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VARIATIONS OF BEACH SANDS WITH SEASONS, BEACH SLOPE AND SHORE DYNAMICS ON THE NILE DELTA COAST

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ABSTRACT

Sandy beaches of the Nile Delta coast show a marked variation of grain size with the season and with the changing shore dynamics. Average median grain size of beach sands ranges from 1.98 ∅ in winter to 2.40 ∅ in summer. Beach face slope is shown to depend primarily on the median diameter and standard deviation of beach sediments. The highest correlation coefficient (0.908) is found between slope and median, and there is also a significant correlation (0.806) betwee nslope and sorting. Relying upon statistical analysis, it is demonstrated that the grain size of beach sands is proportional to the shore dynamics affecting Nile Delta coast. A procedure is suggested for the determination of diameter of sand grains about to be moved or added to the beach under a range of reasonable wave heights and current velocities.

INTRODUCTION

During the last three decades many studies have been carried out concerning the movement of beach sediment and its relation to the causative hydrodynamic factors [ZENKOVICH, 1967; KING, 1972; KOMAR, 1976]. Some of these investigations are based on laboratory experiments. Regarding to the threshold velocity, no measurements have obtained from the field.

The Nile Delta beach is a variable beach facing the open Mediterranean Sea for about 144 km. The presence of cusps, berms, bars and accretion and erosion forms are the main characteristic features of this beach. Its variability according to grain size parameters, beach face slope and the affecting hydrodynamic factors makes it suitable for the study of the relationship between these characteristics.

Published geological informations on the variation of beach sands with time are still few [TRASK and JOHNSON, 1955; TRASK, 1956; Coastal Erosion Studies, 1976; EL-FISHAWI *et al.*, 1976]. The present investigation, however, differs from the others. Its aim is to trace the seasonal variation of beach sands along the coast and not on the same place with different times.

Beach samples were collected along the Nile Delta coast between Rosetta and Damietta mouths *(Fig. 1A)*. Two series of samples were collected during January, 1975 and July, 1978 at 3 km intervals. Littoral currents were measured also along the coast with the same standard interval of beach samples. Repeated beach samples also were collected at different dates from local Burullus beach astride Burullus outlet *(Fig. 1B)*. At the same time, current velocities and wave heights were recorded.

TECHNIQUES

Grain size analyses were carried out by the conventional sieving method using a vibrating shaker. About 80 gm split of each sample was screened for 25 minutes using one-phi interval. The cumulative percentages were plotted on probability paper, and grain size parameters were calculated using the formulae of Folk an Ward [1957].

Wave heights were obtained by means of OSPOS (Offshore Pressure Operated-Suspended) wave records situated just west of Burullus outlet. Measurements of littoral current were made by simple floats whose movements were observed with time between two stations marked by poles. Only surface currents were measured.

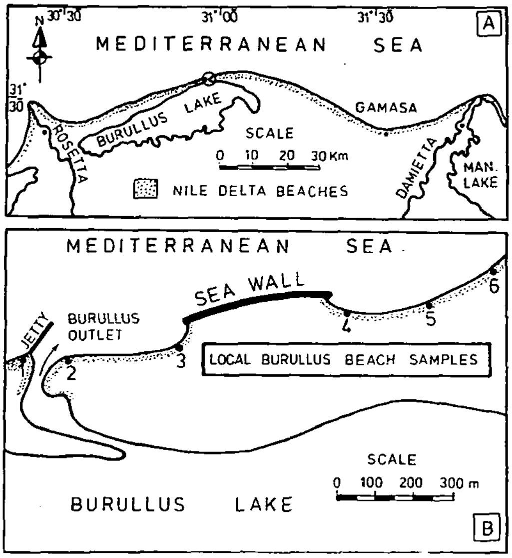

Fig. 1. A. Location map showing Nile Delta beaches.
B. Sites for beach samples — Local Burullus area

The application of statistics should be based upon an average of a large number of data. Although there are 6 times for recording wave heights per day with recording interval of 20 minutes, it is probably long enough for the wave conditions to have changed sufficiently for successive records. Data on the littoral current velocities and wave heights were averaged for each date of sampling of beach sands.

Time variation of beach sands

Many sandy beaches of the Nile Delta coast show a marked variation of grain size with the seasons and with the changing shore dynamics. The coarser sandy beaches, particularly the central part of the coast, are highly variable both from place to place and from time to time. On contrast, beaches with fine sand do not show such marked variations. It is generally true that the grain size of beach sands is larger where the wave energy is greater.

Visual analysis of the data can be made by plotting the cumulative percentages of beach sands with distance along the Nile Delta coast *(Fig. 2)*. The results obtained are suitable to support the previous studies on the variation of beach sands with time. Table 1 summarizes the main differences between winter and summer beach sediments.

TABLE 1

Average grain size of Nile Delta beach sands during winter and summer seasons

Grain size \ Season	Winter	Summer
Median diameter	1.98 Ø	2.40 Ø
Coarse + very coarse sand	14.77 %	2.96 %
Fine + very fine sand	43.56 %	78.41 %

Winter beach sediments:

During winter, 1975 it is observed that the coarse and very coarse sands are added to the beach sediments with a maximum value of 70.95% near Ayash Fort. This percentage, however, decreases east and westwards and ranges between 68% and 2% with an average of 14.77%. The percentage of fine and very fine sands varies along the coast being smaller in the central part and higher near Rosetta and Damietta mouths with an average of 43.56%. The range of grain sizes of the beach sands lies between a median diameter of 0.70 Ø and 2.60 Ø with an average of 1.98 Ø. During the winter season it was found that the lateral variation of grain size is highly variable along the coast.

Summer beach sediments:

During the summer 1978, the beach sediments show large differences in relation to the winter sediments. The main observation is that the coarse and very coarse sands are much reduced to very small values and they occur only astride Burullus outlet

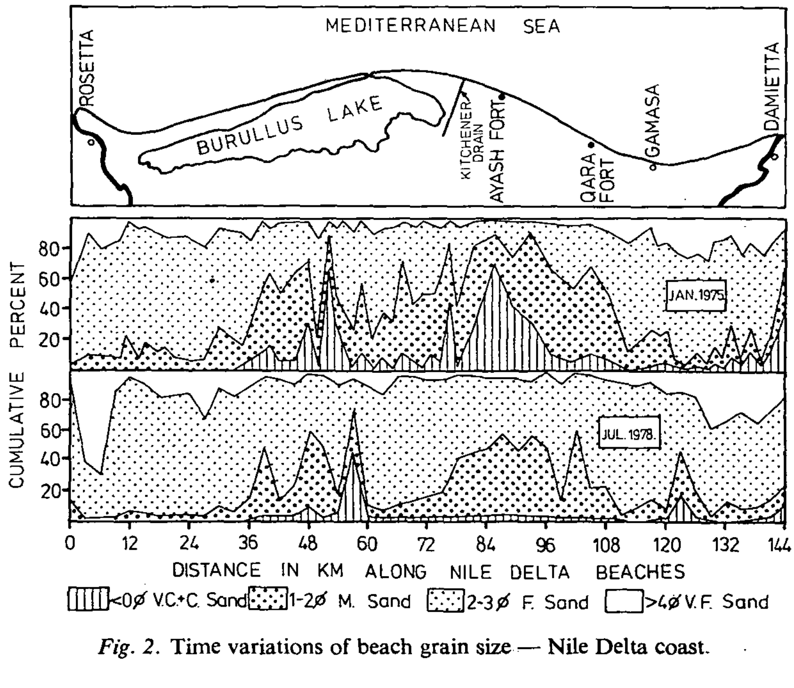

Fig. 2. Time variations of beach grain size — Nile Delta coast.

and near Gamasa. Their percentage ranges between 44% (only on one locality) and 0.02% with an average of 2.96%. On the other hand, fine and very fine sands are much increased with an average of 78.41%. The median diameter varies between 1.15 Ø and 2.90 Ø and averages 2.40 Ø. Grain size variations are much reduced also during summer season.

These changes between the summer and winter may be related to the fact that the beach receives more energy in winter than in summer. This is reasonable for the abundance of coarse sand in winter and fine sand in summer. The coarse materials which feed the beach during winter are available from offshore sources and are periodically added to the beach sediments [EL-FISHAWI, 1977]. The investigation of grain size distribution, as shown in *Fig. 2* deals with another character of Nile Delta beach sands. A general pattern of grain size peaks appear to remain stationary in a very narrow stretch throughout the different yearly sampling and in spite of time variation of beach sands. Two main peaks can be observed east of Burullus outlet and near Ayash Fort. This feature has been observed by Coastal Erosion Studies [1976] and EL-FISHAWI [1977]. Until now, it is difficult to explain why the peaks occur and why they remain there.

Beach face slope and beach sands

The angle of beach face is what a line joining the beach crest to the top of the steps makes with the horizontal. The angle was measured in degress with a modified protractor by the authors. Samples have been collected along Nile Delta coast from the part of the beach face subjected to wave action in order to remove the variability due to seaward variation in grain size parameters.

Table 2 illustrates the littoral current velocity, angle of beach face slope and grain size parameters of beach sands along Nile Delta coast.

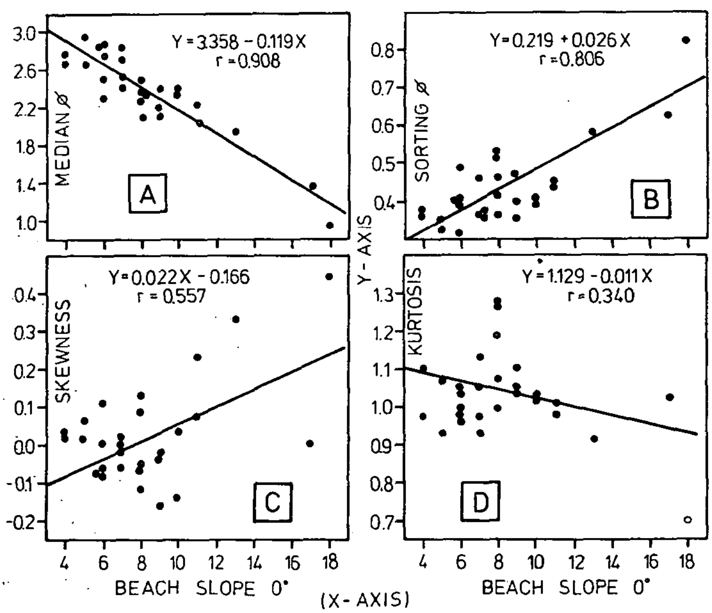

Fig. 3. Relationships between beach face slope and statistical parameters of beach sands

Average current velocity, beach slope and statistical parameters of Nile Delta beach sands during 1978

Location in km.	Curr. vel. (cm/sec.)	Beach slope, 0°	Median, Ø	Sorting, Ø	Skewness	Kurtosis
3 km WBR.	32	—	3.10	0.40	—.14	1.07
6 km WBR.	55	—	3.15	0.40	—.14	1.07
9 km WBR.	41	—	2.70	0.30	0.16	1.23
15 km WBR.	51	—	2.60	0.32	0.07	1.18
18 km WBR.	40	—	2.70	0.39	0.32	1.27
24 km WBR.	42	—	2.70	0.32	0.07	1.18
27 km WBR.	35	—	2.85	0.40	0.14	1.08
33 km WBR.	45	—	2.65	0.42	0.07	0.96
39 km WBR.	44	—	2.00	0.49	0.00	0.94
45 km WBR.	31	—	2.35	0.54	0.01	1.08
48 km WBR.	38	—	1.90	0.54	—.13	0.92
54 km WBR.	34	—	2.40	0.51	—.19	1.23
57 km WBR.	42	7°	2.40	0.46	0.02	1.06
0.0 km EBR.	42	9°	2.20	0.47	—.16	1.06
3 km EBR.	55	8°	2.10	0.52	0.13	1.00
6 km EBR.	37	10°	2.40	0.41	0.04	1.04
9 km EBR.	52	7°	2.70	0.36	0.00	0.98
12 km EBR.	48	18°	0.95	0.83	0.45	0.71
15 km EBR.	45	8°	2.25	0.46	—.05	1.27
18 km EBR.	43	8°	2.50	0.41	0.09	1.08
21 km EBR.	38	9°	2.40	0.35	—.02	1.05
33 km EBR.	35	11°	2.25	0.44	0.07	0.99
36 km EBR.	31	6°	2.50	0.41	—.06	1.04
39 km EBR.	33	6°	2.30	0.40	—.06	1.01
42 km EBR.	37	9°	2.10	0.40	—.02	1.11
45 km EBR.	37	8°	2.35	0.36	—.06	1.28
48 km EBR.	34	10°	2.35	0.40	—.14	1.04
51 km EBR.	39	11°	2.05	0.45	0.24	1.02
54 km EBR.	30	7°	2.50	0.35	—.06	1.14
57 km EBR.	35	5°	2.65	0.35	0.02	0.94
60 km EBR.	31	8°	2.35	0.52	0.12	1.20
3 km EGAM.	27	7°	2.85	0.35	—.02	0.94
6 km EGAM.	27	4°	2.65	0.38	0.02	1.11
9 km EGAM.	40	13°	1.95	0.59	0.34	0.92
12 km EGAM.	33	6°	2.75	0.49	—.07	1.04
15 km EGAM.	30	5°	2.95	0.32	0.06	1.08
18 km EGAM.	34	4°	2.75	0.36	0.03	0.97
21 km EGAM.	32	6°	2.90	0.32	—.11	0.96
24 km EGAM.	47	6°	2.90	0.40	0.00	0.97
27 km EGAM.	45	17°	1.35	0.63	0.01	1.04

Figure 3 shows the relationships between beach slope and grain size parameters. For each relationship, the regression equation is calculated in the form of $Y=\alpha+\beta X$. The correlation coefficient is calculated to measure the correspondence of observations to any fitted equation.

The relationship between beach face slope and median diameter is shown in *Fig. 3A*. It is observed that the beach slope increases with increasing median diameter.

The relationship is linear, ranging from 18 degrees for a coarse diameter of 1 ∅, 11 degrees for a medium diameter of 2 ∅, to 4 degrees for a fine diameter of 3 ∅. The regression equation is $Y = 3.358 - 0.119X$ and $r = 0{,}908$ where X is the beach slope in degrees and Y is the median in phi units. The correlation coefficient 0.908 indicates a strong relationship.

Beach face slope is affected also by the degree of sorting of beach sediments as well as by the median diameter itself. Poorly sorted sand beaches are much steeper than those of well sorted ones as shown in *Fig. 3B*. The transition from a gentle slope (4 degrees) to a steep one (18 degrees) is accompanied with changing from a better sorted sand (0.35 ∅) to a poorly sorted one (0.83 ∅). The regression equation is $Y = 0.219 + 0.026X$ and $r = 0.806$ where X is the slope in degrees and Y is the sorting in phi units. The correlation coefficient 0.806 indicates that the median diameter is more effective in beach slope than the sorting parameter.

In the contrast, the relationships between beach slope and both skewness and kurtosis are not as strong as that between slope and both median and sorting. *Figure 3C* shows that when the beach slope increases the sand becomes more fine skewed. However, the correlation coefficient 0.557 does not exhibit a strong relationship. The variation of beach slope in relation to kurtosis was found to be very weak as shown in *Fig. 3D* ($r = 0.34$).

The increase of beach slope with increasing grain size has been demonstrated by several field studies [Bascom, 1951; Wiegel, 1964; McLean and Kirk, 1969; Dubois, 1972]. Regarding to sorting, Krumbein and Graybill [1965] found that well-sorted coarse-sand beaches have steeper slopes than poorly-sorted coarse-sand beaches. McLean and Kirk [1969] have a wavy curved line rather than being linear for the relationship between slope and grain size. The reason may be related to the different sources of their beach sands. Nile Delta beaches gave a linear relationship indicating probably one source from the offshore zone.

An attempt was made to correlate the beach slope with the littoral current velocity. The result is shown in *Fig. 4*. It is apparent from the scatter diagram that there are two possibilities for the behaviour of the variables. The first is represented by a fitted straight line with a regression equation of $Y = 0.833 + 0.198\,X$ and $r = 0.428$. Although the correlation coefficient is low, the scatter diagram does indicate that beach slope becomes steeper with an increase in the velocity of the littoral current.

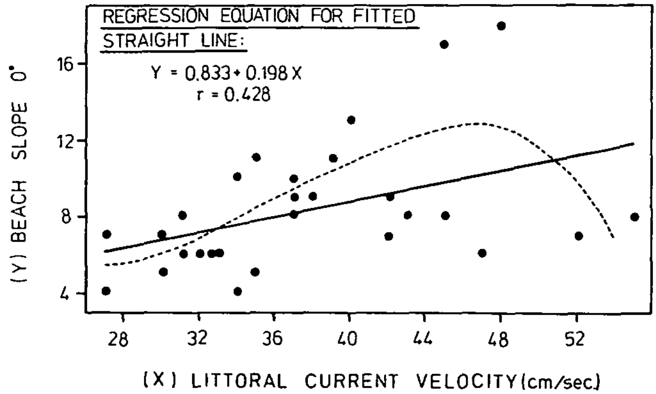

Fig. 4. Relationship between littoral current velocity and beach face slope

The second is a possibility that the beach slope increases with increasing current velocity to a critical value (48 cm/sec). Current velocity higher than this value may be destructive to the beach and will result in a steady decrease in slope. Unfortunately, the resulting scatter diagram does not exhibit a strong relationship, yet there is some suggestion of increasing slope with increasing currens velocity.

Beside the grain size parameters and littoral current, there are several variables effecting the beach slope. RECTOR [1954] found that the greater the wave steepness, the lower the beach slope. A comparison between BASCOM'S [1951] and WIEGEL'S, [1964] data for a given grain size leads to the fact that the low-energy beaches have steeper slopes than the high-energy beaches. KING [1972] showed that an increase in the wave energy will result in a decrease in slope.

Effect of current and waves on grain size of beach sands

Under the action of waves and littoral current, nearshore zone sediments are in motion and could be carried onshore to add to the beach sediments. As the orbital velocity of water flow over a bed of sediments is increased, a stage is reached when the water exerts a force on the particles sufficient to cause them to move from the bed and be transported. This stage is generally known as the threshold of sediment transport. Many equations have been proposed for the threshold of sediment motion under waves [SILVESTER and MOGRIDGE, 1971; KOMAR and MILLER, 1973]. MADSEN and GRANT [1975] and KOMAR and MILLER [1975] were able to compare the threshold under waves with the threshold under unidirectional currents. Due to the difficulties of observation and control, no measurements have been obtained from the field. Therefore, in this subject, an attempt was made to measure directly the change in beach sand diameters due to the action of littoral current velocity and significant wave height.

Correlation of beach sands with littoral current

The estimation data of littoral current velocity along Nile Delta coast and grain size parameters of beach sands as shown in table 2 were used. *Figure 5* shows the relationship of current velocity with median diameter, sorting and skewness of beach sands.

The correlation of median diameter of beach sands with littoral current velocity as shown in *Fig. 5A* gives a general view about the nature of the relationship. With decreasing current velocity, the diameter of beach sands becomes finer. It is clearly seen from the scatter diagram that the current has the ability to move both coarse and fine sediments when its velocity increases. *Figure 5B* shows that beach sands become poorly sorted with increasing current velocity. This means that well-sorted fine-sands can be deposited on the beach under low velocities of current. Both well-sorted and poorly-sorted coarse and fine sands are seen to deposite under high current velocities. Symmetrical skewed sands move under low velocities as shown in *Fig. 5C* while both coarse and fine-skewed sands can be moved under high velocities. In contrast, kurtosis gives no significant trend.

Another branch of this study has been applied on local beach around Burullus outlet. By repeated surveys at different dates, samples have been collected and currents measured under different conditions. Therefore, it is possible to estimate the change in beach sands within the same area according to the variation of littoral current velocity. Table 3 illustrates the data and *Fig. 6* shows the relationship between the variables.

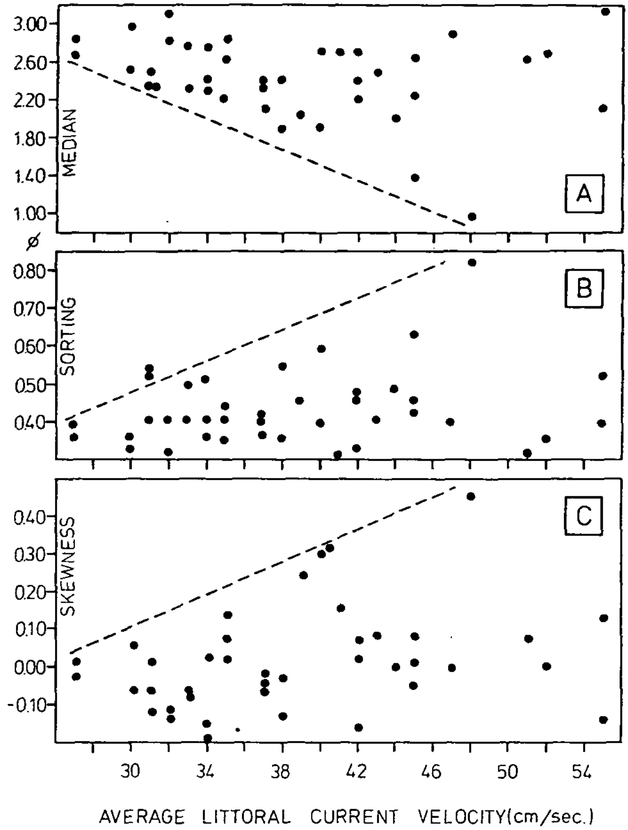

Fig. 5. Relationships between littoral current velocity and statistical parameters of beach sands along Nile Delta coast

The correlation of littoral current velocity with median diameter suggests a procedure for the acceleration of sand sizes to be transported to terminal current velocities within four intervals. The suggested procedure is to assess a suitable current velocity which initiates sediment motion for different grain size. As shown in *Fig. 6,* median diameter finer than 2.10 ∅ can be moved with velocities lower than 24 cm/sec. Median diameter ranging between 2.10—1.60 ∅ would probably be transported under current velocity ranges between 24—30 cm/sec. Sand grains with an average diameter of 1.60—1.20 ∅ tend to move with current velocity of 30—45 cm/sec. Finally, the movement of coarse sands would result with velocities over 45 cm/sec. To sum up, there is a progressive drifting of the coarser materials, from the current load and added to the beach, when the current velocity progressively decreases and vice versa.

Correlation of beach sands with significant wave height

Significant wave height is defined as the average height of the highest one-third of the waves measured over a stated interval of time, usually 20 minutes. It is designated by $H_{1/3}$. Each recording interval results in values for $H_{1/3}$, $H_{1/10}$ and H_{max}.

Littoral current velocity data with relation to median diameter of local Burullus beach sands

Date	D_{50} of west B.		D_{50} of east B.			
	curr. vel. (cm/sec.)	loc. 1	curr. vel. (cm/sec.)	loc. 4	loc. 5	loc. 6
21. 2.74	37	2.35	67	2.35	2.45	2.30
6. 3.74	22	2.30	24	2.15	2.45	1.90
10. 3.74	56	1.70	36	2.25	2.00	2.50
26. 3.74	30	1.90	27	2.15	2.00	1.85
2. 4.74	36	1.90	35	2.25	2.10	2.45
	27	1.90				
9. 4.74	30	1.75	29	2.10	2.30	1.90
	25	1.75				
6. 5.74	35	1.95	34	2.20	2.10	1.60
	39	1.95				
17. 5.74	43	2.20	40	2.35	2.05	2.05
	32	2.20				
7. 7.74	27	1.60	17	2.25	2.35	2.80
4. 8.74	42	2.80	31	2.30	2.80	2.35
26. 8.74	31	2.45	31	2.35	2.05	1.25
16. 9.74	45	2.70	63	2.10	2.45	2.20
18.11.74	31	2.85	39	1.50	1.95	2.10
16.12.74	80	2.65	47	2.65	1.50	1.20
19. 1.75	18	2.10	31	2.55	2.30	1.95
12. 2.75	36	1.40	44	2.00	2.00	2.25
5. 4.75	39	1.30	48	1.50	2.10	1.10
19. 4.75	36	2.50	33	2.05	2.20	1.80

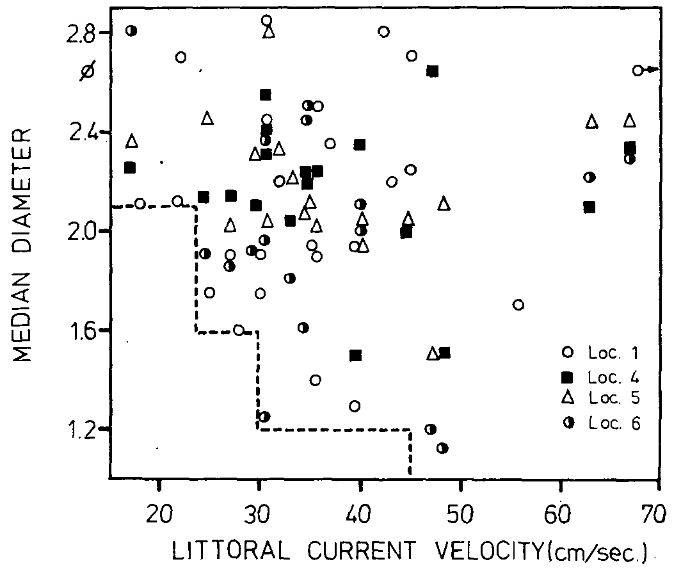

Fig. 6. Relationship between littoral current velocity and median diameter of Burullus beach sands

It was found that there is much better agreement between median diameter of beach sands and the affecting $H_{1/3}$ rather than the other wave parameters.

Table 4 summarizes the main data applied for the correlation between the two variables as shown in *Fig. 7*. The significant wave height evaluated with this scatter diagram has been used to calculate the range of grain sizes which could be set in motion by waves. It is seen that $H_{1/3}$ with an average value of lower than 35 cm is required to move median diameter of finer than 2.10 ∅. $H_{1/3}$ with an average of 60 cm would be capable of moving sediments to median diameter finer than 1.60 ∅. $H_{1/3}$ up to 90 cm moves sediments finer than 1.20 ∅. The motion of coarser grains would result with $H_{1/3}$ values higher than 90 cm.

By replotting the data shown in *Figs. 6* and *7*, a relationship between significant wave height, littoral current velocity and median diameter of beach sands can be

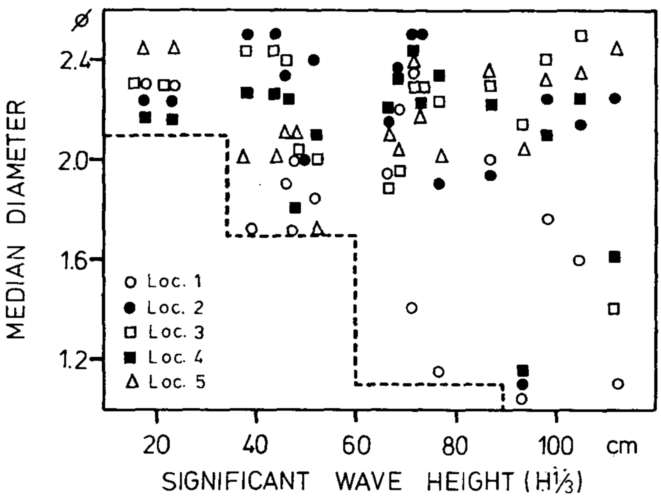

Fig. 7. Relationship between significant wave height ($H_{1/3}$) and median diameter of Burullus beach sands

obtained as shown in *Fig. 8*. This figure permitted the determination of diameter for sand grains about to be moved or added to the beach under a range of reasonable wave heights and terminal littoral current velocities. The range of grain size belonging to both wave height and current velocity was found to be nearly the same because littoral drift of beach sands is shown to depend on the longshore component of wave power which depends on the angle of wave approach.

Bagnold [1966] noted that grains coarser than 250 microns would probably be transported as bed load, and a significant proportion of grains finer than 250 microns by suspension. So, it can be said that sand grains coarser than 250 microns move as bed load under the action of significant wave height higher than 35 cm and current velocity of 24 cm/sec. The finer sediments move by suspensions under the action of shore dynamics with lower values than that mentioned above.

Table 4

Significant wave height data with relation to median diameter of local Burullus beach sands

Date	$H_{1/3}$ (cm)	Median diameter, ∅				
		loc. 1	loc. 2	loc. 3	loc. 4	loc. 5
13.12.72	48	2.00	2.00	2.00	1.80	2.10
1. 2.73	112	1.10	2.25	1.40	1.60	2.45
8. 3.73	51	1.85	2.40	2.00	2.10	1.70
3. 4.73	92	1.05	1.10	2.15	1.15	2.05
13. 8.73	72	2.35	2.50	2.30	2.45	2.35
20. 8.73	87	2.00	1.95	2.30	2.25	2.35
20. 9.73	71	1.40	2.50	2.30	2.25	2.20
30. 1.74	77	1.15	1.90	2.25	2.35	2.00
6. 3.74	19	2.30	2.25	2.30	2.15	2.45
	24	2.30	2.25	2.30	2.15	2.45
10. 3.74	39	1.70	2.50	2.45	2.25	2.00
	47	1.70	2.50	2.45	2.25	2.00
2. 4.74	46	1.90	2.35	2.40	2.25	2.10
9. 4.74	98	1.75	2.25	2.40	2.10	2.30
6. 5.74	66	1.95	2.15	1.90	2.20	2.10
17. 5.74	68	2.20	2.35	1.95	2.35	2.05
7. 7.74	105	1.60	2.15	2.50	2.25	2.35

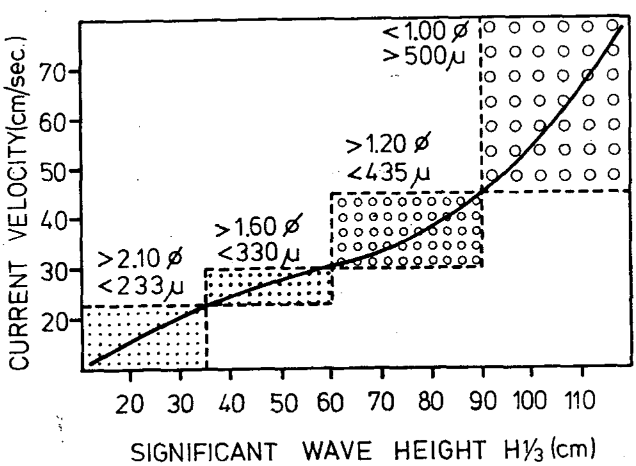

Fig. 8. Combination between significant wave height, littoral current velocity and median diameter of Burullus beach sands

CONCLUSIONS

The central part of Nile Delta beaches is highly variable. Beach sands, particularly the coarse grain beaches, show variations according to seasonal changes. In winter, beach sands are much coarser than that in summer. Great amounts of coarse and very coarse sands are added to the beach sediments during winter season from offshore sources. On the other hand, fine and very fine sands are much increased in summer. The beach zone receives more energy in winter than that in summer and coarse sand is available where high energy can be found.

Concerning the relationship between beach face slope and grain size parameters, it was found that:

(1) Coarse and poorly sorted beach sands are much steeper than those of fine and well sortes ones.

(2) The relationship between slope and both skewness and kurtosis shows a low correlation coefficient.

(3) There is some suggestion of increasing beach slope with increasing the velocity of littoral current.

The results showed that the median diameter of beach sands, littoral current velocity and significant wave height all have diagnostic values in this study. Under the action of weak current velocity and low wave height, fine, well sorted and symmetrical skewed sands can be transported. Higher current velocities and wave heights have the ability to transport various scales of grain size parameters. When the current velocity progressively decreases, it was found that there is also a progressive drifting of the coarser materials from the current load to be added to the beach.

The correlation between beach sands and shore dynamics suggests a procedure for the sand sizes to be moved or added to the beach under these terminal values:

Median diameter of beach sands	*Littoral current velocity*	*Significant wave height*
finer than 2.10 ∅	17—24 cm/sec.	19—35 cm
finer than 1.60 ∅	24—30 cm/sec.	35—60 cm
finer than 1.20 ∅	30—45 cm/sec.	60—90 cm
finer than 1.00 ∅	45—70 cm/sec.	90—120 cm

REFERENCES

BAGNOLD, R. A. [1966]: An approach to the sediment transport problem from general physics. U. S. Geol. Surv., Prof. Pap., No. **422**, (I), 11—137.

BASCOM, W. N. [1951]: The relationship between sand size and beach face slope. Trans. Am. Geophys. Union, **32**, 866—874.

COASTAL EROSION STUDIES [1976]: Detailed Technical Report on Coastal Geomorphology and Marine Geology. UNESCO (ASRT) UNDP, Project Egypt 73/063, Alexandria, 175 pp.

DUBOIS, R. N. [1972]: Inverse relation between foreshore slope and mean grain size as a function of the heavy mineral content. Geol. Soc. Am. Bull., **83**, 871—876.

EL-FISHAWI, N. M. [1977]: Sedimentological studies of the present Nile Delta sediments on some accretional and erosional areas between Burullus and Gamasa. M. Sc. thesis, Alexandria Univ., 143 pp.

EL-FISHAWI, N. M., SESTINI, G., FAHMY, M. and SHAWKI, A. [1976]: Grain size of the Nile Delta beach sands. In: UNESCO (ASRT) UNDP-Proc. Sem. on Nile Delta Sed., Alexandria, Oct. 1975, pp. 79—94.

FOLK, R. L., and WARD, W. C. [1957]: Brazos River bar, a study in the significance of grain size parameters. J. Sedim. Petrol., **27**, 3—27.

KING, C. A. M. [1972]: Beaches and coasts. 2nd ed., London, Edward Arnold Ltd., 570 pp.

KOMAR, P. D. [1976]: Beach processes and sedimentation. Prentice-Hall, Englewood Cliffs. 429 pp.

KOMAR, P. D., and MILLER, M. C. [1973]: The threshold of sediment movement under oscillatory water waves. J. Sedim. Petrol., **43**, 1101—1110.

KOMAR, P. D., and MILLER, M. C. [1975]: Sediment threshold under oscillatory waves. Proc. 14th Conf. on Coast. Eng., pp. 756—775.

KRUMBEIN, W. C., and GRAYBILL, F. A. [1965]: An introduction to statistical models in geology. McGraw-Hill, New York, 574 pp.

MADSEN, O. S., and GRANT, W. D. [1975]: The threshold of sediment movement under oscillatory waves. A discussion. J. Sedim. Petrol., **45**, 360—361.

MCLEAN, R. F., and KIRK, R. M. [1969]: Relationship between grain size, size sorting and foreshore slope on mixed sand-shingle beaches. N. Z. J. Geol. Geophys., **12**, 138—155.

RECTOR, R. L. [1954]: Laboratory study of the equilibrium profiles of beaches. U. S. Army Corps of Eng., Beach Erosion Board, Tech. Memo. No. **41,** 32 pp.
SILVESTER, R., and MOGRIDGE, G. R. [1971]: Beach of waves to the bed of the continental shelf. Proc. 12th Conf. on Coast. Eng., pp. 580—595.
TRASK, P. D. [1956]: Changes in configuration of Point Reyes Beach, California, 1955—1956. U. S. Army Corps of Eng., Beach Erosion Board, Tech. Memo. No. **91,** 49 pp.
TRASK, P. D., and JOHNSON, C. A. [1955]: Sand variation at Point Reyes Beach, California. U. S. Army Corps of Eng., Beach Erosion Board, Tech, Memo. No. **65.**
WIEGEL, R. L. [1964]; Oceanographical engineering. Prentice-Hall, Englewodd Cliffs. 532 pp.
ZENKOVICH, V. P. [1967]: Processes of coastal development. Edinburgh and London, Oliver and Boyed, 738 pp.

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