

Assessment of Marine Litter from Goa, India and Its Impact on Visitor Satisfaction

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Abstract

This study establishes a baseline for marine litter occurrence at five selected beaches in Salcete taluka, South Goa: Colva, Velsao, Benaulim, Cavelossim, and Sernabatim. Monthly surveys were conducted along fixed 1 km beach stretches from August to October 2022. Over 58 visits, researchers collected, categorized, weighed, and removed 2,460 litter items. Colva exhibited the highest mass of marine litter, contributing 67% to the total, while Velsao and Benaulim contributed the least at 5% each. Preliminary assessments identified domestic activities, marine recreational tourism, and fishing as the primary pollution sources. Concurrently, a questionnaire assessed visitor demographics, perceptions of litter pollution, and overall beach quality. Cleanliness and washroom accessibility emerged as the two most critical determinants of visitor satisfaction, closely followed by traffic congestion and the presence of stray animals. Paradoxically, despite 48.86% of respondents being strongly familiar with plastic pollution, 46% reported being only "somewhat concerned" about beach cleanliness. The findings highlight a distinct lack of environmental concern among tourists, particularly domestic visitors. This baseline data underscores the urgent need for adaptation-centric complementary strategies to mitigate marine litter and preserve Goan beaches.

Keywords: Arabian Sea, Litter, Marine Pollution, Plastic, West Coast.

I. INTRODUCTION

Marine litter is recognised as a transboundary challenge, negatively impacting coastal and marine ecosystems and the services they provide, ultimately affecting people's livelihoods and well-being (Vlachogianni et al., 2018; Westlake et al., 2022). Unsustainable production and

consumption patterns, inefficient waste management, haphazard coastal development and population behavior towards waste disposal make India one of the significant contributors to marine litter (Kaviarasan et al., 2020; Nigam et al., 2022).

Goa, the smallest state of India, has been a world-renowned tourism destination (Nigam et al., 2022). It has the highest quantity of marine litter among all the Indian coastal states (Kaladharan et al., 2017), highlighting the influence of tourist-attributable litter. Intensive marine recreational tourism activities in the recent times have resulted in increased litter inputs to the Goan beaches. However, few studies have focused on Goa (for example, Nigam, 1982; Veerasingam et al., 2016; Kaladharan et al., 2017; Karmali, 2018; Nigam et al., 2022). Economic losses due to stranded litter should consider not only costs involved for cleaning the environment but also the reduction of visitors' interest, which may cause revenue reduction (Krelling et al., 2017). Consequently, the present study is focused on establishing a baseline of the occurrence of marine litter at selected beaches in Salcete, South Goa. Specifically, this study is intended to evaluate abundance and composition of marine litter and to analyze the visitor's perception towards beach litter and evaluate its impacts on coastal tourism. It is envisioned to encourage improved legislation or the development of alternative strategies for preventing pollution at source, thus reducing the environmental and negative effect of the litter.

II. METHODOLOGY

The study was conducted for a period of three months, during August-October, 2022. Altogether, a total of 5 sites (Table 1) were

covered and a fixed section of 1 km stretch of beach was monitored. A total of 58 visits were carried out of which, Colva (15) followed by and Sernabatim (14) were the most visited beaches while Cavelossim was the least visited, with nine visits. During the survey, all litter items were sorted by 'category type', weighed and then removed from the beach. All the beach litter collected was disposed properly (Rees et al., 1995). A questionnaire was applied to obtain socio-economic characteristics: assessment of the overall beach quality and perception of beach litter pollution at all sites. Questionnaires were designed to establish the number of visits to a particular site, and the respondents' opinions towards the standard of cleanliness of the beaches.

TABLE 1. STUDY AREA

Locations	GPS coordinates		Substrate	Remarks
	Latitude (N)	Longitude (E)		
Benaulim	15.257644°	73.919419°	Sandy	Fish landing area and a popular tourist site
Velsao	15.355706°	73.88369°	Sandy	Fish landing area and a popular tourist site
Colva	15.27897°	83.91259°	Sandy	Fish landing area and a popular tourist site

Sernabatim	15.2667°	73.9150°	Sandy	A popular tourist site
Cavelossim	15.170408°	73.941403°	Sandy	Fish landing area and a popular tourist site

III. RESULTS AND DISCUSSION

Total number of litter was the highest in Colva (1124) followed by Cavelossim (861), while Velsao had the lowest number of beach litter, with 84 items (Fig.1). Colva was found to be the most polluted and Velsao was the least polluted beach in terms of number of litter.

Table 2 summarizes the number of marine litter collected per visit by location. Altogether, a total of 58 visits were carried out and a total of 2460 litter were collected. The number of marine litter visit⁻¹ varied significantly by location with Colva, followed by Cavelossim, that had the highest number of litter per visit.

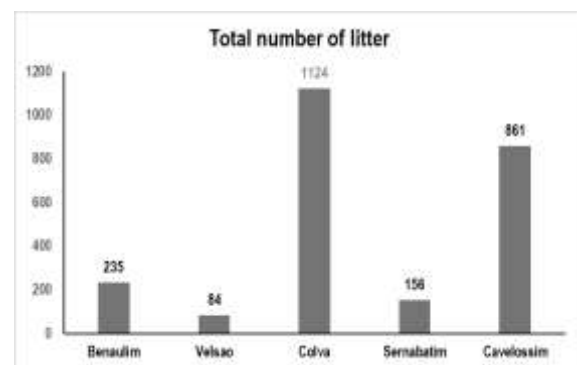


Figure 1. Total number of litter per location

A total 22 types of litter waste was collected from Benaulim (Table 3) where polythene contributed 39.15% to the total marine litter. Plastic containers, plastic spoons, *lays* packets, ice-cream sticks, spray bottles, shoes, mugs,

clothes, toothpaste tubes, crackers and lighters contributed 0.43% to the marine litter in Benaulim. A total of 17 samples of litter were collected from Velsao (Table 4). Milk packets were the most common in litter waste, contributing 19.05% followed by chips packets (16.67%).

A total 37 types of waste was collected from Colva (Table 5) which includes a variety of litter. Among them, miscellaneous plastics contribute 12.04% to the total litter. Most of the litter were observed to be generated from domestic sources. A total of 24 categories of litter was collected from Cavelossim (Table 6). Polythene contributed 18.58% of marine litter which was collected from the beach. There were more number of cigarette butts at Sernabatim (Table 7).

TABLE 2. NUMBER OF MARINE LITTER VISIT⁻¹ FROM THE STUDY AREA. “-” DENOTES NO VISITS.

Location	Total Visits	Total Litter	Mean $\pm$ SD	Range
Colva	15	1,147	76.5 $\pm$ 65.5	18–206
Cavelossim	9	861	95.7 $\pm$ 43.1	40–149
Benaulim	10	235	23.5 $\pm$ 13.5	7–56
Sernabatim	14	142	10.1 $\pm$ 4.9	7–23
Velsao	10	84	8.4 $\pm$ 2.6	6–15

TABLE 3. LIST OF MARINE LITTER (N = 235) COLLECTED FROM BENAULIM

Description	Number of items	Percent contribution
Bottles with caps	10	4.26
Bottles without caps	15	6.38
Plastic cups	14	5.96
Plastic	1	0.43

containers		
Bottle caps	44	18.72
Plastic spoons	1	0.43
Lays packets	1	0.43
Polythene	92	39.15
Cigarette butts	2	0.85
Drinking Straws	5	2.13
Ice-cream Sticks	1	0.43
Ropes	33	14.04
Glass stirrers	2	0.85
Spray bottles	1	0.43
Shoes	1	0.43
Tetra-packs	4	1.70
Mugs	1	0.43
Clothes	1	0.43
Cans	3	1.28
Toothpaste tube	1	0.43
Crackers	1	0.43
Lighters	1	0.43

TABLE 4. LIST OF MARINE LITTER (N = 84) COLLECTED FROM VELSAO

Description	Number of items	Percent contribution
Bottles with caps	9	10.71
Bottles without caps	10	11.90

Cups	0	0.00
Plastic containers	3	3.57
Tobacco packets	7	8.33
Bottle caps	5	5.95
Biscuit packets	3	3.57
Lays packets	14	16.67
Polythene	3	3.57
Tetra-packs	5	5.95
Milk packets	16	19.05
Toothbrush	1	1.19
Plastic pipes	1	1.19
Glass bottles	4	4.76
Clothes	1	1.19
Tin cans	1	1.19
Ropes	1	1.19

TABLE 5. LIST OF MARINE LITTER ($N = 1121$) COLLECTED FROM COLVA

Description	Number of items	Percent contribution
Beer bottles	20	1.78
Beer cans	6	0.54
Belt	1	0.09
Biscuit packets	24	2.14
Bottle caps	125	11.15
Buoys	8	0.71

Cigarette packets	18	1.61
Coconut shells	3	0.27
Footwear	46	4.10
Ice-cream sticks	47	4.19
Light bulb	1	0.09
Lighter	1	0.09
Sanitary products (napkins, gloves)	6	0.54
Milk and lassi packets	112	9.99
Nylon bags (<i>big</i>)	2	0.18
Oil packets	2	0.18
Paint brush (<i>used</i>)	6	0.54
Plastic bottles with caps	75	6.69
Plastic bottles without caps	26	2.32
Plastic toys	6	0.54
Plastic tubes	15	1.34
Rice bag	1	0.09
Ropes	54	4.82
Toothbrush	1	0.09
Tubes	11	0.98
Sprite bottle	1	0.09
Cloths including cloth bag	19	1.69
Dog belt leash	1	0.09
Glass bottles and cups	49	4.37

Spectacles	5	0.45
Other miscellaneous plastics	135	12.04
Soft plastics	85	7.58
Paper cups and containers	8	0.71
Tetra-packs	7	0.62
Polythene bags	132	11.78
Metals (<i>cans, forks, cutter and a piece of steel</i>)	5	0.45
Plastic cutlery	57	5.08

TABLE 6. LIST OF MARINE LITTER (N = 861) COLLECTED FROM CAVELOSSIM

Description	Number of items	Percent contribution
Bottles with caps	43	4.99
Bottles without caps	30	3.48
Cups	46	5.34
Plastic containers	20	2.32
Tobacco packets	68	7.90
Bottle caps	151	17.54
Straws	30	3.48
Spoons	16	1.86
Biscuit packets	121	14.05
<i>Lays</i> packets	24	2.79
Polythene	160	18.58
Tetra-packs	4	0.46

Milk packets	32	3.72
Shampoo packets	24	2.79
Toothbrushes	3	0.35
Spectacles	2	0.23
Beer cans	3	0.35
Cream tubes	4	0.46
Ropes	36	4.18
Glass bottles	2	0.23
Football	1	0.12
Cigarette butts	10	1.16
Soap packets	15	1.74
Ice-cream sticks	16	1.86

TABLE 7. LIST OF MARINE LITTER (N = 156) COLLECTED FROM SERNABATIM

Description	Number of items	% contribution
Plastic bottles	21	13.46
Cigarette butts	35	22.44
Water bottles with caps	19	12.18
<i>Lays</i> packets	20	12.82
Ice-cream sticks	22	14.10
Plastic cups	18	11.54
Lighter	5	3.21
Cigarette packets	10	6.41
Bottle caps	6	3.85

Colva had the highest mass of marine litter, contributing 67% to the total litter. Velsao and Benaulim were the least, contributing 5% each to the total litter (Fig. 2).

An overview of the respondent characteristics are summarized in Table 8. Male and female respondents were equally distributed and the mean age of the respondents was 33 years. Majority of them have obtained their university education (44%) and have been employed. With regard to visitation, almost 71% of the respondents have revealed that they had visited Goa more than once (Table 9), which highlights the need to maintain the visitor satisfaction for sustaining the marine tourism. Among the factors affecting the degree of satisfaction, cleanliness and accessibility to washrooms/toilets were the two most important determinants of visitor satisfaction, closely followed by the factors, 'Traffic/congestion' and, 'Presence of stray dogs/animals' (Table 10).

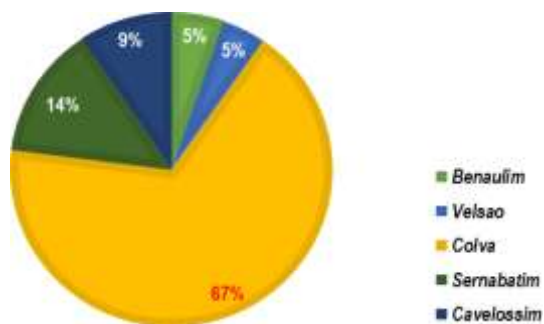


Figure 2. Total weight (kg) of litter

On the contrary, a majority of the respondents (46%) were only 'somewhat concerned' about beach cleanliness. Though a majority of the respondents were strongly familiar (48.86%), with the concept of plastic pollution, our surveys clearly indicate the lack of concern among the tourists about beach cleanliness (Fig.3).

Though marine litter is posing a serious threat, the degree of dissatisfaction based on marine litter is still medium among the respondents and only 6% of the respondents expressed high dissatisfaction (Fig. 4).

TABLE 8. OVERVIEW OF THE RESPONDENT CHARACTERISTICS

Location	Orig in (%) Goa / Ind / For	Gen der (%) Male / Female	Age (Yea rs) Mean ± SD (Range)	Educat ion (%) Uni / Coll / HS / Pri	Main Occupa tion (%)
Benaulim	3 / 84 / 13	49 / 51	33.5 ± 10.0 (18–68)	56 / 33 / 11 / 0	Employ ee (57.1)
Velsao	17 / 57 / 26	46 / 54	34.6 ± 14.0 (18–70)	41 / 23 / 21 / 14	Employ ee (38.6)
Colva	43 / 21 / 36	43 / 57	41.7 ± 20.3 (12–86)	59 / 14 / 24 / 3	Employ ee (51.4)
Sernabat	67 / 29 / 4	61 / 40	26.0 ± 8.7 (16–59)	34 / 36 / 23 / 7	Student (42.0)
Cavelossi	7 / 80 / 13	51 / 49	33.5 ± 7.7 (21–50)	30 / 26 / 27 / 17	Employ ee (51.4)
Overall	27 / 54 / 18	50 / 50	33.6 ± 13.8 (12–86)	44 / 26 / 21 / 8	Employ ee (43.6)

Note: Percentages in combined columns are rounded to the nearest whole integer to ensure layout legibility and prevent text wrapping. "Ind" = Indians excluding Goans, "For" = Foreigners; "Uni" = University, "Coll" = Vocational/College, "HS" = High School, "Pri" = Primary.

TABLE 9. PROPORTION OF RESPONSES (%) REGARDING VISITS BY LOCATION

First time visit	Goa	Benaullim	Velsao	Colva	Sernabatim	Cavelossim
Yes	29.14	55.71	54.29	40.00	12.86	62.86
No	70.86	44.29	45.71	60.00	87.14	37.14

TABLE 10. PROPORTION OF RESPONSES (%) REGARDING FACTORS AFFECTING THE DEGREE OF SATISFACTION

Factors affecting the degree of satisfaction	Proportion of responses (%)	
	Agree	Disagree
Accessibility	56.57	43.43
Presence of lifeguards	56.29	43.71
Bars/restaurants	58.29	41.71
Parking	57.14	42.86
Accessible washrooms/toilets	68.57	31.43
Presence of stray dogs/animals	61.14	38.86
Traffic/congestion	62.0	38.0
Cleanliness	69.71	30.29
Water transparency	55.43	44.57
Calmness	59.71	40.29
Shoreline quality	54.86	45.14

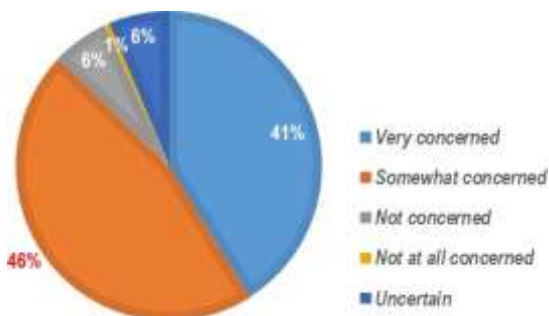


Figure 3. Level of concern among the respondents in reference to beach cleanliness

TABLE 11. LEVEL OF FAMILIARITY AMONG THE RESPONDENTS WITH THE CONCEPT OF PLASTIC POLLUTION

Level of familiarity with the concept of plastic pollution	No.	Percent contribution
Strongly familiar	171	48.86
Somewhat familiar	167	47.71
Not familiar	09	2.57
Not at all familiar	02	0.57
Uncertain	01	0.29

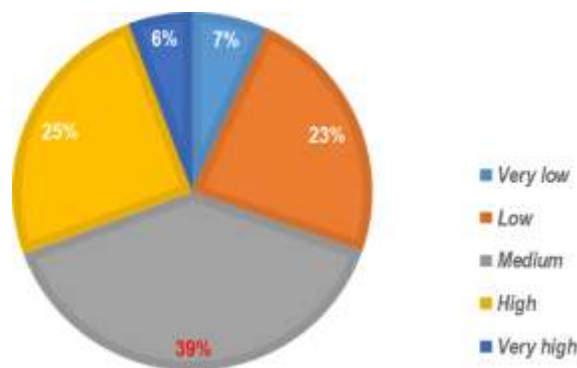


Figure 4. Rate of dissatisfaction (%) based on marine litter

Preliminary assessment of marine litter from Goan beaches indicated that domestic, marine recreational tourism, and fishing were the primary sources of litter. Colva had the highest number of marine litter from various sources, including litter of medical origin, indicative of the lack of solid waste management. Studies conducted elsewhere along the Indian coast have highlighted the significant role of coastal recreational and other anthropogenic activities in increasing marine litter inputs (Kaladharan et al., 2017; Jayasiri et al., 2013; Mugilarasan et al., 2021). Regional-scale implementation and enforcement of management policies could be a solution to these problems. In addition, clean-up programs at regular intervals should also be taken up, though these programs are

reactive and do not provide solutions on a long-term basis (Karmali, 2018).

The cluster of variables influencing the visitor satisfaction is relatively diversified. As the study is based on perception of the visitors, the output is never analogous and is affected through a varied range of demographics, approaches and activities. The present study indicates the factors affecting aesthetics of a beach based on visitors' perception. From the perspective of foreign visitors, Goa is perceived as a low-cost vacation spot with lovely beaches, landscape, a mild climate, and a vibrant nightlife. However, foreign visitors often bring with them a bad perception of Goa, that it is overcrowded and resorts with subpar infrastructure and transportation. Additionally, Goa, with its coastal cuisine, is highly associated by domestic tourists as a travel destination that is accessible and provides a wide range of high-quality lodging options. Most of the litter on the beaches is by the domestic tourists rather than the locals. The foreign tourists as a rule do not litter the place and are willing to undertake beach clean-ups. The baseline information derived from the present study provides opportunities to further reduce the amount of marine litter from Goan beaches through adaption-centric complementary strategies.

IV. CONCLUSION

This study establishes a vital baseline for marine litter across Salcete taluka, South Goa, revealing a stark disconnect between environmental awareness and tourist behavior. The data identifies domestic waste, recreational tourism, and fishing as the primary pollution drivers. Colva beach emerged as the most critical hotspot, accounting for 67% of the total collected litter mass and displaying alarming instances of medical waste. This extreme concentration highlights severe gaps in local solid waste management infrastructure. Perception surveys reveal that visitor satisfaction is dictated by a complex mix of demographics and expectations. A clear behavioral divide exists: beach litter is predominantly generated by domestic tourists rather than local residents. Furthermore, while foreign tourists express a proactive willingness to participate in clean-ups, a passive 46% of total respondents remain only "somewhat concerned" about cleanliness, despite

high general familiarity with plastic pollution (48.86%). Ultimately, reactive measures like periodic beach clean-ups offer only short-term relief. Mitigating Goa's marine litter crisis requires the strict regional enforcement of robust waste management policies. The baseline data provided by this study serves as a framework to deploy adaptation-centric complementary strategies, focusing on cultivating accountability among domestic travelers, upgrading public sanitation, and implementing proactive, long-term coastal preservation frameworks.

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CRediT authorship contribution statement

Andrea M. Furtado, Veloshka E. Pereira, Saili Tonke, Shania Prabhu, Karinagiri Goswami: field work, methodology, investigation; Maria Lizanne: supervision; Preeti A. Pereira: conceptualization, supervision, writing review and editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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