



Awareness, perception and adaptation strategies of fisher community towards marine plastic pollution along Mumbai coast, Maharashtra, India

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ABSTRACT

Plastic pollution in Indian beaches has reached almost unmanageable proportions and practically no documentation is available on the views, occurrence and adaptation methods of the coastal communities exposed to plastic discards in Indian beaches and fishing grounds. This study attempted to fill this gap. The 5-point Likert scale was used to determine the awareness level, perceptions and attitude of respondents towards plastic pollution among the sampled fishers of Versova, Mumbai. Indices to measure these parameters were developed. The results revealed that the respondents were knowledgeable about the ill effects of plastic pollution on the environment. Easy availability (48%), substitutability (26%) and low cost (16%) of plastics were the reasons expressed by respondents for its rampant use in fishing. The perception index scores were found to be highest (1) for “juvenile destruction” and lowest for “damage to crafts and gear” (0). Strategies that provide incentives for change, assured government support, along with environmental awareness and community led management measures are necessary to address this menace. If plastic production and availability is reduced, availability of biodegradable substitutes is increased and information through various media sources reaches the unreached from time to time, it will go a long way to reduce marine plastic pollution.

Keywords: Coastal communities, Fishers, Fishing grounds, Indian beaches, Likert scale, Perception index score, Plastic discards

Introduction

Plastics are lightweight and durable materials, which can readily be moulded into a variety of products (Hopewell *et al.*, 2009). The production and use of plastics has increased markedly over the last 70 years and only in 1970s that the issue of extensive pollution of plastics in the marine environment was recognised (Carpenter and Smith, 1972; Colton *et al.*, 1974). Due to the buoyancy and durability of plastics, they are common in all oceans around the world and the toxic substances absorbed and adsorbed by plastics when they pass through the environment have led some researchers to believe that synthetic polymers in the ocean should be treated as deadly waste (Mato *et al.*, 2001; Rochman *et al.*, 2013; Greber, 2015). It has been estimated that the global production of plastic waste has reached 6.3 billion t, the major chunk of which (79%) has been discarded in landfills and more generally in the environment (Geyer *et al.*, 2017). It has been estimated that 4.8 to 12.7 t of plastic wastes enters the world's oceans every year, a remarkable fraction coming from land-based resources, which are carried by rivers and/or wind (Jambeck *et al.*, 2015). Plastic discards and emissions make way to marine environment through rivers, beaches, marine activities and illegal dumpings in the ocean (Derraik, 2002; Ryan *et al.*, 2009). Now that plastics are pervasive in the marine environment, imperative measures

are needed to alleviate this downward shift (Rios *et al.*, 2007, Rochman *et al.*, 2015).

The increasingly serious issue in the oceanic surroundings is not only the existence of micro and macro plastics in the water column, but also the risk of their entry and build up in the food web. It is only very recently that the menace of plastic pollution in the marine and freshwater environment has been identified as a global problem (Andrady, 2011, Eriksen *et al.*, 2013, Vegter *et al.*, 2014, Eerkes-Medrano *et al.*, 2015, Perkins, 2015). Presently marine plastic pollution has been identified as a serious environmental problem by scientists, governments, non-governmental organisations and general community all over the world (Seltenrich, 2015). As reported, it takes hundreds of years for plastics to completely disintegrate, albeit some of them decompose rapidly into small particles, which in turn end up in the ocean and are washed up on the beach and also enter the seafood stream. Amidst worldwide beachfront clean-ups, the top ranked litter are the single-use plastics. The complete lack of civic consciousness as well as lackadaisical attitude of the local governments in clearance as well as disposal of discarded plastics is responsible for plastics being an eye sore on beaches and a huge problem for the fishers out at sea.

As much as 79% of the plastic waste at any point sits in landfills and dumps in nature, while about 12% are burnt

and just 9% recycled (Geyer *et al.*, 2017). Eighty percent of marine plastics originates from land-based sources and the remaining 20% comes from marine sources (Li *et al.*, 2016). Of the 20% from marine sources, 10% has been reported from fishing fleets (in particular nets, lines and abandoned vessels) and the remaining 10% is made up of abandoned, lost or discarded fishing gear (Macfadyen *et al.*, 2009).

The research and academic circles have only just begun to understand the circulation and repercussions of plastics in the marine environment (Do Sul and Costa, 2014; Wilcox *et al.*, 2016; Hardesty *et al.*, 2017). In order to understand the reasons for the complexity and to develop appropriate management capabilities and mitigation strategies, categorical knowledge ought to be obtained at the local and regional levels (Farhan and Lim, 2011). There are several rules, which have been in force to deal with the issue of different types of wastes such as hazardous wastes, municipal solid wastes, used lead acid batteries, biomedical, plastic wastes and electronic wastes. The Solid Waste Management Rules (SMMR) 2016, E-Waste Management Rules 2016 and Plastic Waste Management Rules 2016 are some of the most prominent rules under the Environment (Protection) Act 1986. Most importantly, the rules stipulate that it is the responsibility of the producers to ensure that the waste generated from their products is disposed of in an environmental friendly manner. This calls for an enhanced understanding of the determinants that lead to unmanaged marine litter and plastic waste in poor researched areas outside residential areas (such as coastal communities). Large sections of the global coastal communities are unaware of this menace.

Mumbai is one of the most densely populated and highly industrialised areas in India. It is believed that poor waste management, coupled with population growth and economic factors, influences the trend of plastic aggregation (Jambeck *et al.*, 2015). Mumbai beaches are under threat of serious plastic debris load and different measures are taken for its mitigation. In a study, between November 2015 and May 2016, Juhu, Versova and Aksa were rated as the worst beaches among the nine beaches studied in Mumbai (Hindustan Times, 2016). Versova is a sub-urban fishing village, situated in Mumbai City in Maharashtra along the coast of Arabian Sea (Fig. 1). Residents of the Versova community cleaned up the beach with the help of an NGO and collected more than 5.7 million kg of garbage, revamping one of the dirtiest beaches in Mumbai into a habitable and enjoyable one (Hindustan Times, 2017).

Improper disposition of debris (including open and uncontrolled dumps) can cause plastic waste to enter the marine environment through waterways, wind and tides



Fig.1. Map showing the study area

(Ritchie and Roser, 2018). The tragedy is that the socio-economic costs of plastic waste are usually borne by the victims themselves and not by the perpetrators (Ten Brink *et al.*, 2009; Mouat *et al.*, 2010). To curtail plastic waste in the environment, approaches followed are usually consumer-oriented (Leal Filho *et al.*, 2019) and changing behaviour (Fowler and Close; 2012, Minton *et al.*, 2012) thus eliminating other potential interference points in this complex system. In India, no published information is available so far about investigations on the fishing community's attitudes towards the invasion of plastic into their working and living environments. This study can claim to be the first to address the level of awareness, attitudes and behaviour of the fisher communities of India towards plastic pollution. Results of this study can also serve as a benchmark for comparison of urban fishers' attitude to plastic pollution with semi-urban and rural fishers. Further, it could also deliver a few pointers and suggestions to the Bombay Municipal Corporation (BMC) to reorganise and restructure their approaches to solve this staggering civic problem. In the given context, the objectives of this study were to assess the awareness and perception of the fishers regarding plastic pollution, to explore adaptation strategies of the fishers to plastic pollution and to suggest suitable control measures.

Materials and methods

Analytical framework

The study was conducted in March 2019 among fishing community from diverse socio-economic background in Versova Landing Centre, Mumbai. Versova is a promising fishing centre in Mumbai located at the mouth of Malad Creek and it is about 30 km to the north of Sasoan Dock Fisheries Harbour. Versova Fishing Village has a fisher folk population of more than 10,000 and active fishermen residing are around 5000. Most of the inhabitants are directly or indirectly dependent on fisheries for their livelihood. A simple random sampling

method was adopted to select fifty fishers for the study. A pre-tested structured interview schedule was developed based on related previous studies and literature review (Wilcox *et al.*, 2016). Respondents selected were full time fishers residing in Versova Village.

The interview schedule comprised of 36 questions that assessed community’s knowledge, awareness, perception and attitudes in relation to plastic pollution. The preferences given by the respondents were ranked and scored to indicate responses pertaining to the adverse impacts of plastic pollution. Twenty-four variables were identified based on the available literature and were categorised under three indicators. Each indicator consisted of different numbers of variables and hence, their range of scores was different. The perception and adaptation strategies score had three broad categories namely, low with a value ranging from 0.00 to 0.33, medium with a value ranging from 0.34 to 0.66 and high with a value ranging from 0.67 to 1.00.

The scores of all the given indicators (Fig. 2 and 3) were converted into unit score by using the formula:

$$U_{ij} = \frac{Y_{ij} - \text{Min}Y_i}{\text{Max}Y_j - \text{Min}Y_i}$$

where, U_{ij} = Unit score of the i^{th} indicator; Y_{ij} = Value of the i^{th} respondent on the j^{th} indicator; $\text{Max}Y_j$ = Maximum score on the j^{th} indicator; $\text{Min}Y_i$ = Minimum score on the i^{th} indicator.

Data analysis

Data were compiled in MS Excel 2010 spread sheet. A 5-point Likert scale was used to determine the various indicators (Likert, 1932). The real or hypothetical situation under study has been proposed in the form of a

Indicators	Variables
Long term changes	<ul style="list-style-type: none"> • Increase in plastics waste • Change in the depth of fishing • Change in type of fishing • Change in fishing grounds • Change in catch composition
Major effects of these long term changes	<ul style="list-style-type: none"> • Harmful to animal welfare • Loss of valuable natural resources • Human health risk • Damage to crafts and gear • Coastal community life • Juvenile destruction • Increase in maintenance costs • Clean up costs • Catch contamination • Decrease in income

Fig. 2. Indicators and variables used for constructing perception index (Adapted from Wilcox *et al.*, 2016)

Indicators	Variables
Preventive/Regulatory organisations	<ul style="list-style-type: none"> • Local and Regional authorities • Other international bodies • NGOs • Individuals • Incentives provided by Government <p>(Adapted from Hammami <i>et al.</i>, 2017)</p>
Items that could be reduced in marine litter	<ul style="list-style-type: none"> • Cigarette butts • Empty plastic bottles • Caps and Lids • Cotton bud sticks • Sanitary towels • Crisps • Carry bags • Straws • Food containers • Single use plastics • Plastic cutlery • Fishing related plastic items <p>(Adapted from Wilcox <i>et al.</i>, 2016)</p>
Adaptation strategies for reduction of plastic pollution	<ul style="list-style-type: none"> • Willingness to spread awareness about plastic pollution to other fishers, friends and family members • Willingness to reuse and bring own bags for shopping • Willingness to support environmental campaigns via monetary contributions • Willingness to do little more for alternative measures that would result in reducing marine litter • Willingness to start a anti-plastic pollution campaign with friends and not rely on government • Willingness to collect the marine litter and not to throw it back in the ocean <p>(Adapted from Hammami <i>et al.</i>, 2017)</p>

Fig. 3. Indicators and variables used for constructing adaptation strategies and attitude index

set of statements. On a metric scale, participants reveal their level of knowledge about long-term changes from “No opinion” to “Very Severe”, role of external agencies from “Not important” to “Very important”, degree of agreement with respect to attitude from “Strongly agree” to “Strongly disagree” (Braga *et al.*, 2017) and the ranks ranged from 1 to 5 (Table 1). All statements as a whole reveal a certain dimension of the relationship with the subject (Singh, 2006).

Results and discussion

Demographic profile

The demographic profile of fishers (Table 2) revealed that 41% of respondents were males with an average fishing experience of 15 years. The household size for the majority of respondents was found to be less than or equal to 5 (58%). With respect to education, it was seen that 26% of the respondents were illiterate and 30% had secondary school education. The average monthly income was found to be ₹0.0065 million.

Table 1. Indicators of Likert scale

Indicators	1	2	3	4	5
Long term changes and major effects of these long term changes	No opinion	Not severe	Severe	Moderately Severe	Very Severe
Role of external agencies	Not important	Slightly important	Important	Fairly Important	Very important
Attitude	Strongly disagree	Disagree	Neutral	Agree	Strongly agree

Table 2. Demographic particulars of Versova Fishing Community, Mumbai

Variable/Category	Sample size (n=50)	Percentage (%)
Gender	Male	41
	Female	9
Age	Less than or equal to 18	-
	18-34	12% (n=6)
	35-50	44% (n=22)
	51-70	42% (n=21)
	>70	2% (n=1)
Level of education	Illiterate	26% (n=13)
	Primary	26% (n=13)
	Secondary	30% (n=15)
	Higher secondary	14% (n=7)
	Graduate and above	4% (n=2)
Marital status	Married	90% (n=45)
	Single	8% (n=4)
	Widowed	2% (n=1)
	Divorced	-
Household size	Less than or equal to 5	58% (n=29)
	6 to 10	40% (n=20)
	>10	2% (n=1)
Occupation	Actual fishing	72% (n=36)
	Fish seed collection	-
	Fishing associated activities	14% (n=8)
	Other fishing related activities	-
	Years in occupation	
	1 to 10	42% (n=21)
	11 to 20	26% (n=13)
	21 to 30	24% (n=12)
	31 to 40	4% (n=2)
	41 to 50	4% (n=2)
	more than 50	-
Monthly income (₹ in millions)	<0.006	30% (n=15)
	0.006-0.012	54% (n=27)
	>0.012	16% (n=8)

Sources and final destination of the plastic wastes

Most of the respondents (38%) considered land run-off as major source of pollution followed by tourism wastes (30%) and household discards (24%). The rest 4% was contributed by hospital wastes and discarded fishing gear. The respondents opined that all these plastic waste discards ended up in ocean (68%) and landfills (32%). Plastic fragments from open landfills reach streams, rivers or directly the ocean in case of in-effective landfills. Beach goes litter cigarette butts, food and beverage

packaging and plastic beach toys (Van Sebille *et al.*, 2016) which further add to the mess.

Plastic utilisation: awareness about trends, causes and types of litter

The vast majority of the fishers responded that the use of plastics was increasing (52%) while others (48%) perceived that it was decreasing. Plastics, in their opinion, were being used rampantly due to easy availability (48%), irreplaceable (absence of substitute material) (26%), have low price (16%) and owing to low level of awareness among people (10%). Fig. 4 shows the variety of litter present in Mumbai coastal waters.

Ameliorative measures for eliminating beach litter

Majority of the respondents perceived the necessity to address litter on beaches as very necessary and very urgent (70%). Respondents opted for bio-degradable products (30%), ban on plastic use (29%) and voluntary boycott (28%) as the best methods to reduce the use of plastic (Fig. 5).

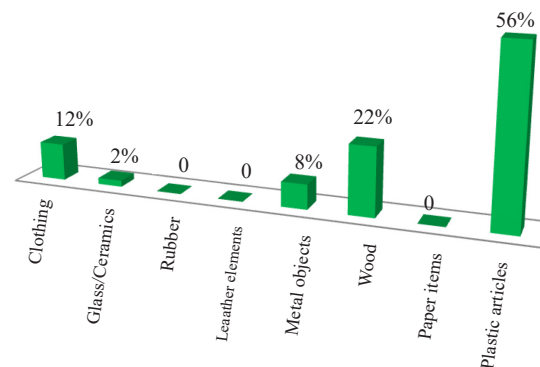


Fig. 4. Types of litter along Mumbai coast

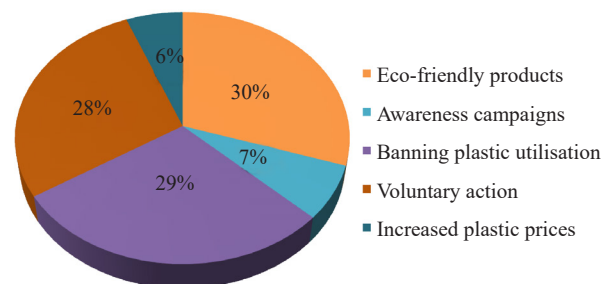


Fig. 5. Preferred ways of reducing plastic pollution

The responders also revealed that being urban fishers, they were exposed to use of biodegradable products and realised the importance of plastic ban as well as voluntary boycott of plastic. This may again be attributed to formal education that the fishers and their children are exposed to in Mumbai, as 30% of the respondents were educated to secondary school level (Table 2). At present, local community schemes have been setup to collect the waste on the beaches; however, this does not solve the main cause of the pollution.

Perception index

The perception of respondents with regard to long-term changes due to plastic pollution in the ocean in last one decade was highlighted using index score. It was seen that score was highest for increase in the plastics and lowest for change in the type of fishing. Among the negative impacts of the long-term changes due to plastic pollution in the last decade, perception index score was highest for juvenile destruction and lowest for damage to gear and crafts (Fig. 6, 7).

Adaptation strategies

After every crisis, human tendency is to acclimatise and adapt. Fig. 8 shows how marine fishers of Versova are coping up with the plastic pollution, which is hindering their fishing operations and affecting their livelihood. Majority of fishers have made changes in fishing strategies necessitated by plastic pollution. Despite the fact that the fishers felt a necessity to change their fishing strategy, they were constrained by many factors such as lack of credit and access to technology.

Those fishers who were able bodied and had crafts that were sea worthy, changed their fishing grounds (18%). Another strategy the fishers adopted was to go to

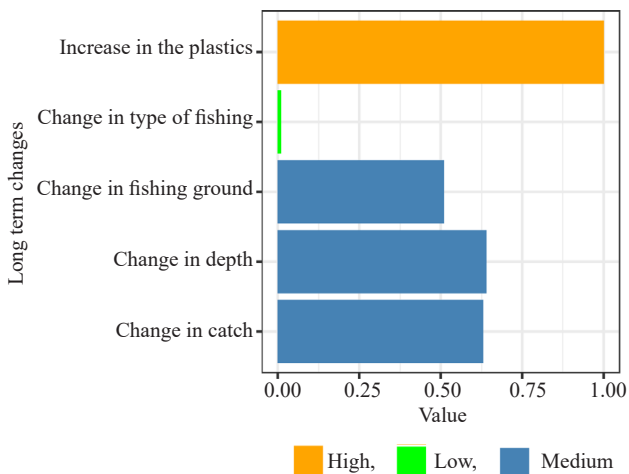


Fig. 6. Long term changes due to plastic pollution over the last decade

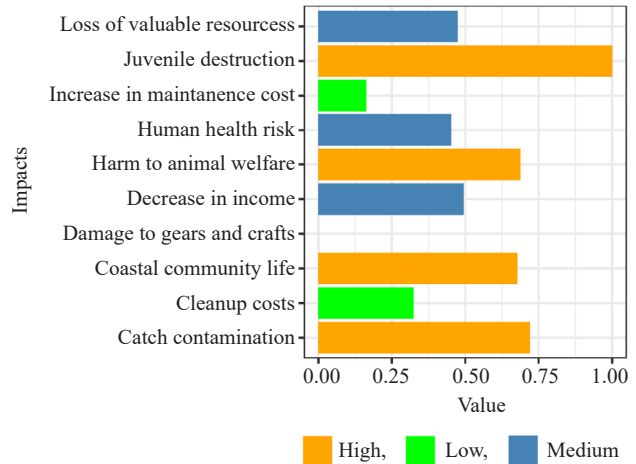


Fig. 7. Main impacts (negative) of the long-term changes due to plastic pollution over the last decade

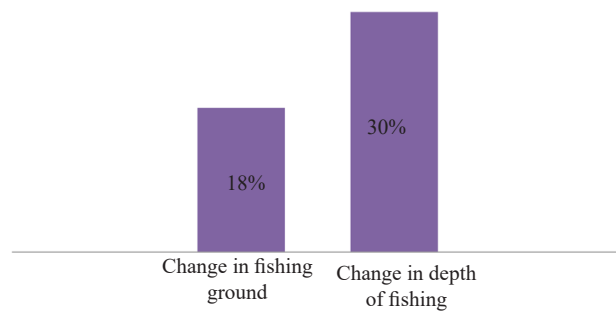


Fig. 8. Adaptation strategies of the fishers, to the long term negative impacts of plastic pollution over the last decade

deeper fishing grounds to avoid their gear being caught up in floating plastic (30%). Often this necessitated fitting outboard engines to their traditional crafts which involved higher overhead costs cutting into their gross income. Also there were others who could not or would not change their strategies as they had resigned to their fate (52%). It turns out that because of the presence of plastic debris in the ocean, respondents have changed their fishing areas and fishing depths in the past decade.

Disposal of marine plastic litter caught up in fishing gear

Respondents preferred two ways of dumping plastic debris that were netted with the catch. It was either dumped back in the ocean or dumped at the landing centre (Table 3). Majority of the respondents (76%) dumped back plastics in the ocean since fishers did not receive any external support for their adaptation to the adverse impacts of plastic pollution. Again, extension workers also did not provide any information on plastic debris and pollution control measures. There is no incentive to get back plastic to the shore and there is no proper disposal system in place

Table 3. Preferred ways of disposing littered plastic picked at sea

Preferred way of disposing littered plastic	%
Dumped back in the sea	76
Dumped at the landing centre	24

which will necessitate bringing back plastics on shore. Keeping these points in consideration, intervention from the government is urgently required.

In order to reduce marine litter, Maharashtra Government agencies such as Maharashtra Water Resources Department, Maharashtra Fisheries (Sea based sources), Mumbai Port Trust (Sea based sources) and Maharashtra Maritime Board (MMB) (Sea based Sources) have been playing a crucial role in reducing marine debris. In order to reduce the amount and impact of marine debris sources, including solid debris and lost cargo, the MMB has established incentives to encourage fishermen to collect marine debris found at sea and transport the debris to the port. In addition, MMB worked with non-state actors in providing support and logistics to communities throughout Mumbai (MMB, 2017).

Adaptation index

The index score for organisations having important role in taking any further action was seen highest for incentives provided by government with an index score of 1 and lowest for other international bodies with an index score of 0. The important roles of private sector and international agencies did not register any response, which can be attributed to the lack of awareness about the role of these agencies in this task (Fig. 9)

In case of extent to which action can be taken to reduce the presence of given marine litter, index score was

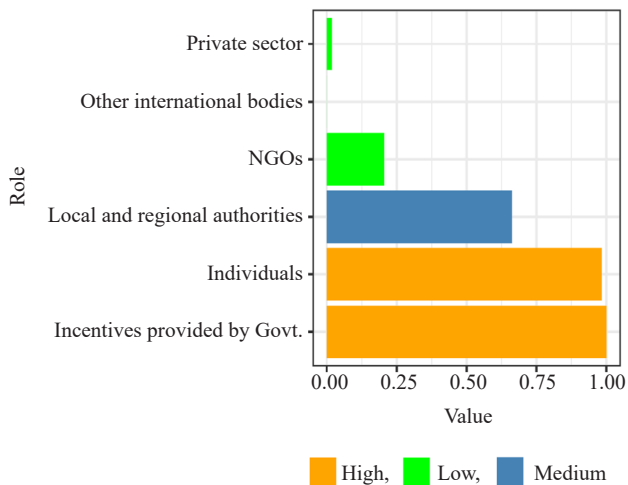


Fig. 9. Organisations having important role in taking further action and initiatives

highest for crisps, plastic wrappers with an index score of 1 and lowest for cigarette butts with an index score of 0. This may be attributed to the strong recall memory of the fishers who see consumption of such snack items by the public on the beaches and throwing away the wrappers callously instead of disposing them carefully (Fig. 10).

Similarly, the index score for attitude towards the reduction of plastic pollution by different ways was seen highest for willing to reuse and bring own bags for shopping with an index score of 0.95 (Fig. 11). The positive and significant attitude of the fishers in expressing their responsibility in bringing back marine plastic litter back ashore and their willingness to disseminate information and share knowledge in respect of adverse impact of plastic pollution needs to be seen as a positive impact of urbanisation.

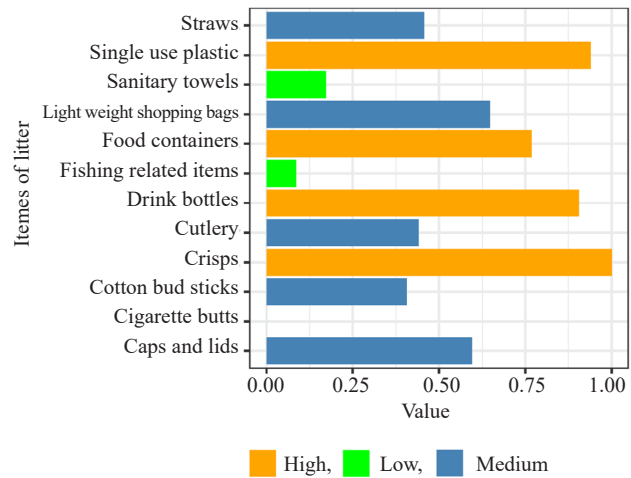


Fig. 10. Extent to which action can be taken to reduce presence of marine litter

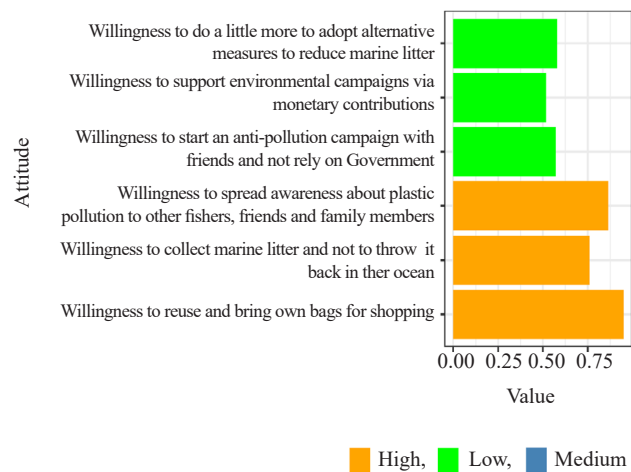


Fig. 11. Attitude towards the reduction of plastic pollution by different ways

Plastic debris continues to crowd the ocean, most of which consist of disposable plastic containers and retail packaging. At the system level, socio-economic costs are usually borne by the people affected, rather than those responsible for transporting and disposing the waste. To a large extent, this study concludes that respondents reflected a very high level of awareness about plastic pollution and its consequences. This may also be attributed to the exposure to a certain level of education among the fisher community as well as to information on adverse impacts of plastic pollution percolating through the fishers. Information is the key and when it is extended to the target audience by Government agencies, Non-governmental organisations and fishers' co-operative societies, it has a multiplier effect and positive externalities are generated. But unfortunately such awareness is not adequately being raised by these organisations in a systematic manner regularly. The recent plastic use ban in Mumbai is a step in the right direction and will help in reducing the marine plastic pollution locally.

Marine plastic pollution through discarded fishing gears were given less consideration by the respondents for causing the problems such as entanglement. This may be attributed to their inherent fear of identifying themselves as a cause for primary marine plastic pollution. Increase in plastics use has not only deteriorated the natural beauty of the beaches but has also led to ghost fishing. Main reasons attributed by the respondents to widespread usage of the plastics were easy availability (48%) of plastics, absence of any substitutable material (26%) and inexpensive nature of plastics (16%). Study indicated that most of the respondents, regardless of their demographic background, are in favour of distribution and usage of eco-friendly products (36%), plastic use ban (30%) and voluntary boycott (28%). Without responsible procurement and use regulations, the ocean plastic crisis cannot be alleviated.

Albeit the problem of plastic pollution needs to be solved in many ways (MacArthur *et al.*, 2016), our findings indicate that coastal communities demand increased manufacturer responsibility and critically need a circular economy. Coastal communities with the poor waste disposal infrastructure need recycling systems and responsible supply chains, as well as substitutes made from non-plastic materials. Intensive campaigns need to be organised in order to mobilise the public and other stakeholders against indiscriminate use and disposal of plastics (single use, in particular), which would help to minimise the excessive accumulation of plastic wastes in the marine environment (Giacovelli, 2018). Fishers need to be incentivised to bring back plastic wastes caught in their hauls to the shore. This will not only reduce the amount of plastic waste being dumped back into the sea

but will also help the government and NGOs to easily collect the waste and ensure proper disposal.

The Government of Maharashtra announced that it would phase out plastic bags, cutlery and polystyrene and has issued an explicit order to the civic authorities. It also suggested fines of ₹5,000-25,000 and jail terms for violators. The Maharashtra Non-Biodegradable Garbage (Control) Act, 2006, banned plastic of less than 50 micron thickness. But now, the government has banned all types of plastic, excluding water bottles and milk pouches. BMC (Brihanmumbai Municipal Corporation) is conducting educational programmes with the help of NGOs, housing societies and educational institutions to create awareness among people. There is no doubt that these steps will go a long way to reduce marine plastic pollution with positive externalities and economic benefits to the fisher community of Versova, Mumbai.

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