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Monitoring the Foredune Restoration by Fences at Buenos Aires Coast

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ABSTRACT

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The coast of Buenos Aires is suffering erosion, which is mainly induced by human activities including urbanization, foredune degradation, artificial channels and sand mining. As consequence beach resorts of coastal localities began to be severely impacted by surge storms. Rapid reestablishment of the fragmented dune system through sand accumulation was essential for the protection of coastal resorts against storm surge. Wood and plastic fences were installed at several localities to reconstruct the foredune and backshore (berm). Sand accumulation associated with these beach fences materials/orientation combinations was measured until buried. The curved obtained showed a point of maximum efficiency 150 days after the structure place where it reached the higher volume accumulation rate (0.12 m^3/m per day). After this point the accumulation velocities diminished to 0.08 m3/m per day. The higher velocities of vertical accretion obtained varied between 0.4 to 0.5 cm/day with a mean speed of 0.25 cm per day. The natural parameters that regulated the accumulation rates were: (1) wind speed (2) wind frequency by direction (3) sand supply and (4) fetch sand area. The orientation, height and gap of the barrier controlled the distribution and morphology of artificial deposits. Erosional cycles were also detected with rates of 0.11 to 0.33 cm/day. The sediments trapped by barriers showed moderate differences in the texture. Between pre and post structure emplacement the mean grain size became coarser, more poorly sorted and the skewness changed to negative. Though time the perpendicular zig-zag wood fence had consistently higher sand accumulation. Transitory perpendicular fences (plastics) were useful for berm reconstruction because of their rapid degradation.

ADDITIONAL INDEX WORDS: *Shore restoration*, *fences, foredune.*

INTRODUCTION

The increase in resident tourism population density, human activities and use of resources in the northern coast of Buenos Aires resulted in a dramatic alteration to the functioning of coastal system. This effect produced an increase of the erosion rates on the beach and foredune (MARCOMINI and LÓPEZ, 1993). As a consequence a coastal management planning has been implemented since 1997 at the Municipalidad de la Costa and Mar Chiquita with the technical assistance of the Geology Department of the Buenos Aires University. Two working aspects were developed, one related to the integrated coastal management and the other to the empirical and experimental analysis of the methodology employed.

The integrated coastal management contemplate social, economical and political issues and was divided in four stages: planning, employed, personal capacitating and implementation.

The purpose of this paper was to analyze the evolution of the aeolian landforms generated by different types of fences on the foredune and backshore and to estimate aerodynamic models that will be useful to improve the efficiency of these types of projects for coastal planning.

Sand fences are frequently used to enhance sand accumulation (HOTTA *et al*., 1991; MENDELSSOHN *et al*., 1991) but recommendations for most effective sand fences configurations vary among sites. Several kinds of fences have been used worldwide. Synthetic fabrics of appropriate porosity (around 50%) are as good as wooden slats fences in accumulation sand. Biodegradable materials are preferred for sand fences as no biodegradable may present a hazard for burrowing animals. Geojut fabric, a product frequently used in erosion, is biodegradable with appropriate porosity, but results very expensive to recover the dune on the area.

Vegetation assists in trapping sand and is essential for anchoring accumulated sand (DAHL and WOODARD, 1977). Because plants recolonization may be slow, recommendations for dune restoration usually include planting of native grasses, with deep fibrous roots that efficiently trap and stabilize sands. In addition these plants are adapted to harsh beach conditions (salt spray, low soil nutrients, low soil moisture and sand abrasion).

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STUDY SITE

The study was conducted in the northeastern coast of Buenos Aires and comprise several beach resorts of the Municipio de La Costa. The coast is a Holocene barrier spit covered by an inactive dune field of abouth 2.5 km width. It is an open coast, straight with a North South shoreline orientation. Predominant wave generated longshore current and corresponding net longshore sediment transport is toward the north, with an increasing gradient. Longshore drift transport range between 300,000 and 1,000,000 m^3 per year (CAVIGLIA *et al.*, 1991).

The coast is storm and wave dominated. Southeast storms (surge storms) play a significant role in modifying the beach.

A microtidal regime is characteristic of the studied area. The amplitude of the tide oscillates between 0.91 m (Spring tides) and 0.61 m (Neap tides) (SHN, 1997).

These small tidal variations in sea level are negligible in conditions of much larger wind-generated variations.

The beaches are sandy, straight, extended laterally with a variable width between 60 and 140 m and with mean slopes under 2 grades.

The area has template climate with a mean annual precipitation of 800 mm, and rainfall peaks in winter. From July to December southerly wind prevail while notherly wind occurr for the remainder of the year. Winds reach higher speeds from October to February.

The foredune is usually partially vegetated with *Panicum racemosum, Ammophila arenaria and Spartina* Ciliata or completely stable covered with *Adesma incana*, *Poa lanuginos* and *Tamaris gallica*.

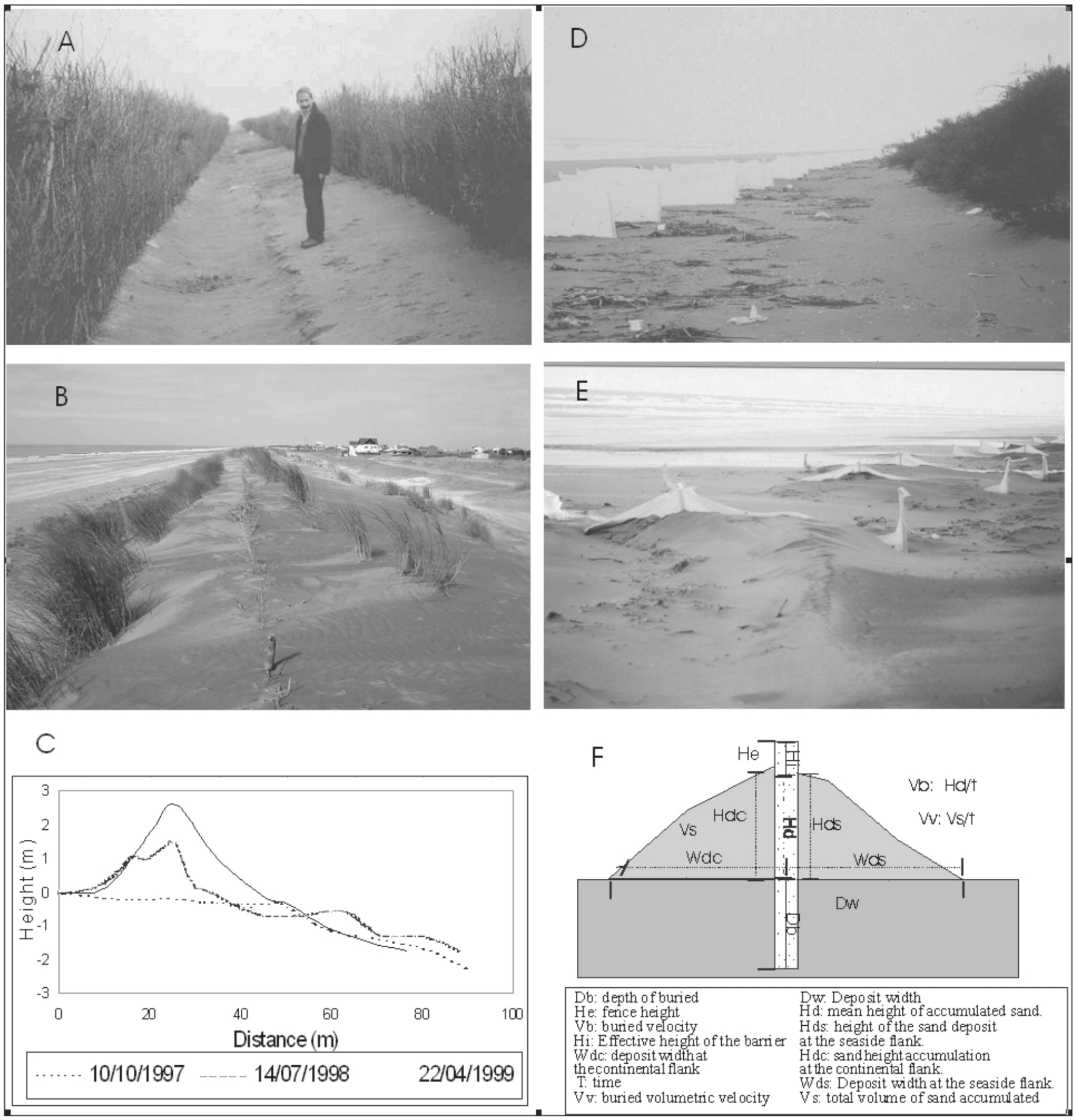

Figure 1. Examples of foredune and beach reconstruction at San Clemente del Tuyu and Costa del Este., A show a permanent fence in San Clemente del Tuyu, B. Dune reconstruction after three years, C. Transverse profiles before and after fixed fences emplacement for San Clemente, D and E examples of transitory fences at Costa del Este used to reconstruct the beach berm, E is a view of the beach after four months, F. Parameters used to estimate the accumulation around the aeolian fences.

METHODS

Aeolian fences were classified in order to define models considering three main factors: durability, plan view, spatial disposition.

According to their durability they were grouped in *permanents* or t*ransitory*. (Figure 1 A and D)

The first ones were fix permeable fences composed by stakes and poplar branches buried about 1 m.

Fences were not degrade until buried and have been usually used to rebuild the foredune . The wood fences consisted of 5 cm wide by 1.5 m high wooden slates bound together with steel wire. The *transitory fences* were made of plastic trellis or geotextiles. They have been used to nourish the backshore and were rapidly eroded during surgestorms (Figure 1 D and E).

The aeolian fences were grouped considering the plan configuration in straight, compound and zig-zag and the spatial disposition in: Type A: parallel to the cost on foredune crest, Type B: parallel to coastline on the seaward base of the dune, Type C: crossing the foredune, and Type D: in angle on the foredune.

Periodical profiles transverse to fences were made in order to quantify the accumulation rates and disposition of the artificial deposits.

Vertical height and volumes of sand were measured to calculate the accumulation rates. Cross profiles grain size analysis of the superficial sediments were also developed to survey the aerodynamic changes.

For each fence type perpendicular transects were surveyed using a work station. Dune height was determined by change in elevation relative to the benchmark for each treatment. Sand accumulation was based on change in relative evaluation of each survey point multiplied by the area represented by the point. A baseline elevation was determined October 1997 and elevation profiles were measured during about 2 years (Figure 1 C).

Grain size analysis for the superficial sediments were sampled for each transect to estimate the aerodynamic changes in the reconstruction of the foredune and berm in the backshore .

Several parameters were defined for monitoring fences and they are shown in Figure 1 F.

RESULTS

After monitoring several permanent fences on the foredune for about 2 years (September March) the curves obtained showed a point of maximum efficiency 150 - 250 days after the structure place where it reached the higher volume accumulation rate (Vv: 0.12 m^3/m per day) and vertical accretion velocities.(Vb: 0.4 cm/day).

After this point the accumulation velocities (Vv) diminished to 0.08 m^3/m per day and the vertical accretion velocities (Vb) to 0.1 cm day (Figure 2 A). This change took place when the fence reduced the effective height (Hi) to about the 50 % because of sand colmatation.

The higher velocities of vertical accretion obtained varied between 0.4 to 0.5 cm/day with a mean speed of 0.25 cm per day (Figure 2 B). Erosional cycles were also detected with rates of 0.11 to 0.33 cm/day showing vertical erosion.

In Figure 1 some field examples of the accumulation capacity of different fences are shown. Figure 1 A and B evidences the development of a new foredune in San Clemente del Tuyu between October 1997 and April 1999 employing permanent fences. An important recovery of the foredune height and width was detected after structure emplacement ,as well as an increase on the beach level with a seaward displacement of the beach subenvironments (Figure 1 C). The development of the backshore using transitory fences increased the beach height and diminish ing the vulnerability to erosion during storms. The fences were emplaced on beach in May 1998 (Figure 1 D). After four month the barriers reached their maximum accumulation capacity (Hd) (Figure 2 E)

The natural parameters that regulated the accumulation rates were: (1) wind speed (2) wind frequency by direction (3) sand supply and (4) fetch sand area. The orientation, height and gap of the barrier controlled the distribution and morphology of artificial deposits.

The sediments trapped by barriers showed moderate differences in the textural statistical parameters on the seaside of fences in comparison with the natural foredune. Between pre and post structure emplacement the mean grain size became coarser, more poorly sorted and the skewness changed to negative. Mean parameters are shown in Table 1.

After reconstruction with fences the foredune was vegetated with *Spartina cilata brognart* (Figure 1 B) which was effective in sand trapping and had the additional advantage of continuing

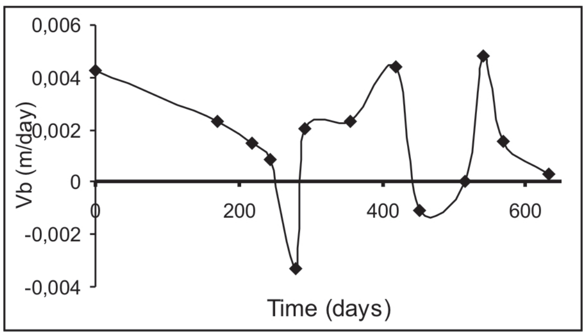

Figure 2. Evolutive models of accumulation on aeolian *permanent* fences type A for Buenos Aires coastline. A Shows the accumulative vertical accretion after the fence emplacement and B changes on the velocities between accresive and erosive cycles.

Table 1. *Comparison of the grain size distribution for the foredune pre (B) and post fence emplacement (A).*

	A		B	
	Seaside	Landside	Seaside	Landside
Mean (phi)	2.28	2.64	2.85	2.67
Standard deviation (phi)	0.43	0.25	0.21	0.21
Skewness	-0.39	-0.12	0.09	-0.05
Kurtosis	0.96	1.41	1.23	1.17

to accummulate sand through upward and lateral growth without additional input.

Spartina ciliata is a plant of about 0.15 to 0.50 m height compound of fibrous roots. They were transplanted directly from inner areas with complete roots and divided into smaller mats. Mean percentage survival of *Spartina Ciliata* ranged from 60 to 70 % during the first year and reached the 50 % in three years. Planting took place on July to September (Winter). No supplement water was provided after planting.

MILLER *et al*. (2001) evaluated the usefulness of fences and vegetation for dune building following overwash of Huracan Opal in Florida. They recognised accumulation rates (Vv) of 0.016 m^3/day and vertical accretinon (Vb) varying between 0.06 to 0.1 cm during the fist year. Similar values of Vv were obtained for the studied site but Vb differed. It suggests that in the studied area the foredune reached higher heights and less width than in comparison with Florida.

DISCUSSIONS

Our experimental showed the usefulness of sand fence for rapid sand accumulation along the coast studied. The reconstruction of the foredune is demonstrated to be a successful methodology employed in the northern coast of Buenos Aires. About 800.000 m^3 of foredune had been recovered along 15 km of coastline during the first year. The plan implementation also had a positive social impact because it applied about 2.800 occupations between 1997 and 1999 with a cost benefits relation of the project estimated in 1 to 6.

The materials employed for the fences construction were authoctonals since they were built with branches of *Populus nigra* which is considered a plagues tree in the area and needs to be pruned several times in a year.

CONCLUSIONS

The implementation of fixed and transitory fences demonstrated to be a very effective methodology to rebuild the foredune and backshore in sectors of coast under erosion.

The low cost of materials and the requirements of man occupation for the construction of the fences increased the socioeconomical activities in the Municipality.

Permanent fences reached their maximum efficiency 150 - 250 days after the structure place. The transitory fences lasted about 120 days leaving the beach less vulnerable to subsequent storms.

Winds blowing parallel to the fence produced sand excavation instead of the sand accumulation, so we recommended compound or zig zag configurations for fences parallel to the coast.

The volumetric accumulation rate obtained varied between 0.08 m^3/m and 0.12 m^3/m per day.

The higher velocities of vertical accretion varied between 0.4 to 0.5 cm/day with a mean speed of 0.25 cm per day. Erosional cycles were also detected with rates of 0.11 to 0.33 cm/day showing vertical erosion.

Grain size changes were more significant on the seaside of the fences. Between pre and post structure emplacement the mean grain size became coarser, more poorly sorted and the skewness changed to negative.

Planting of *Spartina cil*ata was successful after dune reconstruction because was effective in sand trapping and had the additional advantage of continuing to accumulate sand. It reached a survival of 50 % in 3 years without supplemental water.

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LITERATURE CITED

CAVIGLIA, F.L.; POUSA, J.L. and LANFREDI, M.L., 1991.A determination of the energy flux constrant from the dredge records. *Journal of Coastal Research*, 7 (2): 543-549.

DAHL, B.E. and WOODARD, D.W., 1977. Construction of Texas coastal foredune with sea oats (*Unicula Paniculata*) and bitter panicum (*Panicum amarum*). International Journal of Biometeorology, 21(3), 267-275.

HOTTA, S.; KRAUS, N.C. and HORIKAWA, K., 1991. Functioning of multi-row sand fences in forming foredunes. *Coastal Sediments´91* (ASCE), pp. 261-275.

MARCOMINI, S.C. and LÓPEZ, R.A. , 1993. Coastal Protection Effects at Buenos Aires, Argentina. *Proceedings of The Eighth Symposium on Coastal & Ocean Management*. Coastal Zone 93. Nueva Orleans. U.S.A., 3, 2724-2738.

MENDELSSOHN, I.A.; HESTER, M.W.; MONTEFEMENTE, F.J. and TALBOT, F., 1991. Experimental dune building and vegetative stabilization in a sand deficient barrier island setting on the Lousiana Coast, USA. *Journal of Coastal Research*, 7, 137-149.

MILLER, D.L.; THETFORD, M and YAGER, L., 2001. Evaluation of sand fences and vegetation for dune building following overwash by hurricane opal on Santa Rosa Island, Florida. *Journal of Coastal Research*, 17, 4, 936-948.

SERVICIO DE HIDROGRAFIA NAVAL, 1997. Tabla de mareas. 125 p.