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A preliminary assessment of ecosystem process and marine litter in the beaches of Mangalore

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Ecosystem process contributing to the marine litter was assessed by conducting beach litter survey in the beaches of Mangalore followed by gut analysis of oil sardine (*Sardinella longiceps*) and mackerel (*Rastrelliger kanagurta*). Gurupur and Nethravathi had the highest discharge of 28.1 cumecs and1331.2 cumecs respectively in Aug 2012. There was highly significant negative correlation with the sea level pressure ($p<0.001$) and discharge of both Nethravathi and Gurupur rivers. Maximum total number and weight of marine litter was observed in Thannerbhavi (632 numbers /m^2) and Chitrapur (10,923.05g/ m^2) beaches respectively. Group of litter comprising nylon and plastic rope was the most abundant in the beaches. Oil sardine and mackerel caught off Manglore had ingested fragments of nylon and plastic. Significant correlation ($p<0.05$) was observed between the discharge of Nethravathi and Gurupur river with the total weight and number of marine litter indicating that river discharge brought with it the marine litter.

[**Keywords** : Marine litter, river discharge, tides, wind velocity]

Introduction

Marine litter refers to any manufactured or solid waste entering the marine environment irrespective of the source[1]. Monitoring marine litter is crucial to assess the efficacy of measures implemented to reduce the abundance of plastic debris. Plastics degrade and fragment under different conditions [2,3] and varies from place to place, hence the dispersal of all the plastic fragments[4] is yet to be understood. Ingestion of plastic debris occurs much more frequently than entanglement, with almost all individuals of some species containing ingested plastic[5,6]. In the absence of better management, increase of marine litter in the environment is certain[7]. Seabirds and other marine organisms that accumulate plastics in their stomachs offer a cost-effective way to monitor the abundance and composition of small plastic litter. Monitoring plastic debris levels in rivers and storm-water runoff is useful because it identifies the main sources of plastic debris entering the sea and can direct mitigation efforts.

Karnataka coast has rivers originating in the Western Ghats. The course of the rivers does not exceed 150 to 160 km. Rivers are fast-moving, owing to the short distance travelled and steeper gradient. In Mangalore, the major rivers Nethravathi and Gurupur drain into the sea. These rivers originate at an elevation of 1400-1600 m. In the present study, an attempt has been made to understand the type of marine litter predominant in the coast of Mangalore by studying the three beaches adjacent to the bar mouth, Thanneerbhavi (TH), Panambur (PA) and Chithrapur (CH) also offshore to identify the path of marine litter and its effect on fisheries.

Materials and Methods

Nethravathi and Gurupur river forms one of the important estuaries having long spit of sand between it and sea. Fig. 1 shows the location of the study area. Beach litter survey was carried out in the three beaches TH, PA and CH for a period from July 2010 to Aug 2012. TH attracts lot of tourists as well as local population. Initially for the first three months of the study period the beach was not properly maintained. Presently the beach is cleaned and maintained from funds collected as entry fee from the people visiting the beach. PA is adjacent to the Mangalore port and the coast guard station. A ban on carrying plastics to the beach has been enforced by the port trust from 2011. CH is a beach inhabited by people on the upstream side 150-200 m from beach. There is free access to the beach for the fishermen and local people. There has not been any regulation or

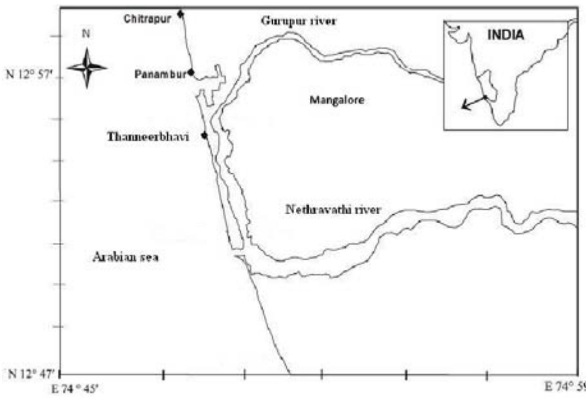

Fig. 1 location of study area

organised cleaning activity taken up till date. Samples were collected from the shore of the beach to the waterline for the entire stretch of the beach at random interval for an area of 1m^2 on a monthly basis. Marine litter was sorted into different classes mainly based on their presence in the beach and to assess the pathway or the origin of marine litter. Salinity of the water in the beaches was monitored potentiometrically using WTW multi-parameter (model 320i) to know the impact of river discharge on the beaches. Monthly river discharge data was collected from the Central Water Commission. Monthly average wind velocity and sea level pressure data was collected from India Meteorological Department. Gut content analysis of pelagic fishes, such as mackerel (*Rastrelliger kanagurta*) and oilsardine (*Sardinella longiceps*) were done to assess any impact of marine litter on the fishes. The gut volume was made up to 10-20 ml and subdivided into smaller volumes of 1-5 ml and observed under the microscope (Magnus MS24). Visual surveys in fishing craft were undertaken during low tide as well as high tide in the river and sea to assess the transportation of marine litter and its impact on the ecosystem. Pearson's correlation and ANOVA between parameters observed was carried out using SPSS software.

Results and Discussion

The list of items found during the study period, the length range and the grouping followed is given in Table 1. Grouping was done mainly to assess the quantity and possible origin of the marine litter. The variation in total weight and number of marine litter observed at the various stations and in different groups during the period is given in Table 2 and 3.

Table 1 List of items, length range and grouping system followed based on the presence in the beaches

Item	Group	Length range in cm		
		TH	PA	CH
Cap, spoon, small satchets, syringe, paste tube, straw, pen assorted, plastic bits, bead, hairband	A	0.2-28	1-40	1-45
Nylon and plastic rope	B	1-183	2-220	2-200
Plastic cover	C	0.4-122	2-200	1-114
Plastic bottle	D	3.5-84	5-35	11-29
Plastic slipper, rubber	E	2.5-28	18-29	4.8-29
Thermocole, sponge	F	3.5-24	0.01-29	0.01-28
School bag	G	*	750	*
Plastic mat	H	*	*	120-180
Glass bottle, bulb, tube, medicine bottle	I	*	*	10-19

*item not observed

Table 2 Mean value of the total weight and total number(±SD., n=26) and range of marine litter

Station	Total wt(g)/ m^2	Range Total wt(g)/ m^2	Total numbers/ m^2	Range Total numbers/m^2
TH	233.86±375.01	5-1680	24.3±25.5	1-102
PA	141.7±138.9	5-494	19.46±15.57	3-71
CH	420.11±743.07	0-3727	20.73±18.72	0-76

At TH, the maximum numbers/m^2 of marine litter was observed in group B(42%) followed by that of A(21%) while the maximum weight (g /m^2) was in group E(33%) followed by that of C(30%). At PA, the maximum numbers/m^2 of group B (39%) was observed followed by C(24%) while the maximum weight g/m^2 was in group E (29%) followed by that of B (27%).

Table 3 Mean values ±SD., n= A(76), B,D to I (78),C (75) of marine litter (weight and number) under various groups

Group	wt(g)/m^2	Numbers/ m^2	Ratio
A	24.84±49.80	4.88±6.16	5.08
B	43.71±121.97	8.18±11.03	5.34
C	54.43±111.15	4.82±7.62	11.15
D	12.05±39.91	0.32±0.81	37.6
E	65.26±121.77	0.62±1.05	106.04
F	19.59±40.22	2.79±4.44	7.01
G	9.62±84.92	0.01±0.11	750
H	38.46±339.68	0.04±0.34	1000
I	9.62±84.92	0.09±0.79	107.14

At CH the maximum numbers/m^2 of group B (32%) was observed followed by C (25%) while the weight /m^2 maximum was in group H (27%) followed by that of E (19%). The percentage of group B items (numbers/m^2 of nylon and plastic rope) was higher for all the three stations. Ratio of the weight to the number of the various groups ranged from 5.08-1000. Indicating that, items of heavy weight though it adds to the beach litter it may not be a cause for concern. In CH, the group H adds to the total weight of marine litter and hence has the highest ratio, but it is not present in other beaches. This is because people at times perform some rituals for the dead and do not take back the materials from the beach. Ratio of A and B was the least indicating that its occurrence in the environment is more frequent. Hence, its origin and transportation need more long term monitoring.

The river discharge from Nethravathi was significantly different ($p<0.001$) yearly. But this was not so in Gurupur and the flow was reduced during summer (Fig.2). ANOVA showed significant difference yearly between the total number of plastics and weight of plastics/m^2. This could be due to the cleanup of the beaches taken up by various organizations.

No significant difference was observed for number of plastics and weight of plastics/m^2 between stations. This could be due to the effect of the discharge of the river Nethravathi affecting all the three stations as its discharge is more compared with that of Gurupur. Not much trapping of marine litter was observed on the upstream of Nethravathi river. Significant correlation ($p<0.05$) was observed between the

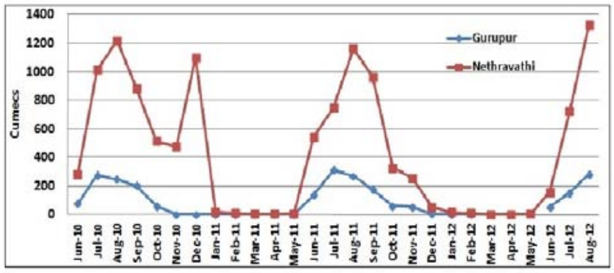

Fig. 2 Discharge rates of Gurupur and Nethravathi rivers

discharge of Nethravathi and Gurupur river with the total weight of marine litter/m^2 as well as number of marine litter/m^2. While highly significant correlation ($p<0.001$) was observed with the total number of plastics/m^2 with that of Nethravathi river discharge.

Monthly significant difference was observed in salinity at the three stations and the river discharge of Gurupur and Nethravathi. Minimum salinity of 19.2 ppt was observed at TH and PA during Jan 2012 and the maximum of 36.3 ppt at PA and CH during May 2012. It was seen that[8] lower (higher) salinity at the coast leads to higher (lower) coastal sea level. There was highly significant negative correlation with the sea level pressure ($p<0.001$) and discharge of both Nethravathi and Gurupur rivers, indicating the tidal influence on the rivers. Since the discharge is less in Gurupur river and the course of the river runs parallel to the sea, the tidal influence and the incursion of saline water into the river is more. This results in more of marine litter being trapped on the land masses locally known as “Kudru”. Depending on the variation in tidal difference, during high tide, the litter will be trapped in the upland area. Roots of the trees and plants prevent the further movement during receding tide, while a portion of the material not trapped, flows to the sea from the river.

Mangrove patches and their roots also act as an excellent filter for trapping the litter. But young mangrove plants are entangled by nylon and plastic ropes and the succulent stem cut by the upstream and downstream movement of tide in the Gurupur river.

Tides and the seasons (Fig. 3) play a major role in the movement, transportation and deposition of marine litter in the beaches. Heavy rainfall and consequent discharge from the rivers combined with the seasonal current bring large amount of roots, stems and marine litter to the beaches.

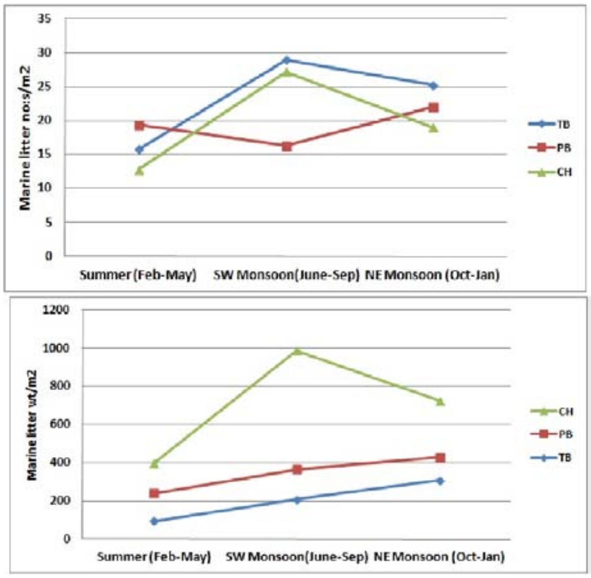

Fig. 3 Seasonal changes in marine litter at different stations

This is often sorted and collected by the people living near the beaches for firewood and for recycling the waste. Compared to TH and PA, CH beach was not maintained by any organization and hence it reflects the seasonal trends in the beaches.

Seasonal beach profile changes, bury a large amount of marine litter (Fig.4) in the beach and also in the river. Soil movement in the beaches due to wave action takes place to a depth of 5-6 feet and width of 25-50 m from the sea level. Seasonal sea level changes submerge an area between 8-12m wide. This further disintegrates the marine litter by the action of the waves and movement of the tide and currents.

Lost and discarded fishing gear is a primary cause for environmental, economic and public safety concern[9, 10]. Ingestion of marine litter by marine biota can lead to major health issues and even death[11,12-13]. Often fishermen using "Maranabale" (a traditional entangling gillnet used near shore) have to abandon their fishing net (Fig. 5) when it catches all the buried marine litter with little or no fish. This method of fishing is good way of collecting the buried marine debris from the near shore which otherwise is not visible on the outside, as layers of sand get deposited on the litter with the changing season and wind action.

Average wind velocity was significantly negatively correlated ($p<0.001$) with the total number of marine litter/ m^2 as well as the number of materials of group B/m^2 and group C/m^2.

It was also significantly negatively correlated with the weight of group C/m^2. Table 4 gives the variation in wind velocity, sea level pressure and salinity.

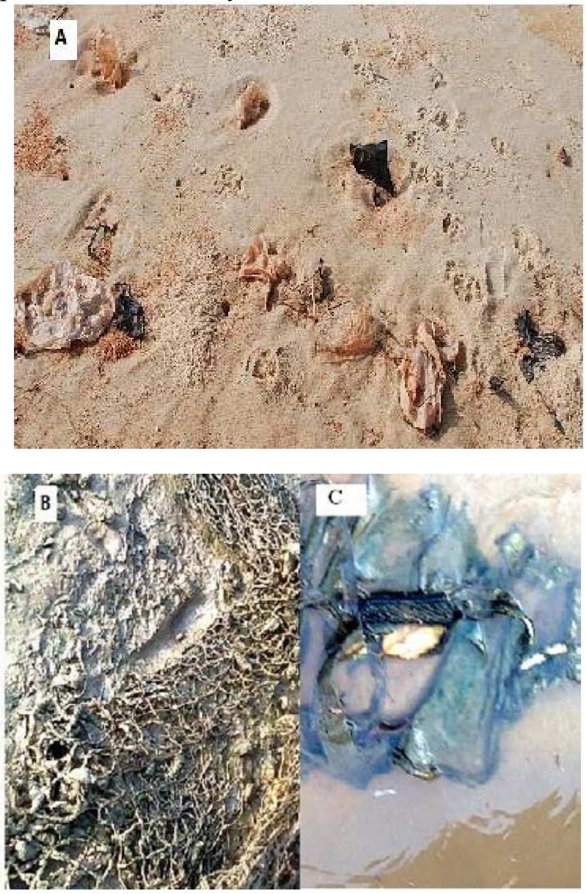

Fig.4 -A CH beach during dry season, B& C buried net and bag in Gurupur river

Fig 5-A Casting the Maranabale net, B & C Fishing and abandoned net

Sea level pressure ($p<0.05$) was significantly negatively correlated with the total number of group C/m^2. This indicates that the wind force assisted in the transportation and burial of polythene covers by the beach sand during dry weather period while the water flow was mainly responsible for the transportation of materials.

Table 4 Variation in mean (±SD., n=18 in 2010,36 in 2011 and 24 in 2012) of wind velocity, sea level pressure and salinity.

Year	Wind velocity km/hr	Sea Level Pressure hpa	Salinity ppt
2010	7.83±0.383	1007.33±1.53	31.21±1.64
2011	8.5±0.971	1008.5±1.05	32.49±4.03
2012	9.125±0.797	1008.25±1.594	32.85±4.97

In summer, in Arabian Sea strong south westerly winds blow from the ocean towards land, mixing the water[14]. The rough monsoon season erode more of the beach and calm postmonsoon season buries the marine litter. It was observed that at PA, during successive years, an additional 5-8 m of the beach was encroached by the waves, creating lesser beach width. This could be due to higher waves hitting the shore during the rough season. Materials collected in Maranabale included the items like school bags, tarpaulin, gunny bags, plastic bags, fishing nets, nylon ropes, slipper, polyethene cloth, cigarette lighter, pen tips and cassettes. During the rough monsoon months of July-September, the number of waves and the wind action on the coast is usually higher which causes further disintegration and transportation of marine litter. Amount of plastic accumulated[15] in trawl net for 45 min duration off Mangalore varied from 0.4 to 1.2 g/m$^{2.}$ These act as a substrate for other living organisms in the sea or on the intertidal area. This when ingested by higher organisms, may end up in the food web. Sampling of pelagic fishes like Oil sardine and Mackerel from trawl, purse seine and gillnet off Mangalore revealed the presence of fragments of plastic and nylon in the gut. This year, though ban of plastic covers has been enforced in these beaches, analysed samples during July and Aug 2012 revealed that 5 out of 10 fish samples of mackerel (Fig 6) and 6 out of 10 fish samples of oil sardine (Fig 7) had fine fragments ranging from 0.5- 3 mm in length and width of < 0.1mm. This is because both the fishes are plankton feeders and fine fragments flow in the current with the feed of these fishes.

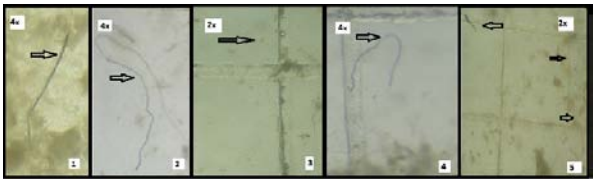

Fig 6 Digested gut content of Mackerel and undigested plastic strand

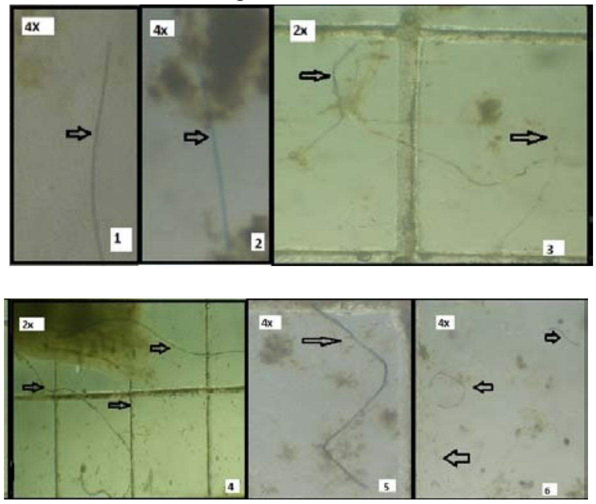

Fig 7 Digested gut content of Oil sardine and undigested plastic strand

Conclusion

In Gurupur river, since the discharge is less, the tidal effect acts as a sink for the marine litter at the tail end of the river. Hence, more litter is found on the landmasses in the river and is also seen buried during the low tide. Litter carried away into the marine environment gets further disintegrated by various forces like the currents, tidal variation, wind, sunlight, mechanical abrasion by the soil particles, and also by the chemical action resulting from various organisms in the intertidal area. These fragmented particles then become a part of the food web and is ingested by oil sardine and mackerel. More research work needs to be carried out to assess the damage to the ecosystem and in turn the loss in revenue for the community which depends on it. Need of the hour is better ecosystem management so that rivers don't choke and marine environment is protected.

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