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TECHNICAL COMMUNICATION

Tracing Beach Sand Movement Using Fluorescent Quartz Along the Nile Delta Promontories, Egypt

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ABSTRACT

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Two main problems affecting the Nile delta coast: one problem is due to the loss of sand and the other one is related to the siltation of coastal lake outlets and the mouths of the Nile branches. To address these problems, the dispersion and rate of sediment movement have been carried out by using fluorescent sand tracers at Rosetta, Burullus and Damietta Nile delta promontories. Results indicate that there is a net eastwards littoral sand transport in the surf zone of the three delta promontories. The average drift rate measures at Rosetta ($3.21 \times 10^6 m^3/yr$), Burullus ($1.48 \times 10^6 m^3/yr$) and Damietta ($1.8 \times 10^6 m^3/yr$) show a wide difference which in part explains the severe erosion that has occurred at the tips of these promontories. Dispersion of the surf zone fluorescent tracers in vicinity of these promontories indicates that the most significant portion of sediments ($0.40 \times 10^6 m^3/yr$, $0.39 \times 10^6 m^3/yr$ and $0.44 \times 10^6 m^3/yr$) is partly responsible for the silting of the Rosetta exit, Burullus lake outlet and Damietta exit, respectively.

INTRODUCTION

The Nile delta coast (Figure 1) is situated in the south-eastern part of the Mediterranean sea. It extends from the west at Abu Quir headland near Alexandria to the east at Port Said, a total distance of about 240 km. The sandy coast line has three promontories at Rosetta, Burullus and Damietta. These promontories are separated by embayments in coastal configuration, backed by low sandy backshore plains, fields of sandy dunes and three large brackish water lakes connected to the sea: Idku, Burullus and Manzala. There are also four channels which empty into the sea, two distrubutaries of the Nile at Rosetta and Damietta, and two drains at kitchener and Gamasa. Three major harbors are located on the coast: Alexandria, new Damietta and Port Said.

The Nile delta coast is a dynamic system formed by the Nile river sediments discharged into the Mediterranean sea through the historic seven Nile branches (SAID, 1981; AL-ASKARY and FRIHY, 1986; COERTELLIER and STANLEY, 1987) which have subsequently silted up and been replaced by the present-day two branches namely Rosetta and Damietta (Figure 1). Since the building of the High Aswan Dam on the main river in 1964, no additional sediment reaches the coast. However, the waves and currents continue to move the sediment alongshore as some beaches are retreating while others are advancing. These rapid shoreline changes coupled by on-going littoral drift, sea level rise in the Mediterranean and subsidence of the land in the northern part of the delta (STANLEY, 1988, 1990; FRIHY, 1992; EL-FISHAWI, 1993) lead to an increasing recession rate of about 106m/yr, 6.5m/yr and 10.4m/yr at the Rosetta, Burullus and Damietta promontories, respectively (FRIHY and KOMAR, 1993). However, erosion is not the only trouble affecting the delta coast, but also siltation of the coastal lake outlets and the exits of the Nile estuaries is now a grave problem as it hinders fishing activities and coastal navigation besides harming the lake ecosystem. Understanding the drift of sand along the beach is especially important to address these problems.

The aim of this study is to estimate the drift rate and dispersion of longshore sediment transport across the surf zone of the Nile delta promontories by using fluorescent sand tracers. The Coastal Research Institute at Alexandria is conducting a program for management of these problems and of their impacts on surrounding neighborhoods.

TECHNIQUES AND METHOD OF STUDY

Field experiments using fluorescent-dyed grains were performed within the surf zone at two stations on each side of Rosetta exit, Burullus outlet and Damietta exit (Figure 1). These experiments were carried out during January and July, 1993. Such period represents different sea conditions during winter and summer seasons. The length of each station along the beach was about 150 m and the width of surf

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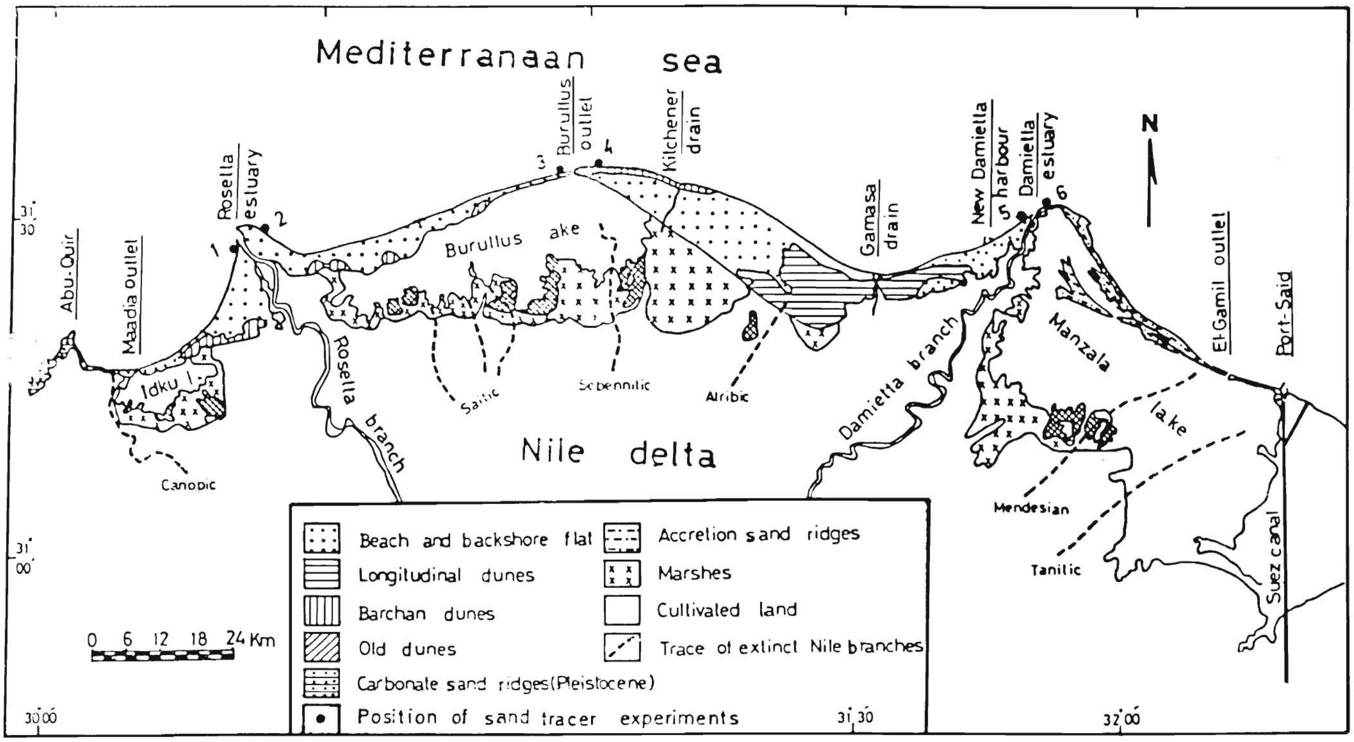

Figure 1. Geomorphological map of the lower Nile delta coast and the positions of tracer experiments.

zone was about 60m. The field and laboratory techniques were made according to INGLE (1966). Fluorescent sand grains in the present study have the same grain size distribution, specific gravity and shape features of the natural coastal sands.

Generally, three release points were located and 21 kg fluorescent sand usually released at the up drift side of sample stations distributed on a rectangular grid system. Samples were collected by pressing 10 × 10 cm bentonite-coated wood plank onto the sea bottom surface. Two series of samples were collected from each stations after release. A total of 672 samples were collected during the 12 tests. In laboratory, each sample was viewed under short wave ultraviolet light to count the number of tracer grains.

CURRENT AFFECTING THE COAST

Longshore current have been measured within the surf zone twice daily along the study areas during fluorescent sand tests. The collected data during January and July 1993 have been subjected to statistical analysis to determine the probability distribution of the longshore current. Results indicated that the predominant current direction was found to be from west to east. The maximum measured current velocities were 82 and 67 cm/sec, towards east and west, respectively while the average velocity is about 40 cm/sec.

RESULTS AND DISCUSSION

Fluorescent Sand Movement and Dispersion

The technique of the present study depends upon at what rate fluorescent sand left the respective sample grids. After establishing the approximate number of tracer grains released during each field test, a planimeter analysis was made of each individual tracer dispersion pattern constructed from adjust tracer concentration values (Figure 2). The data resulted from applying the equation of INGLE (1966) yield a wide range of drift rates due to variety of locations, seasonal effect and surf conditions prevaling during each tracer test. The examination of the fluorescent sand movement (Table 1) revealed that erratic current has played an important role in the sediment dispersion. The erratic current and sediment distribution patterns were created due tó the low angle of breaker incidence which was too small to cause a strong unidirectional current. The results of sediment movement (Figure 3) along the three promontories were discussed as follows:

At Rosetta coast, the average grain velocity was 3.12 and 1.72 m/min at the western and eastern sides of Rosetta mouth, respectively. The thickness of the mobile bed layer was determined by using core sampler. It was 2.0 and 4.2 cm at the western and eastern sides of Rosetta mouth. Therefore, the average sediment drift is estimated to be 3.21 × $10^6 m^3$/yr. The greatest tracer dispersal occurred in seaward (45%

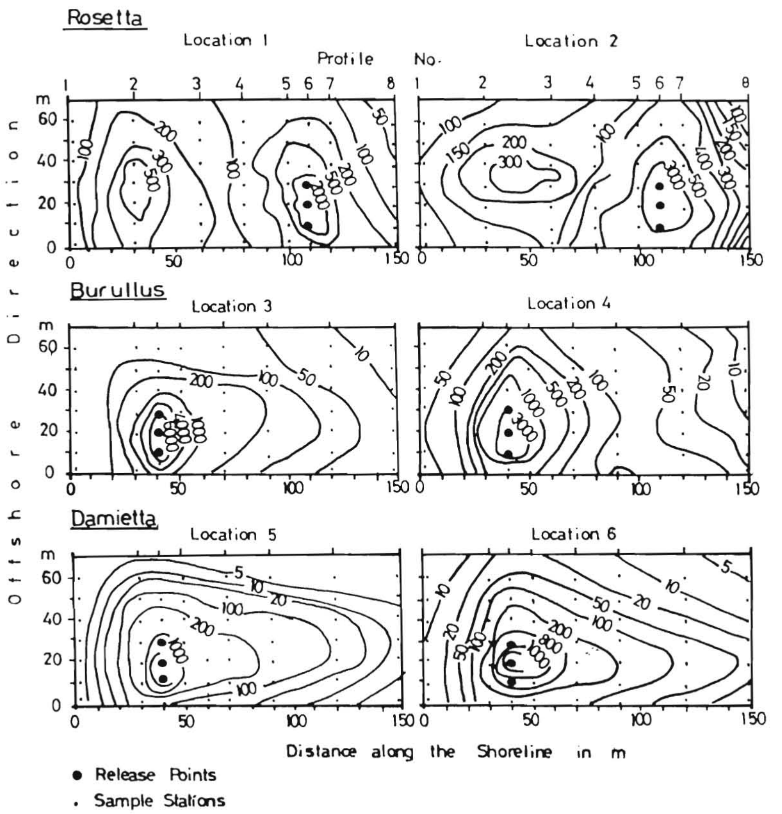

Figure 2. Dispersion of fluorescent sand grains astride Nile delta promontories during January, 1993.

Table 1. *Percentage of occurrence and drift rates (× 10^6 m^3/yr) for each direction of sediment movement astride Rosetta, Burullus and Damietta promontories.*

Area	Location	Date	Total Drift Rate	Offshore		To E		To W		Landward	
				%	Drift Rate	%	Drift Rate	%	Drift Rate	%	Drift Rate
Rosetta	1	1-1-1993	5.13	65	3.33	12	0.60	23	1.20	—	—
	1	1-7-1993	3.15	49	1.55	6	0.20	45	1.40	—	—
	2	2-1-1993	2.79	40	1.12	40	1.12	20	0.55	—	—
	2	2-7-1993	1.75	25	0.44	50	0.87	25	0.44	—	—
Average	—	—	3.21	45	1.61	27	0.70	28	0.90	—	—
Burullus	3	3-1-1993	1.20	25	0.30	33	0.40	8	0.10	33	0.40
	3	3-7-1993	0.92	22	0.20	41	0.38	11	0.10	26	0.24
	4	5-1-1993	2.10	66	1.38	17	0.36	17	0.36	—	—
	4	4-7-1993	1.70	70	1.20	15	0.25	15	0.25	—	—
Average	—	—	1.48	46	0.77	27	0.35	13	0.20	15	0.16
Damietta	5	7-1-1993	1.08	25	0.27	59	0.64	16	0.17	—	—
	5	10-7-1993	0.78	32	0.25	31	0.24	37	0.29	—	—
	6	7-1-1993	3.76	17	0.66	64	2.40	19	0.70	—	—
	6	10-7-1993	2.78	55	0.86	29	0.45	16	0.26	—	—
Average	—	—	2.10	32	0.51	46	0.93	22	0.36	—	—

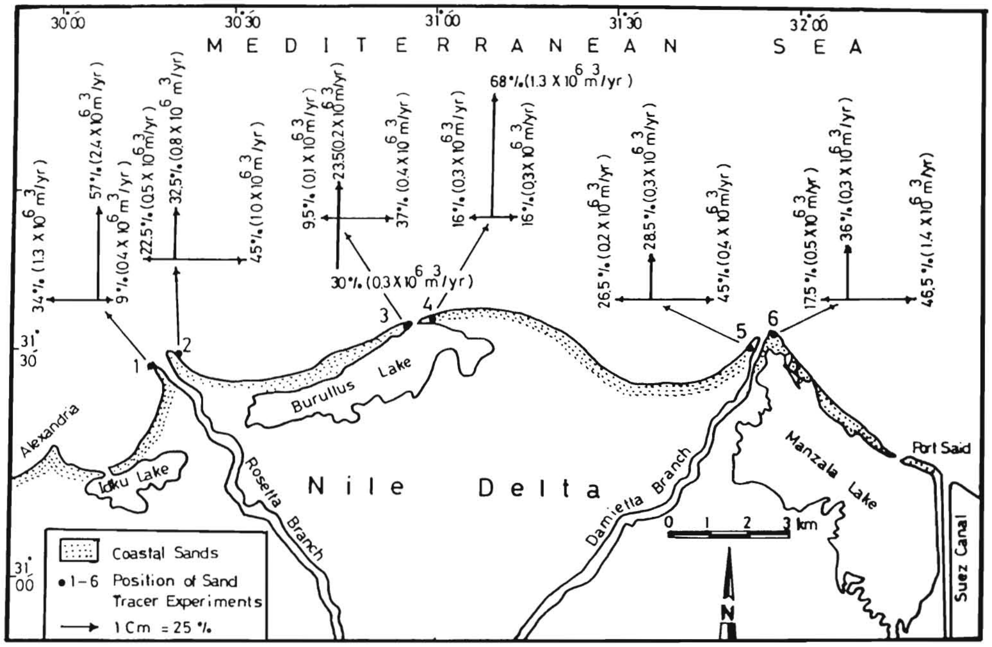

Figure 3. Sediment drift rates astride Nile delta promontories.

offshore). It was found 1.61 × 10⁶m³/yr and therefore the offshore sediment movement is mainly responsible for the severe coastal erosion. A significant portion of the sediments showed a distinct tendency to move westward which was estimated to be 0.90 × 10⁶m³/yr. So, the westward movement is also contributed to the severe coastal erosion. The least portion at the western side of Rosetta mouth was found to move eastward (9%) with an average annual drift rate of 0.40 × 10⁶m³/yr. The silting problem of Rosetta exit may be related to that eastward drift. This is in agreement with EL-FISHAWI *et al.*, 1991.

At Burullus coast, the area west of Burullus outlets was subjected to continued accretion after the construction of the western jetty, calculated rates of sand movement increased from 0.92 × 10⁶m³/yr to 1.2 × 10⁶m³/yr. On the other hand, the areas located at the eastern side of Burullus outlet subjected to continued erosion and the drift rate increased from 1.70 × 10⁶m³/yr to 2.1 × 10⁶m³/yr where the maximum destruction of the beach and coastal dunes is found. The average grain velocity was 1.65 and 3.12 m/min at the western and eastern side of Burullus outlet, respectively. The thickness of mobile bed layer at the same sides was 1.6 and 2.7 cm. The most prominent portion of tracer grains (33–41%) was moved eastwards at the western side which was estimated to be 0.39 × 10⁶m³/yr. It is partly responsible for silting up of Burullus outlet and creating difficulties to the fishermen. Beside the landward drift was estimated to be 0.32 × 10⁶m³/yr. A contrast situation was found at the eastern side where the waves attack the foot of the coastal dunes. The most prominent portion of the sediment movement (68% and estimated to be 1.29 × 10⁶m³/yr) was moved offshore. Although eastward and westward drifts were represented (0.31 × 10⁶m³/yr), the high rate of beach erosion and destruction of the coastal dunes may be related to high rate of offshore drift. Similar result was arrived by EL-FISHAWI and BADR (1992).

At Dameitta coast, the average grain velocity was 2.24 and 3.07 m/min at the western and eastern side of Damietta mouth, respectively. The thickness of mobile bed layer at the same sides was 1.5 and 2.7 cm. Therefore, the average annual drift was found to be 0.93 × 10⁶m³/yr at the western side. It can be subdivided into: 0.26, 0.44 and 0.23 × 10⁶m³/yr of sediments moved offshore, eastwards and westwards, respectively. The most portion of sediment moving eastwards is partly responsible for the silting up of the Damietta exit. The westward drift causes similar difficulties at the new Damietta harbor (Figure 1). The average annual drift was estimated to be 2.67 × 10⁶m³/yr of the eastern side. It can be subdivided into: 0.76, 1.43 and 0.48 × 10⁶m³/yr of sediments moved offshore, eastwards and westwards, respectively (Figure 3). The most prominent portion of sediments which moved eastwards may be responsible for the construction of the spit at the far east of Damietta. On the other hand, sediment drift moved westwards used to silt up the Damietta mouth and creating difficulties to the navigation. Offshore drift causes severe erosion. Similar result was arrived by KADIB (1972) and EL-FISHAWI and BADR (1993).

CONCLUSIONS

The higher grain velocity and thicker mobile bed layer at the western side of Rosetta mouth, eastern side of Burullus outlet and eastern side of Damietta mouth may be responsible for the loss of sand in front of these beaches. During different sea conditions, the fluorescent sand tests indicate that the drift rate tend to be higher in winter than in summer. The average drift rate was estimated to be 3.21, 1.48 and 1.80 $\times 10^6 m^3/yr$ at Rosetta, Burullus and Damietta promontories, respectively. Offshore drifts were found 1.61, 0.77 and 0.51 $\times 10^6 m^3/yr$ which has caused severe erosion along the same promontories. Sediments moved westwards (0.40, 0.39 and 0.44 $\times 10^6 m^3/yr$) used to silt up the Rosetta mouth, Burullus outlet and Damietta mouth, respectively. As a result, the Burullus outlet, Rosetta and Damietta mouths used to be silted up creating difficulties to the navigation and inhabitants who are mainly fishermen.

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