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Qualitative and Quantitative Beach Cleanliness Assessment to Support Marine Litter Management in Tropical Destinations

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Abstract: In addition to its ecological and recreational relevance, beach cleanliness is also one of the five most important aspects (i.e., the "Big Five") for beach visitors around the world. Nonetheless, few efforts have been carried out to guide the sound management of this rising issue. This paper presents a quantitative and qualitative method to assess the level of beach cleanliness, in order to allow managers to focus their attention on the environmental management of the most frequent and relevant types of litter in tropical areas. In a first step, a survey on users' perception was applied to 361 beachgoers in eight beaches in Colombia to identify the most relevant types of beach litter and the weighting factors to obtain quantitative calculations. In a second step, the thirteen categories of litter identified were analyzed in relation to beach cleanliness, origin of litter, and environmental impact, to define its individual weighting importance. Some categories were also selected according to particularities of tropical countries, such as the presence of abundant natural vegetation debris and gross polystyrene items, largely transported by rivers in great quantities. In a third step, the method was then tested at eight beaches in the Caribbean coast of Colombia through a period of four months, during which 192 transect samplings were carried out. The qualitative module of the proposed technique, named Beach Litter Assessment Technique—Qualitative and Quantitative (BLAT-QQ), identified the main types of beach litter and the quantitative module gave an overview on the state of beach cleanliness. The method is demonstrated to be quick and effective in diagnosing beach cleanliness, providing a simple instrument to carry out sound environmental management actions in coastal destinations.

Keywords: beach litter; vegetation debris; beachgoers' perception; Big Five; Colombia

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1. Introduction

The presence of litter, independent of its origin, is a factor of utmost importance for the aesthetic experience, health and safety of beach users, and for the beach ecosystem itself [1,2]. According to Williams [3], the absence of litter has been empirically identified as one of the five most important factors for visiting a beach. The author carried out >4000 questionnaire surveys concerning beachgoers' priorities and preferences in many countries, e.g., UK, Malta, Turkey, Croatia, New Zealand, Portugal, and USA, and confirmed that there are five main parameters (namely the "Big Five") that beach users look for. These are water quality, safety, facilities, scenery, and no litter, which is the object of this paper. The importance of each one of them ranges from place to place and is a function of beach users' cultural background, age, sex, education, etc. [3].

Litter deters visitors [4] and consequently decreases the probability of return visitation [5], significantly affecting local economies [6,7]. Regarding safety and health concerns,

litter has been found to be a common cause of injuries [8,9] and health problems caused by pathogenic agents that proliferate in food scraps left on the beach [10], as well as fecal coliforms found in animal feces [11]. Further, marine litter has a significant impact on flora and, especially, fauna [12,13], e.g., due to ingestion [14,15] together with entanglement of animals in abandoned nets, fishing lines, ropes, and ribbons [16,17].

Litter is also an important element of the environmental beach quality—EBQ. In general terms, the EBQ represents the state of this socio-natural system in a certain time, concerning its ecosystem functionality and satisfaction of several human needs such as leisure, subsistence, and identity [18]. EBQ covers three dimensions: sanitary, ecological, and recreational. Within this conceptual framework, beach litter is a parameter of importance for the three BQE dimensions [19]. Although several researches recently have identified emerging pollutants such as microplastics, the interest of this paper is mainly focused on macro-litter that includes most visible items to beachgoers, i.e., items that most affect their recreational experience.

All the above favored a great number of studies on marine litter. A search in the Web of Science carried out in 2020 by the authors using the keywords "marine", "beach", "litter", "debris" and "waste" found 1003 studies (excluding studies focusing only on microplastics), of which 119 were studies of macro-litter on beaches, with 89 employing some sort of methodological solution to identify and quantify litter. Numerous studies from different parts of the world have consistently confirmed the high importance given to litter perceived by beachgoers in Australia [20], Colombia [21], Italy [22,23], Mexico [24], Poland [25], Kenya [26], Portugal [27], South Africa [28], Israel [29], Spain [30], UK [31], USA [32], Malta, and Turkey [24].

The aim of this work is to define a method to support the environmental management of beach litter, as one of the five most important assets for beachgoers. Among many commonly used frameworks designed to assess litter such as OSPAR [33], EU MSFD TGML D.10 [34], UNEP / IOC [35], and NOAA [36], this study is partially based on the methodology proposed by EA/NALG [37], which was developed as the result of a search for a standardized framework that enables site data to be compared among different projects. The methodology uses the universal method for area sampling used by OSPAR, EU, UNEP, and NOAA. However, it employs standardized grades and categories for describing beach litter, from areas with no evidence of litter to areas heavily littered, similarly to the EA/NALG technique [37,38]. A similar grade concept was applied and calibrated in this work, through a beach users' survey (interviewed beachgoers = 361), for its use in Colombia and, potentially, in Latin America and other tropical areas. Stemming from the concept of environmental beach quality, two mathematical formulas are proposed to transform the litter abundance into quantitative measurements and make easy to local authorities to focus their efforts on the types of litter with the highest impact. Finally, the method was applied in eight beaches in Colombia.

2. Materials and Methods

A survey of beach users was carried out at eight Colombian Caribbean beaches (1: Bahia; 2: Playa Blanca; 3: El Rodadero; 4: Salguero; 5: Pozos Colorados; 6: Bello Horizonte; 7: Aeropuerto; 8: Salgar, Figure 1). The sample (n = 361) was statistically based on an infinite universe with 90% confidence in recognition that beaches are open areas without accurate counting of visitors. The questionnaire was self-administrated to users on the beach, and had eight questions designed to gather information about the types, levels of impact and sighting frequencies of beach litter, among other aspects (Table 1). The survey was carried out on the beaches during the second semester of 2018, mainly on Sundays, when beaches in Colombia receive the highest number of visitors [21].

The survey administration followed a random sampling of beachgoers along each beach, to whom the research team gave a briefing of the goal of the research and answered all the doubts/questions raised during the enquiries by participants.

The most relevant categories of litter were defined based on the result of this survey, and on a comparison of data sets of beach litter grades from different countries, such as Ecuador, Colombia, and Cuba [38–40], based on the EA/NALG [37]. The final list of litter items has categories covering issues such as consumption patterns, litter management, ecosystem-based dynamics, and cultural traits. In particular, the final beach litter categories/types and the establishment of weighting variables were based on questions Q4 and Q5. Although other results were extracted from the survey, they are out of the scope of this paper.

The qualitative measurements of beach cleanliness followed the same procedure than the EA/NALG [37], but ranges of litter quantities were divided into five levels or grades (A–E). This small adjust allows to provide compatibility with other commonly-used methods, such as the sector analysis developed by Williams et al. [40].

Table 1. User survey applied on beaches of the Northern Caribbean coast of Colombia and sociodemographic data of respondents.

Q1. What kind of activity do you engage in on the beach? a. Tourism b. Recreation c. Street sales d. Commerce				Q5. According to the litter types in the previous question, state their degree of impact during your stay on the beach: a. Nothing b. A little c. Moderate d. High e. Excessive		
Q2. How often do you visit the beach? a. Every day; b. More than once in a week; c. Once in a week; d. Once in a month; e. Several times in a year; f. Once in a year				Q6. Which activities do you consider as a source of beach litter? a. Recreational activities; b. River inlets; c. Sewage system d. Fishing activities e. Aquatic transport f. Inappropriate disposal of litter g. Coastal facilities h. Others		
Q3. How often have you been affected by the beach litter? a. Always b. Nearly always c. Sometimes d. Never				Q7. Do you consider that beach litter has a negative impact on the visitors' well-being and the quality of the beach? a. Yes b. No		
Q4. Which types of litter you frequently identify on the beach? 1. Sewage related debris (Condom, nappies, cotton buds, hair, similar); 2. Gross litter (Car parts, appliances, similar); 3. General litter (Cans, food wrappers, plastic bottles, similar); 4. Potentially harmful litter (Broken glass, glass bottles, blades, similar); 5. Voluminous vegetation litter (Wooden trunks, similar); 6. Non voluminous vegetation litter (Leaves, algae, moss, similar); 7. Organic litter (Vegetable/fruit peel, food scraps, similar); 8. Gross Polystyrene litter (Coolers, disposable packaging, similar); 9. Cigarette butts; 10. Accumulations; 11. Oil; 12. *Faeces*; 13. Others				Q8. If the previous answer was "yes", indicate: What consequences have beach litter? a. Impact on the environmental quality of the beach b. Disturbance of flora and fauna c. Impact on health d. Disturbance from bad odors e. Impact on the aesthetics of the attraction		
Gender	Female 171	Male 213				
Age	<18 25	18–29 134	30–39 101	40–59 110	>60 14	
Education	Primary 28	Secondary 157	Technical 75	Degree 110	Postgraduate 14	
Occupation	Employed 109	Self-employed 152	Student 88	Retired 3	Unemployed 32	
Origin	Local 217	National 161	Foreign 6			
Incomes(US $)	0−250 112	750−1500 44	1500−2500 25	250−750 73	>2500 7	No response 123

Figure 1. Location map of the beaches where litter surveys were carried out. Numbers refer to beaches where enquiries were carried out (see text).

Regarding the procedure followed to obtain quantitative measurement of beach cleanliness, it was designed to enable a numeric measure of beach litter abundance (Figure 2). Firstly, grades were associated with a weighting value representing an exponential curve (A = 10, B = 30, C = 90, D = 300 and E = 1000) to define the maximum and the minimum ceilings of the equation. Then, ranges were defined for each grade based on weighting calculation between the grade value and the obtained frequencies for each litter category/type in the user perception survey. Finally, two calculation constants for each litter category/type were estimated considering the results of two of the surveyed issues: the degree of impact (α = experience of quality) and the perceived frequency of beach litter (FC = weighting correction factor). The former refers to the impact that litter produces on the beach in the three dimensions of environmental quality defined by Botero et al. [41]: sanitary, ecological, and recreative. These constants enabled the development of the calculation formula (Equation (1)) to obtain the beach litter value. In addition, these values were normalized, to determine the relationship between the beach litter value and the beach environmental quality [18].

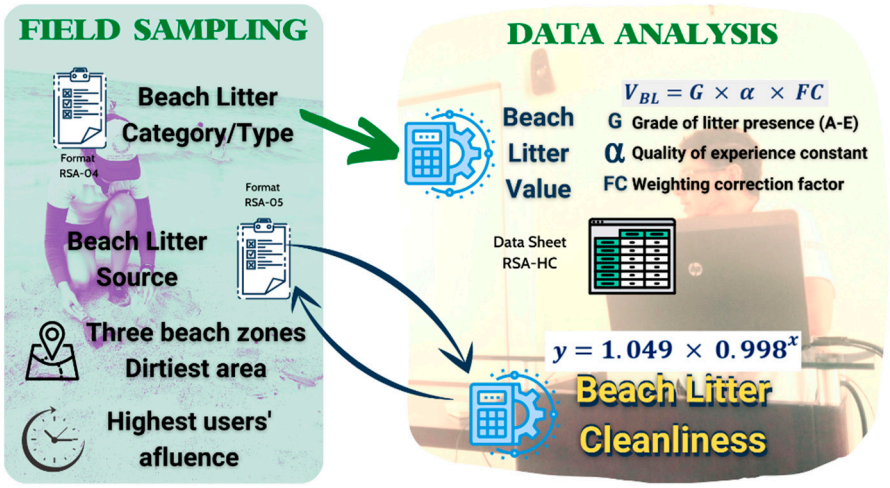


Figure 2. Procedure followed to obtain beach litter grades (qualitative module) and Equations (1) and (2) (quantitative module).

Later, Equation (2) was used to convert the beach litter value, which ranges from 20 to 2000 (Table 2), to a beach litter cleanliness index, ranging from 0 to 1 (Table 3). In this way, the beach litter value is obtained according to Equation (1):

$$V_{BL} = G \times \alpha \times FC \quad (1)$$

where V_{BL}: beach litter value, G: weighting value for each qualification grade (A–E), α: experience quality, a constant for each litter category/type and FC: weighting correction factor for each litter category/type.

Table 2. Qualitative interpretation of beach litter values.

Beach Litter Value	Environmental Status
20	Excellent
21–60	Good
61–180	Acceptable
181–600	Fair
6001–2000	Poor

Table 3. Qualitative interpretation of beach litter cleanliness.

Beach Litter Cleanliness	Environmental Status
1.00	Excellent
0.99–0.90	Good
0.89–0.70	Acceptable
0.69–0.30	Fair
0.29–0.00	Poor

The Equation used to calculate the level of beach litter cleanliness is:

$$y = 1.049 \times 0.998^{x} \quad (2)$$

where y: Beach litter cleanliness and x: Beach litter value.

Finally, the obtained technique, called BLAT-QQ (Beach Litter Assessment Technique—Qualitative and Quantitative), was applied as part of a project to develop an index to measure the environmental quality of tourist beaches (www.sistemascosteros.org/icar_icaptu/, accessed on 1 October 2021), based on the original proposal of Botero et al. [41]. In this paper, the technique was applied on eight (8) beaches of the four North-Caribbean departments of Colombia, i.e., (i) La Guajira (Riohacha, Mayapo), (ii) Magdalena (Playa Blanca, Pozos Colorados), (iii) Atlántico (Puerto Velero, Caño Dulce), and (iv) Bolívar (Bocagrande, Punta Arena). Sampling was carried out during a four-month period in 2018 (28 July, 1 September, 29 September, and 27 October). The data were collected twice a day (morning and afternoon) on the three parallel strips (consisting of 192 transect samples) into which the beach environment is divided by the Colombian legislation (Decree 1766 of 2013). The Decree establishes which beachgoers' activities and beach uses are allowed in each beach strip. The mobile app Kobo Collect was used to compile the sampling information in the field. The qualitative results were analyzed to classify in five grades, from "A" (null/low litter presence) to "E" (great abundance of litter), each litter category/type. Finally, the quantitative results were estimated using the weighted equations 1 and 2 to obtain numeric values that indicated the cleanliness status of the eight beaches sampled.

3. Results

The results obtained from this work are classified into three main categories: (a) Litter categories/types identified by beach users, (b) Visitors' perceptions of the degree of beach pollution and (c) Application of the qualitative and quantitative calculations of the BLAT-

QQ. Figure 3 shows the beach users' responses to question 4 (Q4, Table 1) that asked to identify the most common litter types.

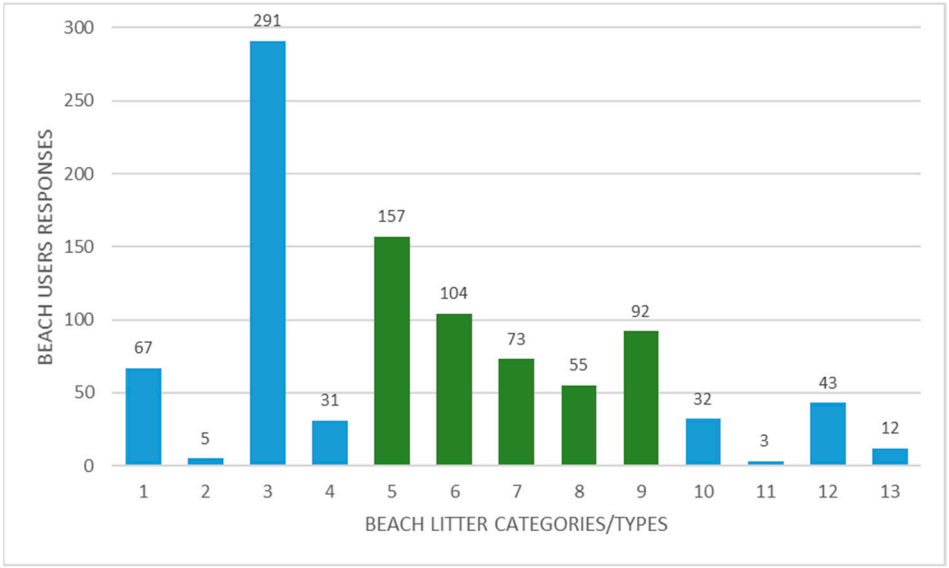


Figure 3. Litter categories/types identified from the users' survey. See Table 4 for litter types.

Table 4. Beach litter assessment instrument.

Category		Type	Beach Litter Units per Qualification Grade					Factors	
			A	B	C	D	E	α	FC
Sewage related debris	1	Condoms, diapers, cotton buds, hair	0–24	25–49	50–69	70–99	100+	0.25	0.24
River transported litter	2	Sandals, toothbrushes, domestic items	0–24	25–49	50–69	70–99	100+	0.25	0.24
General gross litter	3	Car parts, appliances	0	1–4	5–14	15–24	25+	0.02	0.02
General litter	4	Cans, food wrappers, plastic bottles	0–99	100–499	500–799	800–1199	1200+	1.00	1.06
Potentially harmful litter	5	Broken glass, glass bottles	0	1–4	5–24	25–44	45+	0.13	0.12
	6	Others (Syringes, blades, similar)	0	1–9	10–19	20–29	30+	0.13	0.12
Gross vegetation litter	7	Wooden trunks	0	1–49	50–99	100–199	200+	0.51	0.57
Small vegetation litter	8	Leaves, algae, moss	0–49	50–99	100–199	200–299	300+	0.32	0.38
Organic litter	9	Dead animals, fresh fish scraps	0	1–4	5–9	10–14	15+	0.27	0.26
	10	Vegetable/fruit peel, food scraps	0–14	15–49	50–89	90–124	125+	0.27	0.26
Gross Polystyrene litter	11	Coolers, disposable packaging	0–14	15–29	30–44	45–59	60+	0.21	0.20
Cigarette butts	12	Number of cigarette butts	0	1–49	50–99	100–149	150+	0.38	0.34
Accumulations	13	Number of points of beach litter grouping	0	1–4	5–9	10–14	15+	0.30	0.12
Oil	14	Appearance of the oil	Absent	Trace	Acceptable	Nuisance	Objectionable	0.04	0.01
Feces	15	Number of feces	0	1–4	5–9	10–14	15+	0.19	0.16

Litter types with the highest frequency were: Type 3 (general litter), Type 5 (voluminous vegetation debris: tree trunks, similar), Type 6 (non-voluminous vegetation debris: leaves, moss, similar), Type 7 (organic litter: vegetable/fruit peels, food scraps,

similar), Type 8 (gross polystyrene items: coolers, disposable packaging, similar), and Type 9 (cigarette butts), Figure 4.

Figure 4. Example of beach litter categories 2 (river transported), 5 (gross vegetation) and 8 (gross polystyrene).

It should be noted that Types 5 and 8 can be considered somehow controversial. The common definitions of litter do not consider vegetation debris as litter [40,42] but, from the managerial perspective, the aesthetic and safety (physical and microbiological) aspects of vegetation and organic debris have been considered an important issue on beaches used primarily for tourism [8,43–48]. In this study, unprocessed wood (essentially trunks, branches, etc.) is considered gross vegetation litter. As observed in numerous studies, river discharges constitute one of the primary sources of litter [49–53], and wooden debris has been reported to be one of the most numerous items found on beaches especially after heavy rains [54–56]. The management of large organic debris entering the sea through big rivers is a major problem on many tropical beaches around the world. Although there is not much scientific literature on this issue, the abundant quantity of vegetation debris seems to be consequence of both natural reasons, i.e., the favorable tropical climate temperatures and abundant precipitation favor the development of vegetation along the riverbanks, which are often flooded and therefore vegetation is carried away; and anthropogenic activities, i.e., large areas are often deforested for agricultural purposes or urban developments and vegetation debris is thrown into nearby streams and rivers ending up in the sea.

Furthermore, plastic is well recognized as the main marine litter material; however this category is very wide. In the case of Colombia, polystyrene items are quite common [57], and the relevant visual impact that they generate on the perception of beachgoers was confirmed by the survey's respondents. Additionally, the COVID–19 pandemic increased the use of disposable elements for food-packaging, which had negatively impacted beaches in several countries of Latin America with plenty of polystyrene items [58].

Figure 5 shows beach users' responses to question 5 (Q5, Table 1) that indicates the perceived degree of impact of litter. This figure also shows a relationship between beach litter categories/types previously detailed and the perception of impact by users. Many types of litter included in BLAT-QQ (5, 6, 7 and 8) were perceived to cause "moderate" and "high" impacts. Similarly, Type 4 (potentially harmful litter: broken glass, glass bottles, blades, similar), Type 11 (oil), and Type 12 (feces) were identified to have a disproportionate level of impact, although the frequency of appearance of those types was relatively low (Figure 3). Despite the low frequency of Type 2 (general gross litter: car parts, appliances, similar), it was included in the classification because it was associated with a "moderate" level of impact and this litter type represents a significant problem for beach management [48].

Lastly, Type 13 (others) had the highest level of impact but, because of its indeterminacy, it was discarded.

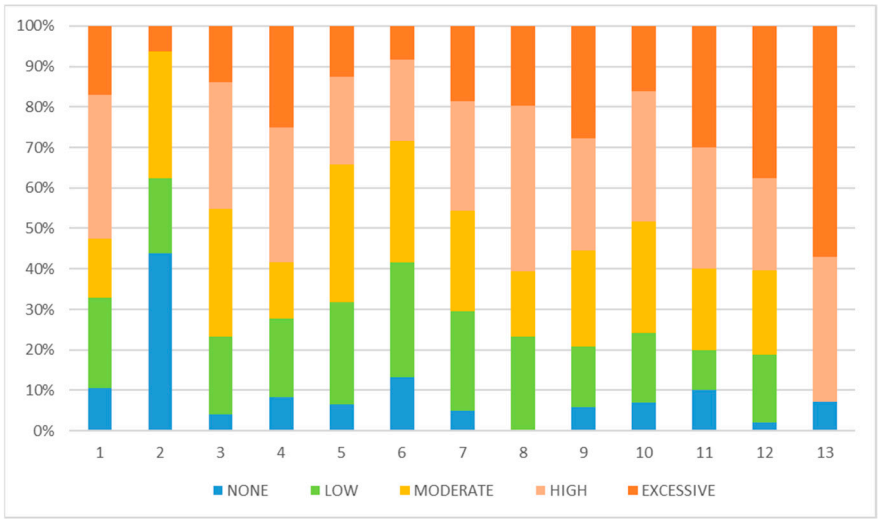
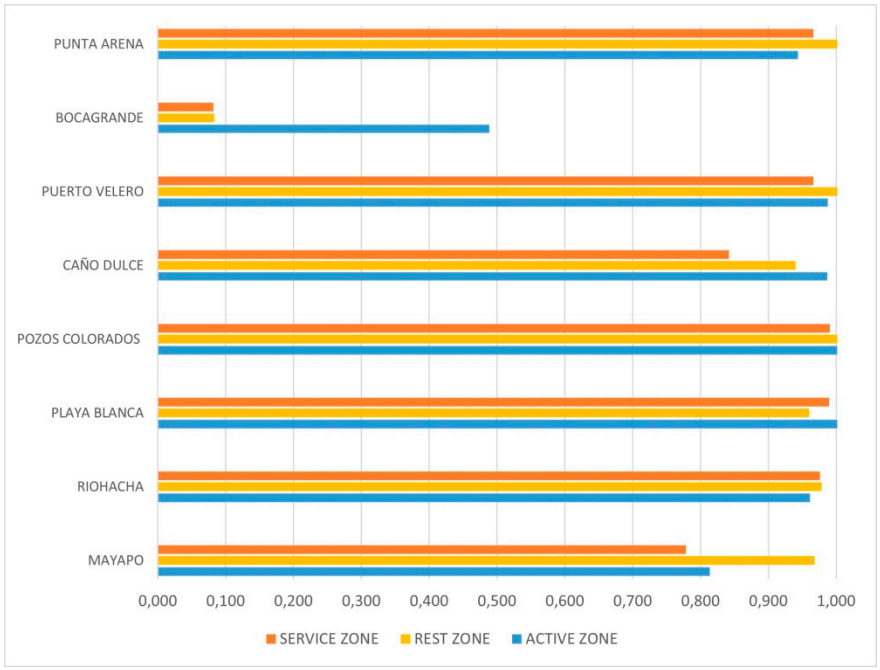


Figure 5. Beach users' perceptions of the degree of impact of different litter categories/types.

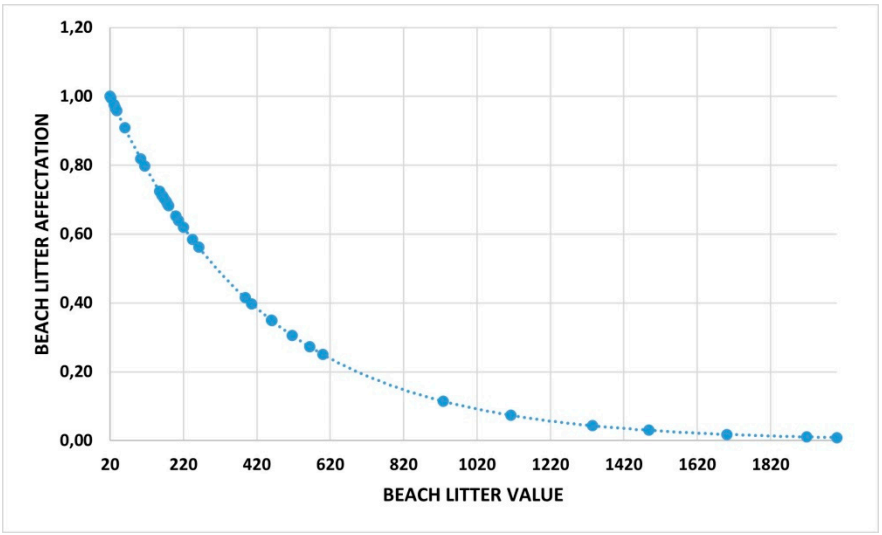
The results from the beach litter survey allowed for the development of an instrument capable of covering qualitative and quantitative calculations. The qualitative approach corresponds with other techniques, based on the assignation of qualitative grades depending on the quantity of litter in each category. The categories range between A (very good) and E (poor). The range for each grade was obtained from the frequency of responses to Q4. The results show that general litter was the type with the highest importance factor, followed by gross vegetation litter, which is a new type included in the BLAT-QQ instrument. However, the presence of oil had the lowest weighted values, closely followed by gross general litter. Other litter types such as cigarette butts and vegetation litter debris had relatively high importance factors, which is supported by their high level of beach impact and frequency of appearance, respectively. Table 4 shows the beach litter assessment instrument with 13 categories and 15 types of litter, ranges, the extended qualification grades (A–E), and the weighted factors for the quantitative calculation.

As the results show, the litter type with the largest importance factor was general litter, followed by gross vegetation litter. The presence of oil had the lowest weighted values, closely followed by gross general litter. Other litter types, such as cigarette butts and small vegetation litter, had relatively high factors, which is supported by their strong effect on beach users' perception of beach quality and frequency of appearance, respectively.

As the last stage of the research, the average results of the application of the BLAT-QQ instrument were compiled and illustrated (Figures 6 and 7). Figure 6a shows the beach litter values per sampling strip for the eight beaches, calculated from Equation (1). In general terms, all beaches showed similar patterns in the three strips of beach, except for the urban beach Bocagrande, where the beach strips "service" and "rest zones" (terminology according to the Colombian legislation, Decree 1766 of 2013) had extremely low values. As noted above, the beach litter values were normalized using Equation (2) to obtain the beach litter cleanliness. Figure 6b shows the mathematical relationship in which lower beach litter values (20) correspond with minor levels of cleanliness (1.0) and vice versa. In short, this calculation transforms a linear parameter (beach litter) to a cumulative value represented by an exponential pattern, providing a better measure of the impact of beach litter on environmental quality [41].



(**a**)



(**b**)

Figure 6. Application of the quantitative results of the BLAT-QQ technique in eight Colombian beaches (**a**). beach litter cleanliness in the three stripes of each beach; (**b**). mathematical function of BLAT-QQ calculation).

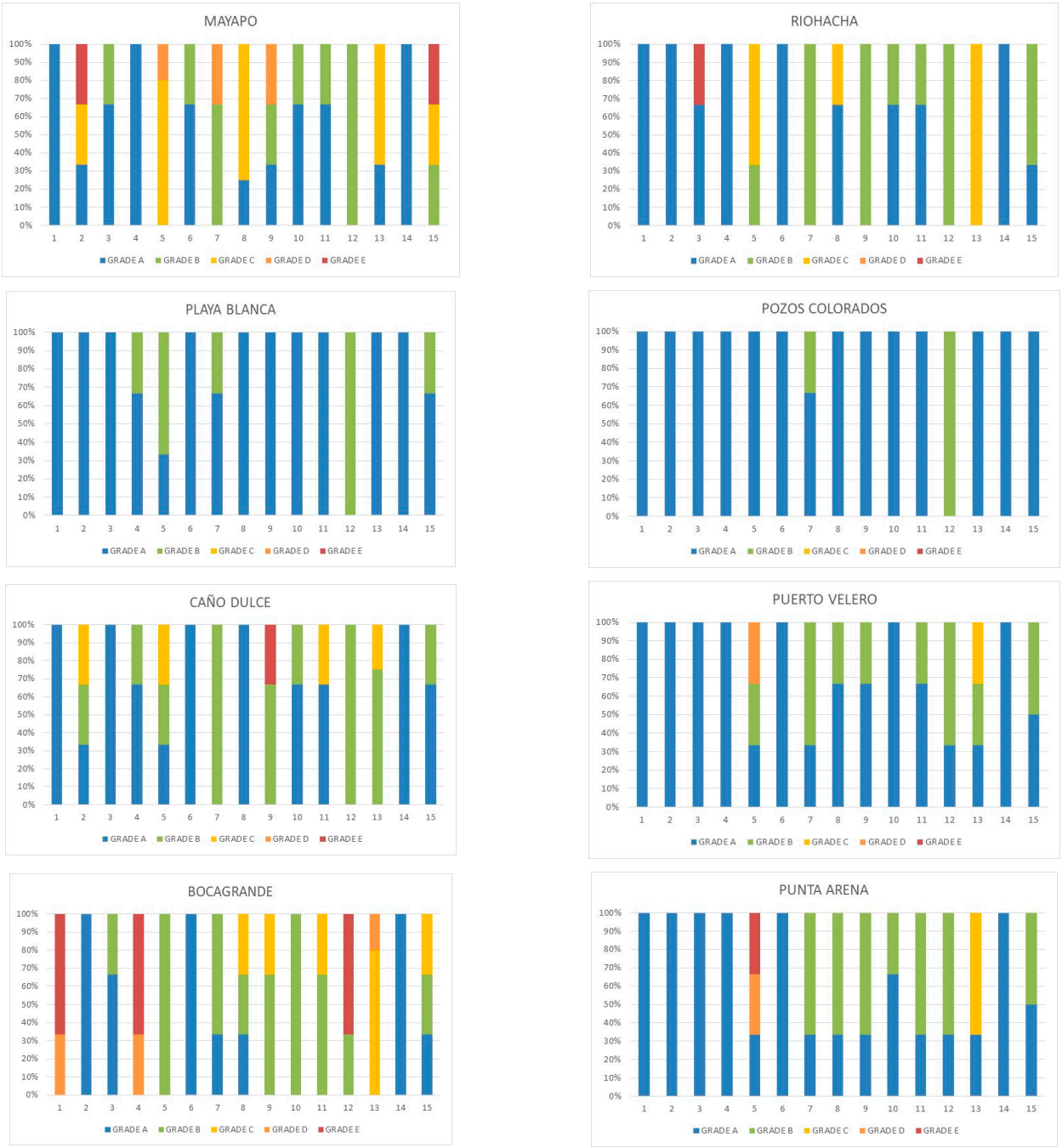


Figure 7. Application of the qualitative results of the BLAT-QQ technique.

Figure 7 shows the results of the application of the qualitative calculation on the same beaches. The comparison of the results from eight beaches indicates that the BLAT-QQ method has enough sensitivity to differentiate beach cleanliness levels. As an example, Playa Blanca and Pozos Colorados beaches had better grades for each litter type than Punta Arena and Riohacha beaches; however, those beaches had better results than Mayapo and Bocagrande beaches, which had the lowest grades in several litter types. The method also allows differentiation between the types of beach litter with precision. Considering Type 5 (potentially harmful litter: broken glass, glass bottles, similar) litter as an example, all beaches had completely different valuation grades (Mayapo: C and D; Riohacha: B and C; Playa Blanca: A and B; Pozos Colorados: A; Caño Dulce: A, B and C; Puerto Velero: A, B and D; Bocagrande: B; Punta Arena: A, D and E).

These results are consistent with other studies published, which included some of these eight beaches. As an example, Puerto Velero and Caño Dulce beaches had low grades with BLAT-QQ (D and E respectively), which is broadly similar to the results presented by Rangel-Buitrago et al. [56]. Nevertheless, in the majority of the studies published about Colombian beaches, the beaches were sampled only once or twice [40,56,58,59], meanwhile Figure 7 shows well consolidated data that correspond to four sampling days per beach.

4. Discussion

In recent decades coastal tourism has been constantly growing worldwide, mainly due to the attraction of the "Sun, Sea and Sand" ("3S") tourism [60]. Williams and Micallef [61] and Williams [3] have demonstrated that five parameters (the "Big Five") have a major importance on beach choice and their effective management can increase beach quality. Therefore, the sound management of one or several parameters can favor an increase in overseas/local tourism, quality of recreational opportunities, promotion of sustainable coastal development and effective utilization of an increasingly valuable socioeconomic/ecological national resource [62]. In current coastal zone management programs, indicators are used to monitor environmental quality, indexing progress/non-progress of policies [63]. The method presented here to assess beach litter cleanliness can constitute one of the indicators chosen by local administrations, as it has been proven to be useful in monitoring projects in Colombia. However, it is also applicable to similar areas, i.e., tropical regions.

This study confirms that the concept of "Big Five" is very relevant in Colombia too. Figures 3 and 5 highlight the importance of litter for recreational quality, which is one of the dominant functions of sandy beaches [64,65]. Although ecological and protective functions are very important for beach management [66] within the framework of environmental quality, the recreational aspect is equally or even more relevant for urban and resort beaches [67], especially for those that maintain or plan to obtain a beach certification, which requires a functional waste management system, including planning and cleaning operations [68–70]. In general terms, the cleanliness depends on two variables: (i) litter sources and (ii) cleaning operations. The former defines the latter, in the sense that the clean-up operations of each beach should be designed according to the type of litter prevalent there. As an example, if the main source of litter is the tourist frequentation, litter management should be focused on tourist behavior, e.g., by increasing their sensibility to the problem; on the contrary, if rivers are the main source of debris, litter management should be focused on cleaning campaigns after storms or heavy rivers' discharges to the sea. Unfortunately, the scientific literature about this topic is still scarce [48].

As much as one may desire to manage all beaches in the function of the environment, the reality is that the management of recreational beaches is focused on the maintenance of key parameters for users' enjoyment rather than environmental recovery or conservation of the natural environment that has already been altered by heavy use [48]. Fortunately, many of the environmental factors such as beach cleanliness or conservation of key ecosystems are also valued by visitors, which show that perception-based evaluation techniques can be very useful in management of recreational beaches.

The advantage of the qualitative approach of BLAT-QQ is based on the simplicity of interpretation by environmental managers. Additionally, the method provides ranges of items that define the grades of cleanliness, allowing a researcher to obtain a unique value of the litter on the beach and a normalized value of the level of beach litter impact. The technique is compatible with other beach surveys such as the "Sector Analysis" developed by Williams et al. [40], which allows the comparison of the relationship between litter and scenery of the same beach in a very simple chart. Both, the litter and scenery belong to the "Big Five", therefore the integration of those two tools makes evaluation of recreational quality more robust.

In terms of beach management, the BLAT-QQ focuses on the sources of pollution, classifying beaches according to the type of litter that causes the highest degree of impact,

which allows beach managers to address the main sources of pollution. Furthermore, classification of the items according to their physical characteristics can provide valuable information to develop policies aimed at limiting the use and production of items that are commonly found in the litter assessment studies (e.g., Litterbase—litterbase.awi.de, accessed 1 October 2021).

In sum, the BLAT-QQ was primary designed as a part of the Environmental Recreational Quality Indicator of the Environmental Beach Quality Index [41], as was stated in the methodology, however the technique could be used also for public health purposes within the Environmental Sanitary Quality Indicator [19,41].

Further limitations of BLAT-QQ include its validation only on Colombian beaches; Therefore, the technique is highly applicable to the Caribbean context and, in general, in tropical areas. Nevertheless, the technique could be used in other contexts, but some categories will not have relevance, as can be happen in countries without abundant rivers' discharges or robust circular economies.

Additionally, because the survey was done in beaches visited mainly by local and national visitors than international tourists (see socio-demographic data of Table 1), the results are more representative for urban beaches than other beaches essentially frequented by international tourists. Lastly, the BLAT-QQ could be reinforced with a survey application or digital platform that allows non-expert users to sample the beach litter and report through this tool. In sum, litter management is still a challenge globally, and there is no indication that this trend will change in the near future [71]. Reliable, yet simple, techniques to monitor beach cleanliness can play as important role in environmental management as more complex and robust methods commonly used in litter assessment studies.

5. Conclusions

Beach litter has been an increasingly popular topic for scientific publications during the last decade. Hundreds of researchers have counted thousands of items and tons of litter on beaches all around the world. The contribution of this paper is centered in the demonstration of a technique for beach litter surveying that is very suitable for Latin American conditions and, in general, tropical regions. The BLAT-QQ technique was designed and implemented with primary data sampled on Caribbean beaches of Colombia but also observed in many other Caribbean countries, allowing the adjustment of the qualitative and quantitative modules of the instrument.

The method integrates a clear and simple list of litter categories. The BLAT-QQ technique solves three major challenges for beach litter management: 1. Ssimplicity of interpretation, 2. mixed-approach analysis (qualitative-quantitative) and 3. robustness to calculate beach environmental quality linked to litter presence.

In conclusion, this paper shows a relatively quick and effective method to diagnose beach conditions in terms of debris. It is a simple technique that can be used in monitoring programs as well as to evaluate the effectiveness of beach cleaning programs. It is robust enough to identify major litter categories, which can provide information required for litter priority management and contribute to outreach about beach cleaning conditions. Lastly, a wider validation is still needed to ensure its pertinence to other geographical regions.

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