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New approach for the occurrence and characteristics of the coastal sand dunes, North of Nile Delta, Egypt

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Abstract: This manuscript were studied the formation of coastal sand dunes and its sedimentological properties. As well as it studied the type of coastal sand dunes in the past and in the present. The mean size and sorting are the main parameters of the beach and sand dunes that used to distinguished between the beaches and the sand dunes. In general, Mz of dunes is finer than the corresponding beaches and the sorting in the coastal sand dunes are better than that in the corresponding beaches.
Keywords: Sand dunes – Beach – Gamasa – Baltim – Burg EL-Burullus- Sorting- Grain size.

Introduction:

The occurrence and the characteristics of the coastal sand dunes in the Nile Delta depends on the natural and human activities. To determine occurrences and characteristics of these sand dunes, many parameters must be studied. These parameters are grain sizes, mineralogy, waves, tides, wind, and the available materials, mud, sand, cobbles, boulders, shells, etc.. Moreover, these parameters of the coastal sand dunes are considered a part from the sedimentology and mineralogy of the Nile Delta.

Before the construction of Aswan High Dam in 1964 the Mediterranean sea was annually receive 134 Millions tons of sediments and about 55.5 Billion m3 of water [1,2]. After the construction of Aswan High Dam the quantity of sediments (arrived to Mediterranean Sea) has been decreased, thus these decreasing of sediments negatively affected on the agriculture lands and the most coastal geomorphologic units.

Many authors studied the sedimentology and mineralogy of the Nile Delta coast in relation with accretion and erosion of beach [3,4,5,6,7] and others. They suggested that near the river promontories the sand is finer and the coarse sand transported to accreted areas by long shore currents. They added that the heavy minerals accompanied with the eroded areas near the river mouth of the finer sediments, and decrease with long shore currents in the accreted areas.

The northern coastal zone of the Nile Delta (between Port Said and Alexandria) include a strip of coastal sand dunes and many coastal forms. This strip consists of five classes such as coastal dunes and barren soil, water body, urban areas, agricultural land, and fish farms [8]. The classes of coastal sand dunes and barren soil were decrease by about 45% from 1990 to 2014 (from 1897 km2 to 846 km^2) [9].

9 suggested that the area of erosion followed by the area of accretion in the shoreline of the Nile Delta. They were estimate the eroded and accreted areas along the shoreline of the Nile Delta, where, the eroded area was about 19.64 km2 and the accreted area was 16.94 km2 during the period from 1990 to 2014. At the both promontories Rosetta and Damietta the erosion highly recorded, where the maximum retreat of shoreline at

Rosetta was 823.2m and at Damietta was 1330 m during the period from 1990 to 2014. The area between the two promontories suffering from smoothing process, where the eroded areas were 4.44 km2 and the accreted areas were 6.53 km2, thus the deposition rate more than erosion rate creating a new added land (2.09 km2) to the terrestrial lands during the period from 1990 to 2104 [9].

Table. (1): Quantitative evaluation of land use changes during the period from 1990 to 2014[9].

Class	Area 1990 (Km^2)	Area 2014 (Km^2)	Area increase/decrease (Km^2)	% of changes	Yearly rate
Water	1099.8	617.2	−482.6	− 44%	−1.8%
Fish-farm	81.3	936.8	+855.6	+1052%	+44%
Urban	249.5	1685.5	+1436	+576%	+60%
Agriculture	3232.9	2267.6	−965.2	−30%	−1.25%
Coastal Sand and Bare Soil	1897.4	1050.9	−846.5	−45%	−1.9%
Total	6560.8	6558.1	0.0	0.0	0.0
Deficit		2.7	Overall shoreline retreat		

[10] believes that the barchan dunes type can only occur when the wind is nearly unidirectional, and the longitudinal (linear) dunes are formed when strong wind blow with bidirectional. He also suggested that barchan dunes can be formed in the longitudinal troughs between multiple seif chains where the effect of cross winds is excluded. [11] suggested that the barchan dunes develop at lower wind velocities and longitudinal dunes are formed when the wind velocities are higher.

[12] suggested that west of Gamasa, the southern parts of longitudinal dunes tend to modify a series of isolated barchan dunes. Such modification occur with the direction of prevailing wind. [13] suggested that the longitudinal dune created by vortex currents within a unidirectional wind regime.

It is known that the waves, currents and tides transfer the sands from the bottom of the sea to the beach, where NW wind is very important for this process. On the beach the sands transferred by winds and deposited due to decreasing the wind velocity or/and due to the obstacles in the ground such as vegetation, witness, broken rocks and change in relief of ground.

In the previous centaury, the northern coastal strip contain huge numbers of the coastal sand dunes especially from Gamasa to Edku. Many early authors classified these dunes into older and younger or into lower and upper dunes [12,14,15]. In the area between Baltim and EL-Burg contain a lot of dunes with longitudinal or linear type that aligned sub-parallel to the dominant NW–SE winds. In the area without sand dunes contain small dunes and sand mounds around bushes or vegetation on the beach parallel to the shoreline [16].

According to [17] the berms are increased in width and height and form coastal dunes due to .the obstacles on the berms. Where, the foredunes were built up due to growing the berms and the presence of vegetation as obstacles. [18] defined the foredunes as foremost vegetated sand dunes formed on the backshore by aeolian sand deposition within vegetation. In the eroded coast, foredunes occurred with other types or lonely occurred [19]. They distinct from beach ridges, where, the beach ridges formed during storm wave and elevated water level events [20].

The sources of sands for sand dunes in the northern coastal strip from the beach sands and from Sebennitic sediments, where, the Sebennitic branch was one of the principal Nile River distributaries during 7000 to 3000 B.C [14] transformed from west to the east by long shore current and by aeolian processes.

To determine the occurrences and characteristics of the coastal sand dunes in the northern Nile Delta, the sedimentology of the beaches and sand dunes must be carefully studied.

Materials and Methods:

The main sites of the coastal sand dunes occurrences are in the area between Baltim and Burg ELBurullus, as well as some few occurrences in the area between Gamasa and Baltim (Fig.1). Longitudinal dunes are mainly occurred east Burg EL-Burullus toward Baltim, also small barchans and longitudinal dunes are occurred in he area west Gamasa toward Baltim.

About 41 samples were collected from the coastal sand dunes in Gamasa, Baltim and Burg EL-Burullus and from the beaches in the same areas (27 samples of Beaches and 14 samples of Dunes). Beach samples collected from the shoreline and the dunes samples were collected from bottom stoss side, top stoss side, bottom lee side, top lee side and the crest of coastal sand dunes.

About 100 grams of each samples were first soaked in water to facilitate their desegregation. The carbonate content were removed using HCl (10%), each samples was treated with H_2O_2 [21] to remove organic matter. The sand was separated by sieving using 0.063 mm sieve. The sand fraction weighted and subjected to dry sieving using Ro-Tap shaker and set of standard sieves of one Phi intervals. The values of mean sizes (Mz) and sorting (ʒ) were obtained from the formulas of [22] and they were classified according to [23].

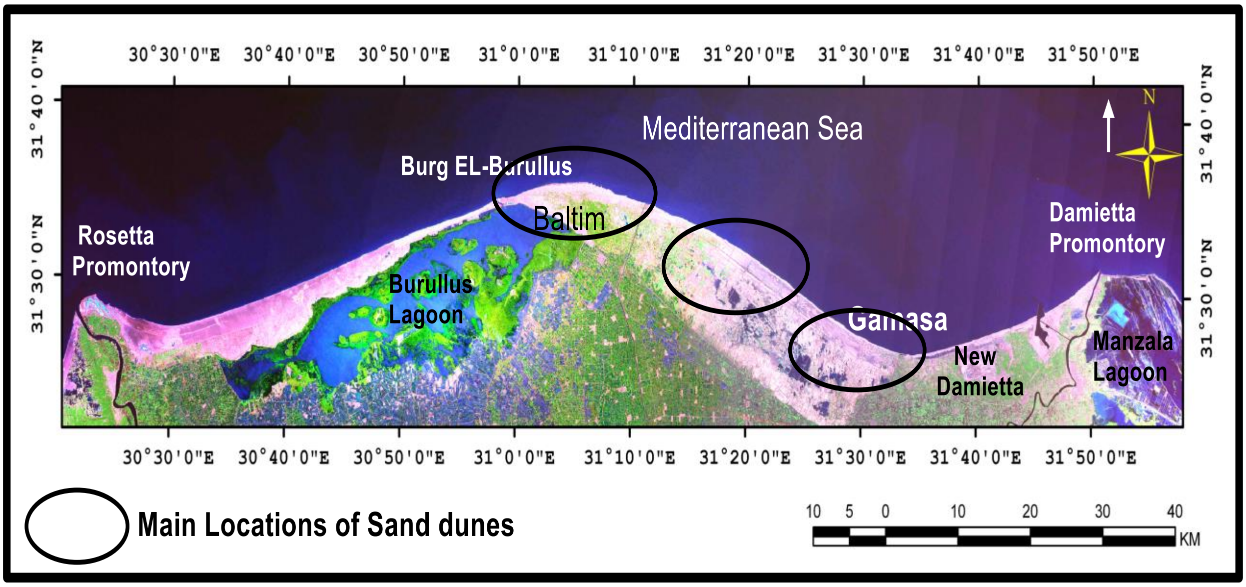

Fig. (1): location map of the study area and the main sites of coastal sand dunes

Occurrence and origin of coastal sand dunes:

There are three main sources of sediments in the Nile Delta called Rosetta, Damietta and Sebennitic branches where the Rosetta and Damietta branches are still present as well as the Sebennitic branch which was one of the principal Nile River distributaries during 7000 to 3000 B.C.[14]. The prevailing wind in this area comes from WNW, NW and N and the strong wind occur during the winter (from December to March) especially during December and January with a minor trend from E and NE [12]. The annual frequency shows that wind comes from W to N sector with predominately NW direction, while the strong storms attack the coast from W to NE [24,25]. [26] told that the months of winter are windiest with dominant wind from NW and WNW, less frequently from N and NE over the eastern Mediterranean coast and in summer, as a result average wind speeds during summer are greater, in July the dominant winds are from WNW and W over central and eastern Mediterranean coast of the Nile Delta.

The coastal sand dunes in the study area formed from sand transferred from the bottom of the sea to the beach by waves and current (longshore current) as well as by the wind on the beach. These sands move to beach to deposit as mounds sand and berms, these berms grow due to the advancing of shoreline to form many dunes parallel to the shoreline. Where, the small dunes (embryo dunes) formed on the backshore then large dunes (coastal sand dunes) formed after backshore.

Steps of coastal sand dunes formation (Fig. 2) as following:

1. Sand transported from offshore and the eroded beaches to deposited on the beach (foreshore) due to the action of currents and waves
2. Due to the action of current, wave and winds, the sand transported from the foreshore to backshore to form dunes, berms and sand mounds parallel to the shoreline (Fig. 3).
3. The obstacles and vegetation are stopped the motion of sand on the backshore to form the such formations (dunes, berms and mounds) during the calm weather
4. Berms are the initial stage for dunes formation parallel to the shoreline
5. Berms grow, where its widths and heights increased
6. By growing the berms, the coastal sand dunes or foredunes formed, where, foredunes are considered as the vegetated sand dunes parallel to the shoreline formed on the backshore zone by deposition of sand within vegetation, where they more or less completely stabilized by vegetation. Not all sand dunes on the backshore or foreshore zones are foredunes but there are many types of coastal landforms such as coastal sand dunes types and ridges
7. The coastal sand dunes are occurred in the study area due to the vegetation are not dense or absent on the beach, where the types of coastal sand dunes are formed due to the accumulation of sand by different obstacles and few of vegetation, thus they not mainly stabilized by vegetation as in foredunes.
8. Thus, due to coalescence of berms and growing them, the many coastal land forms are formed (Coastal sand dunes and Foredunes) (Fig. 4).

In the area between New Damietta and Baltim, the coastal sand dunes and sand mound were occurred before 2000, now due to the urbanization, industrial and agricultural activities, the coastal sand dunes disappeared. The sand mound and small longitudinal and barchan dunes formed and removed directly in short time due to the speed human activities.

In the area between Baltim and Burg EL-Burullus, the longitudinal belts of coastal dunes occurred on the beach. These longitudinal coastal sand dunes have been occurred adjacent to the shoreline from a long time ago.

The strand plain of the area between New Damietta and Baltim is wide and contain many human activities without sand dunes (rarely small dunes), while the strand plain of the area between Baltim and Burg EL-Burullus is very narrow with continues belt of longitudinal coastal sand dunes on the shoreline.

[6] suggested that there is a relation between threshold velocity and mean diameter, where he mentioned that the lowest calculated wind velocity were detected at Gamasa dunes and the highest values were detected at Baltim dunes. He also suggested the wind velocity at both Gamasa and Baltim in the range of 4 to 16 KT (205.6 to 822.2 cm/sec) indicating that these wind velocities are roughly able to transport equal amount of sands with grain diameter in the range of 177 µm to 250 µm to height between 5 to 10 m. The movement of El-Burg dunes is at the rate of about 3 m/yr and the average movement of Gamasa–Baltem dunes is about 8 m/yr.

According to [27] there are five factors that control the type, alignment, and size of dunes:-

1. The characteristics of wind regime, especially its directional variability. This is the main factor determining the dune type.
2. The amount of sand supply is also the major factor to determine the types of dunes
3. The grain size of sand dunes
4. Vegetation cover
5. The role of time

Before 2000, longitudinal sand dunes and little of barchans dunes were occurred in the area between New Damietta and Baltim, where high sand supply due to the strand plain is very wide with variable winds (bidirectional wind), while, now there are small mounds of sand and small isolated barchans on the wide strand plain.

The coastal sand dunes (longitudinal) have been occurred in the narrow strand plain, where, there is a very little sand supply (strand plain is very narrow) and almost unidirectional winds in the area between Baltim and Burg EL-Burullus. Longitudinal or linear sand dunes formed due to the growing of the berms parallel to the shoreline. Longitudinal or linear dunes are occurred with sub-parallel to the dominant NW winds.

The old situation:

The results extracted due to the earlier studies [11,10,28,29,30] and from many other authors such as [12,14,15,16] that it is clear that there are mainly two reasons that determine the dune type, these are sand supply and wind velocities. Before 2000, The barchan dunes located mainly adjacent to the shoreline in the area between Burg El-Burullus and near to Kitchener drain (Fig., 5) where a limited amount of sand and strong winds are available, and present in small numbers near Gamasa. The longitudinal dunes on the other hand are recorded mainly west of Gamasa far from the shoreline (Fig. 6), owing to high amount of sand supply and low velocities of winds, they also recorded in small numbers in the area between El-Burullus and Kitchener.

The sand supply increases with the increase of the width of the strand plain from Kitchener to the west of Gamasa city. The longitudinal dunes found near Gamasa, in this area the sand supply is increased and the wind velocities is lower than that at Baltim and El-Burge[6]. While, the sand supply is low in the area between kitchener and Burg EL-Burullus due to the narrow strand plain, and the wind velocity is higher than that at Gamasa. Thus the barckan dunes have been occurred.

Field observations show that the barchan dunes have been occurred near Gamasa, the barchan dunes near the shoreline where the sand supply is low and the wind velocity is relatively high. Thus the distance between dunes and shoreline is important role to determine the type of dune.

The longitudinal dunes have been occurred in this area due to the modification of barchan dunes by the wind to longitudinal dunes. Where the sand supply is relatively high and wind velocity is relatively low. Thus, the dune becomes longitudinal in shape when the distance between the dunes and shoreline increase or due to the modification of barchan dunes.

The current situation:

The study area between New Damietta City and Burg EL-Burullus is considered a very mobility or very sensitive areas, where it suffering from many natural and human activities, especially the coastal strip which contain the coastal sand dunes.

With respect to coastal sand dunes, many of its formation factors are changed especially the sand supply, vegetation and wind direction. As well as the formation factors of the coastal sand dunes are changed due to the speed human activities. Thus, most of these formation factors are may be similar in most study area or may be inversely changed.

Now, the area between New Damietta City and Baltim does not allow the dune formation due to the dune formation factors have changed, where, the human activities are increased from about fifteen years ago due to the strand plain is very wide. The area between Baltim and Burg EL-Burullus still contain the longitudinal belt dunes adjacent to the shoreline. The dune formation factors little changed due to the narrow strand plain, where, the coastal sand dunes still retain its types, shape and sizes. In the area between New Damietta City and Baltim contain many of sand mounds and small barchans dunes near Gamasa (Fig. 7) and rarely small longitudinal dunes (Fig. 8). The strong dunes belts occurred in the area east of Burg El-Burullus, where they are connected with each other as a longitudinal belts (Figs. 9 and 10), where,these belts considered the first defense against the sea.

Approximately, coastal sand dunes in the study area are barren of vegetation or without any vegetation. They now suffering from destruction by humans activities and many by disappear in near future, these result agreed with [16].

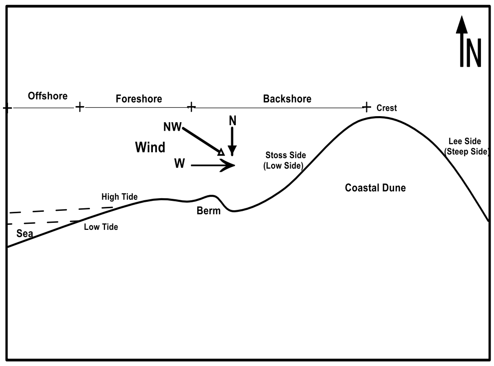

Fig.(2):formation of coastal sand dunes in he study area

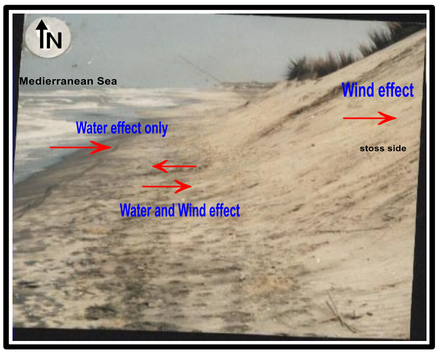

Fig.(3): effects of waves and winds on the coastal sand dunes and beach

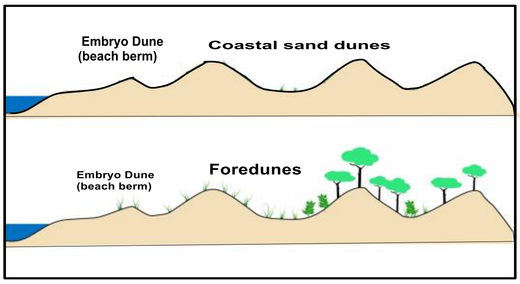

Fig.(4): profiles of coastal sand dunes and foredunes

Fig.(5) Barchans dunes between Baltim and Burg el-Burullus

Fig. (6): Longitudinal Gamsa dunes before 2000

Fig. (7): Small Gamasabarchan dunes after 2000

Fig. (8): Small Longitudinal or Linear Gamasa dunes after 2000

Fig. (9): belts of longitudinal dunes east of Burg EL-Burullus

Dune and beach relationship:

Sedimentological properties:

Now, there are many belts of coastal sand dunes in the area between baltim and Burg EL-Burullus, where these dunes with longitudinal shape formed adjacent to the beach. As well as some sand mounds and small longitudinal and barchans dunes in the area between new Damietta City and Baltim. Here, in this study the longitudinal or linear dunes belts and the beach between Baltim and Burg EL-Burullus were carefully studied in addition to some details for dunes and beach between New Damietta City and Baltim.

From sedimentological point of view, the collected surface sedimentary samples (beach and dunes) were subjected to carbonate – sand – mud analyses. The sand sediment are recorded mainly in sandy shore zone and sand dunes, where the sand reach to 99.99 % in beach and 100 % in dunes.

1- Average Grain Size

[22] proposed the graphic mean size (Mz) which is much superior to the median because as it takes the mean of diameter at three points on the cumulative curve as follow.

Mz =1/3 ($\Phi_{16} + \Phi_{50} + \Phi_{84}$)

El-Burg beaches (3 samples) have the Mz values range from 2.13ϕ to 2.53ϕ. (fine sand). Baltim beach between two detached breakwater samples have Mz values from 1.55ϕ to 2.4ϕ. The samples were collected from east to west between two detached breakwaters (between two Tombolo) (Table. 2) The coarser and medium sand occurred adjacent to the detached break water and near to the center between two Tombolo, while the fine sand occurred near the body of detached breakwater away from the center in each side.

Gamasa beach is represented by five samples, they are fine sand where Mz values range from 2.06ϕ to 2.65ϕ, the samples near Kitchener (east of Kitchener drain) is medium sand where the Mz is 1.83ϕ (Table. 2 and Fig 10),this location is considered the beginning of erosion toward Baltim.

El-Burg coastal sand dune were showed that Mz of top lee side is 2.67ϕ, the bottom lee side is 2.15, Mz of top of stoss side is 2.52ϕ, and bottom of stoss side is 2.15ϕ (Table. 3 and Fig 11).

In Baltim dune, the Mz of bottom of lee side is 2.25ϕ, Mz of top lee side is 2.32ϕ, the Mz of bottom stoss side is 1.56ϕ, and the Mz of top of stoss side is 2.23ϕ. Thus, the finer sand occurs in the top and in the lee side of the dunes more than that in the bottom and in the stoss side of the dunes (Table. 3 and Fig 11).

Gamasa Dunes are represented by 6 samples. Four samples for the linear dune and two samples for the small barchan dune. The linear dune of Gamasa show that the mean size (Mz) of bottom of lee side is about 2.37ϕ and the top of lee side is about 2.62ϕ, the bottom stoss side 2.25ϕ and the top of stoss side is 2.53ϕ (Table. 3 and Fig 11).

In the small barchans dune, the Mz of stoss side is 2.45ϕ and the lee side is 2.56ϕ . Thus, the finer sand occurs in the top and in lee side of dunes more than that in the bottom and in stoss side of dunes.

The Mz value of the beach is not indicator for accretion or erosion, in general, the beach samples in the study area ranges from medium to very fine sand. The finer sand in the dunes occurred in lee side and in the top of dunes more than in stoss side and bottom of dunes

The relation between Mz of beach and Mz of dune in each area showing that the Mz of beach is coarser than the corresponding dunes as in Gamasa due to the large distance between the Gamasa beach and Gamasa dunes. On the other hand the beaches and dunes of Baltim and El-Burg have nearly the same Mz due to the very small distance between the shoreline and dunes. Thus, from the beach passing through the bottom and up to the top of dunes, the percentages of fine sand increase.

2- Sorting (measure of uniformity)

The values of sorting were obtained from the cumulative curves and calculated according to formulas of [22]:

Sorting (δ_I) = $\Phi_{84} - \Phi_{16}/ 4 + \Phi_{95} - \Phi_5/ 6.6$

The sorting of the collected samples classified according to [23] as following:-

In El-Burg beach, the sorting ranges between moderately well sorted to well sorted (0.61ϕ to 0.37ϕ) (Table. 2 and Fig 10). El-Burg dunes, the sorting of samples ranges between moderately well sorted to very well sorted (0.45ϕ to 0.34ϕ to) (Table. 3and Fig 11).

In west Baltim beach, the sorting of samples ranges from 0.3ϕ to 33ϕ (very well sorted) (Table. 4). In Baltim beach, the sorting ranges between moderately sorted to very well sorted to (0.65ϕ to 0.3ϕ). In east Baltim beach, the sorting ranges between 0.65ϕ and 0.31ϕ (from moderately well sorted to very well sorting) (Table. 2 and Fig 10). In Baltim dunes, the sorting of samples ranges between moderately well sorted to well sorted (0.56ϕ to 0.37ϕ) (Table. 3 and Fig 11).

In Gamasa beach the sorting of samples range from moderately sorted to very well sorted (0.81ϕ to 0.34ϕ) (Table. 2 and Fig 10). In Gamasa dunes, the sorting of samples ranges between moderately well sorted to very well sorted to (0.54ϕ to 0.32ϕ) (Table. 5), where the sorting improved in the top and in lee side of dune (Table. 3 and Fig 11)

[3,31,32] recorded that the accreted sands are coarser and less well sorted than the eroded sands. Each beach has the eroded and accreted areas adjacent to each other, and thus the sorting changes many times in the same beach from one locality to another. Thus there is not stable role the study area and it is difficult to detect the change in the sorting from Rosetta to Ras EL-Bar but each one can be studied as individual beach.

The sorting improving from beach to dune as in, Gamasa (improve from Gamasa beach to Gamasa dunes), Baltim (improve from Baltim beach to Baltim dunes) and El-Burg (improve from EL-Burg beach to EL-Burg dunes). The sorting may be improving on the top and lee side of dunes or may be the same without any changes on each sides of and on the top and bottom of the dune. The sorting improves from beach to dune due to the wind action on the fine grains where, the wind moves them from the beach to the dune and from the dune bottom to the top.

Table (2): The grain size parameters of the beach samples

Samples	Location of beach	Md	Mz		δ	
1	EL-Burg Beach	2.1	2.13	F.S	0.54	M.W.S
2		2.5	2.53	F.S	0.37	W.S
3		2.45	2.48	F.S	0.57	M.W.S
4	Baltim beach	2.35	2.4	F.S	0.51	M.W.S
5		1.65	1.66	M.S	0.58	M.W.S
6		1.8	1.85	M.S	0.39	W.S
7		1.6	1.6	M.S	0.48	W.S
8		1.3	1.33	M.S	0.5	M.W.S
9		2.05	2.15	F.S	0.59	M.W.S
10		1.85	1.91	M.S	0.45	W.S
11		1.65	1.65	M.S	0.32	V.W.S
12		1.55	1.55	M.S	0.37	W.S
13		1.75	1.81	M.S	0.46	W.S
14		1.8	1.88	M.S	0.42	W.S
15		1.9	2	F.S	0.46	W.S
16		1.65	1.65	M.S	0.26	V.W.S
17		2	2.06	F.S	0.41	W.S
18	West Baltim Beach	2	1.95	M.S	0.33	V.W.S
19		2	2	F.S	0.30	V.W.S
20	East Baltim Beach	2.05	1.99	M.S	0.65	M.W.S
21		2.05	1.89	M.S	0.53	M.W.S
22		2.2	2.21	F.S	0.31	V.W.S
23	Gamasa Beach	1.8	1.83	M.S	0.57	M.W.S
24		2.55	2.65	F.S	0.69	M.W.S
25		2.1	2.13	F.S	0.81	M.S
26		2.55	2.51	F.S	0.65	M.W.S
27		2.45	2.45	F.S	0.34	V.W.S

F.S = fine sand M.S = medium sand V.W.S = very well sorted
W.S = well sorted M.W.S = moderately well sorted

Table (3): The grain size parameters of the dune samples

Samples		Location of Dunes		Md	Mz		δ	
1	**Burg el-Burullus Dunes**	**Linear**	**Stoss side bottom**	2.2	2.15	F.S	0.44	W.S
2			**Stoss side top**	2.62	2.52	F.S	0.35	V.W.S
3			**Lee side bottom**	2.23	2.15	F.S	0.45	W.S
4			**Lee side top**	2.9	2.67	F.S	0.38	W.S
5	**Baltim Dunes**	**Linear**	**Stoss side bottom**	1.53	1.56	M.S	0.37	W.S
6			**Stoss side top**	2.11	2.23	F.S	0.47	W.S
7			**Lee side top**	2.22	2.32	F.S	0.45	W.S
8			**Lee side bottom**	2.45	2.25	F.S	0.56	M.W.S
9	**Gamasa Dunes**	**Dune 1 Small barchan**	**Lee side**	2.6	2.57	F.S	0.39	W.S
10			**Stoss side**	2.65	2.45	F.S	0.38	W.S
11		**Dune 2 Linear**	**Stoss side top**	2.52	2.53	F.S	0.34	V.W.S
12			**Stoss side bottom**	2.22	2.25	F.S	0.54	M.W.S
13			**Lee side top**	2.62	2.62	F.S	0.32	V.W.S
14			**Lee side bottom**	2.44	2.37	F.S	0.44	W.S

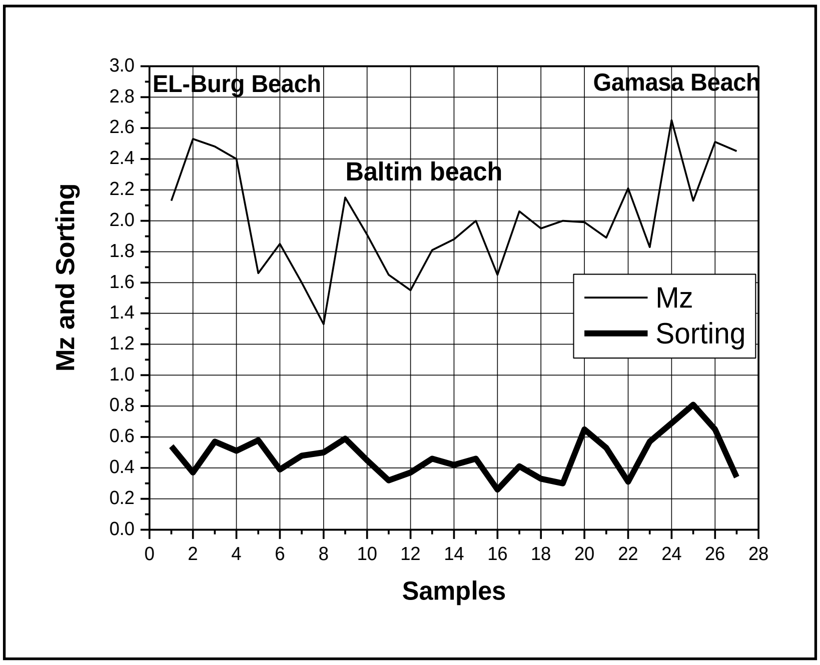

Fig.(10): Mz and Sorting of he beaches of the study area

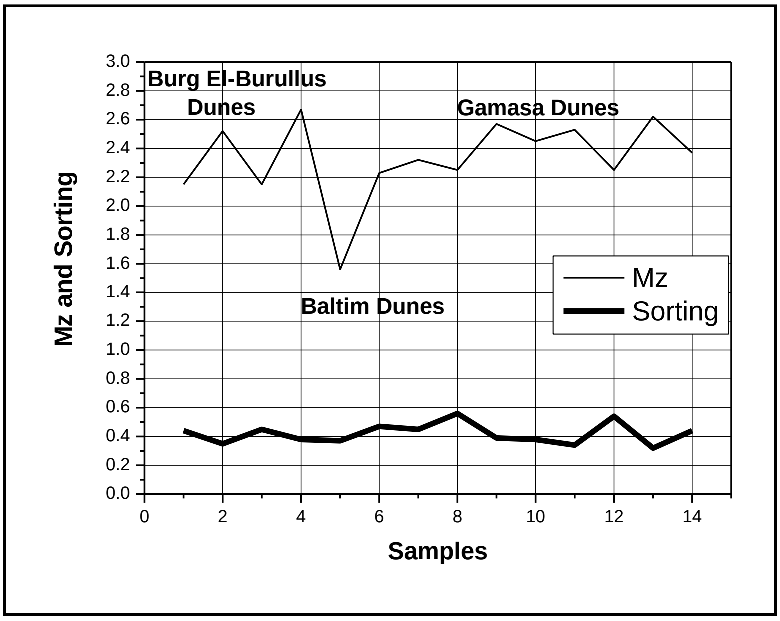

Fig.(11): Mz and Sorting of the coastal sand dunes of the study area

Conclusions:

The sand transferred from the bottom of the sea to the beach drifted by waves, wind and currents. These sands move to beach to deposit as mounds sand and berms, these berms grow due to the advancing of shoreline to form many dunes parallel to the shoreline.

In the study area, there are different beaches and dunes in many subareas. Each subarea has its beach and dune containing a special beach/dune system. In the subarea between Gamasa and Kitchener the beach is nearly flat and wide. The wideness of the beach and strand plan as well as the fast drying of the sand of both beach and strand plan by winds and sun led to the formation and movement of longitudinal dunes. In the subarea between the Kitchener and Burg El-Burullus the conditions is different where the beach is very narrow and steeper. Thus the sand in this area dries faster by the winds and the sun, the wind velocity in this area also is higher than that at Gamasa. Accordingly the sand moves up and the barchan dune in this area are higher than the longitudinal dune at Gamasa. Now there are longitudinal dunes in the area between Baltim and Burg EL-Burullus, while small dunes and sand mounds are occurred in the area between Gamasa and Baltim.

Recently, the most of coastal sand dunes removed due to the agricultural, industrial and urbanization activities. Now, the coastal sand dunes concentrated in the coastal strip between Baltim and EL-Burg and the others coastal area without dunes such as in New Damietta and Gamasa as well as the coastal area between Gamasa and Baltim.

The Mz of beach is coarser than the corresponding dunes as in Gamasa On the other hand the beaches and dunes of Baltim and El-Burg have nearly the same Mz due to the very small distance between the shoreline and dunes. Sorting improved from the beaches to the sand dunes on the backshore.

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