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Magnitudes, sources, and management of beach litter along the Atlantico department coastline, Caribbean coast of Colombia

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ABSTRACT

Twenty-six beaches belonging to Atlántico department, Caribbean coast of Colombia, were surveyed to determine magnitudes, sources, and management of litter. Beach litter was observed along the entire coastline, and a total of 7,597 items weighing 412 kg were collected from all 26 beaches surveyed. The average abundance of litter found along the study area was 2.9 items m^{-1}. Vegetation debris and plastic items dominated the samples respectively with 59% (Avg: 1.72 items m^{-1}) and 27% (Avg: 0.82 items m^{-1}). Other litter groups were polystyrene 3% (Avg: 0.1 items m^{-1}), rubber 3% (Avg: 0.08 items m^{-1}) and glass 2% (Avg: 0.04 items m^{-1}). Metal, organic, processed wood, paper and biohazards items reached 5%, while textiles and miscellaneous represented less than 1%. Concerning buoyancy characteristics, the most represented litter category was persistent buoyant litter (with 91% of items), followed by short-term (6%) and non-buoyant litter (3%). The primary source of litter corresponds to litter transported by rivers, mainly the Magdalena River, together with human activities related to beach use (*i.e.* tourism). Litter produced poor scenic scores along the Atlántico department coastline and improvement can easily upgrade scenic beach quality scores. Results such as those given are necessary to identify, improve and conserve beaches standards together with the contribution that they make to the environmental, social and economic, well-being of local communities. Beach litter management along the study area (as well along the Caribbean coast of Colombia) must be based on strategies to reduce or eliminate litter sources. For that, it is necessary to consider beach types to define the intensity and periodicity of actions to be implemented.

1. Introduction

Coastal zones are very fragile environments easily affected by disordered infrastructures emplacement and activities such as industry, tourism, agriculture, and fishing. Diverse human activities have concentrated along coastal areas, which often are often least able to incorporate those activities, and where adverse responses are apparent (European Commission, 1995). Coastal zones play a significant role as a place for human settlement and tourism (Barragan and Andreis, 2015). However, in the last years, there has been overdevelopment of these areas, and this has led to degradation of the environment due to problems that include, among others, beach litter (Williams et al., 2013).

Beach litter consists of items that have an anthropogenic origin an have been deliberately discarded, unintentionally lost, or transported by winds, waves, currents and rivers, onto coastal areas (Williams et al., 2013). This is a global and a constant issue affecting almost all coastal zones of the world and is constant increase has been recorded. Beach litter raises environmental, health, economic and aesthetic problems associated with deficient waste

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management practices, the insufficiency and/or absence of adequate infrastructure for their collection and treatment, arbitrary human activities and behaviours, and an inadequate understanding on the part of the public of the potential consequences of their actions (UNEP, 2009; Williams et al., 2016a, b).

Beach degradation related to litter issues produces in beach users a rejective reaction due to a feeling of unhealthy conditions and poor beach aesthetic value, among other aspects. As a result, litter presence is a strong reason not to visit and leave a beach (Ryan et al., 2013). Likewise, beach litter cleaning operations generate a significant financial investment for local authorities. For example, Gilbert (1996) recorded that, because of marine and coastal pollution, the County of Kent (UK), spent as direct and indirect costs, c. 16 million US$ during 1995. Similarly, Araujo and Costa (2006) established that the monthly cost of beach cleanup at the municipality of Tamandare (Brazil) was 10,630 US$, corresponding to 9% of total municipal taxes income. The increasing cost of cleaning operations has recently led local managers and actors to seek out more efficient and lasting measures/solutions.

Beach litter contamination affects not only the socio-economic system but also diverse coastal ecosystems. Within beach litter, plastics are the predominant litter items and the principal vector of contamination (Williams and Simmons, 1997; Ryan et al., 2009). Their impacts are related to their great abundance in all natural environment, their high persistence (complete mineralization takes place after hundreds or thousands of years), formation of toxic substances, and their ability of acting as a vector for contaminants, including Persistent Organic Pollutants (POPs) and heavy metals.

Likewise, wood, polystyrene, rubber, and debris also common litter types, are transported by rivers and then deposited in coastal environments (Williams and Simmons, 1997; Viehman et al., 2011). Some non-buoyant or non-persistent litter items, such as glass, metal, and organic litter, are frequently attributed to non-riverine sources, like direct litter dumping (Bravo et al., 2009).

Transport and deposition regimes of litter in coastal zones are associated with climatic and oceanic conditions, mainly wind, waves, nearshore currents and tidal characteristics (Carson et al., 2013), as well as with coastal geomorphologic features such as beach morphodynamic state, level of sheltering, etc. (Araujo and Costa, 2007; Williams et al., 2016a, b). The magnitudes and composition of litter on beaches is furthermore related to land use, and social/economic activities developed into coastal zone and river basin areas (Carson et al., 2013; Lechner et al., 2014).

The above implies that adequate coastal zone management and tourist development must include the characterization of magnitudes, sources, and impacts of beach litter. Once the typology and dynamics of beach litter are known, local administrations may correctly intervene in their management by, for example, developing clean-up campaigns and establishing and reinforcing existing environmental education plans.

Marine and coastal tourism are one of the fastest-growing sectors of the tourism industry, one of the largest in the modern world (Hall, 2001; EEA, 2006). Their contribution to Gross Domestic Product (GDP) of a coastal country can oscillate from 2% for small scale tourism countries to more than 10% for countries such as Colombia (Briguglio, 1995; Rangel-Buitrago et al., 2013; Williams et al., 2016a, b). Currently, tourism represents one of the most important economic activities in South American countries especially in Colombia, which occupies the 5th place, i.e. 0.23% of total arrivals in the world (MinCIT, 2016). The development capacity of Colombian tourism appears to be almost limitless. An increase of 320,528 international arrivals occurred between 2014 and 2015, and a similar behavior was recorded with 118,599 foreign visitors during January–June 2016 (MinCIT, 2016). Tourist industry rapid growth means an increase of almost US$ 270–280 million per year in the Colombian GDP (Rangel-Buitrago et al., 2015a, b). This GDP relating to tourism activities (>US$ 3600 million in the balance of payments for travel/transportation), is the third highest source of foreign exchange in Colombia after oil and coal, exceeding exports of coffee, and others products.

A coastal area in optimal conditions means millions of dollars profit, in this sense, beach users play a significant role in coastal tourism success because they are the motor and last receptor of the related economy. To be economically competitive, a country, such as, Colombia must increase coastal tourist numbers and to obtain that it is important to know coastal tourist preferences. Five parameters are of the greatest importance to coastal visitors: i) water quality, ii) safety, iii) facilities, iv) scenery and v) no litter (Williams, 2011).

The coastal area of the Atlántico department of Colombia has a limited tourist potential if compared with other national destinations, such as, Tayrona Park characterized by beautiful scenic sites, white sand beaches with turquoise water colour, no litter, facilities, etc. (Rangel-Buitrago et al., 2013). As evidenced by preliminary studies (Rangel-Buitrago et al., 2013; Williams et al., 2016a, b), the Atlántico department coast presents low scenic values, poor water quality (due to water turbidity), an abundance of vegetation debris and litter, no beach facilities and security (no lifeguards). Despite previous assumptions, the investigated coast has a great potential for local and (partially) national tourism associated with "family" and "a friendly and relaxed atmosphere" parameters qualified as of great importance by Botero et al. (2013a, b), as a result of numerous inquiries carried out along the Caribbean coast of Colombia.

Hence, to develop coastal tourism along the investigated area, several actions are needed, such as implementation of beach facilities, the increase of safety and the execution of cleaning operations to reduce vegetation debris and beach litter and the latter is the focus of this paper. Surveys carried out in this paper provide a first step in the characterization of beach litter at different areas along the Atlántico department, a preliminary intent aimed to determine the characteristic, magnitude, sources and impacts of beach litter on environmental, sociocultural and socioeconomic sectors.

Results presented are extremely useful to local or national coastal managers and planners, who need coastal, landscape inventories based on ascertained facts in order to adopt sound management decisions.

2. The Atlántico department coastline

The Atlántico department coastline is a developing region divided into five municipalities with 1,278,822 inhabitants. This population, which represents 3% of the Colombian population, is mainly concentrated at Barranquilla, the largest and most populated city of the Caribbean coast of Colombia.

The study area includes 26 beaches distributed along a 72 km coastline belonging to the Atlántico department (Table 1 and Fig. 1). The coastline orientation is NE-SW with some sectors oriented E-W that has generated the alternate of medium - long linear segments with Z curve bays. The Atlántico department coastline is a complex region where tectonic processes have defined the actual topography with landscape units ranging from low-medium mountain areas to coastal plains.

Coastline evolution was strongly influenced and linked to the Magdalena River Delta modifications and the impact of neotectonic processes (Anfuso et al., 2015). Quaternary interactions among tropical climate, oceanographic processes, and tectonic activity give rise to a great diversity of unstable littoral geomorphologic features characterized by terrigenous sandy beaches, sand spits, Tertiary