



Assessment of marine debris in the stake net fisheries of Vembanad Lake, Kerala, India

G. Shylaja^{*1}, V. Kripa¹, D. Prema¹ and K. S. Abhilash¹

School of Environmental Studies, Cochin University of Science and Technology, Kochi-682 022, India.

¹ICAR- Central Marine Fisheries Research Institute, Kochi-18, Kerala, India.

*Correspondence e-mail: g.shylajacmfri@gmail.com

Received: 18 July 2018 Accepted: 29 July 2018 Published: 30 July 2018

Original Article

Abstract

The stake net fishery of Panambukad in the main channel area of Vemband Lake, Kerala was studied during the first fortnight of August 2014. The observations indicated that the average catch including the marine debris ranged from 1.04 to 2.04 kg net⁻¹ day⁻¹ with an average of 1.34 kg net⁻¹ day⁻¹. The percentage of marine debris in the stake nets ranged from 42.68 to 73.4%. Plastic items formed 97% by weight and 99% by number of the total marine litter. The observed litter stuff was categorized as per UNEP system of classification of marine litter where, they are first identified based on their material composition (litter codeeg. PL) and then by their form (RL classes). Items found in the collection included plastic covers (PL07, RL15), metal cap (ME02, RL01), plastic bottle (PL02, RL02), fishing net (PL20, RL05), plastic cup and food containers (PL06, RL09), thermocol (FP 04, RL13), rubber sheet (RB05, RL28), plastic sacks (PL24, RL23), diaper (OT02, RL18) etc. Among them, plastic covers were most dominant and their average number and weight net⁻¹ day⁻¹ was 28 nos and 985 g respectively. The study also showed positive signs of decline in plastic bottles as a major litter item due to its targeted collection by recycling industry within a span of three years. In a survey conducted among the stake net fishers, there was consensus on the view that plastic litter in Vembanad Lake has increased during the last 10 years and this has affected the resources and the fishery. The stakeholders also expressed their willingness to pay for restoration of the fishery resources of the lake. The study recommends

the need to establish proper solid waste management systems in coastal villages, to reduce the use of plastics, and provide facilities for disposal of litter which gets collected in stake nets and to increase the awareness among the public about the impacts of marine debris on ecosystem and resources.

Keywords: *Marine debris, plastic litter, fishery decline, solid waste management*

Introduction

The estuaries along the Indian coast have always served as an important fishing ground for the coastal villagers. Several passive gears like the dip nets, cast nets, gill nets and stake nets are operated in these regions and the catch mainly consists of euryhaline fishes, crabs and shrimps. The Vembanad Lake of Kerala is one of the major water bodies which joins the Arabian Sea through two permanent opening, one at Kochi and another

at Azhikode. The fragmented mangroves and the backwaters with several interlinking canals have been identified as one of the major nursery grounds of several species of shrimps (Menon, 1951; George, 1958). Taking advantage of the rich shrimp resources and the good tidal flux, stake nets have been operated in Vembanad Lake for several decades. The stake net shrimp fishery has been well documented since 1950s which gives a clear picture of the richness of this important coastal ecosystem (Menon and Raman, 1962; George, 1973; Nandakumar, 2004). Such bag nets are operated in different estuarine areas especially in Maharashtra and West Bengal (Manisseri and Rao, 2000). However, threats to this fishery from human activities has not been indicated as a problem in the earlier studies.

During the past two decades, the coastal districts of Kerala witnessed high growth in population and urbanization and one of the consequences being the increase in generation of non-degradable solid waste, of which plastics form a major component. These reach the sea through rivers and estuaries due to improper disposal at its site of origin. Sometimes they are discarded directly into the aquatic ecosystem. Globally, the occurrence of plastics and similar non-biodegradable litter in different types of habitats were studied (Gall and Thompson, 2015). Since these persist in the ecosystem in one form or the other for centuries, they are considered as one of the most serious threats to the marine ecosystem (Barnes *et al.*, 2009). A preliminary study conducted in the northern part of Vembanad Lake to assess the quantity of litter in fishing gears indicated that the stake net fishery is severely impacted by the quantity of litter which gets accumulated in the nets (Kripa *et al.*, 2012). During 2014, a targeted study was conducted to assess the quantity and types of non-degradable litter in the stake nets and its impact on the fisheries. The main objective of the study was (i) To estimate the different types of non-degradable waste which gets collected in the stake nets (ii) To understand the view of the fishers on marine litter and (iii) To suggest management measures for reducing marine litter in the marine ecosystem.

Material and methods

Stake nets are normally operated in the shallow waters and estuaries where the tidal currents are strong. They are fixed bag nets with rectangular mouth opening which is kept open against the current by means of stakes driven to the bottom (Fig 1. a and b). The principle of operation here is that the organisms which drift with the tidal current enter the net set against the current and are filtered and retained in the cod end (Boopendranath and Hameed, 2010). The stakes are installed in series at a distance of about 4 - 4.5 m, to facilitate the operation of a number of nets. The net is set at the onset of ebb tide. The hauling is done when the tide begins to slacken towards the end of the ebb tide. Stake nets are normally operated for

catching shrimps. The study was conducted for thirteen days covering one complete fishing phase during the first fortnight of August 2014 at Panambukadu village of Ernakulam district (Lat10°00'35" N and Long76°14'547" E) which is about 3.5 to 4 km downstream of Vypin Ferry.

Eighteen active stake net fishermen of the twenty-five in the area were contacted individually and garbage bags were distributed to them. They were asked to deposit all the litter



Fig. 1a. View of the stake net poles erected across the Vembanad Lake near Panambukad b. Opening of the stake net which is tied on to the poles. c. A view of the marine debris collected in the stake nets along with shrimp catch

(Non-biodegradable waste) accumulated in the net into the garbage bag and later through a participatory mode, the marine debris was assessed (Fig. 1c). The collected litter was sorted weighed and counted to estimate the abundance of the same, as per UNEP (2009) guidelines. The observed litter were classified to give litter codes based on their material composition (eg. plastic, glass, rubber, metal). The items under these classes can again be classified depending on their form (e.g. bottles, sheets, fishing nets, etc.). The UNEP has attributed Remote Litter Classes (RLC) to debris collected through lesser resolved operations, based on the type of object found as litter. The litter items in each net were thus classified in both ways (Table 1).

Table 1. Classification of litter items observed as per UNEP (2009)

Litter item	Litter Code (Material type)	RLClass (Object type)
Plastic cover	PL07	RL15
Metal cap	ME02	RL01
Plastic bottle	PL02	RL02
Fishing net	PL20	RL05
Plastic cup and food containers	PL06	RL09
Thermocol	FP 04	RL13
Rubber sheet	RB05	RL28
Plastic sack	PL24	RL23
Diaper	OT02	RL18

The data on litter collected from all nets per day were pooled, to express their total as abundance and weight. Consequently, their item wise average occurrence per day per net and the percentage weight of litter objects were estimated. Based on the percentage occurrence of each type of litter they were classified as Rare 1 to 29%; Occasional 30 to 59%; Common 60 to 90% and above 90% was considered as most common.

The total weight of the shrimp catch in each net was noted and from this percentage of shrimp catch and litter in each net per day was estimated. A rapid survey was also conducted to understand fisher's view on marine debris and their opinion on health of the ecosystem and their willingness to pay for a plastic free ecosystem.

Results and discussion

Marine debris in stake nets

Stake nets are passively operated filtrations in which shrimps, fishes and other items which flow with tide get trapped. Hence in the observations all macro plastics and non-biodegradable debris (NBW) in the column waters and which move from the estuary to the sea through tidal waters were retained.

In the present study (N=234), shrimp catch varied from 100 to 1650 g day⁻¹ net⁻¹. The average quantity of shrimp per net per day for the entire period was 582 g with a range of 513 to 668 g per net. The average quantity of marine debris ranged

from 476 to 1503 g day⁻¹ net⁻¹ (Fig. 2). However, there were instances when the quantity of litter in individual stake nets was as high as 5220 g. The percentage of marine debris in the stake nets ranged from 42.68 to 73.4% (Fig. 3). Shrimp catch including the marine debris ranged from 200 to 5820 g per day per net during the observation period. The percentage composition of shrimp catch and NBW are depicted in Fig. 3. Here, the mean percentage of shrimp catch and NBW were 44.95 and 55.05 respectively.

In none of the studies conducted earlier covering the period from 1950 to 1990 have marine debris been recorded in the catch of stake nets (Menon and Raman, 1962; George, 1973; Manisseri, and Rao, 2000; Nandakumar, 2004). In the detailed account of prawn fisheries of India by Manisseri and Rao (2000) marine debris has not been reported in any of the stake nets operated along the coast of different maritime states during the last century. However, during this decade marine debris in bag nets has been identified as the major threat faced by the fishermen especially bag net fishers (Kripa *et al.*, 2012, 2016; Pawar *et al.*, 2018; Ratheesh *et al.*, 2018; Tarachand *et al.*, 2018; Ibrahimi, *et al.*, 2018). In the conical bag nets operated by traditional fishers in the Satpati creek of Maharashtra during monsoon, presence of macro plastics has

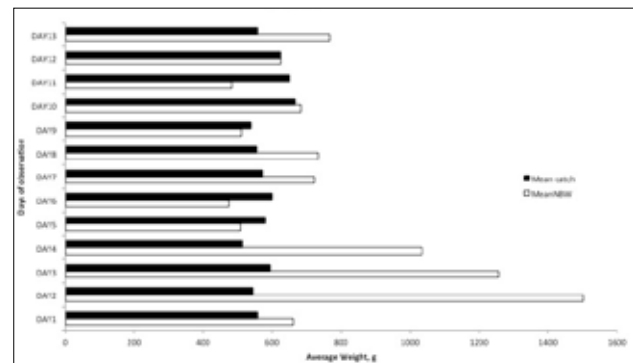


Fig. 2. Average quantity of marine debris and shrimp catch (g) in the stake nets during different days of observation

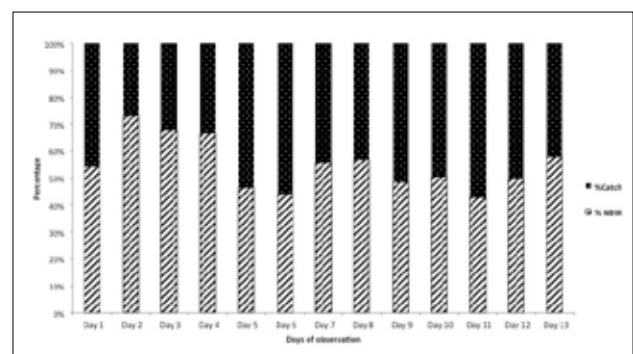


Fig. 3. Percentage composition of shrimp catch and non-biodegradable waste (NBW) in stake nets during the period of study

become a major problem for fishermen. In an experimental net operation during July 2017, about 25 to 30 kg of marine debris was obtained in a two-hour operation and the catch was mainly fish, 2 to 3 kg hour⁻¹ (Ratheesh *et al.*, 2018). The quantity of marine debris in the Satpati creek fishery is considerably higher than the present observation in Vembanad Lake. Contrary to these recent observations, Jyothilal *et al.* (2015) who studied the stake net fishery of Ashtamudi Lake did not indicate the occurrence of marine debris in the catch. This can be either due to insignificant quantity of litter or may be the authors focused on only the biota of the fishery.

There was variation in the type of litter and percentage contributed by each item. Plastics consisting of covers, food containers, bottles, cups, sacks, fishing nets, thermocol, toys etc. contributed 97.5% by weight and 99.7% by number of the total marine litter. Out of these, the nine items classified under UNEP litter classes were the major components (Table 2). Among these, plastic covers were the most common. These were seen in all the stake nets on all days. Plastic bottles (PL 02) were common occurring in 62% of the observation days, while diapers (OT02) and different types of plastic sacks and rubber sheets (PL 24, RB05) were occasionally seen. Metal caps (ME 02) and fishing net pieces (PL 20) were also observed but these were rare occurring only during 23% and 8% of observation days. In similar studies also along the Indian coast, plastics formed a major component. Pawar *et al.* (2018) observed high quantity of debris in the bag (dol) nets operated in Mahul creek of Maharashtra. Ibrahimi *et al.* (2018) indicated that the marine litter which gets collected in the bag nets reduce the filtering efficiency of the nets.

Plastic covers were the predominant litter item and the average number was estimated as 28 nos. net⁻¹ day⁻¹ and ranged between 22 to 43 nos net⁻¹ day⁻¹. The corresponding average weight was 985 g and the range was 704 to 1674 g net⁻¹ day⁻¹ (Fig.

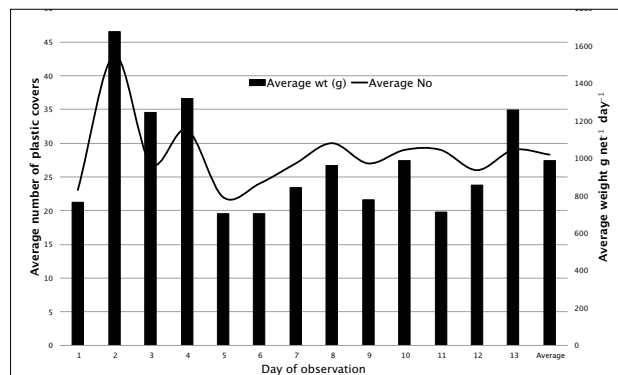


Fig. 4. Average number and weight (in g) of plastic covers per stake nets at Panambukadu, Kerala

4). In the Hoogly Estuary, in the bag net fishery at Godhakali, plastic covers were the major component in the litter and these formed 45% of the debris (Ramesan *et al.*, 2018)

The abundance of other items was low (Fig. 5); the average number of the plastic sack and rubber sheet noted were 4 nos net⁻¹ day⁻¹ with corresponding average weight of 264 and 138 g respectively. Diapers were also low in number but had an average weight of 280 g. One interesting observation was the comparatively low number of plastic bottles in the stake nets. In a similar study conducted during 2011 in northern Vembanad Lake, Kripa *et al.* (2012) had observed that the major litter item was plastic bottles. However, the drastic reduction in plastic bottles in the present study indicates a change in litter composition. Even though there is no proper waste management in the coastal villages, plastic bottles are now collected by waste pickers. This has led to a change in attitude in throwing the plastic bottles in open spaces. This may be the reason for low number of plastic bottles in the litter items in the stake nets.

Table 2. Details of occurrence of litter items observed in the stake nets along with shrimp catch (Occurrence categorized according to percentage- 1 to 29 Rare; 30 to 59 Occasional; 60 to 90 Common; above 90 - Most common)

UNEP Litter Code	Remote Litter Class	Item categories	Day of Observation													Category (Percentage occurrence)	
			1	2	3	4	5	6	7	8	9	10	11	12	13		
ME02	RL01	Metal cap	√					√	√								Rare (23%)
PL02	RL02	Plastic bottle	√	√		√		√	√	√		√	√				Common (62%)
PL20	RL05	Fishing net	√														Rare (8%)
PL06	RL09	Plastic cup, food wrappers	√	√	√	√		√					√				Occasional (46%)
FP04	RL13	Thermocol	√			√											Rare (15%)
PL07	RL15	Plastic cover	√	√	√	√	√	√	√	√	√	√	√	√	√	√	Most common -100%
RB05	RL28	Rubber sheet,	√	√	√									√			Occasional (31%)
PL24	RL23	Plastic sheet		√					√			√		√			Occasional (31%)
OT02	RL18	Diaper		√	√	√	√			√	√			√			Occasional, (54%)

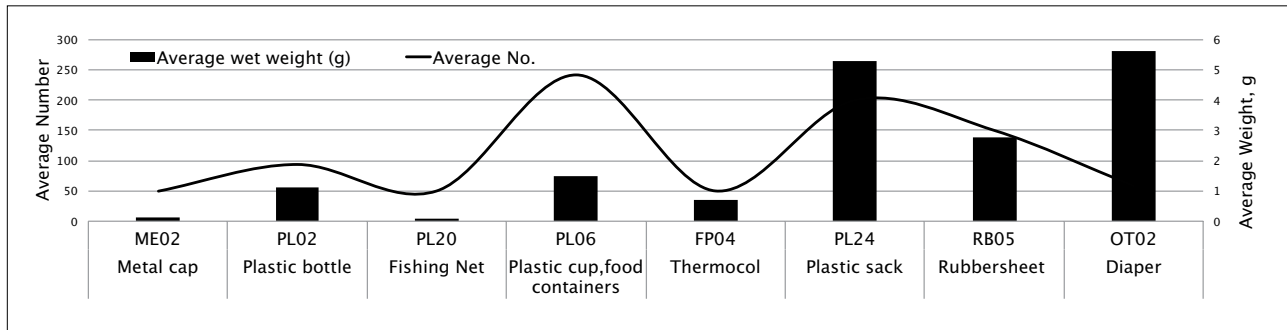


Fig. 5. Average weight (in g) and number of marine debris per day in the stake net operations at Panambukad, Vembanad Lake

Fisher's views on marine litter and its management

All the respondents of the survey had more than 20 years of experience and the fishers strongly agreed that there is increase in the presence of plastic litter in Vembanad Lake over the last 10 years which has affected the resources and the fishery. All the respondents opined that the catch has drastically declined and that their nets gets damaged by the marine litter which has led to economic loss also. Regarding the disposal of litter collected along with the catch, all the respondents said that they throw the litter back to estuary. Though they are aware that there are rules against dumping waste into water, there is no other alternative. The individual land holding of the fishermen is very low and there is no facility to dispose the waste which accumulate in their stake nets.

Willingness to pay

The survey indicated that most fishers are aware of the necessity to protect the natural resources and more than 90% of them showed willingness to contribute about 10% of their income to lake clean-up operations if required.

The study indicated that the abundance of column litter in backwaters is considerably high and affecting the livelihood of fishers. If concerted efforts are made to reduce generation of non-biodegradable waste on land, the progressive increase in marine debris can be reduced. The Suchitwa Sagaram project of Kerala Government where the marine debris which gets into the trawl net operated from Neendakra Harbour is collected from the fishers and processed by the District administration, is a model program which can be adopted in a similar manner in coastal villages where stake nets are operated. Plastic covers form the major component of marine litter. Hence use of cloth/paper bag for daily use is recommended. Awareness programs and mass media campaign especially through Radio and TV should be prepared and repeatedly shown as advertisements to reduce the use of plastic carry bag and other single use plastics

in daily life. Collection spots for plastic wastes and other litter should be provided at various points for easy disposal of litter including fish landing centres. Periodic removal of litter from collection points should be strictly followed. Local governing bodies / Panchayats must be provided funds and necessary guidelines to dispose litter.

Acknowledgements

The authors are thankful to the Director CMFRI for all the support and encouragement. We also express our gratitude to the fishermen of Panambukadu who co-operated with the marine debris assessment

References

- Boopendranath, M. R. and M. S. Hameed. 2010. Energy Analysis of the Stake Net Operations, in Vembanad Lake, Kerala, India. *Fish. Tech.*, 47 (1): 35-40.
- Barnes, D. K. A., F. Galgani, R. C. Thompson and M. Barlaz. 2009. Accumulation and fragmentation of plastic debris in global environments. *Philos. Trans. Roy. Soc.*, B 364, 1985–1998.
- Gall, S. C. and R. C. Thompson. 2015. The impact of debris on marine life. *Mar. Pollut. Bull.*, 92: 170–179.
- George, M. J. 1958. Observations on the plankton of the Cochin Backwaters. *Indian J. Fish.*, 5 (2): 375-401.
- George, M. J. 1973. The influence of backwaters and estuaries on marine prawn resources. In: *Proceeding of the symposium on living resources of the seas around India*, Mandapam Camp.
- Ibrahim Abuthagir, S., Suraj Kumar Pradhan, T. Nirmal, Nakhawa Ajay Dayaram, R. Ratheesh Kumar and Latha Shenoy. 2018. *Dol net an ingenious fishing gear or a debris collector?* In: D. Prema, Molly Varghese, Shelton Padua, R. Jayabaskaran, et al. (Eds.), National Conference on Marine Debris (COMAD 2018), Book of Abstracts and Success stories, MBAI, April 11-12, 2018, Kochi, p. 98.
- Jyothilal C. S., F. G. Bennopereira, C. Suresh, S. R. Sachin and V. Binilshijith. 2015. Stake net Catch analysis of Ashtamudi Lake, *Int. J. Aquacult.*, 5(14): 1-5.
- Kripa, V., D. Prema, P. S. Anilkumar, B. Jenni, and Sharma Rakesh. 2012. Habitat destruction: a case study on the evaluation of litter in the marine zone of north Vembanad Lake, Kerala. *Mar. Fish. Infor. Serv. T. & E. Ser.*, (212): 1-3.
- Kripa, V., P. Kaladharan, D. Prema, R. Jayabaskaran, P. S. Anilkumar, G. Shylaja, K. K. Saji Kumar, A. Anasu Koya, G. Preetha Nair, K. S. Abhilash, A. M. Dhanya, John Bose, T. V. Ambrose, N. D. Divya, P. G. Vishnu and Gishnu Mohan. 2016. National Marine Debris Management Strategy to conserve marine ecosystems. *Mar. Fish. Infor. Serv. T. & E. Ser.*, 228: 3-10.
- Manisseri Mary, K. and G. Rao Sudhakara 2000. Prawn fisheries of important brackishwater and estuarine systems in India. In: *Marine Fisheries Research and Management*. CMFRI; Kochi, 499-510 p.
- Menon, M. K. 1951. The life history and bionomics of an Indian prawn *Metapenaeus dobsoni*. *Miers. In Proc. Indo-Pacif. Fish. Council.*, 6 section II: 82-83.
- Menon, M. K. and K. Raman. 1962. Observations on the prawn fishery of the Cochin backwaters with special reference to the stake net catches. *Indian J. Fish.*, 8(1):1-23.

- Nandakumar, G. 2004. Shrimp fishery by stake nets in Cochin barmouth area with special reference to *Metapenaeus monoceros* (Fabricius), *Indian J. Fish.*, 51(4): 431-439.
- Pawar, N. A., V. V. Singh, U. H. Rane, A. D. Nakhawa, V. D. Mhatre, P. Khandagale, S. Ramkumar, C. Anulekshmi, K. V. Akhilesh, R. Ratheesh Kumar, S. N. Bhendekar, D. Prema and V. Kripa. 2018. *Temporal variation of plastic litter in traditional bag net off Mahul hemmed in by densely populated city, Mumbai*. In: D. Prema, Molly Varghese, Shelton Padua, R. Jeyabaskaran, *et al.* (Eds.), National Conference on Marine Debris (COMAD 2018), Book of Abstracts and Success stories, MBI, April 11-12, 2018, Kochi, 98 pp.
- Ratheesh Kumar, R., Ajay Dayaram Nakhawa, C. Anulekshmi, K. V. Akhilesh, D. Vaibhav, Mhatre, N. A. Pawar, S. N. Bhendekar and V. V. Singh. 2018. *Plastic menace to the monsoon bokshi net fishers of Satpati, Maharashtra*. In: D. Prema, Molly Varghese, Shelton Padua, R. Jeyabaskaran, *et al.* (Eds.), National Conference on Marine Debris (COMAD 2018), Book of Abstracts and Success stories, Marine Biological Association of India, April 11-12, 2018, Kochi, 108 pp.
- Remesan, M. P., V. R. Madhu, K. K. Prajith, and P. Pravin. 2018. *Plastic debris upsets bag net fishery along Hooghly Estuary, West Bengal*. In: D. Prema, Molly Varghese, Shelton Padua, R. Jeyabaskaran, *et al.* (Eds.), National Conference on Marine Debris (COMAD 2018), Book of Abstracts and Success stories, Marine Biological Association of India, April 11-12, 2018, Kochi, 37-38 p.
- Tarachand Kumawat, Latha Shenoy and K. K. Joshi. 2018. *Plastic waste component in the bag net fishery along the Maharashtra coast, India*. In: D. Prema, Molly Varghese, Shelton Padua, R. Jeyabaskaran, *et al.* (Eds.), National Conference on Marine Debris (COMAD 2018), Book of Abstracts and Success stories, Marine Biological Association of India, April 11-12, 2018, Kochi, 81 pp.
- UNEP/IOC. 2009. *Guidelines on Survey and Monitoring of Marine Litter, Regional Seas Reports and Studies*, No.186, IOC Technical Series No.83, 117pp.