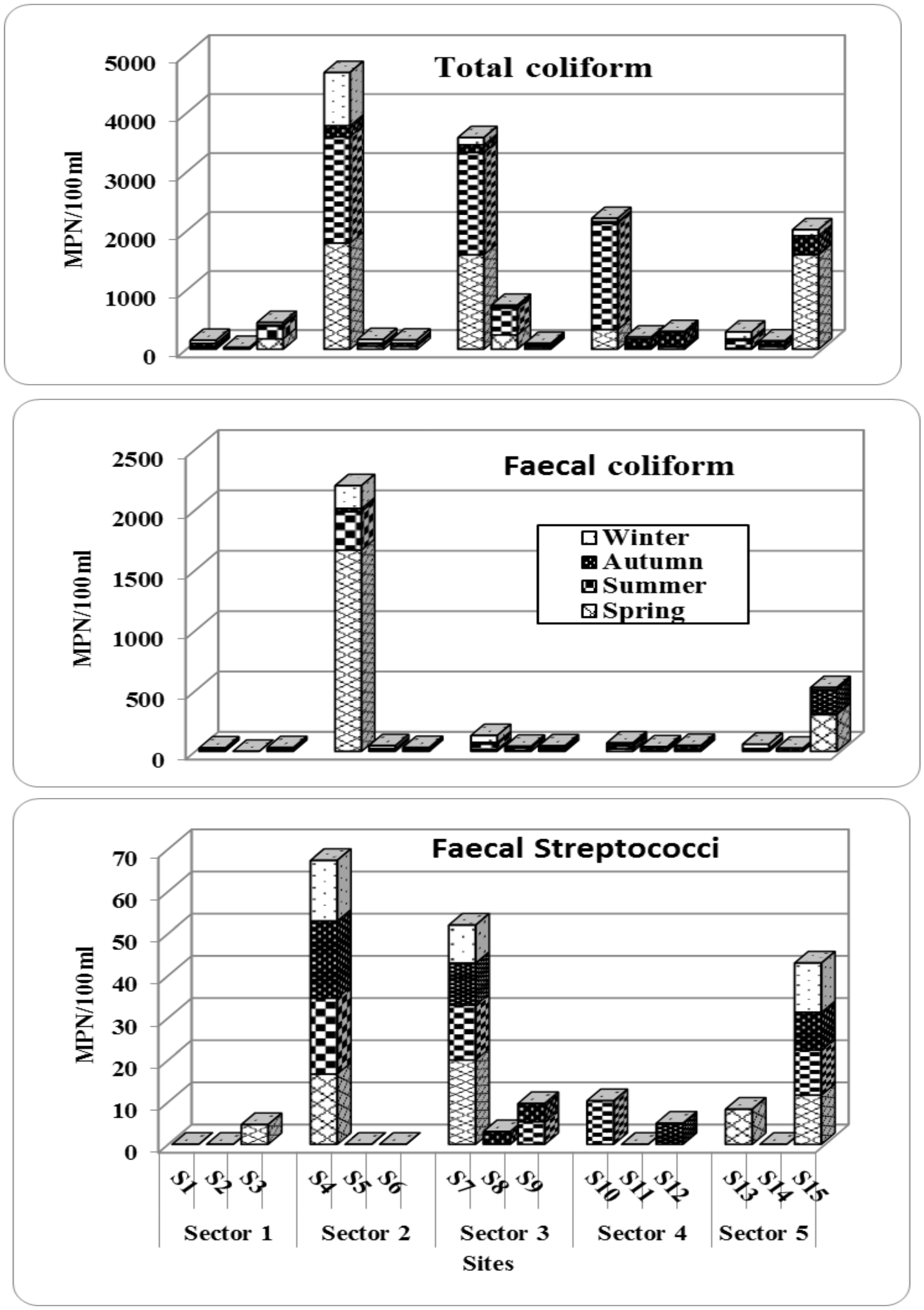

Fig. 4. Cumulative bacterial indicators of pollution in water samples obtained along the different sites of Aswan governorate affected by different sources of wastewater. (S_1 to S_{15} refer to Fig. 1).

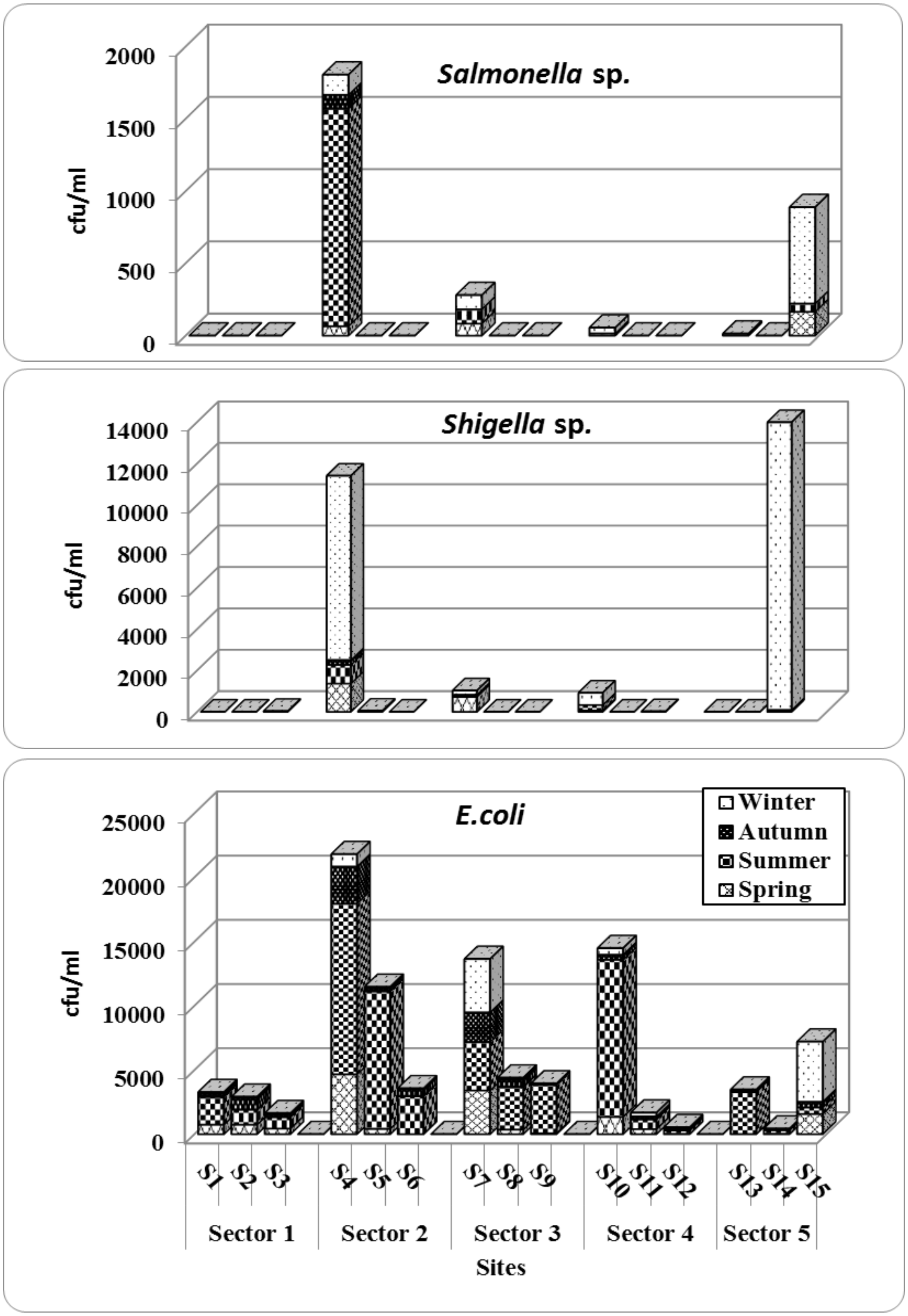

Fig. 5. Cumulative pathogenic bacteria (*Salmonella* sp., *Shigella* sp. and *E. coli*) in water samples obtained along the different sites of Aswan governorate affected by different sources of wastewater. (S_1 to S_{15} refer to Fig. 1).

4. Physicochemical properties

Additionally, the results of physicochemical analyses for the water samples obtained along the different sites of the River Nile in Aswan, affected by different sources of wastewater are illustrated in Fig. (6). This results illustrated that the disposal of wastewater affects the physicochemical characteristics of water as well as water quality. All sites of the current study that were proved to be exposed to wastes (disposal sites) (El-Sail drain, $S_{4;}$ Kom Ombo drain, $S_{7;}$ Edfu ferroalloys drain S_{10} and Edfu sugar cane factory drain S_{15}) recorded increases in some parameters, such as total dissolved solids and biological oxygen demand. While decreases were recorded in other parameters such as dissolved oxygen compared to other sites at the same sector (Fig. 6). This was noticed particularly in El-Sail drain samples, which recorded the highest values for electrical conductivity, EC (678 µs/cm), total dissolved solids, TDS (438.1 mgl^{-1}), biological oxygen demand, BOD (45.5 mgl^{-1}), ammonia, NH_3 (10669 μgl^{-1}), nitrite, NO_2^- (70.4 μgl^{-1}), orthophosphate, PO_4^{3-} (961.2 μgl^{-1}) (Fig. 6). Moreover, Kom Ombo drain recorded the highest values of water temperature (27.3 ºC) and nitrate, NO_3^- (2733.4 μgl^{-1}) as shown in Fig.(6). Significantly ($P<0.05$) the lowest values of hydrogen ion concentration (pH) was recorded at Kom Ombo drain (6.89), and the lowest values of DO was recorded at El-Sail drain (0.34 mgl^{-1}).

5. Water quality index (WQI)

The obtained results showed that the investigated parameters were within the permissible limits of **(EWQS, 2007)** except for NH_3 and NO_2^- in El-Sail drain samples. The WQI of the water samples at the selected 15 sites are illustrated in Table (1). Data showed that the area around El-Sail drain water has the lowest WQI value (55.68) and it was classified as marginal. Three areas around Kom Ombo drain, Edfu ferroalloys factory drain and Edfu sugar cane factory drain were classified as fair, and all other sites were good in their WQI ranks, while the excellent rank was not recorded for any sites.

DISCUSSION

Monitoring researches are very important for the evaluation of water quality. There are several methods **(APHA, 1998; Fathi *et al.*, 2018)**, and several standards such as water quality indexes **(Hoseinzadeh *et al.*, 2015; Barakat *et al.*, 2018)** are used to evaluate water quality.

In the present research, bacterial quantity (counts) and quality (types) were used as indicators of water quality, physicochemical properties and water quality index (WQI). Disposal sites recorded higher bacterial load compared to other sites in the same sectors (Fig. 2, 3, 4 & 5), this reflects the pollution occurance resulting from the discharged effluents at those sites. Moreover, both Kom Ombo drain and Edfu sugar drain showed increased bacterial load during winter and spring, due to the fact that those two factories (Kom Ombo and Edfu sugar cane) only operate during those two seasons (from

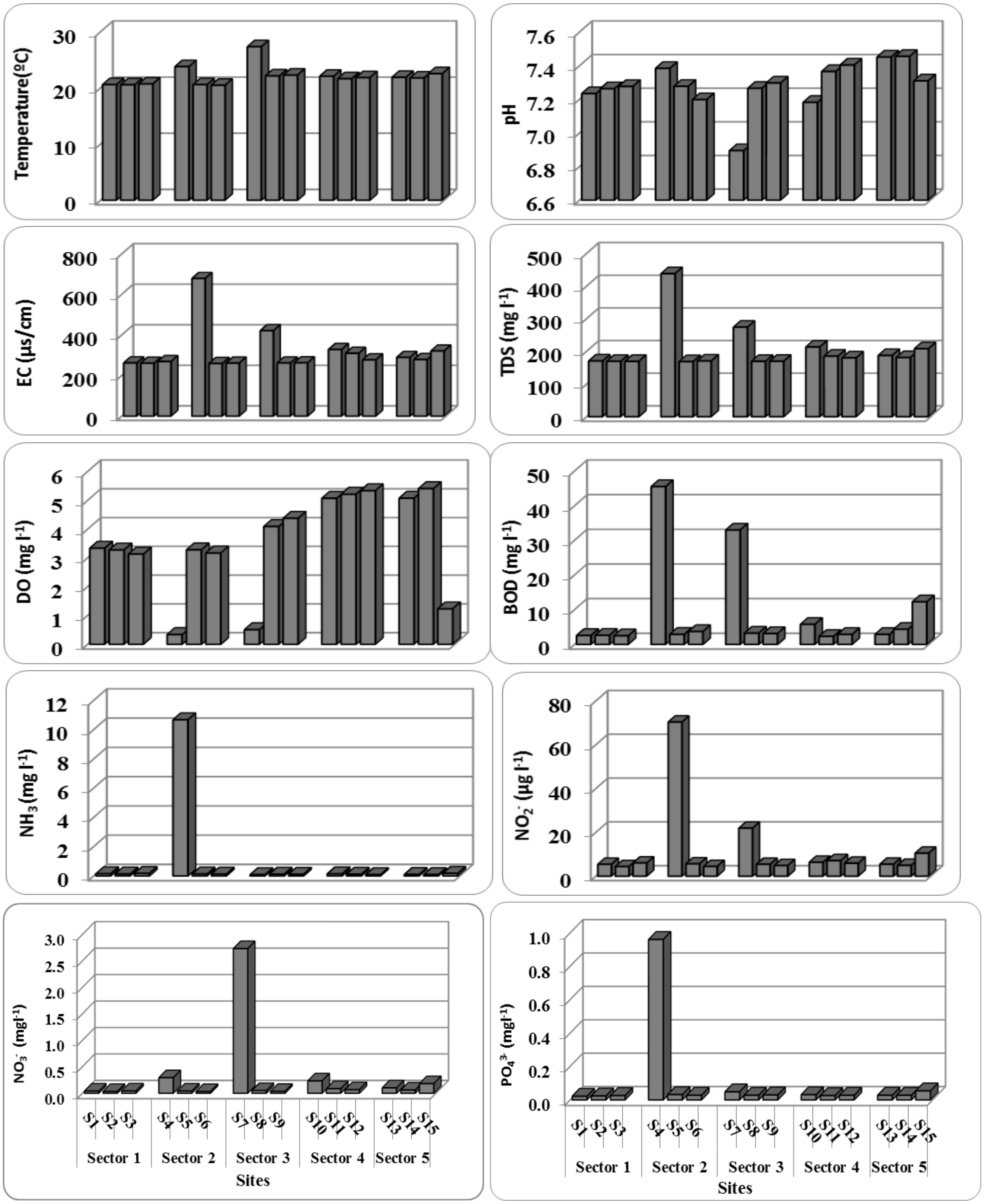

Fig. 6. Average of all physical and chemical determinations of water samples obtained along the different sites of Aswan governorate affected by different sources of wastewater. (S_1 to S_{15} refer to Fig. 1).

Table 1. The calculated values of Water Quality Index (WQI) of the River Nile water collected in Aswan governorate.

Sites	Total variables	Failed variables	Total tests	Failed Tests	F1	F2	Nse	F3	WQI	Rank
S1	10	1	40	1	10	2.5	0.005	0.497	94.04	Good
S2	10	1	40	1	10	2.5	0.015	1.477	93.98	Good
S3	10	1	40	2	10	5.0	0.057	5.437	92.82	Good
S4	10	2	40	8	20	20	2.492	71.35	**55.68**	**Marginal**
S5	10	1	40	4	10	10	0.092	8.466	90.48	Good
S6	10	1	40	3	10	7.5	0.055	5.213	92.18	Good
S7	10	2	40	5	20	12.5	0.354	26.15	**79.66**	**Fair**
S8	10	1	40	2	10	5.0	0.061	5.660	92.76	Good
S9	10	1	40	1	10	2.5	0.080	7.407	92.67	Good
S10	10	1	40	4	10	10	0.482	32.54	**79.51**	**Fair**
S11	10	1	40	2	10	5.0	0.202	16.83	88.32	Good
S12	10	1	40	3	10	7.5	0.085	7.834	91.48	Good
S13	10	1	40	2	10	5.0	0.050	4.761	92.98	Good
S14	10	1	40	2	10	5.0	0.152	13.23	89.99	Good
S15	10	1	40	4	10	10	0.521	34.21	**78.62**	**Fair**

(S_1 to S_{15} refer to Fig. 1).

December to June). In addition, the site around Kom Ombo drain is exposed to thermal pollution and recorded the highest water temperature value and thermophilic bacteria **(Elbadry, 2019)**. Hence, a significant positive correlation between thermophilic bacteria and water temperature (r=0.422) is detected. Furthermore, the higher microbial load (TBC at 22 °C) was recorded at Kom Ombo drain, followed by Edfu sugar drain and El-Sail drain. The highest TBC at 37°C was recorded at El-Sail drain followed by Kom Ombo drain. In addition, the ratio of TBC at 22°C/TBC at 37°C ranged from 0.13 to 87.8, and the lowest ratio was recorded at the disposal sites. This indicates that the Nile waters are proved to be under pollution effect, especially at the disposal sites (compared to the permissible standard of 10:1 according to the **ministry of health (1939**).

The pollution sites recorded increases in coliform counts, which led to fecal pollution occurance in those sites **(WHO, 1963)**. Highest counts of fecal coliform were recorded at the El-Sail drain region, during four seasons, due to large quantities of sewage, domestic and industrial wastes being discharged in El-Sail drain **(Ali *et al.*, 2015)**. Generally, the highest numbers of indicator bacteria (TC, FC, and FS) were detected in warm seasons (spring and summer), which can be attributed to high temperatures and wastewater discharged during those seasons **(Abu-Shady *et al.*, 1996; Isobe *et al.*, 2004)**. The FC/FS ratio of both El-Sail and Edfu sugar drains was about 32.7 and 12.3, respectively. This indicates the existence of sewage contamination, particularly, where the ratio of FC/FS determines the source of feces whether it is human (>4) or animal (<0.7) **(Geldreich, 1976)**.

El-Sail drain recorded the highest value of *Salmonella* sp. and *E. coli*; a result that agrees with that reported by **Ali *et al.* (2015)**. The presence of salmonella in the River Nile water should be regarded seriously due to its effect on human health **(Minor, 2003)**.

The significant positive correlation between *Salmonella* sp. and *Shigella* sp. (r =0.584) and *E. coli* (r = 0.586) indicated that all are originated from the same source.

Moreover, El-Sail drain showed the highest EC and TDS values, as shown in Fig. (6). This reflects the high quantities of ions in the water, and EC changes in the Nile water that can be used as an indication of potential effects **(Abdel-Satar *et al.*, 2017)**. The present findings coincide with those of **Ali *et al.* (2015)** and **Elbadry (2019)**. The increase of EC and TDS values during the cold seasons (winter and autumn) is attributed to the increase of soluble salts, cations and anions, as a result of low water levels during the drought period **(Abdo *et al.*, 2010)**. The TDS showed a positive correlation with EC (r = 0.991, n = 180), which means that both TDS and EC are dependent on each other **(Salaah *et al.*, 2018)**.

The lowest dissolved oxygen (DO) values were recorded at the sites exposed to pollution, which may be due to its consumption by the oxidation of nitrogenous compounds **(Deai *et al.*, 1991)** and organic matter **(Loagu, 1993)**. Additionally, the highest BOD values were recorded at areas under the impact of pollution which reflect the large load of organic matter discharged into the River Nile at those sites **(Elbadry, 2019)**. The BOD showed negative significant correlations with DO (r = – 0.629 n = 180) and this result is in agreement with the result obtained by **El-Sayed (2011)**. There are significant positive correlations between BOD and TBC at 37 ºC, thermophilic bacteria, *Salmonella* sp., E. coli, TC, FC and FS (r = 0.609, 0.817, 0.636, 0.568, 0.766, 0.573 and 0.825 n=180 respectively), and this may be due to the increasing rate of oxygen consumption through different biological activities of those microorganisms.

El-Sail drain showing the highest NH_3 and NO_2^- values agrees with the findings of **Ali *et al.* (2015)**, **Abdel-Satar *et al.* (2017)** and **Elbadry (2019)**. Notably, the increase of ammonia concentration may be attributed to the activity of denitrifying bacteria **(Ghallab, 2000)**. Kom Ombo drain contained the highest level of NO_3^-; a result that matches with that of **Elbadry (2019)**. Significantly, the polluted area showed the highest PO_4^{3-} level, where El-Sail drain recorded the highest level due to the considerable amounts of sewage, domestic and industrial wastes discharged directly into the River Nile at this site. Moreover, significant positive correlations of PO_4^{3-} with BOD (r = 0.689, n=180) indicates that a large amount of PO_4^{3-} in the River Nile water was associated with organic matter **(Abdel-Satar, 2005)**.

To illustrate, the low WQI values were recorded at polluted sites with the lowest value at El-Sail drain water. The current results are in agreement with those obtained by **Elbadry (2019),** who reported that the water of the River Nile in Aswan and Luxor governorates was classified as slightly to moderately polluted except for that collected from El-Sail drain sector. The previous author added that the afore- mentioned sector was considered seriously polluted as a result of the discharged wastes from El-Sail drain containing high load of organic pollutants.

CONCLUSION

The River Nile water is affected by pollution inputs from untreated domestic and industrial wastewater. Pollutants enter the River Nile through direct discharge or runoff. This study revealed that both El-Sail drain and Kom Ombo drain are the main sources of the River Nile pollution in Aswan. Therefore, wastewater effluent must be treated before being discharged into the Nile.

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