



SPATIAL VARIABILITY IN GROWTH AND CONDITION OF NILE TILAPIA *Oreochromis niloticus* LINKED TO POLLUTION GRADIENTS IN THE NILE RIVER, EGYPT

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ABSTRACT

This study investigated spatial variations in growth, condition factor, age, and longevity of *Oreochromis niloticus* populations along a pollution gradient in the Nile River, Aswan, Egypt. We compared a reference site (Ferial, Site I) with two polluted sites: El-Sail Drain (Site II) and Kom Ombo (Site III). Water and fish samples were collected monthly from January to December 2021 to analyze physicochemical parameters, heavy metals, age structure, growth, and condition factor. The results revealed significant spatial disparities. Fish from Site I exhibited the highest growth potential, with an asymptotic length (L_{∞}) of 27.22 cm, a growth coefficient (K) of 0.17 year⁻¹, and a maximum age of 13.5 years. In contrast, populations from Site II and Site III showed reduced growth (L_{∞} = 25.46 and 24.52 cm, respectively), higher K values (0.19 and 0.24 year⁻¹, respectively), and shorter lifespans (11.9 and 9.2 years, respectively). Although the growth performance index (ϕ) was similar among sites, annual length increments and condition factors were significantly lower at the polluted sites. These findings demonstrate that environmental degradation, primarily from industrial and domestic wastewater, adversely affects the somatic growth and physiological conditions of *O. niloticus*, highlighting the urgent need for enhanced pollution control and management strategies in the Nile River.

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INTRODUCTION

Inland fisheries and fish farms that capture Nile tilapia *Oreochromis niloticus* in Egypt are threatened by pollution, environmental changes, and degradation. The Nile River is an important source of fresh water, with the primary biota of interest being *O. niloticus* and *Lates niloticus*. The river is subjected to intense ecological stress as a result of urban sprawl with its attendant wastewater, unregulated industrial discharges, and agricultural effluents (AbouelFadl and Farrag, 2020; Kassem et al., 2023). Uncontrolled pollutants have consistently lowered water quality owing to the overabundance of nutrients, organic materials, and heavy metals (Elsayed et al., 2020; Gad et al., 2022). The primary industrial activities responsible for increased ecotoxicological are the use of metal and industrial manufacturing (Abdel-Satar, 2017; Mekkawy et al., 2023). These persistent pollutants bioaccumulate in the food chain, primarily in fish, leading to metabolic depression, organ system failure, immunosuppression, endocrine system derangement, stunting, and alterations in fish population age structure (Aziz et al., 2023; Shaalan, 2024). Consequently, fish stocks and communities that primarily depend on fish for food and livelihoods on the Nile River are in a vulnerable position due to the potential health concerns inflicted by such degradation (Abidemi-Iromini et al., 2022).

In addition, climate change effects, such as rising temperature, floods, and droughts, further aggravate the physiological stress in fish caused by pollution and fragment essential ecosystems (Khallaf et al., 2020). Similarly, Elsayed et al. (2020) and Mekkawy et al. (2025) confirmed the same concept that the combined effects of pollution and climate stress have led to the severe degradation of the Nile ecosystem, with notable negative impacts on Nile tilapia populations.

Individuals of *O. niloticus* exposed to polluted waters under conditions of global warming exhibited impaired health status, were more prone to disease, and burdened with harmful elements than their counterparts in untainted bodies of water (Shaalan, 2024). The age structure, population growth rates, and condition factors of a stock, which describe its overall well-being, are important for understanding the retention and recruitment of that stock (Robinson and Motta, 2002; Simon and Mazlan, 2010). The condition factor, a non-lethal health indicator, is highly sensitive to environmental factors such as temperature fluctuations, pollution stress, and food availability (Ighwela et al., 2011; Gupta and Tripathi, 2017).

Ali et al. (2022) argued that environmental degradation substantially contributes to the decline in fish catches, increased food insecurity, and growing poverty among artisanal fishers. Continued fish research is needed to assess the impact of pollution and climate change on fish growth and productivity. This problem is compounded

because most research focuses on top-down, hydrological, governance, and resource accounting frameworks, while ignoring basin-level, integrated spatiotemporal approaches needed for water resource and fishery basin management (Khallaf et al., 2020). Furthermore, the integration of the physiological characteristics of fish populations with social and ecosystem dynamics in the context of socio-economic resilience remains largely uninvestigated.

This study investigates the impact of anthropogenic water pollution on Nile tilapia *O. niloticus* in the Aswan region of the Nile River, Egypt. We conducted a comparative field analysis, measuring key physicochemical parameters and assessing the health status of fish from one reference site and two polluted sites. The objective was to evaluate how differing levels of pollution, particularly from heavy metals, affect fish growth performance, physiological condition, and lifespan. The findings are believed to form a sound basis for policies to control pollution, manage fishery resources in the Nile, restore the health of the basin's ecosystems, and reinforce the resilience of fishing communities.

MATERIALS AND METHODS

This study was conducted on the Nile River in Aswan Governorate, Egypt. Three sites were selected to represent the anthropogenic pollution gradient (Fig. 1). Site I (Ferial), (24°02'11.13" N; 32°52'65.13" E), served as a reference site, characterized by minimal agricultural and industrial influences. Site II (El-Sail Drain), (24°07'06.34" N; 32°53'54.93" E), is located downstream of El-Sail Drain, which receives treated and untreated domestic and industrial wastewater, representing a site under urban and industrial stress. Site III (Kom Ombo), (24°26'48.09" N; 32°55'21.71" E), is situated downstream of the Kom Ombo sugar factory and is primarily affected by industrial effluent. These sites were chosen based on preliminary environmental surveys and existing local water quality reports to ensure a clear pollution gradient for comparative analyses (Ali, 2023).

Water and fish samples were collected monthly from January to December 2021. A total of 144 water samples were collected monthly, with 48 samples obtained at each site from a depth of 2 meters using PVC Van Dorn bottles. The temperature and pH levels were measured in situ utilizing a Horiba U-10 water checker. For laboratory analyses, samples were preserved in 1-liter polyethylene bottles and transported in ice boxes. Dissolved oxygen (DO), chemical oxygen demand (COD), and nitrate (NO_3^-) were analyzed on the same day, following the standard methods outlined by APHA (2017).

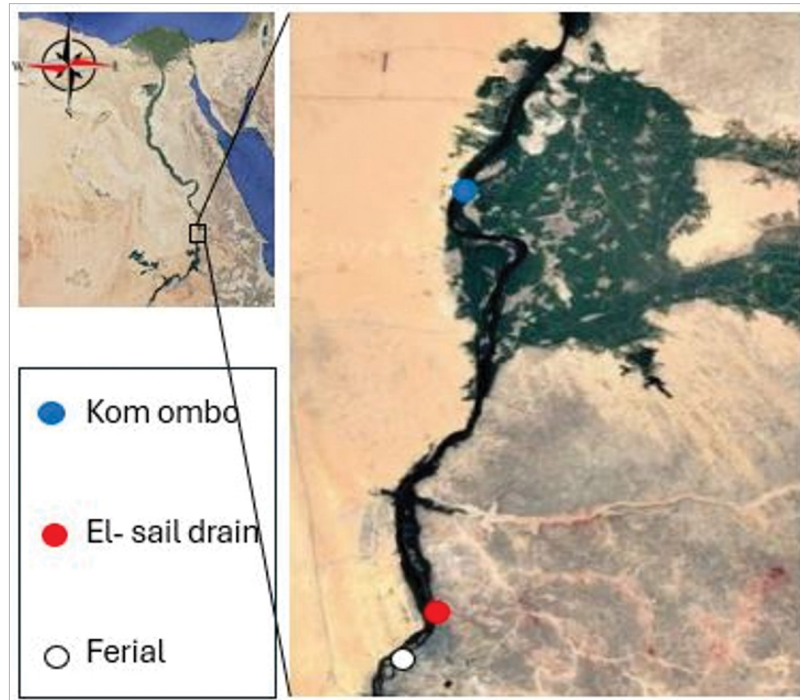


Fig 1. Study area showing the three sampling sites along the River Nile in Aswan, Egypt

A total of 1,459 *Oreochromis niloticus* specimens were collected from the Nile River at Aswan using trammel nets, which featured an inner mesh size of 22 – 28 mm and an outer mesh size of 100 – 120 mm, as commonly employed in local fisheries research. The distribution of samples by site was as follows: Site I (n = 557), Site II (n = 423), and Site III (n = 479). The total length (TL) of each specimen was measured to the nearest 0.1 cm, while total weights were recorded to the nearest 0.1 g. The length-weight relationship is described by the equation:

$$W = aL^b,$$

where b represents the growth exponent and a is a constant (Le Cren, 1951). The absolute condition factor (Fulton's K) was calculated using the formula:

$$K = (W/L^3) \times 100,$$

where W is the total body weight (g), and L is the total length (cm), as described by Bagenal and Tesch (1978).

Age was determined using the sagittal otoliths of the fish (Fig. 2).

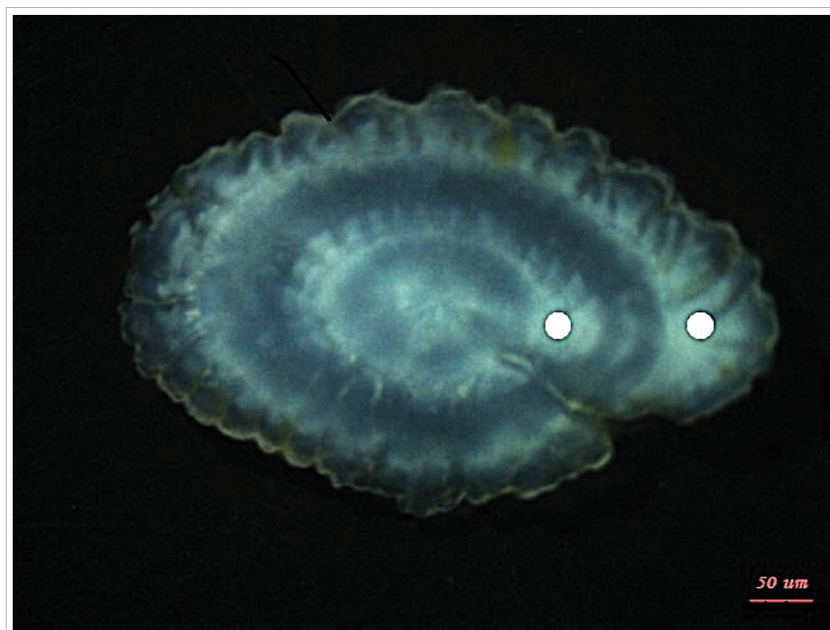


Fig 2. Sagittal otolith of *Oreochromis niloticus* from the River Nile, Aswan, showing annuli for age determination

The otoliths were cleaned, dried, and viewed under a stereomicroscope (Zeiss Stemi 508, Germany) with an attached camera for further analysis. Annuli were counted after immersion in 50% glycerol with side illumination following the method of Campana (2001).

Growth was modeled using the von Bertalanffy (1938) growth function:

$$L_t = L_\infty [1 - e^{-k(t - t_0)}],$$

where L_t is the length at age t , L_∞ is the asymptotic length, K is the growth coefficient, and t_0 is the theoretical age at zero length. Parameters were estimated by fitting length-at-age data from otolith readings using nonlinear least squares in FiSAT II software (Gayanillo et al., 1997).

The growth performance index of *O. niloticus* was calculated using Pauly and Munro's (1984) model as follows:

$$\phi = \log k + 2 \log L_\infty.$$

Longevity (t_{max}) was estimated according to Pauly's (1980) equation:

$$t_{max} = (3/K) + t_0,$$

where K is the growth coefficient in the von Bertalanffy growth equation, and (t_0) is the hypothetical value of age at zero total fish length.

Data were analyzed using STATISTICA 8. Descriptive statistics (mean \pm standard deviation SD) were calculated. One-way Analysis of Variance (ANOVA) followed by Duncan's post-hoc test was used to compare the means of water quality parameters, condition factors, and growth parameters among sites, with a significance level of $\alpha=0.05$. The FiSAT II package was used for fisheries-specific analyses.

RESULTS

Water quality analysis indicated a clearly defined spatial distribution of the water quality parameters (Table 1). At all sites, pH remained positive and slightly above 7 (8.26-8.31) with no considerable distinctions ($P > 0.05$). The water temperature also remained roughly constant (23.75 - 24.4 °C). In Site I, DO was 7.43 mg/L, indicating good oxygen conditions. Its concentration decreased significantly in the other polluted sites, measuring 5.93 mg/L in Site II and 5.18 mg/L in Site III ($P < 0.05$). Nitrate levels were significantly lower at Site I (0.42 mg/L) than at Site II (0.60 mg/L) and Site III (0.71 mg/L). The highest COD was observed at Site III at 10.25 mg/L, which was significantly higher than the 10 mg/L standard and the average for the other sites. The concentration of iron (Fe) was also the highest at Site III (0.14 mg/L), with Site II (0.12 mg/L) at an intermediate value, and Site I (0.073 mg/L) with the lowest value. At all sites, lead (Pb), copper (Cu), cadmium (Cd), and zinc (Zn) were quantified at low levels, with the more polluted sites having higher but not significantly discernible concentrations.

The length-weight relationship analysis of *Oreochromis niloticus* showed that the growth exponent (b) was less than 3 across all sites. This confirmed the region-wide negative allometric growth pattern of this species. Interestingly, Site I had the lowest b value, whereas Site II and Site III had the highest exponents. Moreover, the coefficients of determination (R^2) at all sites were high, indicating a strong relationship between the total length and total weight of *O. niloticus* (Fig. 3).

Table 1. Physicochemical water quality parameters at the three sampling sites along the Nile River, Aswan, Egypt

Parameters \ Sites	Ferial Site I (Mean \pm SD)	El-Sail Drain Site II (Mean \pm SD)	Kom Ombo Site III (Mean \pm SD)	Permissible limit
pH	8.29 \pm 0.16 ^a	8.26 \pm 0.048 ^a	8.31 \pm 0.31 ^a	7 - 8.5
Temperature (°C)	23.75 \pm 4.66 ^a	24.25 \pm 5.19 ^a	24.4 \pm 4.36 ^a	Over 5 °C
DO (ppm)	7.43 \pm 0.36 ^b	5.93 \pm 1.02 ^{ab}	5.18 \pm 1.61 ^a	< 5
NO ₃ (ppm)	0.42 \pm 0.06 ^b	0.60 \pm 0.14 ^a	0.71 \pm 0.07 ^a	10
COD (mg/L)	7 \pm 0.82 ^a	8 \pm 0.82 ^a	10.25 \pm 1.26 ^b	10
Fe (mg/L)	0.073 \pm 0.39 ^a	0.12 \pm 0.013 ^{ab}	0.14 \pm 0.049 ^b	1
Pb (mg/L)	0.011 \pm 0.004 ^a	0.013 \pm 0.005 ^a	0.016 \pm 0.0037 ^a	0.05
Cu (mg/L)	0.0088 \pm 0.0027 ^a	0.0091 \pm 0.0019 ^a	0.012 \pm 0.0099 ^a	1
Cd (mg/L)	0.000095 \pm 1.87 ^a	0.00013 \pm 1.61 ^a	0.00031 \pm 0.0003 ^a	0.1
Zn (mg/L)	0.015 \pm 0.0086 ^a	0.016 \pm 0.016 ^a	0.028 \pm 0.011 ^a	1

^(a, b, c) Superscripts denote statistical groupings (ANOVA). Same letters indicate no significant difference; different letters indicate a significant difference ($P < 0.05$). SD = Standard Deviation, DO = Dissolved Oxygen, COD = Chemical Oxygen Demand.

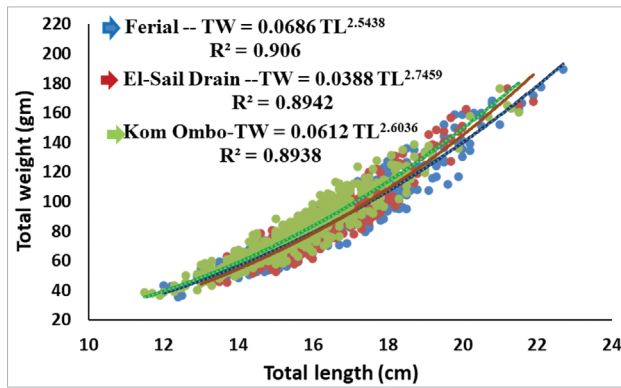


Fig 3. Length–weight relationships of *Oreochromis niloticus* from the three studied sites (Ferial, El-Sail Drain, and Kom Ombo) in the Nile River, Aswan, Egypt

The absolute condition factor (K) of *O. niloticus* showed distinct monthly pattern changes across the three studied sites (Fig. 4). At Site I, K values were the highest within the range of 2.53 in January, declining to a minimum of 1.78 in July. Gradual recovery followed in the remaining months, allowing Site I to reach 2.06 by December. Site II showed lower K values but was more stable. Variation was small, mostly between 1.78 in October and 1.94 in January, sustaining a lack of notable highs and lows throughout the year. Site III displayed intermediate K values and experienced more fluctuations than Site II. The monthly peak values of February (2.12), September (2.12), and October (2.19) were above the highest range, with lower values of 1.81 in April and July. Most of the monthly values were higher than those of Site II.

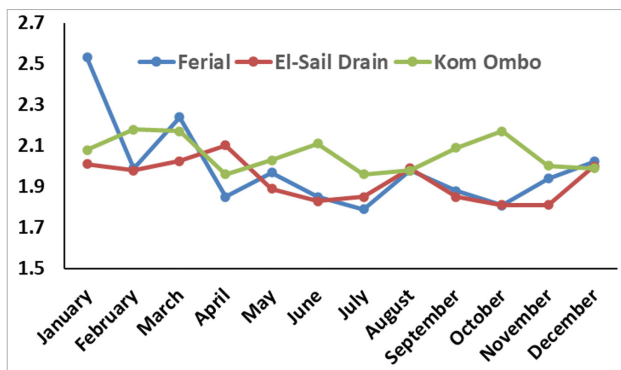


Fig 4. Monthly trends of absolute condition factor (K) for *Oreochromis niloticus* across the three studied sites in the Nile River, Aswan, Egypt

The growth patterns of *O. niloticus* showed clear spatial differences in the three studied sites, based on both the age-length data and the corresponding growth curves. At every location, there was an increase in total length with increasing age. However, the growth and increased patterns were notably different between locations. Site I showed the greatest growth potential, as the fish attained the highest average length in each age group and reached

a maximum observed length of 22.7 cm in age group IV (Table 2). Moreover, the annual length increments at Site I for younger fish were the highest, illustrating strong early growth, followed by a moderate decline in the growth rate as maturity was reached. In contrast, Site II exhibited moderately reduced average lengths and annual increments for both younger and older fish relative to Site I, suggesting moderate growth suppression likely due to site-specific environmental factors. The lowest growth performance was recorded in Site III, which had the shortest average length with a stunted age structure and fish only reaching age group III, yielding a maximum mean length of 19.0 cm (Table 2).

As demonstrated by the growth curves (Fig. 5), Site I exhibited a more pronounced and continuous increase in length with age than did the other two sites. Site II and Site III showed earlier plateaus in growth and diminished annual increments in older age groups. Overall, the results highlighted striking differences in somatic growth and age among *O. niloticus* populations from the three sites. The optimal conditions for growth were recorded at Site I and progressively reduced at Site II and Site III.

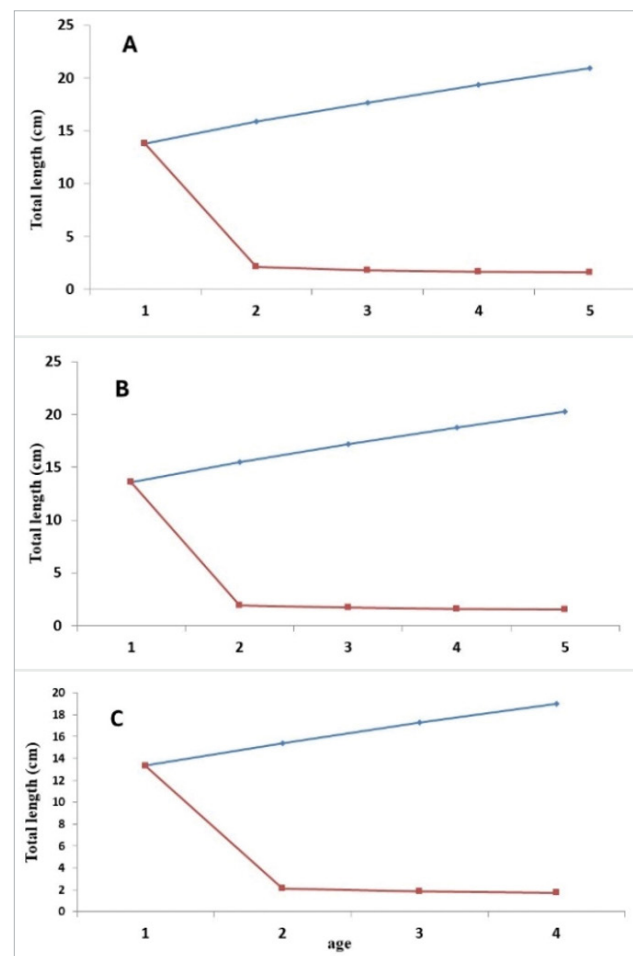


Fig 5. Growth curves in length and annual increment of *Oreochromis niloticus* from the Nile River at Ferial (A), El-Sail Drain (B), and Kom Ombo(C) sites, Aswan, Egypt

Table 2. Mean fish length at the end of each year and sample size (n) in each age group at Ferial, El-Sail Drain and Kom Ombo sites, Aswan, Egypt

Sites	Age group	No. of fish (n)	Range of length (cm)		Average length (cm)	± SD	Increment (cm)
			Min.	Max.			
Ferial	0	55	12	14.9	13.78	0.62	13.78
Site I	I	311	14	17.5	15.88	0.95	2.1
	II	141	16.1	18.5	17.68	0.58	1.8
	III	34	18.2	20.2	19.34	0.51	1.66
	IV	16	20	22.7	20.9	0.82	1.57
El-Sail	0	20	13	14.2	13.57	0.35	13.57
Drain	I	259	13.9	17	15.47	0.62	1.99
Site II	II	114	16.3	18.3	17.18	0.46	1.7
	III	19	18.1	19.7	18.56	0.46	1.58
	IV	11	19.3	21.9	20.25	0.87	1.49
Kom	0	71	11.5	14	13.34	0.62	13.34
Ombo	I	309	14	17.3	15.42	0.81	2.08
Site III	II	71	16.5	18.3	17.28	0.49	1.68
	III	28	18	21.5	19	0.5	1.72

SD= Standard Deviation

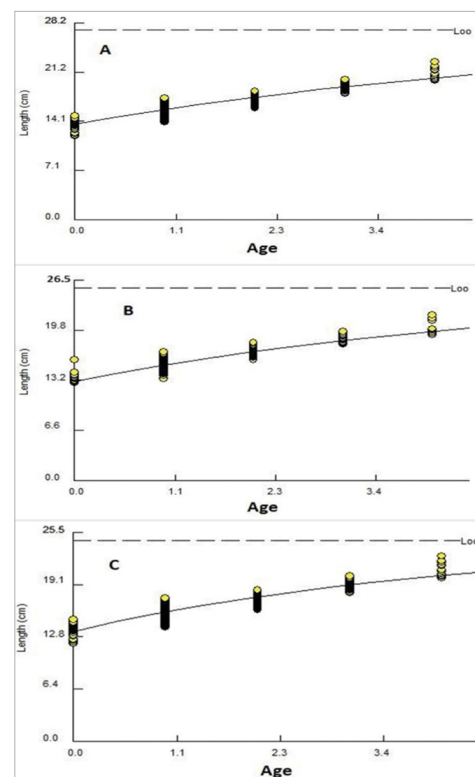
Analysis of the spatial growth dynamics of *O. niloticus* from the three studied sites indicated significant differences in the von Bertalanffy growth parameters and lifespan (fig. 6). In Site I, the asymptotic length (L_{∞}) was 27.22 cm, with a growth coefficient (K) of 0.17 year⁻¹ and a theoretical age at zero length (t_0) of -4.10 years. Site II exhibited a lower L_{∞} of 25.46 cm, a slightly higher K of 0.19 year⁻¹, and a t_0 of -3.80. Site III recorded the lowest L_{∞} at 24.52 cm, the highest K at 0.24 year⁻¹, and t_0 of -3.30. The respective von Bertalanffy growth equations were as follows:

$$\text{Site I, } L_t = 27.22 [1 - e^{-0.17(t + 4.10)}];$$

$$\text{Site II, } L_t = 25.46 [1 - e^{-0.19(t + 3.80)}];$$

$$\text{Site III, } L_t = 24.52 [1 - e^{-0.24(t + 3.30)}].$$

The growth performance index (ϕ') values were 2.09 at Site I and Site III, and 2.06 at Site II. The maximum estimated ages (t_{max}) based on otolith readings were 13.5, 11.9, and 9.2 years for Site I, Site II, and Site III, respectively. These values clearly demonstrate the disparity in growth potential and lifespan among sites.

**Fig 6.** Von Bertalanffy growth function (VBGF) models for *Oreochromis niloticus* at three Nile River sites in Aswan, Egypt: Site I (A), Site II (B), and Site III (C)

DISCUSSION

The present study indicated that the pH, temperature, and nitrate concentrations were elevated at the polluted sites (II and III) compared to those at the reference site (I). Moreover, DO values were lower at Sites II and III, likely due to higher organic matter and eutrophic conditions from human activities. In accordance with our findings, Ali et al. (2015) showed that wastewater from Site II caused significant changes in the water quality of the Nile River, including reduced oxygen downstream of the discharge point and increased pH and heavy metal concentrations as a result of large amounts of sewage and industrial waste. The persistence of heavy metals in water and their damaging effects on ecosystem balance make them a significant concern for water pollution (Masresha et al., 2021). Among these metals, Cd and Pb are particularly toxic because they have no biological utility. Although Cu and Zn are essential in trace amounts, they are harmful at high concentrations (Yacoub et al., 2021; Al-Afify and Abdel-Satar, 2022). Similarly, Aly and Abouelfadl (2020) reported sharp increases in physicochemical parameters and heavy metal concentrations downriver of Site II, along with increased bioaccumulation of metals in the local fish populations. In addition, our results showed that the water and fish tissues collected from Site II and Site III contained the highest concentrations of Fe, Pb, Cu, Cd, and Zn. Site I exhibited the lowest concentrations of these heavy metals. This finding, together with previous research, suggests that urban and industrial wastewater drains are the main sources of these metals, leading to metal pollution and ecological damage in the Nile system (Ali et al., 2015; Aly and Abouelfadl, 2020).

Length and weight ratios are important biological measures for assessing the health and status management of fish populations (Froese, 2006; Karuppiah et al., 2021; Kassem et al., 2023). In the present study, the regression coefficient (b) for all sites was below three, suggesting that *Oreochromis niloticus* of both sexes exhibited negative allometric growth patterns. Site I had the lowest b value, whereas Site II and Site III had comparatively higher exponents. In his study of *O. niloticus* in Lake Mariut, Bakhom (1994) reported higher b values from the polluted areas than from the unpolluted basins, and ascribed these differences to the combined effects of environmental stress and altered metabolic allocation, which supports the findings of the present study.

The absolute condition factor (K) of tilapia from Site II reflects the effects of site-specific stressors on fish health. It is worth noting that all population mean K values were greater than 1.0, suggesting that the populations were relatively healthy. However, tilapia from Site II displayed more stable but lower K values. This result agrees with the findings of Aly and Abouelfadl (2020) and Bakhom (1994) who reported that the condition indices of populations with greater exposure to pollution underwent a substantial decline. Chronic exposure to metals, stress

from low oxygen, high contaminant levels (Froese 2006; Famoofo and Abdul, 2020; Gupta and Tripathi, 2017), and reduced food quality and availability are potential contributors to lower K values. The modestly higher K value at Site III is more indicative of sporadic boosts in food supply or reduced competition within the same species, although the suggestion of underlying stress effects remains plausible.

Understanding the age and growth dynamics of fish stocks is fundamental for efficient fishery management because it sheds light on fish mortality and recruitment rates, as well as the possible yield of fish stocks (Froese, 2006). In this study, the highest asymptotic length (L_{∞}) of *O. niloticus* was at the least polluted reference Site I (27.22 cm), but it diminished with increasing pollution, yielding 25.46 cm at Site II and 24.52 cm at Site III. The gradient of increasing pollution and decreasing asymptotic length was well documented by Bakhom and Faltas (1994). They noted that fish populations in polluted waters have smaller asymptotic lengths because of the lack of environmental and water quality resources that support their growth.

The growth performance index (ϕ) showed a complex pattern, with the value at polluted Site III and reference Site I being $\phi = 2.09$, suggesting an overall compensatory growth strategy under severe pollution for the fish at Site III. This suggests that ϕ may be less sensitive to multi-stressor conditions than direct size or age measures, or that it reflects density-dependent effects, where reduced competition in stressful conditions allows for higher relative growth efficiency in survivors (Bakhom and Faltas, 1994; Gupta and Tripathi, 2017). This phenomenon has been observed in other polluted aquatic systems, where only the most resilient individuals survive under high-stress conditions. Therefore, while ϕ is a valuable metric, our results underscore that it must be interpreted in conjunction with other fundamental population parameters (such as L_{∞} and t_{max}) to avoid misleading conclusions and achieve a comprehensive assessment of population health under pollution stress (Froese, 2006). In the present study, the unequivocal decline in asymptotic length and maximum age across the pollution gradient remains the most robust indicator of the detrimental effects of environmental degradation on *O. niloticus* in the Nile River.

While reviewing the age structure of Nile tilapia populations among the three studied sites, the results showed a notable decline in the actual observed age at Site III, as fish only reached the age of 3, while at Site I and Site II they reached age 4. This aligns with the pattern observed in the present study of the maximum estimated longevity derived from growth models and otolith analyses. Tilapia specimens from the unpolluted Site I were estimated to live 13.5 years, followed by those from Site II at 11.9 years and Site III at 9.2 years. The notable reduction in both the observed ages and the estimated maximum age at Site III strongly indicates that the site's high levels of pollution and environmental strain limit not

only the population's potential age but also its actual age structure.

This analysis supports the conclusions of previous studies showing that environmental degradation, particularly from heavy metals, low dissolved oxygen, and chronic stress, reduces survival and increases the mortality rate in tilapia populations (Bakhoum and Faltas, 1994). Bakhoum and Faltas (1994) noted that the maximum and observed ages of *Oreochromis aureus* biota diminished in the polluted basins of Lake Mariut, and attributed these declines to suboptimal environmental conditions. The agreement between the observed and model-estimated ages helps strengthen the ecological hypothesis that the severely degraded environment at Site III imposes biological constraints on fish survival at older ages. Conversely, the relatively better conditions upstream at Site I and Site II support advanced ages, and hence greater longevity and wider age distribution in the population. These declines in realized and potential longevity, which reflect direct environmental stressors, can affect population resilience, recruitment dynamics, and fishery sustainability (Froese, 2006). Therefore, the present findings underscore the need to enhance water quality and reduce pollutant sources in order to mitigate the negative impacts on tilapia age structure and safeguard the ecosystem health in the Nile Basin.

CONCLUSION

This study confirmed that urban and industrial pollution in Aswan Governorate increases ecosystem degradation of the Nile River and negatively influences the growth, health, and longevity of Nile tilapia *Oreochromis niloticus*. The fish samples at the unpolluted reference Site I showed better growth, higher condition factors and longevity than fish from Site II and Site III, which suffered from higher pollution loads. The reduced growth and lifespan potential of fish, particularly at the most polluted sites, underscores the importance of improved waste discharge control and stricter evaluation of wastewater quality. These actions are necessary to protect fish stocks, ensure their sustainable recruitment, and support the productivity of inland fisheries in Egypt. More monitoring and active research are needed to help with the adaptive governance and sustainable management of the Nile River. Subsequent research should focus on evaluating histological changes, heavy metal bioaccumulation, and genetic impacts in *O. niloticus*, aiming to clarify the extended effects of water pollution.

PROSTORNA VARIJABILNOST U RASTU I KONDICIJI NILSKE TILAPIJE (*Oreochromis niloticus*) POVEZANA SA STUPNJEVIMA ZAGAĐENJA U RIJECI NIL, EGIPAT

SAŽETAK

U ovom istraživanju ispitivane su prostorne varijacije u rastu, faktoru kondicije, dobi i dugovječnosti populacija *Oreochromis niloticus* u različitim stupnjevima zagađenja u rijeci Nil, Asuan, Egipat. Usporedili smo referentnu lokaciju (Ferial, Lokacija I) s dvjema onečišćenim lokacijama: El-Sail Drain (Lokacija II) i Kom Ombo (Lokacija III). Uzorci vode i riba prikupljeni su mjesečno od siječnja do prosinca 2021. godine radi analize fizikalno-kemijskih parametara, teških metala, dobne strukture, rasta i faktora kondicije. Rezultati su pokazali značajne prostorne razlike. Ribe s Lokacije I imale su najveći potencijal rasta, s asimptotskom duljinom (L_{∞}) od 27,22 cm, koeficijentom rasta (K) od 0,17 godina⁻¹ i maksimalnom dobi od 13,5 godina. Za razliku od toga, populacije s Lokacije II i Lokacije III imale su smanjen rast (L_{∞} = 25,46, odnosno 24,52 cm), više K vrijednosti (0,19, odnosno 0,24 godina⁻¹) i kraći životni vijek (11,9, odnosno 9,2 godine). Iako je indeks rasta (\emptyset) bio sličan među lokacijama, godišnji prirasti duljine i faktori kondicije bili su značajno niži na onečišćenim lokacijama. Ovi nalazi pokazuju da degradacija okoliša, prvenstveno zbog industrijskih i kućanskih otpadnih voda, negativno utječe na rast i fiziološko stanje *O. niloticus*, što naglašava hitnu potrebu za poboljšanom kontrolom i strategijama upravljanja onečišćenjem u rijeci Nil.

Cljučne riječi: dobna struktura, slatkovodno ribarstvo, rast, onečišćenje i rijeka Nil

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CONFLICT OF INTEREST

The authors have declared no conflict of interest.

DATA AVAILABILITY STATEMENT

The datasets generated and/or analysed during the current study are not publicly available but are available from the corresponding author on reasonable request.

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