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The First Record of the Distribution and Abundance of Plastic Wastes Along the River Nile Shores, Upper Egypt

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ABSTRACT

Using the visual observation method, this study provides an overview of the distribution and abundance of plastic waste on the shores of the main course of the River Nile at twelve different sites across six successive governorates in Upper Egypt. Among these sites, Assiut, Nagaa Hammadi, and Suhag, three urban sites, had the greatest distribution and abundance of plastic waste. El-Wasta, a rural site, came in second. Luxor, Aswan, and Edfu, three tourist sites, had the least distribution and abundance of plastic waste. Only Assiut and Suhag had piles of plastic waste. The most abundant type of plastic waste was plastic bags, followed by a variety of other plastics, including boat mooring ropes, plastic foams, lids, food wrappers, packaging material, bottle caps, cutlery, and plastic pipes. Next came bottles, tires, the obvious appearance of personal hygiene products, and very little fishing gear. Megaplastics, mesoplastics, and microplastics all had lower percentages than macroplastics, which had the highest percentage. The abundance of plastic waste was lower in the southern governorates (Aswan and Luxor) than in the northern governorates (Assiut, Qena, Suhag, and El-Minya). Our current research would contribute to the global trend of examining plastic in rivers, and the findings would aid in the establishment of a mechanism to lessen and eventually eliminate plastic waste, particularly along the Nile's shores, as well as a law to better regulate it.

INTRODUCTION

Rivers are the primary conduits for land-based waste to enter the ocean, and they are particularly impacted by plastic waste **(Schmidt *et al.*, 2017; Meijer *et al.*, 2021)**. Microplastics (MPs < 5mm) from this waste reach aquatic organisms and have a variety of physiological effects **(Hamed *et al.*, 2019, 2020)**. A current global trend is the study of plastic pollution in rivers **(Shabaka *et al.*, 2022)**, and plastic waste has been observed on riverbanks in recent years. Examples include the Pan-European RIMMEL project, which found plastic waste in over than 40 rivers **(González-Fernández *et al.*, 2019)**. In addition, examples cover the Rhone River **(Castro-Jiménez *et al.*, 2019)** and the Tiber River **(Cesarini *et al.*, 2023)**.

One of the methods that are frequently employed was used in these studies, the visual measuring method from bridges **(González-Fernández *et al.*, 2016; van**

Emmerik *et al.*, 2018; Castro-Jiménez *et al.*, 2019). They provide a dependable way to gather data and are easy to use. For a predetermined period of time, observers stationed on bridges count the quantity of readily discernible floating and barely submerged plastic. The method is provided by sparse measurement techniques and is a useful tool for estimations of floating plastic transit and accumulation along riverbanks **(van Emmerik & Schwarz, 2019)**. The development of more advanced technological methods for flux and stock measurements, such as remote sensing, which has been used in recent studies, is a major focus at the same time. These methods will enable a rapid scale-up of observations around the world **(Gomez *et al.*, 2022; Simpson *et al.*, 2022)**. The Nile River, with a length of 6693km, is regarded as the longest river in the world despite being one of the most significant rivers in the world, if not the most famous **(World Atlas, 2019; Khan *et al.*, 2020)**. There is currently little known about plastic pollution in the River Nile, and there hasn't been adequate study on how frequently plastic debris is found on the Nile's shores **(Khan *et al.*, 2020)**. Even though the Nile flows through many nations in Africa, Egypt has always been inextricably linked to it, and it has been called the "source of life for Egypt" **(Ali *et al.*, 2014)**. Because of its well-known contribution to the development of ancient Egyptian culture and civilization and the ongoing belief in it as a primary source of freshwater needed for drinking and irrigation **(Dumont, 2009; Ali *et al.*, 2014)**, in addition to its importance in river navigation, tourism, and being an important source of freshwater organisms like fish and others.

Egypt is the biggest plastics consumer in all of Africa **(Babayemi *et al.*, 2019)**. Aquatic habitats are being negatively impacted by Egypt's high plastic use, poor waste management, and careless disposal of plastic waste **(Hamed *et al.*, 2019)**. Unfortunately, Egypt was one of the top three nations in the Mediterranean Sea for plastic pollution **(WWF, 2019)**. MPs have been found recently in water, sediments, and some fish in the River Nile in Lower Egypt **(Khan *et al.*, 2020; Shabaka *et al.*, 2022; Khallaf *et al.*, 2023)**, additionally, meso-and macroplastics (>5mm) have been found recently in water, sediments, and fauna of the River Nile in Upper Egypt **(Hassan *et al.*, 2023)**. These studies showed that the main source of these plastic particles is plastic waste on the Nile's shores, making it a research priority and an essential and necessary step in identifying the issue and coming up with workable solutions. The current study was conducted at the same time as Egypt of hosting the Climate Summit of the Parties (COP27), which was held in Sharm El-Sheikh in November 2022 to discuss environmental issues on a global scale, such as climate change and plastic pollution. This coincided with the current increase in interest by the Egyptian state in environmental issues **(Ministry of Environmental Affairs, Egypt, 2022)**.

The current study's goal was to advance our knowledge of the distribution, abundance, and composition of various plastic wastes along the shores of the River Nile in various Upper Egyptian governorates.

MATERIALS AND METHODS

Study Sites

The current study was conducted in six consecutive Upper Egyptian governorates along the main River Nile course: Aswan, Luxor, Qena, Suhag, Assiut, and El-Minya. Two sites were chosen in each governorate to survey plastic waste on the shores of the River Nile during December 2021 and January 2022: Aswan and Edfu (Aswan governorate), Armant and Luxor (Luxor governorate), Qena and Nagaa Hammadi (Qena governorate), Gerga and Suhag (Suhag governorate), El-Wasta and Assiut (Assiut governorate), and Sawada and El-Minya (El-Minya governorate). Aswan, Luxor, and Edfu are tourist locations, while Armant, Qena, Nagaa Hammadi, Gerga, Suhag, Assiut, and El-Minya are urban locations, and El-Wasta and Sawada are rural locations. In order to conduct a plastic waste survey along the entire length of the River Nile, consideration was given to the distance between these locations as well as the varying levels of urbanization and population densities (Fig. 1 & Table 1).

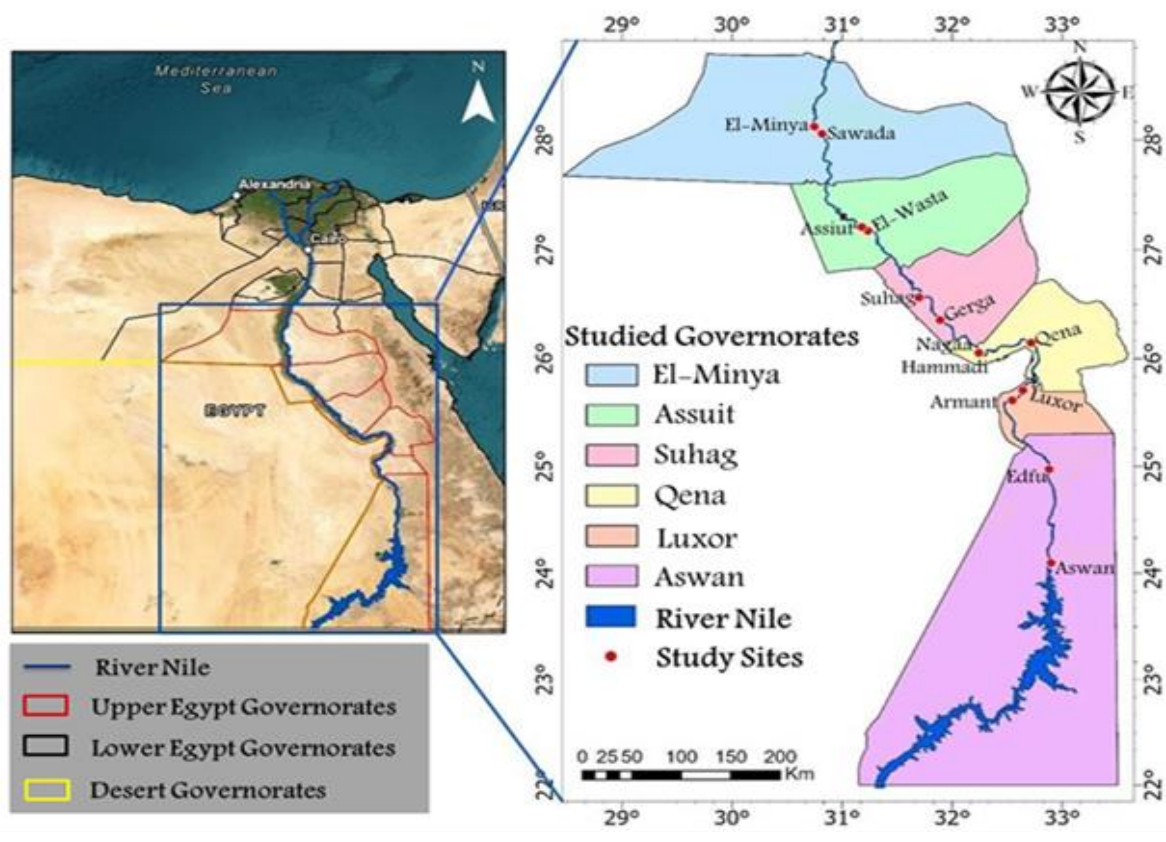

Fig. 1. A map of the study sites of the River Nile in Egypt: Aswan and Edfu (Aswan Governorate), Armant and Luxor (Luxor Governorate), Qena and Nagaa Hammadi (Qena governorate), Gerga and Suhag (Suhag Governorate), El-Wasta and Assiut (Assiut Governorate), and Sawada and El-Minya (El-Minya Governorate)

Plastic waste monitoring and surveying

The abundance and composition of plastic waste were surveyed at each of the twelve sites using the quadrate technique (1 m^2 with five replicates in each site), a digital camera, and visual observation **(Sayed *et al.*, 2021)**. The quadrate method was used to calculate the percentages of plastics and the percentages of their types and sizes (Fig. 2A). Plastic waste was classified into six categories according to their shapes: plastic bags, bottles, tires, fishing gears, personal hygiene products, and a group of other plastic waste, which includes boat mooring ropes, plastic foams, lids, food wrappers, packaging materials, bottle caps, cutlery, cigarette butts, personal tools, and plastic pipes **(El-Naggar *et al*., 2024)**, as well as being classified according to their size into: (megaplastics >1m), (macroplastics 25mm–1m), (mesoplastics 5mm–25mm), and (microplastics <5mm), this classification has been adopted by **UNEP (2020)** (Fig. 2B). The percentage of plastics and their types and sizes in each governorate, as well as the general percentage of plastics and the general percentage of their types and sizes on the shores of the River Nile at all sites, were calculated using this data.

Table 1. Location (longitude and latitude) and population density (number of individuals) according to the Central Agency for Public Mobilization and Statistics, Egypt, in 2021, of the 12 surveying sites (6 governorates)

Governorate	Site	Longitude and latitude	Population density	Shore length (m)
Aswan	Aswan	24◦05′20″N, 32°53′59″E	199306	300
	Edfu	24◦58′41″N, 32°52′44″E	150238	500
Luxor	Armant	25◦37′0″N, 32°32′00″E	78695	500
	Luxor	25◦41′0″N, 32°39′00″E	268640	300
Qena	Qena	26◦10′00″N, 32°43′00″E	252883	500
	Nagaa Hammadi	26◦03′00″N, 32°15′00″E	59601	400
Suhag	Gerga	26◦20′12″N, 31°53′15″E	151256	300
	Suhag	26◦33′38″N, 31°41′30″E	146011	700
Assiut	El-Wasta	27◦10′36″N, 31°13′22″E	326441	400
	Assiut	27◦11′13″N, 31°10′17″E	242594	700
El-Minya	Sawada	28◦04′39″N, 30°47′43″E	739279	300
	El-Minya	28◦07′10″N, 30°44′40″E	739279	400

Fig. 2. Photographs of the study site in Assiut showing: A) A plastic waste survey using the visual observation method, camera, and quadrate technique; B) Determined different categories of plastics according to plastic type (1= plastic bags, 2= bottles, 3= tires, 4= fishing gears, 5= personal hygiene products, and 6= other plastic waste) and according to plastic size (a= megaplastics, b= macroplastics, c= mesoplastics, and d= microplastics)

Determination of plastic waste by remote sensing

At the most numerous sites containing piles of plastic waste on the shores of the River Nile, remote sensing techniques have been used to track the presence of these piles in the past years (2016, 2019, and 2020).

RESULTS

Plastic waste distribution, abundance, and composition on the River Nile's shores at different sites

The findings demonstrated that a variety of pollutants, including plastic waste, which is the main pollutant, are present along the River Nile shores at the study sites. These pollutants include metals, fabrics, glass, paper, wood, construction materials, and organic pollutants. Additionally, it was observed that the amount of plastic waste that was spattered along the River Nile's shores varied from site to site and that piles of plastic waste only appeared at the two sites, Assiut and Suhag. It was also observed that there was a difference in the site description and human activities at the sites (Fig. 3 & Table 2).

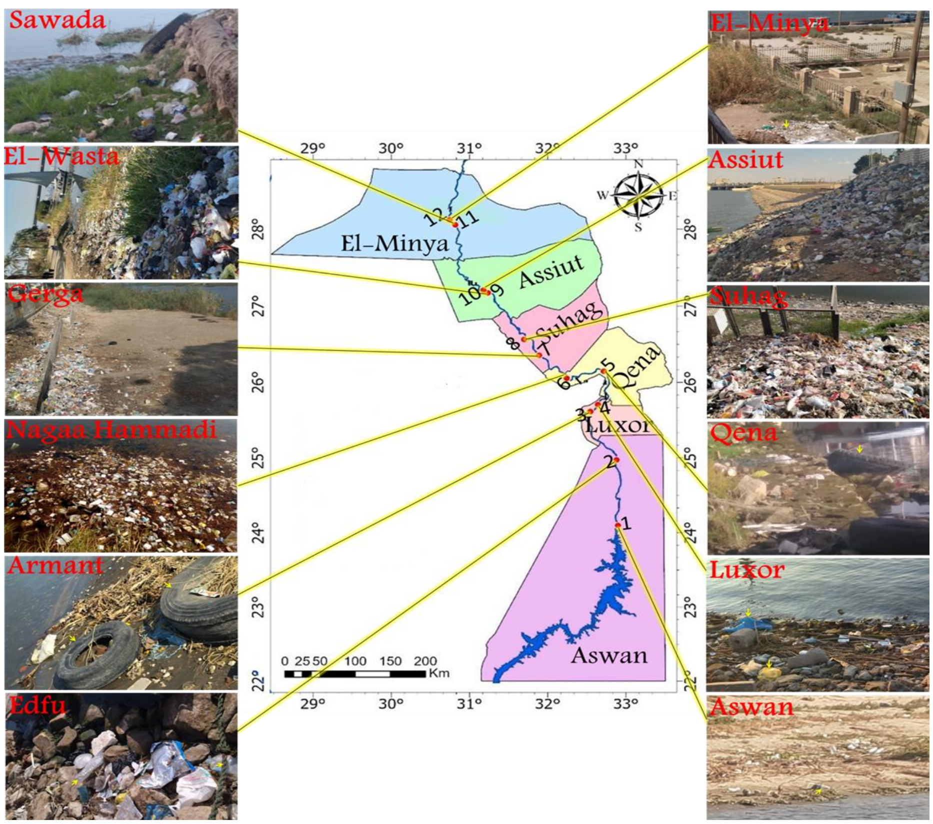

Fig. 3. Photographs of plastic waste on the River Nile's shores at the survey sites: Aswan and Edfu (Aswan Governorate), Armant and Luxor (Luxor Governorate), Qena and Nagaa Hammadi (Qena Governorate), Gerga and Suhag (Suhag Governorate), El-Wasta and Assiut (Assiut Governorate), and Sawada and El-Minya (El-Minya Governorate)

Table 2. Site description and the main human activities

N.	Site	Description of survey site	Main anthropogenic activities
1	Aswan	Sandy shores with the natural composition of the shoreline looking like a small peninsula when the water level is low. It is located in a tourist area.	Tourism, water sports, shipping, and fishing.
2	Edfu	Rocky/sandy shore with an artificial shore composition and the anchorage of navigation ships. It is located in a touristic urban area.	Tourism, shipping, fishing, and transporting citizens from the center to villages are mostly done by wooden boats.
3	Armant	Muddy shore with a natural shore composition is located next to parking. It is located in an urban area.	Changing used car tires, transporting citizens from the West Bank to the East Bank and back mostly by wooden boats, and fishing.
4	Luxor	Rocky shore with an artificial shore composition. It is located in a tourist area.	Tourism, fishing, and recreational activities.
5	Qena	Rocky shore with an artificial shore composition. It is located in an urban area.	Recreational activities and fishing.
6	Nagaa Hammadi	Rocky shore with an artificial shore composition. It is located in an urban area.	Recreational activities, industrial activities, urban waste, and fishing.
7	Gerga	Muddy shore with a natural shore composition, located in an urban area next to the family club	Urban waste and fishing.
8	Suhag	Sandy shore with a natural shore composition, located in an urban area.	Urban waste (especially household waste), and fishing.
9	El-Wasta	Muddy/sandy shores with the natural composition of the shore, located in a rural area.	Household waste, agriculture activities and fishing.
10	Assiut	Sandy shore with natural shore composition, located in an urban area.	Urban waste (household waste) and fishing.
11	Sawada	Muddy shore with the natural composition shore, located in a rural area.	Household waste, agriculture activities, and fishing.
12	El-Minya	Sandy shore with natural shore composition, located in an urban area.	Fishing.

According to the findings, the percentage of plastic waste varied at each site. Assiut, Nagaa Hammadi, and Suhag have the highest average percentages of plastic waste on the River Nile shores, with 78%, 77%, and 73%, respectively (Fig. 4A). Plastic bags were the most abundant type at the three sites, with an average percentage of 69%, 42%, and 89% at the three sites, respectively. The group of other plastic waste, which includes (boat mooring ropes, plastic foams, lids, food wrappers, packaging material, bottle caps, cutlery, cigarette butts, personal tools, and plastic pipes), came in second with 14% and 8% in Assiut and Suhag, respectively. While in Nagaa Hammadi, bottles came in second (23%), respectively (Fig. 4B). El-Wasta (63%) came in second, plastic bags, personal hygiene products, and the group of other plastic waste were the most abundant types with average percentages (71%, 16%, and 12%, respectively). The lowest amount of plastic waste was found along the Nile's shores in Luxor, Aswan, and Edfu (average percentages of 20%, 24%, and 37%, respectively) (Fig. 4A). At Luxor and Edfu sites, plastic bags were the most abundant type of plastic waste (39% and 45%, respectively), followed by the group of other plastic waste (30% and 29%, respectively), while in

Aswan, bottles were the most abundant type (47%), followed by plastic bags (24%) (Fig. 4B).

Generally, plastic bags were the most abundant type at all sites, except for Aswan, Armant, and Qena. Bottles were the most abundant type in Aswan, and tires in Armant and Qena, respectively. Generally, plastic bags were observed with the highest percentage in Suhag; bottles recorded the highest percentage in Aswan; fishing gears were recorded with the highest percentage in Edfu; personal hygiene products with the highest percentage in El-Wasta; and tires and the group of other plastic waste with the highest percentage in Armant (Fig. 4B). In addition, the results showed that macroplastic (25mm- 1m) was the plastic size with the highest percentage at all sites, except Armant and Qena, where megaplastic (> 1m) was the plastic size with the highest percentage. Moreover, differences were deteted in the percentages of plastic sizes at each site: megaplastic (> 1m) had the highest percentage in Armant, Qena, Sawada, and Nagaa Hammadi, respectively, while macroplastic (25mm-1m) was recorded with the highest percentage in El-Minya; mesoplastic (5mm-25mm) had the highest percentages in Gerga, while microplastic (< 5mm) had the highest percentage in Edfu (Fig. 4C).

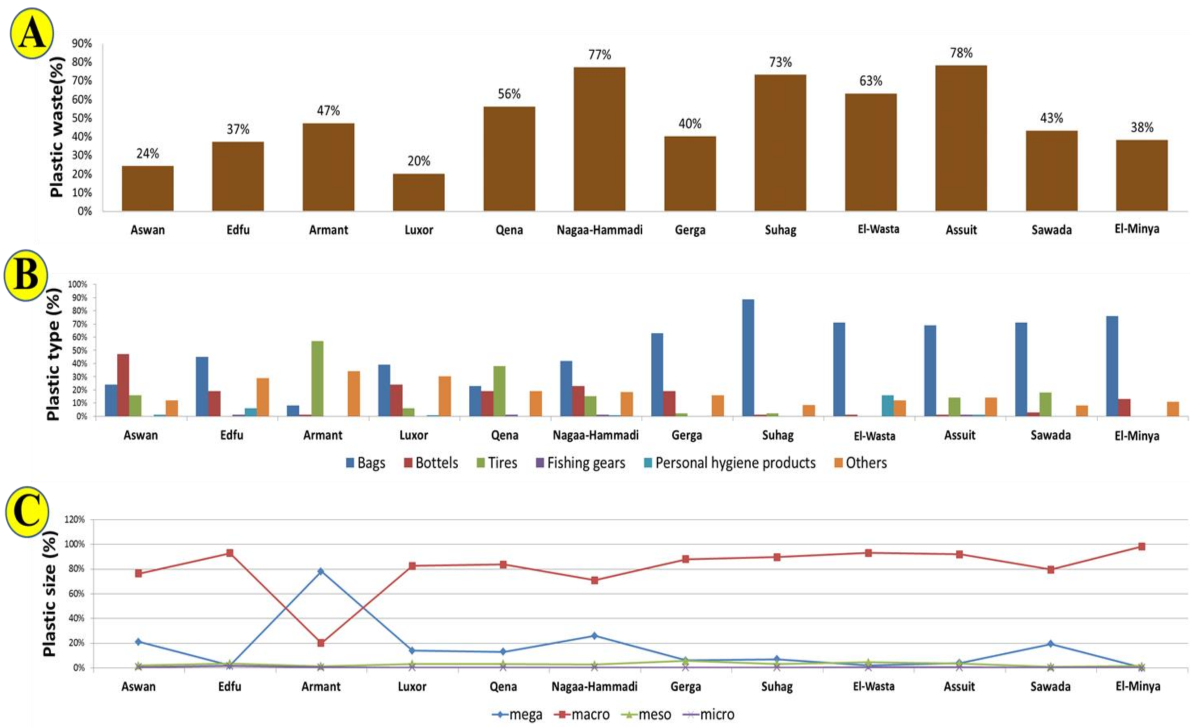

Fig. 4. Different types and sizes of plastic items as a percentage of all plastic waste found: (A) Percentage of plastic waste found at each survey site; (B) Percentage of each type of plastic waste at each site, and (C) Percentage of each plastic size at each site: megaplastic (>1m), (macroplastic 25mm-1m), (mesoplastic 5mm-25mm), and (microplastic <5mm) (C)

The urban governorates (Assiut, Qena, Suhag, and El-Minya) generally had the highest percentages of plastic waste, at average percentages of 71%, 67%, 57%, and 41%, respectively (Fig. 5A). Plastic bags formed the type with a huge abundance in the four governorates, recording an average percentage of 70%, 33%, 76%, and 74%, respectively. This type was followed by another group of other plastic wastes, which includes (boats mooring ropes, plastic foams, lids, food wrappers, packaging material, bottle caps, cutlery, cigarette butts, personal tool, and plastic pipes), detected in Assiut Governorate, Suhag governorate, and El-Minya governorate with an average percentage of 13%, 12%, and 10%, respectively, while in Qena governorate tires represented the second source of waste, with an average percentage of 27% (Fig. 5B). Aswan and Luxor, governorates with a high tourist influx, have the least amount of plastic waste at average percentages of 31% and 34%, respectively. In Luxor Governorate, tires and other plastic wastes were the most abundant, with an average percentage of 32% for both, followed by plastic bags with 24%. On the other hand, in Aswan Governorate, plastic bags were the most abundant type, with an average percentage of 35%, followed by bottles with 33% (Fig. 5B).

The abundance of plastic wastes decreases in the southern governorates and increases in the north, however, Qena Governorate recorded a higher percentage of plastic waste on the shores of the River Nile than in the northern Suhag Governorate. Whereas, Assiut Governorate recorded a higher percentage of plastic wastes on the shores of the River Nile compared to the northern El-Minya Governorate (Fig. 5A). Generally, plastic bags were registered with the highest percentage in Suhag Governorate; bottles had the highest percentage in Aswan Governorate; tires and the group of other plastic wastes displayed the highest percentage in Luxor Governorate; fishing gear was recorded with the highest percentage in Aswan, Qena, and Assiut governorates, while the personal hygiene products exhibited the highest percentage in Assiut Governorate, (Fig. 5B). In all the studied governorates, macroplastics were determined with the highest percentages, followed by megaplastics, while mesoplastics and microplastics were recorded with the least percentage. It is worthy to mention that, megaplastics had the highest percentage in Luxor and Qena governorates; macroplastics had the highest percentage in Assiut, El-Minya, Suhag, and Aswan governorates, while mesoplastics had the highest percentage in Suhag governorate, and microplastics were recorded with the highest percentage in Aswan governorate (Fig. 5C).

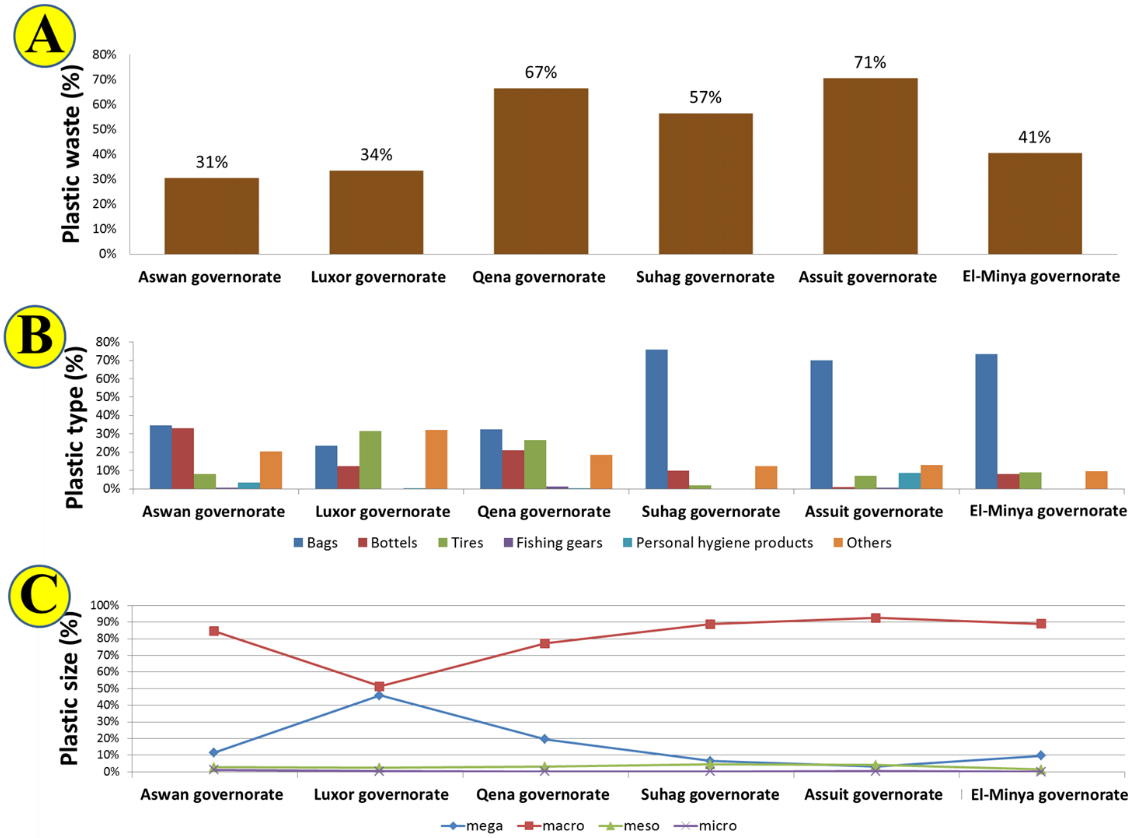

Fig. 5. Different types and sizes of plastic items as a percentage of all plastic waste found in the studied governorates: A) Percentage of plastic waste found at each studied governorate; B) Percentage of each type of plastic waste in each studied governorate; C) Percentage of each plastic size in each studied governorate: megaplastic (>1m), macroplastic (25mm-1m), mesoplastic (5mm-25mm), and microplastic (< 5mm)

Generally, at all study sites, plastic waste outweighed all other pollutants, with a total average percentage of 50% (Fig. 6A). This percentage was classified into six different types of plastic. Plastic bags (52%) were the most abundant type, followed by the group of other plastic wastes (18%), viz. boats mooring ropes, plastic foams, lids, food wrappers, packaging material, bottle caps, cutlery, cigarette butts, personal tools, and plastic pipes. The second type of plastics was followed by bottles (14%) and tires (13%), the obvious appearance of personal hygiene products (~3%), and a low average percentage of fishing gear that didn't exceed (0.00000001%) (Fig. 6B). Additionally, it was classified into different sizes: macroplastic (77%) with the most abundant size, followed by megaplastic (16%), mesoplastic (6%), and microplastic (1%) (Fig. 6C).

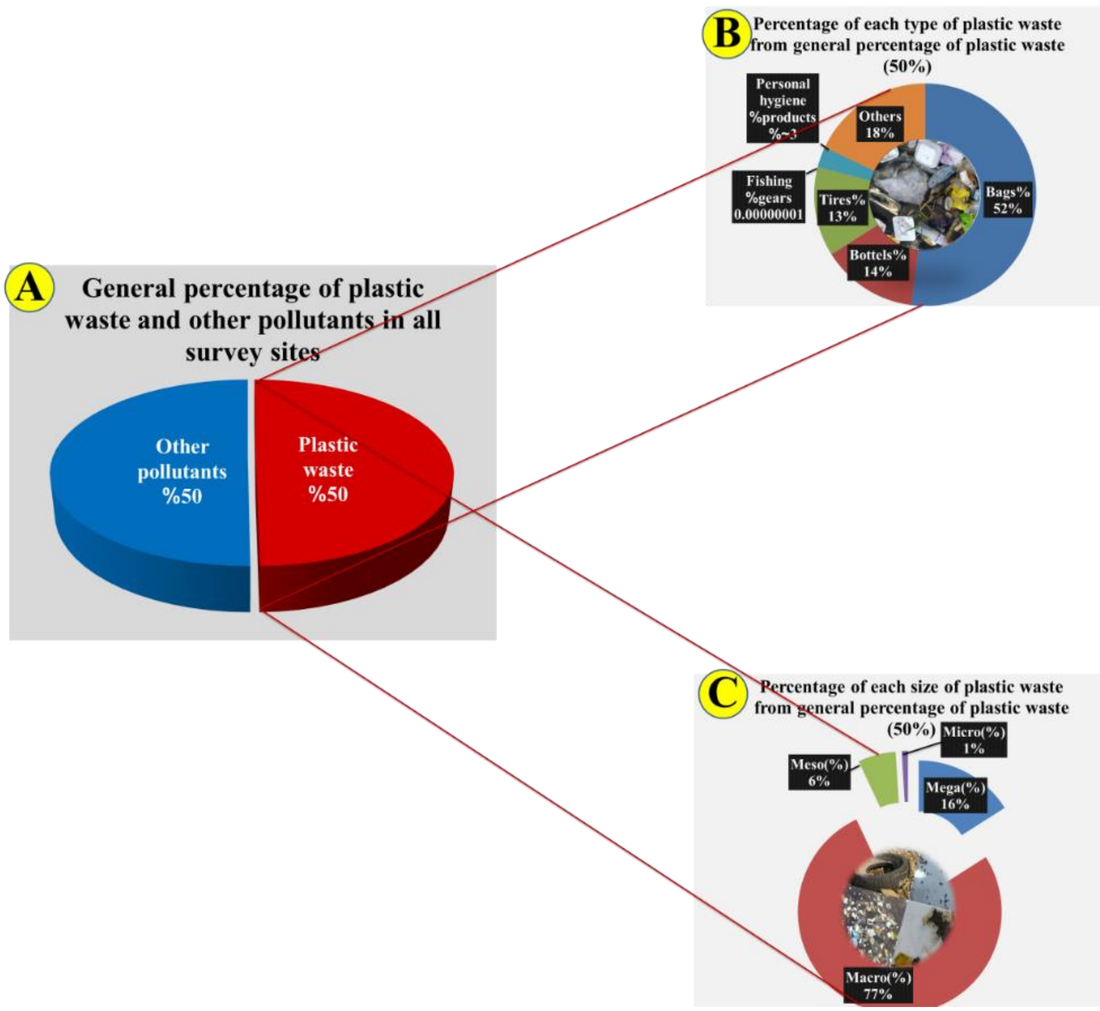

Fig. 6. (A) General percentage of plastic wastes and percentages of other pollutants such as metals, fabrics, glass, paper, wood, construction materials, and organic pollutants; (B) General percentages of each plastic type based on the percentages of plastic wastes; and (C) General percentages of each plastic size based on the percentages of plastic wastes: megaplastic (>1m), macroplastic (25mm-1m), mesoplastic (5mm-25mm), and microplastic (< 5mm)

Tracking the appearance of plastic waste piles on the River Nile's shores at Assiut site

Assiut was the site with the largest plastic waste piles. The remote sensing monitoring results revealed that similar quantities of these piles were present during the previous years at the site (Fig. 7).

Fig. 7. Remote sensing photographs showing the appearance of piles of plastic wastes on the River Nile's shore at the Assiut site during 2016, 2019, and 2020.

Despite the fact that there is a buildup of plastics at the two sites, Assiut and Suhag, these mounds are regularly sorted and eliminated, which slows down the rapid way through which they enter the aquatic environment and spread among living organisms. Consequently, we cleaned up the River Nile shores at Assiut site during the current study (Fig. 8A, B). Although plastic waste at the survey site in Nagaa Hammadi did not proliferate forming piles as the case in Assiut and Suhag, it was one of the most abundant survey sites for plastic wastes, with some of these wastes floating on the water on top of weeds and aquatic plants and others submerged beneath it, as shown in Fig. (8C).

Fig. 8. A) Photographs taken during the sorting and removal of plastic waste in Assiut; B) Photographs taken after clean-up campaign; and C) Photographs of the prevalence of plastic waste in the River Nile in Nagaa Hammadi

DISCUSSION

This investigation of plastic wastes along the River Nile's shores—the longest river in the world—may be the first of its kind. The River Nile's shores in twelve different locations across six consecutive governorates in Upper Egypt, from Aswan in the far south to El-Minya in the north, were the subject of this extensive investigation spotting the accumulation, distribution, abundance, and composition of plastic wastes. In all study locations, plastic wastes were observed to outnumber all other pollutants. Our findings make it cristal clear that there is no connection between the variations in population densities at the study sites with the distribution and abundance of plastic wastes on the River Nile's shores.

This finding is consistent with a study conducted by **Rech *et al.* (2015)** in some rivers in Chile, postulating that pollution was present at all study sites, whether the rivers flowed through sparsely populated or densely populated areas. This finding is particularly intriguing because research has frequently linked urban populations and industrial areas to litter in or above rivers or on coastal beaches **(Moore *et al.*, 2011; Neto and da Fonseca, 2011; Carson *et al.*, 2013)**. According to **Kiessling *et al.* (2019)**, more polluted rivers were discovered along the Rhine and Danube systems, which, relative to the coastal environment, flow through Germany, the most and the second most populated area. There is no doubt that the various proportions of plastic wastes on the shores of the Nile are clearly caused by the differences in the characteristics of the sites between urban, rural, and touristic, in addition to the multiplicity and diversity of anthropogenic activities and the various levels of interest in the cleanliness of the shores. The urban sites (Assiut, Nagaa Hammadi, and Suhag) in addition to the rural site (El-Wasta), contained the highest distribution, abundance, and composition of plastic wastes on the shores of the Nile, in contrast to the tourist destinations (Luxor, Aswan, and Edfu) that receive more attention for their cleanliness. Our findings corroborate those of **Carr *et al.* (2016)**, who noted that the majority of rivers with notable plastic waste rates are located close to sizable urban centers, where the growth and diversity of anthropogenic activities (such as urban development, recreational activities, transporting, commercial activities, industrial activities, agricultural activities, and fishing) may additionally be purposefully dumped on river shores in some regions of the world. Due to modernity and systems for managing liquid waste, particularly in urban and rural areas, this is only now legally prohibited **(Kalčíková *et al.*, 2017; Hassan *et al.*, 2023)**. This may give a clear explanation for the results of remote sensing monitoring in our study, which indicated the presence of plastic waste piles on the Nile's shores at the Assiut site during the previous years.

Generally, the slow disposal of plastic waste on the Nile's shores is the main cause of its appearance in the form of piles at two sites (Assiut and Suhag), whereas in Nagaa Hammadi, its inability to appear in the form of piles despite its high proportion may be related to the constructed shoreline, which made it harder to gather waste on the dry part of the shore, indicating that it was destined for the water, in contrast to the natural shores at two sites (Assiut and Suhag). Depending on their inherent densities, plastic particles in the water column may float or sink to the bottom **(Kowalski *et al.*, 2016)**. Vertical mixing within the water column caused by strong winds and wave activity may potentially revive plastic debris from the bottom **(Reisser *et al.*, 2015)**. Our results were in line with those of **Rech *et al.* (2015)** and **Kiessling *et al.* (2019)**, who found a clear regional difference in the amount of plastic waste accumulating along river banks. According to our results, it is also clear that the dominance of macroplastics is due to the fact that most of the plastic waste on the shores of the Nile was material resulting from fishing, tourism, and household waste, such as plastic bags and bottles. The increase in megaplastic in Armant and Qena may be ascribed to the fact that most of the plastic materials on the shores of the Nile at these two sites were tires, while the increase in mesoplastic in Gerga is due to the fact that most plastic wastes are bottle caps or light materials such as bags that are easy to break down into small particles.

The increase of microplastics in Edfu may be due to two reasons: first, Edfu is located in the extreme south, where the high temperature helps plastic waste breakdown into microplastics; this is called secondary microplastics **(Galgani *et al.*, 2013)**. Second, the presence of a coating on ships and vessels; this material was originally manufactured to have a size less than 5mm and is called primary microplastics **(Cole *et al.*, 2011; Browne, 2015)**. The fact that the northern governorates are urban governorates with a variety of anthropogenic activities, particularly household waste, making it clear why they have a higher percentage of plastic waste on the shores of the Nile than the southern governorates. The main sources of plastic waste in the southern governorates, which are tourist governorates, are tourism, leisure, and commercial activities like water sports, shipping, fishing, and harbor operations. The governorates of Aswan and Luxor have the highest number of hotels as a result of their tourist and recreational activities. These activities harm the tourism industry economically posing grave biological risks to aquatic life **(Avio *et al.*, 2017)**. According to the current study, the flow of the Nile water from the south is another reason causing the increase in plastic waste rates in the northern governorates. Qena governorate's location along the U-shaped curve of the River Nile—which can be seen on the map of Egypt's River Nile—which may slow the water current—could be the cause of the increase in plastic waste in Qena Governorate than in Suhag Governorate, which is located north, while the decrease in plastic waste levels in El-Minya Governorate is greater than in Assiut Governorate, which is located south. Thus it is probable that at the urban site in El-Minya Governorate (El-Minya), there are policemen to secure the sunken ship, and thus it was recorded with a low percentage of plastic wastes, and at the rural site (Sawada), there are some animals such as caws and donkeys that may eat these plastic items. Additionally, with the presence of a small canal, residents of the area dispose garbage on the canal’s shores being the closest spot from the course of the River Nile. Accordingly, Lower Egypt (Cairo and the Delta) is predicted to have a higher percentage of plastic wastes on the Nile's shores compared to Upper Egypt. In light of the abundance and variety of human activities and sources of plastic pollution in the governorates of Lower Egypt compared to the governorates of Upper Egypt, the previous finding may explain why microplastic MPs (size < 5mm) appeared at a high rate in the Nile fish in Cairo and the Nile Delta in the studies conducted by **Khan *et al.* (2020)** and **Khallaf *et al.* (2023)**, as well as an increase in their abundance in the water and sediments of the Nile Delta in the study conducted by **Shabaka *et al.* (2022)**.

Notably, Egypt's excessive plastic consumption, which has recently increased in an obvious way from 2.1 million metric tonnes in 2017 to approximately 5.4 million metric tonnes per year **(Babayemi *et al.*, 2019; Ritchie & Roser, 2020)**, as well as insufficient waste management and unrestricted plastic waste production, are the primary causes of the growing proportion of plastic wastes and its dominance over all other pollutants found on the shores of the Nile **(Hamed *et al.*, 2019)**. According to the current study, the direction of the Nile flow from south to north may be another reason for this increase, as Egypt is the last country through which the Nile flows before the Mediterranean Sea, where Egypt occupies the leading position in the list of plastic pollutants detected in it **(WWF, 2019)**. The afore-mentioned concept is based on data showing that rivers are the main conduits for plastic waste from terrestrial sources to the ocean **(Lebreton *et al.*, 2017; Zhang *et al.*, 2017)**. It has been reported that 80% of the plastic wastes detected in the aquatic environment are sourced from littering on land **(Andrady, 2011)**, while the remains are originated from the direct discharge **(Anderson *et al.*, 2016; Bellasi *et al.*, 2020)**. The previous finding may explain the cause of the increasing number of MPs (<5mm) in water and sediment in the Nile Delta **(Shabaka *et al.*, 2022)**. The percentage of MPs were recorded with 33.9% and 59.7% for two fish addressed in the study of **Khallaf *et al.*, (2023)** in the Nile Delta, while more than 75% was recorded for MPs in the target fish covering Cairo (before the Nile estuary) in the study of **Khan *et al.* (2020)**. On the other hand, the MPs percentage was only 20% for the target fish in Lake Victoria (the Nile upstream) in the study of **Biginagwa *et al.* (2016)**. Generally, the prevalence of plastic trash over anthropogenic litter along freshwater and marine shorelines is a global tendency. Despite the dearth of information about rivers, the great majority of research claims that plastic garbage predominates as a contaminant on riverbanks. Examples include the studies carried out in German and Chilean rivers by **Rech *et al.* (2015)**, **Kiessling *et al.* (2019)** and **Tramoy *et al.* (2019)**, who found a polluted beach on the banks of the Seine River that was covered in plastic. Moreover, **Castro-Jiménez *et al.* (2019)** elucidated that plastic wastes predominate in the river litter floating on the Rhone River and representing 77% of the identified items. Our current research, which focuses on the River Nile, the longest river in the world, contributes to this worldwide trend.

Egypt consumes roughly 14 billion plastic bags yearly **(Cedare, 2019)**, increasing the proportion of plastic bags in the research compared to other forms of plastic, just as there was an increase in the proportion of bottles owing to their increased use. When it comes to tires, some are used to shield boats from friction caused by collisions with the industrial shorelines, as in Qena, Sawada, and Nagaa Hammadi, while others are a result of parking close to the shorelines, as in Armant, in addition to discarding used tires, which makes up the smallest percentage, as in Suhag and Gerga. Personal hygiene products, fishing gear, and other plastic garbage, such as boat mooring ropes, plastic foams, lids, food wrappers, packaging material, bottle caps, cutlery, cigarette butts, personal tools, and plastic pipes, are all byproducts of human activity, including fishing, tourism, and municipal waste. The trend on the Nile may agree with the findings of **Castro-Jiménez *et al.* (2019)**, who found fragments (2.5-50cm) (equivalent to macroplastic size 25mm-1m) and single-use plastic (i.e., bags, bottles, and covers/packaging) were among the most abundant items in surface waters from the Rhone River.

On the contrary, the current results differ from those of **Tramoy *et al.* (2019)** addressing a polluted beach on the shores of the Seine River. The previous authors found that half of the plastic debris in number is represented by preproduction pellets. In addition, the present findings are different from those of **Battulga *et al.* (2019)**, who illustrated that the most abundant plastic debris on the Selenga River is polystyrene foam (PSF), which is usually used in construction and packaging. Personal hygiene products, such as masks, which were only 3% in our results, were 20% of the litter items in the Thames River **(Morritt *et al.*, 2014)**. It is noteworthy that the current study was carried out between the end of 2021 and the beginning of 2022, during the COVID-19 global epidemic, which, despite its positive effects in reducing the waste in the river environment and thereby reducing the dumping of plastic waste, may be a reason for increasing the use of plastic in the production of masks and protective and cleaning tools. According to **McCormick and Hoellein**'s **(2016)** hypothesis, the season may also have an impact on the amount of plastic debris entering rivers, which determines the number of individuals visiting the river ecosystem. It is important to keep in mind that the present survey was carried out in December 2021 and January 2022, which fall within Egypt's winter season. As a result, these percentages are probably going to rise throughout summer. Indeed, plastic waste is a global problem, and it appears that this trend will persist. Plastic manufacturing and environmental leakages are expected to rise in the coming decades despite multiple international attempts conducted to address this emerging environmental issue **(Borrelle *et al.*, 2020)**. Due to continuous advancements in the industry, plastics have evolved into a practical and multipurpose material with a wide range of applications. They might be used in the future to assist in addressing some of the most urgent issues facing humanity, like food shortages and climate change. Therefore, it is necessary to develop infrastructure for the handling of plastic waste.

CONCLUSION

Our study can offer precise data on the frequency of plastic material discoveries along the River Nile shoreline, as well as the locations of increased abundance, accumulation, and distribution of plastic waste on the Nile shores, to help decision-makers take the right action to dispose of this waste. Additionally, it would support the researchers' investigation into the plastic contamination of the River Nile. Finally, we suggest monitoring the River Nile in the future and promoting environmental awareness and cleanliness campaigns for schoolchildren and the general public.

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