SURVEY REPORT ON

TRANSBOUNDARY MARINE LITTER

ON THE WESTERN PROVINCE OF SRI LANKA - 2023

By The Pearl Protectors

SURVEY REPORT ON TRANSBOUNDARY MARINE LITTER

ON THE WESTERN PROVINCE OF SRI LANKA

Shalanka Ranjula

Bimali Keerthisinghe

Samudra de Silva

Muditha Katuwawala

Acknowledgement

We wish to thank the Federation of Environmental Organizations (FEO) Sri Lanka, for supporting this initiative through funding. We extend our gratitude to the Citizen Scientists and the coastal communities, for their contribution and cooperation to this research. We acknowledge the input of our Research Assistants: Dimashi Sathsara, Dineshi Gunawardana, Hashani Senavirathna, Isuru Kularathna, Lochana Amandi, Rashmi Bandara, Shalini De Silva, Suyama Sanjunee, Vishadi Wijenayaka, and the support received from Sivapriyan Kankishkar when writing this report.

This document should be cited as: Ranjula, M. A. S., Keerthisinghe, B., De Silva, S., Katuwawala Don M., (2023). *Survey Report on Transboundary Marine litter on the Western Province of Sri Lanka.* The Pearl Protectors, Colombo

Executive summary

Transboundary Marine Litter hereafter referred to as (TBML) is a growing environmental concern with significant impacts on marine wildlife, ecosystems, and economy. In order to mitigate these impacts, it is essential to understand the various forms in which TBML occurs. This study was conducted to address the knowledge gap regarding TBML in the Indian Ocean region, and to establish a baseline for comprehending the accumulation of TBML along Sri Lanka's Western Province over time. The research considered that foreign marine debris discovered that cannot be purchased locally is TBML. The findings of this study will contribute to the development of effective strategies for addressing TBML in the Indian Ocean region.

What is compelling about TBML is that, how the behavior of consumers of one country would affect the environment and citizens of another country, as a result of poor management of waste. TBML can travel from areas of high abundant pollution to areas of less pollution making any ecologically sensitive areas vulnerable. TBML can entangle, suffocate and otherwise harm marine animals, settle underwater and degrade the quality of marine habitats, and often act as a carrier for invasive species. TBML of peculiar characteristics than those of local litter can impose additional risks on environment and human health. It can be challenging to collect and remove marine litter due to its widespread distribution, inaccessibility to some marine environments, its presence in large quantities and physical & chemical weathering over time. It can equally be challenging to trace back to the source of TMBL, making it hard to understand the cause of litter and to take targeted measures to lessen its impact.

It is clear that TBML is a complex and far-reaching problem that requires a multifaceted approach to mitigate its impacts. Further research is needed to better understand the different forms and origin of TBML and, to develop strategies for reducing the amounts of litter entering the ocean, as well as improving the removal and recycling of existing litter. It is a timely need to actively address the issue of TBML and protect our oceans, marine life, and ecosystems for future, and for all.

Contents

1 Introduction

Marine litter has rapidly evolved into a global concern over the past decade, receiving comparable media attention and public salience to other mega-crises such as climate change (Borrelle et al., 2017; Dauvergne, 2018; Gabrys, Hawkins, & Michael, 2013). Marine litter can be identified as any persistent manufactured or processed solid waste that ends up in the marine environment, either intentionally or unintentionally (Duhec et al., 2015). Although floating debris such as messages in bottles and tropical seeds have captured people's imagination for centuries (Muir 1937: Bergmann et al., 2015), this review focuses on the past 50 years, as the environmental impacts of marine litter are closely tied to the advancements in plastic materials.

The production of plastics has seen a steady increase since 1950, starting at 2 million metric tons and reaching 348 million metric tons in 2017, with a compound annual growth rate of 8.4% (Geyer et al., 2017; Gibb, 2019). In total, an estimated 8.3 billion metric tons of plastics have been manufactured worldwide, including 7.3 billion metric tons of resins and additives and 1 billion metric tons of fibers (Geyer et al., 2017; Gibb, 2019). The vast majority of the trash found in shorelines, the ocean surface, and the seafloor is plastic, making up 95% of the litter (Edwards & Stachowicz, 2010). The most prevalent types of litter on beaches, accounting for over 80% of the trash found, are plastic bags, fishing gear, food and beverage containers (Topçu et al., 2013; Thiel et al., 2013). These materials decompose slowly, if at all, causing a continued presence of plastic waste in the ocean with detrimental effects on marine ecosystems and species. The accumulation rates of marine litter can vary widely, influenced by factors such as the presence of large cities, shore use, hydrodynamics, and maritime activities (Bergmann et al., 2015).

Transboundary Marine Litter (TBML) refers to marine debris that crosses international borders and can come from various sources such as shipping, fishing, and land-based activities. TBML is made up of materials such as plastic, metal, and rubber which are non-bio degradable and often persistent in the environment for long periods of time. Due to the highly mobile nature of TBML by ocean currents it can have serious consequences for marine ecosystems and wildlife, as well as human health and safety.TBML can accumulate in

areas with high concentrations of debris, and can lead to entanglement, ingestion, or habitat alteration, causing significant impacts on the local environment and wildlife. It is no longer a local issue but a concern beyond borders, since waste of one country can impact the people and environment of another country, irrespective of their existing waste management strategies. To effectively address this issue, it is necessary to understand the sources, the pathways, and the impacts of TBML, comprehensively.

The Indian Ocean is unique, with monsoon winds playing a significant role in shaping the physical environment, generating currents, waves, variations in sea surface temperature, and other abiotic factors (Subarna, 2018; Rathnasuriya et al., 2021). This is especially evident during the southwest monsoon period when there are distinct patterns in physical properties that differentiate the eastern and western regions (de Vos et al., 2014; Krakstad et al., 2018; Rathnasuriya et al., 2021). These differences can also impact the distribution and accumulation of marine litter, including TBML. Understanding the role of monsoon winds in shaping the physical environment and their effect on TBML accumulation is essential for developing effective strategies to address this environmental issue.

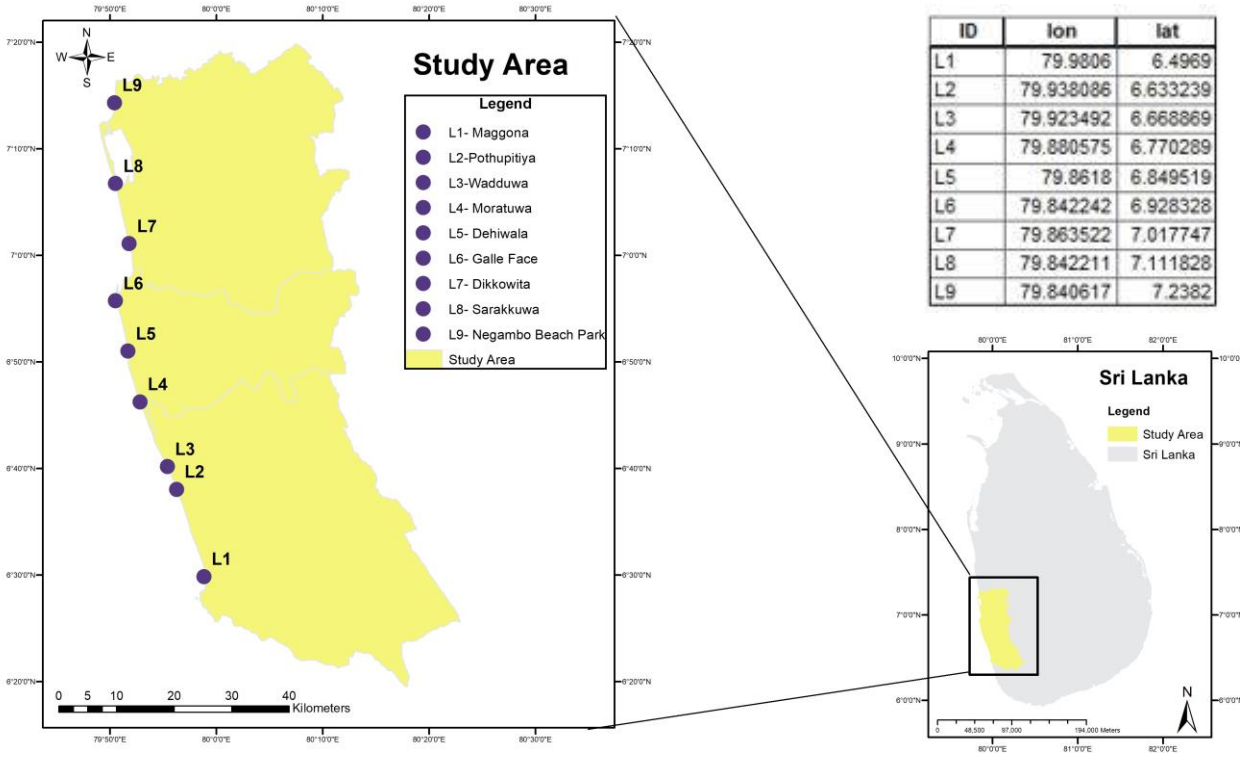
However, studies on TBML is scarce, especially in the Indian Ocean region. This study is significant as it seeks to address the knowledge gap regarding TBML in the Indian Ocean region, by establishing a baseline for comprehending the accumulation of TBML along Sri Lanka's Western Province coast and how it changes over time. The knowledge gained through the study, would contribute to the development of effective strategies for addressing the issue of TBML in the Indian Ocean region.

2 Methodology

This study postulates that all foreign marine debris that cannot be purchased locally is considered TBML, and that TBML discovered with nylon ropes is most likely to have been used for fishing. The study comprised of two components; the main survey and the Citizen Science survey, and two sets of data were collected and analyzed separately.

2.1 Main survey

2.1.1 Selection of the Location



ID	lon	lat
L1	79.9806	6.4969
L2	79.938086	6.633239
L3	79.923492	6.668869
L4	79.880575	6.770289
L5	79.8618	6.849519
L6	79.842242	6.928328
L7	79.863522	7.017747
L8	79.842211	7.111828
L9	79.840617	7.2382

Figure 1: Survey Locations along the west coast

After a pilot survey, 9 locations from the districts of Kalutara, Colombo, and Gampaha were selected for the survey (3 locations from each district). The selection of these locations was based on the accessibility, visibility, and prevalence of marine litter in the area.

2.1.2 Selection of survey area

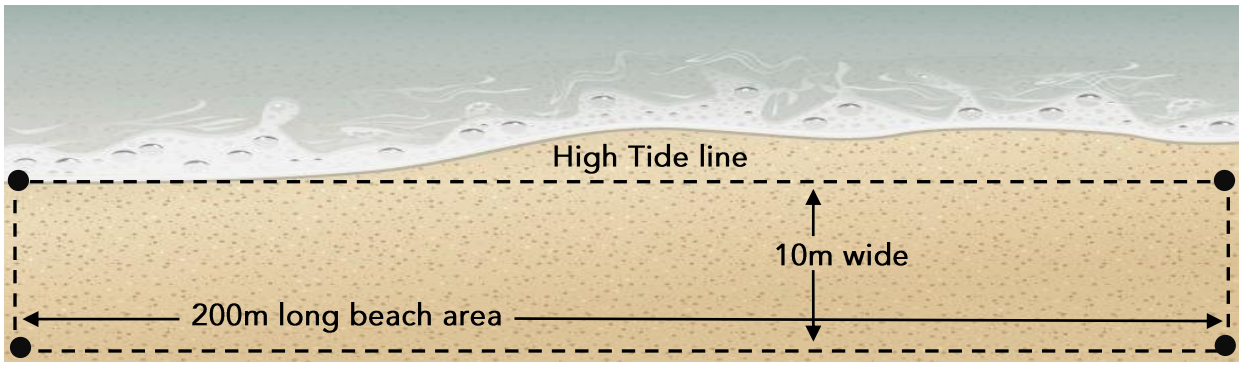


Figure 2: Survey area

The survey area was determined as a 200m x 10m stretch extending from the tide line to a maximum of 10 meters inland or to the point where vegetation began. The survey area was divided into four equal sections, with southern and northern points (S1, N1) and two points in between (S2, N2).

2.1.3 Sampling

Nine research assistants were assigned to nine locations and samples were collected once a month within three days of the full moon, representing each monsoon season, namely the Southwest Monsoon, the Northeast Monsoon and two inter-monsoons. The focus of the survey was on stranded liquid containers, and any TBML encountered was clearly photographed from the front, back, and with a label and the GPS location of the TBML was recorded. In addition to TBML, the survey also recorded the presence of local marine litter and marine animal stranding on the beaches.

2.1.4 Data Analysis

At the end of each month, the data was compiled into a report by the back office analyst and categorized by the country of origin and the survey location. The manufactured location of TBML was considered as the point of origin of TBML. The accumulation of TBML was analyzed according to the country of origin, location, and monsoon season.

2.2 Citizen Science Survey

2.2.1 Data Collection

Data collection was conducted with the help of a Google form which was accessible to the general public. Participants, known as Citizen Scientists, were requested to provide metadata about themselves, the exact location of the TBML found, and clear images of the TBML (including the country of origin and brand name).

2.2.2 Citizen Scientist Profile

The collected data was recorded on an excel sheet and a dedicated profile was maintained for each Citizen Scientist. This allowed for efficient tracking and analysis of the contributions made by each individual. The profile included information such as the name and contact information of the Citizen Scientist, the number of submissions made, and a record of their submissions. This information was used to recognize and acknowledge the efforts of the top contributors through the creation of a Citizen Scientist ranking system.

2.2.3 Ranking System

To incentivize participation in the survey, and as a motivation for the Citizen Scientists to continue participating in the survey, a ranking system was introduced based on the contribution. Novice Citizen Scientists had 10-40 submissions, Expert Citizen Scientists had 41-100 submissions, and Legendary Citizen Scientists had over 100 submissions. This tier system acted as below.

Novice Citizen Scientist
10-40 submissions

Expert Citizen Scientist
41- 100 submissions

Legendary Citizen Scientist
101 and above submissions

Data collected through the Citizen Science survey was analyzed separately to ensure that there was no overlapping with the main survey. Only the country of origin was considered in the analysis. The extensive Citizen Science program aimed to involve students from academia, coastal communities, and beachgoers, and an easy-to-use online data gathering mechanism was established as part of the survey to make it accessible to a large number of people.

Figure 3: Citizen Scientists surveying

3 Results

3.1 Main Survey

3.1.1 Variation of Trans-boundary Marine Litter (TBML) in Total PET Bottles

During the survey period from May to December, a total of 6057 PET bottles were collected from the coastal stretch of the survey locations along the Western Province coast of the island. Out of these, 13% were identified as TBML as shown in Figure 4.

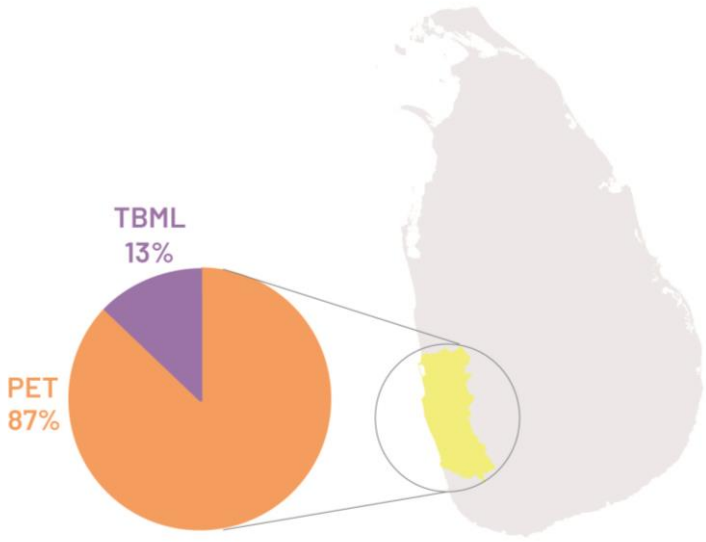
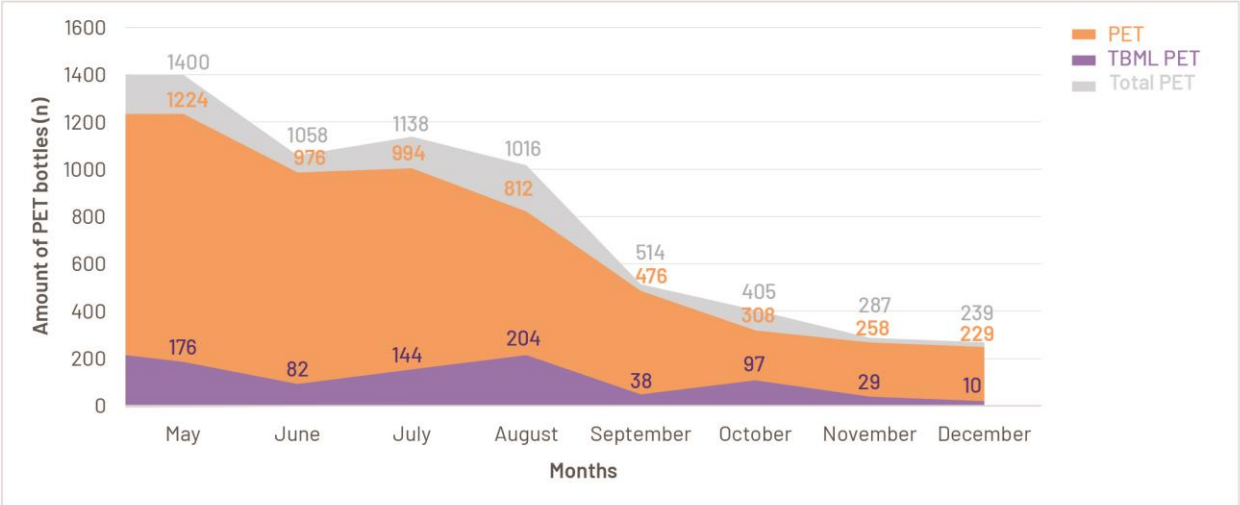


Figure 4: Variation of Trans-boundary Marine Litter (TBML) in Total PET Bottles Found during the Survey

The variation of the total amount of TBML, local PET bottles, and total PET bottles was monitored monthly and is represented in Figure 5. The data shows that while the local PET variation and total PET variation displayed a declining trend towards December, the variation of TBML exhibited an increase in two months August and October.

The percentage of TBML increased from July to August (n=144 to 204) and from September to October (n=38 to 97) while the total PET amount declined from 1138 to 1016 and from 514 to 405 respectively in those months.

The highest amount of TBML was recorded in August (n=204) and the lowest in December (n=10), while the total PET amount recorded its highest in May (n=1400) and the lowest in December (n=239). The relative percentage of TBML along with the total PET bottles was recorded as 13%, 8%, 13%, 20%, 7%, 24%, 10%, and 4% respectively from May to December.



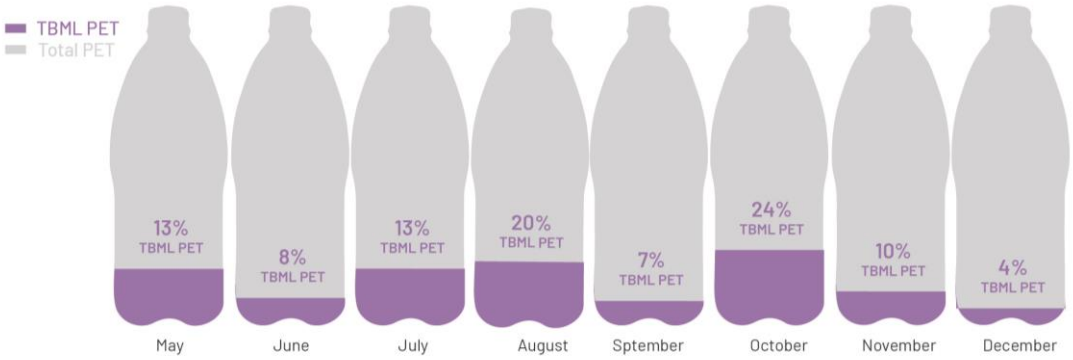


Figure 5: Variation of TBML, Local PET with Total PET Bottles

3.1.2 Origin Countries of the Transboundary Marine Litter

Part of the study included determining the origin countries of the TBML surveyed. Regarding the total of 780 TBML encountered during the survey, the origin countries and their contribution as a percentage are illustrated in figure 6 & Figure 8. India was the major contributor (66.79%) to the TBML, followed by China (14.62%). When considering the continent-wise contribution (Figure 9), Asia is the major contributor (90.4%) to the TBML. Europe contributed 1% to the TBML, followed by Africa with 0.5% contribution. The contribution of both North and South America was lower than 0.5% (0.3% and 0.1% respectively). Out of 780 records, 7.7% were categorized as unidentified as the point of their origin was ambiguous.

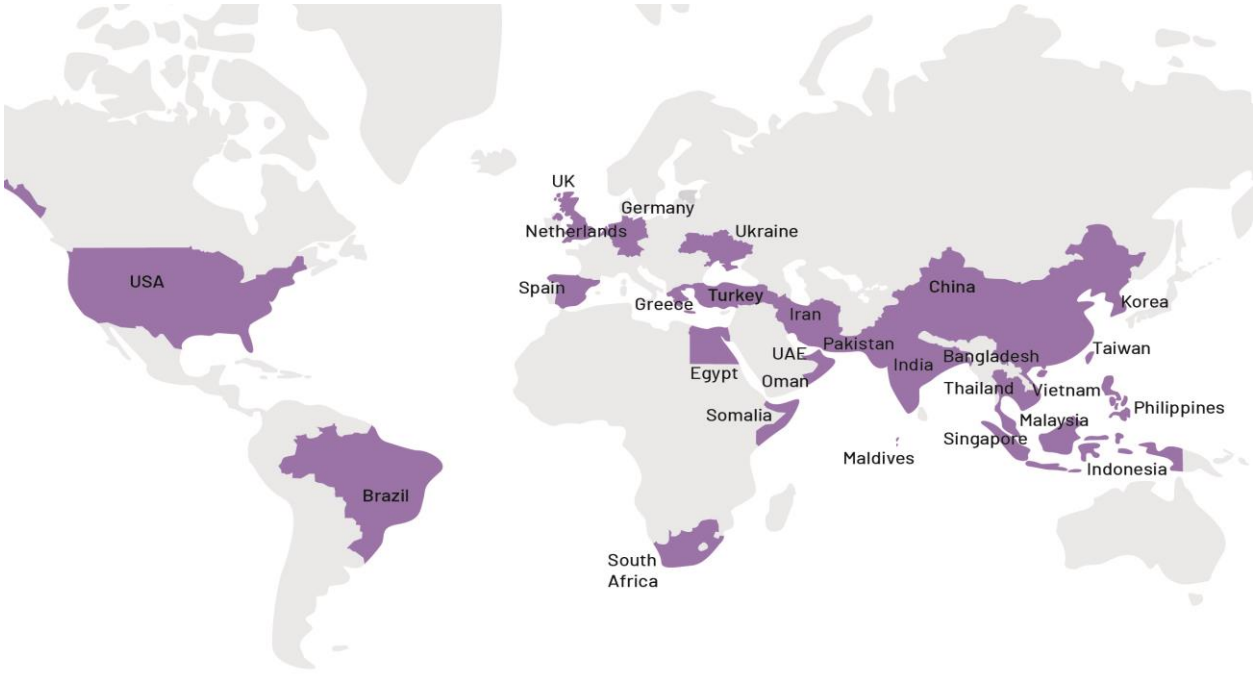


Figure 6: Origin Countries of the Transboundary Marine Litter

Figure 7: TMBL PET Bottles found during the survey

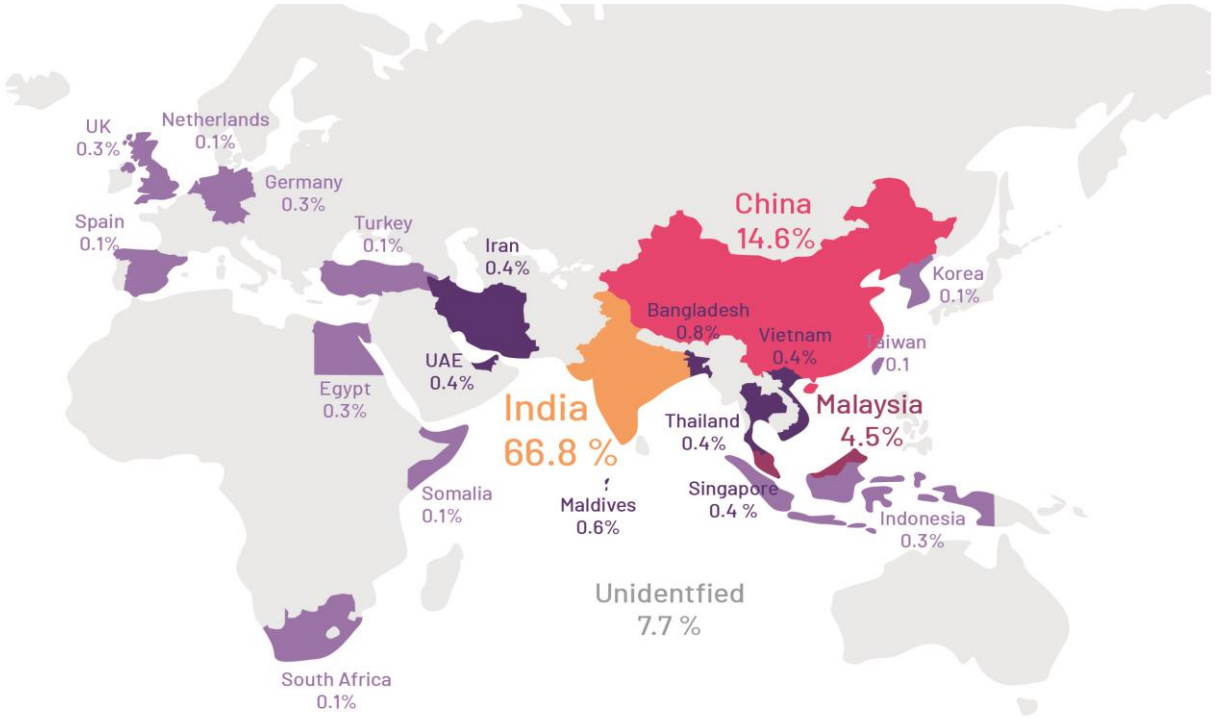


Figure 8: Contribution to TBML by countries

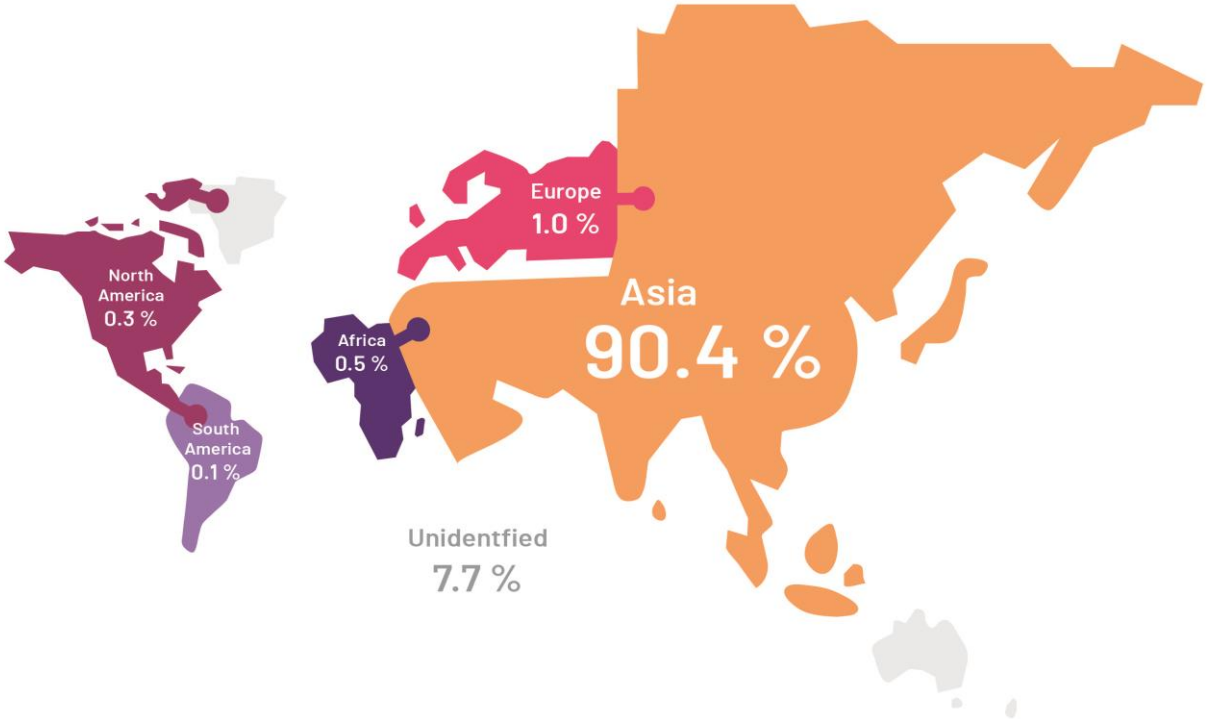


Figure 9: Contribution to TBML by continents

3.1.3 Contribution of Indian states to TBML

The TBML originating from India was categorized into 12 states: Tamil Nadu, Maharashtra, Karnataka, Haryana, Gujarat, Andhra Pradesh, Uttar Pradesh, West Bengal, Rajasthan, Goa, Madhya Pradesh and Jammu & Kashmir. As seen in Figure 10, the majority of the TBML was recorded from Tamil Nadu, with 145 instances. Maharashtra and Karnataka followed with 72 and 65 recorded instances respectively. The least contribution was from Madhya Pradesh, with 1 recorded instance. Out of the 522 TBML bottles originating from India, 200 whose state of origin was ambiguous, were classified as unidentified.

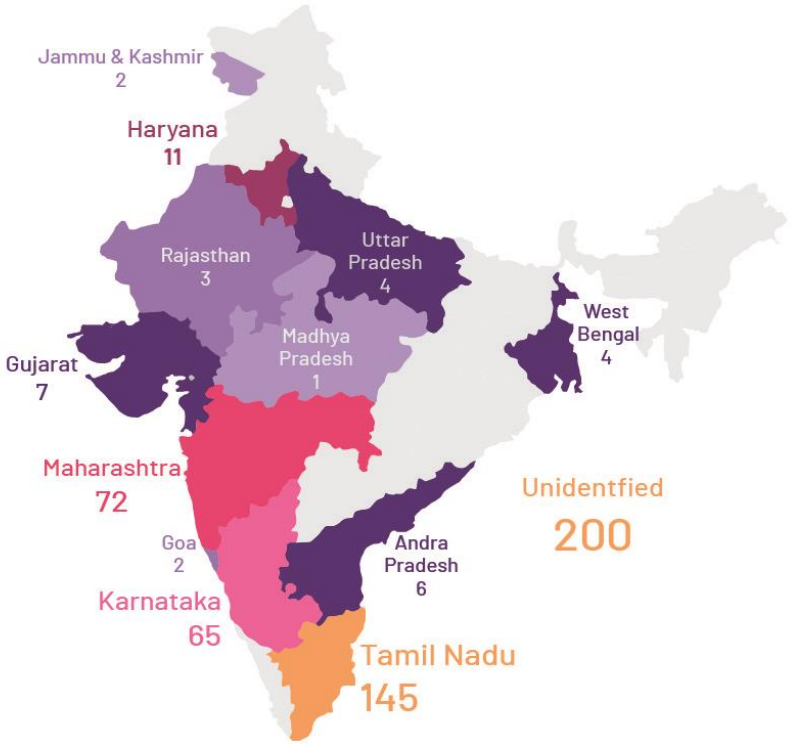


Figure 10: Contribution of Indian states to TBML

3.1.4 Spatial variation of TBML along the Western Province coast

The results of the survey indicate that the highest concentration of TBML was recorded at Maggona Beach, with 139 items recorded. The lowest concentration was found at Negombo Beach Park, where only 19 items were recorded. The accumulation of TBML was found to be the highest in the Kalutara district, which slightly decreased towards Wadduwa.The distribution of TBML increased towards Galle face and had a plunge at

Dikkowita. Sarakkuwa had a clear increment in the number of TBML, while the lowest was recorded at Negombo Beach Park.

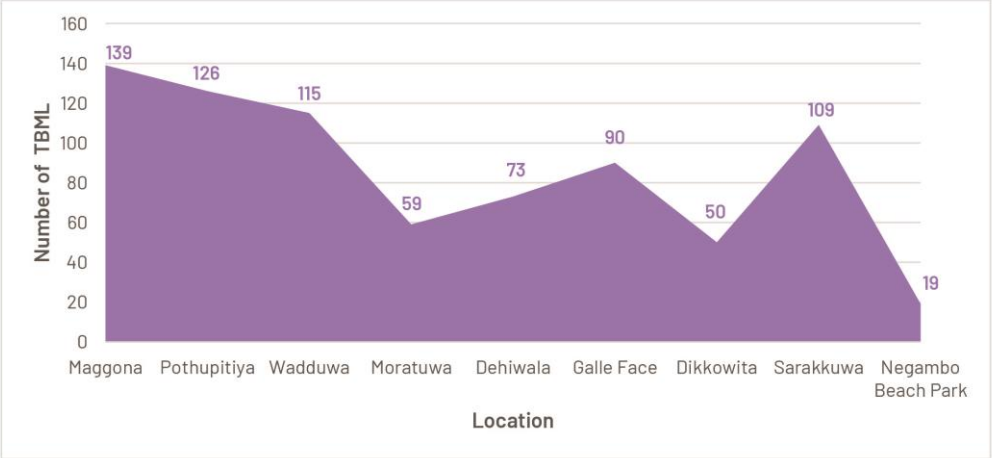


Figure 11: Spatial variation of TBML along the west coast

3.1.5 Temporal Variation of TBML along the Western Province coast

The survey data collected over a period of 12 months are shown in figure 12. The figures 12a to 12i depict the TBML records of different survey locations. The temporal variation of TBML was characterized by fluctuations in the number of records during different months. In Maggona (figure 12a), the amount of TBML increased in May, peaked in August (n= 39) and then dropped in September (n=7). There was a spike from 7 to 24 in October and the records were nearly constant in last two months. In Pothupitiya (figure 12b), the amount of TBML remained nearly constant at 10, except for spikes in May (n= 37) and August (n= 49). There were no records in December. In Wadduwa (figure 12c), the average number of records was 14, with the highest being 23 in July and the lowest being 2 in December. In Moratuwa (figure 12d), the number of records did not show a clear pattern and the highest was in May (n= 25), with none reported in September. The variation in Dehiwala (figure 12e) started with the highest in May (n= 28), followed by a plunge to n= 5 in June and a slight increase up to n= 23 in August. Decreased to n= 3 in September, followed by an increment of 1 in October. None reported in November and December. In Galle face (figure 12f), the records increased from n= 12 (May) to n= 39 (July) followed by a drop to n= 3 in

September, with no records in last three months. In Dikkowita (figure 12g), 20 records were reported as the highest in May, and none reported in June, November, and December. The records slightly increased from July (n=3) to October (n=12). In Sarakkuwa (figure 12h), fluctuations occurred with the highest in August (n=38) and May (n=11), July (n=3), August (n=2), and October (n= 3), but none during the other months.

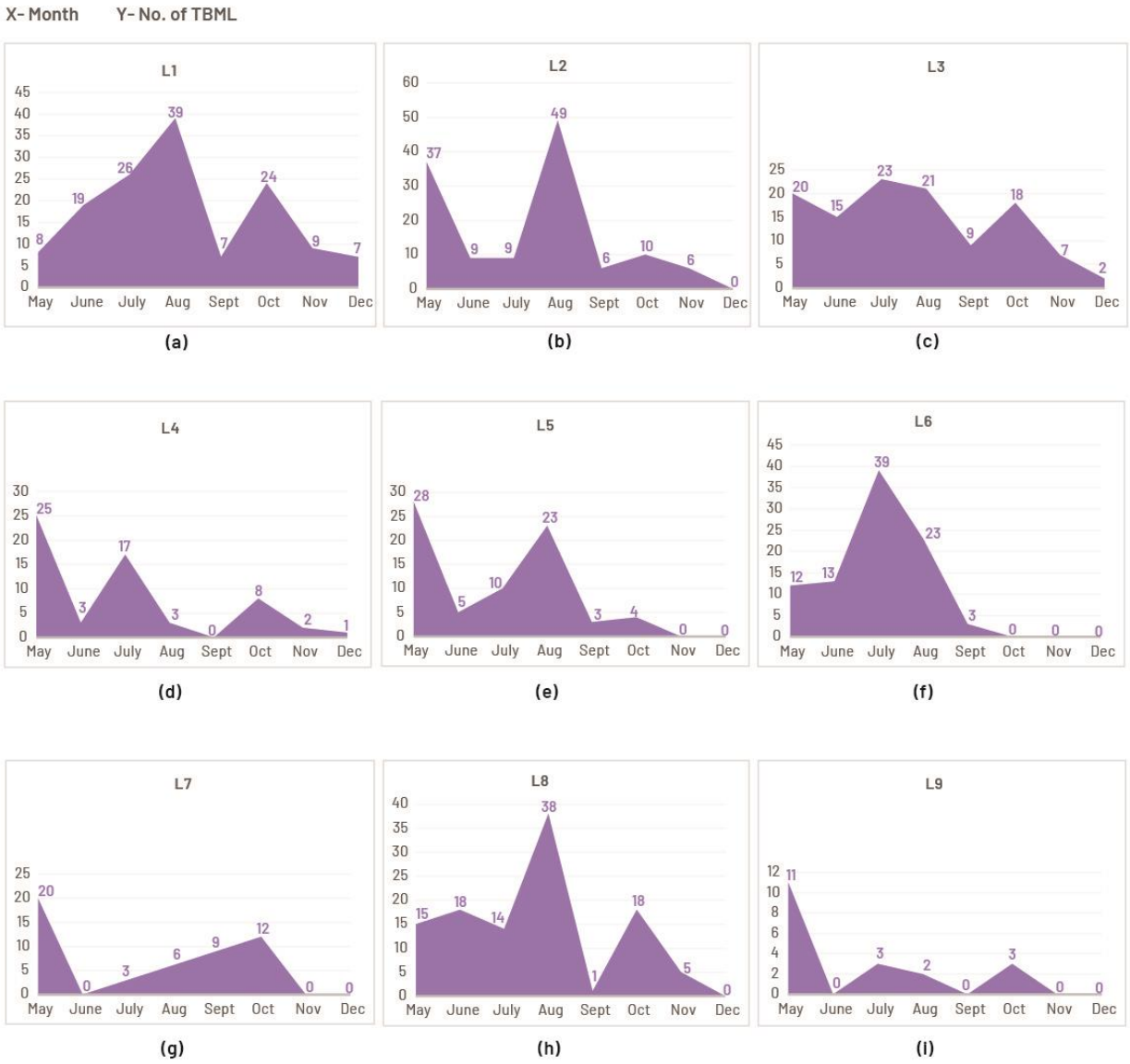


Figure 12: Temporal Variation of Transboundary Marine Litter along the west coast (a).Maggona, (b). Pothupitiya, (c).Wadduwa, (d). Moratuwa, (e). Dehiwala, (f). Galle Face, (g). Dikkowita, (h). Sarakkuwa. (i). Negambo Beach Park

3.2 Citizen Science Survey

Eight (8) locations were identified as survey locations (figure 13) according to the records related to citizen science survey which was conducted during May to December. Browns beach and Negambo blue beach had represented Gampaha district and six beaches (Galle Face, Wellawatte beach, Dehiwala beach, Ratmalana beach, Moratuwa beach and Koralawella beach) were recorded within Colombo district. None of records were found within Kalutara district.

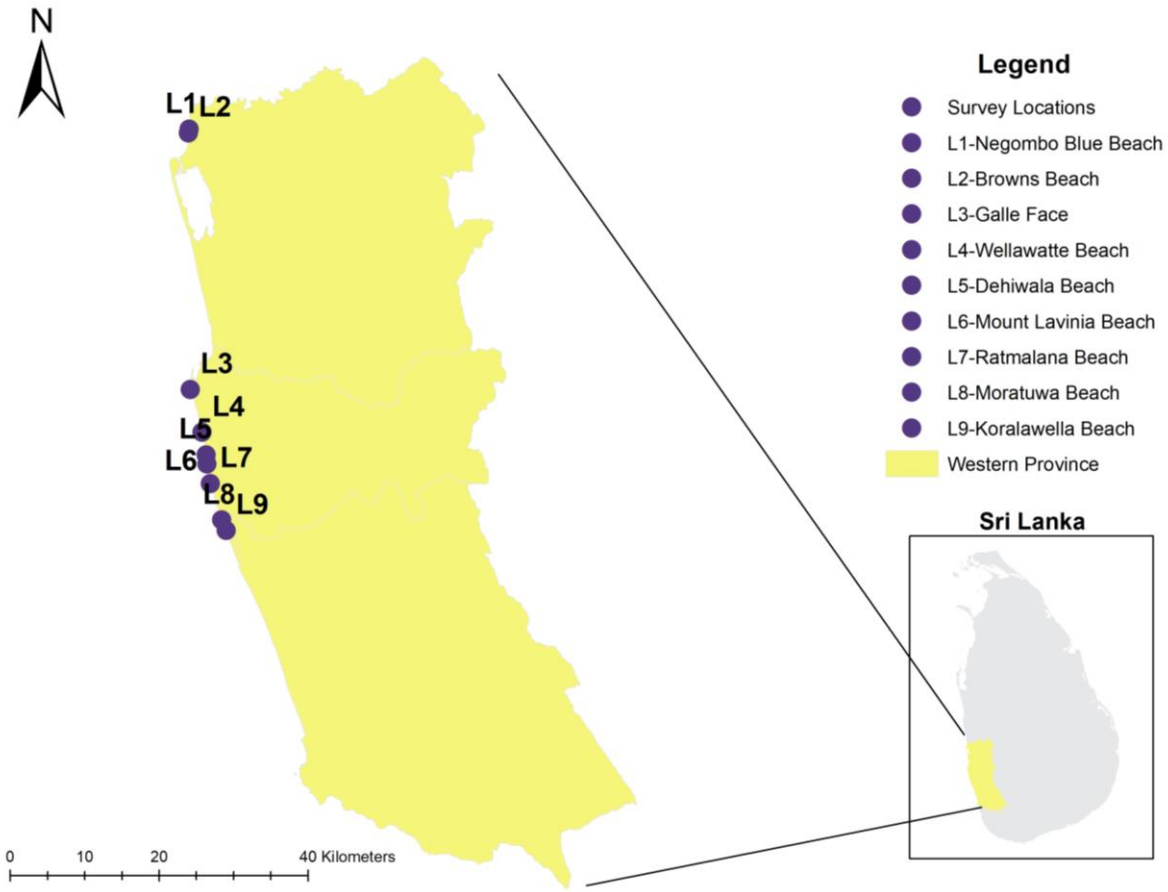


Figure 13: Survey Locations along the Western Province coast

3.2.1 Origin countries and their contribution to TBML

The Citizen Science survey conducted in this study also revealed the origin countries and their contribution to TBML. A total of 324 TBML items were recorded, and the results showed that India was the largest contributor, accounting for 59.4% of the litter, followed by China at 22.8%. Other countries such as Turkey, Myanmar, Bangladesh, Vietnam, Thailand, the USA, and Switzerland contributed up to 0.3%, while Iran and Singapore contributed up to 0.6%. The remaining contributions were reported from Malaysia (8.9%), UAE (2.5%), Indonesia (1.2%), and Maldives (1.8%). Additionally, the study found that 99% of TBMLs were reported from the Asian continent, while Europe and North America had a contribution of only 1%.

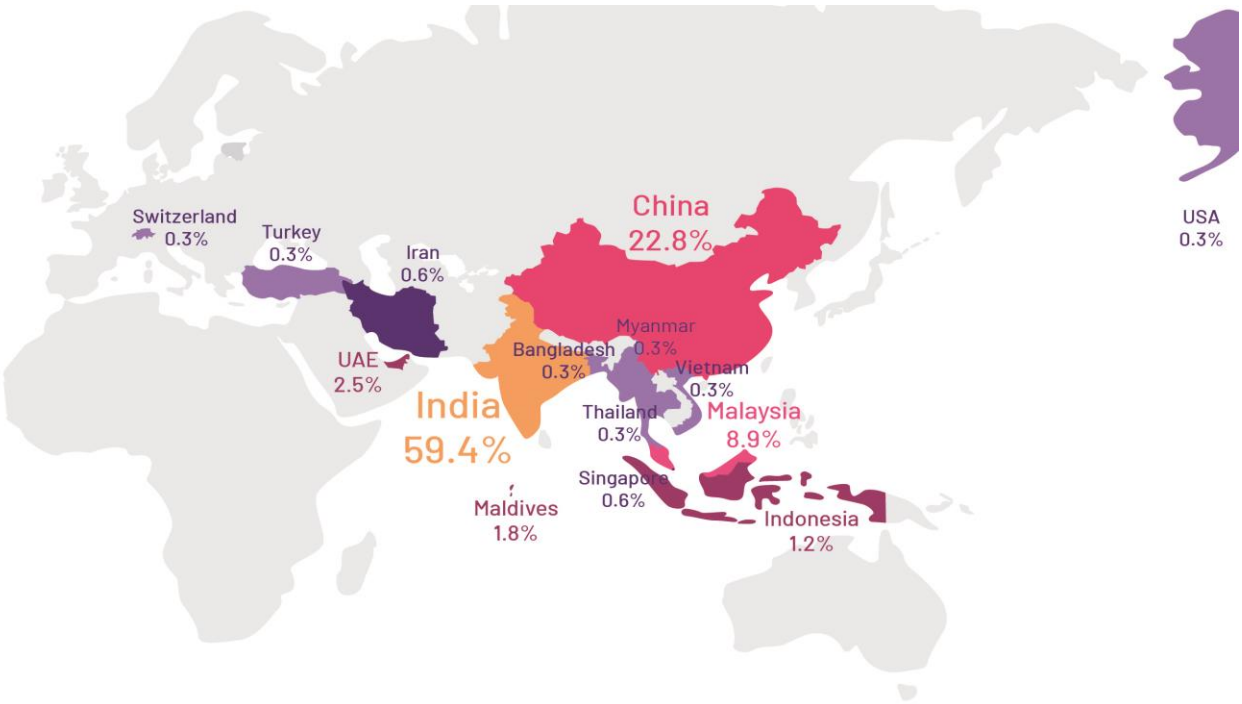


Figure 14: Origin countries and their contribution to TBML

3.2.2 Contribution of Indian states to TBML

The results of the Citizen Science survey further provide insight into the contribution of different states in India to the issue of TBML. Out of the 192 TBML identified in the survey, 13 states were found to be the origin of the litter. As seen on Figure 15, Tamil Nadu, located on the southeastern coast of India, was the major contributor to TBML, accounting for 27.7% of the total TBML identified. Kerala and Gujarat followed closely, with contributions of 24.3% and 22.8%, respectively. The remaining states had contributions of less than 10%.

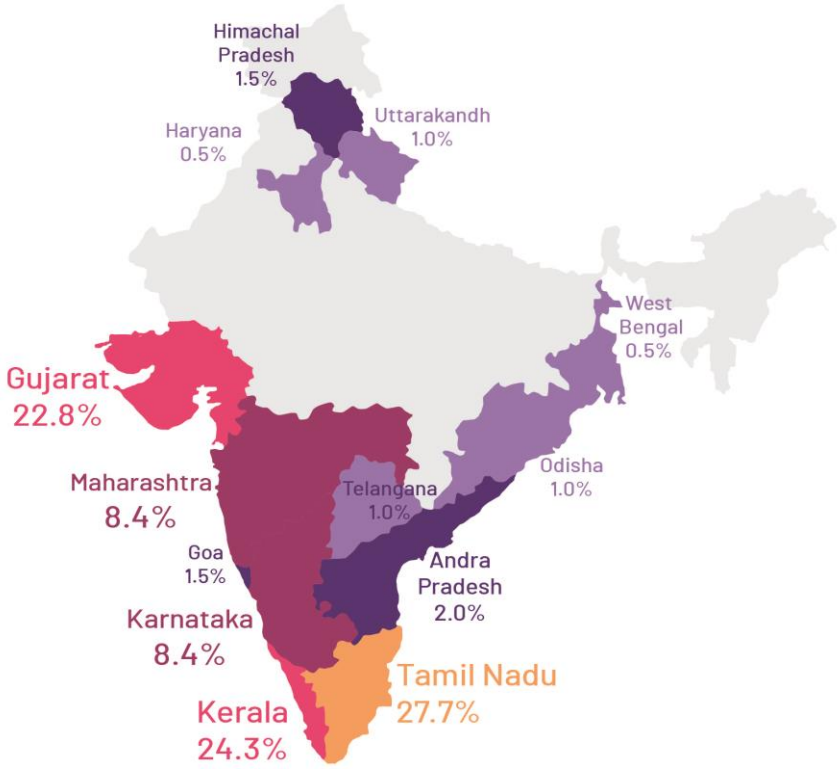


Figure 15: Contribution of Indian states to TBML

4 Discussion

4.1 Main survey

The results of the survey on the coastal stretch along the Western Province coast of the island show that the amount of TBML collected was 13% of the total 6057 PET bottles collected during the period of May to December. The monthly variation of TBML, local PET bottles, and total PET bottles was analyzed and represented in Figure 5. The data shows that while the local PET bottles and total PET bottles displayed a declining trend towards December, the number of TBML recorded peaked in two months, August and October.

Further analysis of the data revealed that the relative percentage of TBML increased from July to August and from September to October, while the total amount of PET bottles declined in those months. The highest amount of TBML was recorded in August, while the lowest was recorded in December. The total amount of PET bottles was recorded as the highest in May and the lowest in December. The relative percentage of TBML along with the total PET bottles was also recorded from May to December.

The origin countries of the TBML were determined as part of the study. The data collected showed that **Asia was the major contributor to the TBML encountered during the survey, accounting for 90.4% of the total.** Of the 780 records of TBML, 7.7% were unable to be identified and confirmed as to their origin. Europe contributed 1% to the TBML, while Africa contributed 0.5%. The contribution from North and South America was lower than 0.5% each. A closer examination of the data showed that **India was the leading contributor to the TBML, accounting for 66.79% of the total, followed by China at 14.62%.** These findings provide insight into the source of the TBML along the Western Province coast and highlight the importance of international collaboration in addressing the issue of marine litter.

The results of the study indicate that India was a significant contributor to the TBML found along the Western Province coast. The origin of the TBML was traced back to 12 different states in India, with Tamil Nadu being the major contributor followed by Maharashtra and Karnataka. **The data shows that 145 instances of TBML were recorded from Tamil Nadu, while 72 and 65 instances were recorded from Maharashtra and Karnataka respectively.**

Despite efforts to identify the origin of the TBML, 200 of the 522 instances recorded as originating from India were unable to be confirmed.

The distribution of TBML along the coastal stretch was found to vary greatly among the different survey locations. The concentration of TBML was highest at Maggona Beach and lowest at Negombo Beach Park. In terms of districts, Kalutara had the highest accumulation of TBML, which gradually decreased towards Wadduwa and drastically decreased in Moratuwa. The distribution of TBML increased towards Galle face and a sudden decrease at Dikkowita, with a clear increment in the amount of TBML in Sarakkuwa. These results provide an understanding of the distribution of TBML along the coastal stretch and highlight the areas that require further attention and intervention to reduce the amount of TBML in the region.

The results indicate that the temporal variation of TBML is characterized by fluctuations in the number of records during different months of the year. The results show that the highest concentration of TBML was recorded in May and August in most locations, with a drop in the number of records in September. However, there were some locations where the number of records did not show a clear pattern. The results also suggest that there were no records found in December in some of the survey locations.

The results highlight the importance of analyzing the temporal variation of TBML as it provides information on the dynamics of the accumulation of TBML at different locations. The study highlights the need for continuous monitoring of the distribution of TBML in order to better understand the mechanisms behind the accumulation of TBML and implement effective mitigation measures. As per results, the temporal variation of TBML is a multifaceted area, and requires further research to understand the causes of these fluctuations.

Sources of TBML

The study of TBML is important in order to understand its causes and develop effective strategies to lessen its impact. There are diverse sources of TBML, including:

Dumping from foreign countries: This occurs when litter is not properly disposed in one country and instead, is released into the ocean, where it can be carried by ocean currents and winds to another location.

Fishing activities: Fishing gear such as nets and lines can easily become lost or discarded in the ocean, where they continue to trap and harm marine life. In addition, some fishing vessels may also illegally dispose of litter at sea.

Freight: The shipping industry is a major contributor to TBML, with litter often being released accidentally during the transportation of goods. This can include non biodegradable items such as packaging, containers, and other waste material.

Littering: Littering, including on beaches and near waterways, can also result in litter being carried into the ocean and contributing to TBML.

Marine debris from natural disasters: Hurricanes, typhoons, and tsunamis can result in large amounts of debris being carried into the ocean, affecting marine ecosystems and wildlife.

Land-based sources: Runoff from land-based sources, such as rivers and coastal communities, can carry litter into the ocean, and can be moved to other locations by ocean currents and winds.

Transport by animals: Marine animals can inadvertently transport litter, such as by ingesting plastic debris and carrying it to new locations.

It is important to note that the sources of TBML can be complex and diverse, with multiple sources contributing to the problem in different ways. Further research is needed to better understand the causes and extent of TBML, in order to develop effective strategies for mitigating its impact.

The Impacts of Marine Litter including TBML

· **Traps marine life:** Litter can entangle, suffocate or injure marine animals, making it hard for them to move, feed, or mate.

·**Degrades the underwater habitats:** Litter can get accumulated in underwater habitats, such as sea beds or coral reefs, physically damage these environments, block sunlight, or alter the air quality and chemical composition of surrounding water, lowering the overall quality of those habitats.

· **Degrades coastal ecosystems:** Litter that washes up on the shore can impact coastal ecosystems, in ecologically sensitive areas, such as nesting sites for birds or habitats for sea turtles.

· **Acts as a carrier for invasive species:** Litter can carry non-native species to new environments, where they can outcompete native species and disrupt local ecosystems.

· **Breaks into micro plastics:** Marine litter can weather and break down into smaller plastic particles, known as micro plastics, which can be ingested by marine life and enter the food chain.

· **Challenging to collect, remove and recycle:** It can be hard to collect marine litter due to its widespread distribution, inaccessibility to many marine environments. And challenging to remove & recycle due to its presence in large quantities, and physical & chemical weathering over time.

· **Persistent in the environment:** Litter can remain in marine environments for centuries if they are non biodegradable, and continue to cause adversity.

· **Induce pollution in unpolluted areas:** Due the highly mobile nature of TBML by ocean currents and winds, it can travel from areas of high pollution to areas of lower pollution, and to areas where there were no pollution at all, adding up to the overall pollution in the region.

· **Waste of one country impacts people & environment of another country:** TBML allows the consumer behavior and poor waste management practices of one country, to impact people & environment of another country, irrespective of their own waste management strategies.

· **Litter of peculiar characteristics can cause unprecedented risks:** Litter from foreign sources can have different chemical or physical properties than local litter, which can pose unpredicted environmental & health risks.

· **Ambiguity of the source of TBML can desist targeted measures:** It can be challenging to trace back TBML to its original source, making it difficult to identify the cause of litter and to take any targeted measures to minimize its impact.

Figure 16: Barnacles attached to TBML

Figure 17: TBML prevalent at survey location

Figure 18: Surveying in Mt. Lavinia Beach

Figure 19: Research assistants surveying

4.2 Citizen Science Survey

The findings clearly demonstrate that **India is the largest contributor to TBML, accounting for 59.4% of the litter, which is a more than half of the total amount.** This suggests that there is a pressing need to address the root causes of marine litter in India to mitigate its impacts on the marine environment.

China's contribution of 22.8% to TBML is clearly a matter for concern. The study highlights the need for international collaboration to address the issue of TBML, which cannot be tackled by a single country alone. The contribution of other countries, such as Turkey, Myanmar, Bangladesh, Vietnam, Thailand, the USA, and Switzerland, while smaller, is still significant, and it emphasizes the need for a coordinated global response.

The study also found that 99% of TBML were reported from the Asian continent, while Europe and North America had a contribution of only 1%. This is not surprising given that Asia has the highest population and population growth rate in the world, leading to a continuous increase in waste generation. The findings underscore the need for global cooperation to address the issue of marine litter, which is a problem that affects all countries and regions, regardless of their location.

The contribution of different Indian states to the issue of TBML is an important aspect to consider in understanding the magnitude and spread of the problem. The results of the citizen science survey reveal that **Tamil Nadu, Kerala, and Gujarat were the top contributors to TBML, accounting for more than 75% of the total TBML identified.** These findings are significant, as they suggest that certain states may be more vulnerable to the problem of TBML due to their proximity to major shipping lanes or other factors such as population density, industrial activity, and waste management practices.

The high contribution of Tamil Nadu to TBML is particularly notable, as it is located on the southeastern coast of India and has a long coastline. The state is also home to several major ports and harbors, including Chennai Port and Kamarajar Port. The results suggest that these ports may be significant sources of TBML and that efforts to reduce the problem should focus on these areas. Kerala and Gujarat, the second and third top contributors, also

have long coastlines and major ports. Kerala is known for its tourist industry and has a significant population density, which could contribute to the generation of waste and the accumulation of litter. Gujarat, on the other hand, has a strong industrial sector and is home to several major ports, including Kandla Port and Mundra Port. These factors may explain the high contribution of these states to TBML.The results also indicate that the remaining states had relatively low contributions to TBML, which suggests that the problem is not uniform across India. This finding underscores the need for localized solutions to address the problem of TBML in specific regions, based on an understanding of the factors that contribute to the problem.

5 Conclusion and Recommendation

The study aimed to investigate the extent and distribution of TBML in different locations in Sri Lanka and to identify the origin countries and states of the litter. The results of the study indicate a significant presence of TBML along the coastlines of Sri Lanka, with the highest concentration being recorded at Maggona Beach. **The majority of the TBML was found to originate from Asia, with India being the major contributor, followed by China.** The 11 states in India that contributed to the TBML were primarily from Tamil Nadu, Maharashtra, and Karnataka. The study also revealed temporal variation in the amount of TBML, with the fluctuation of highest number of records being recorded during certain months of the year. Since the temporal variation of TBML is determined by several variables, further study is recommemded. The findings of this study provide insights into the magnitude and distribution of TBML in Sri Lanka and its origin countries and states, and can serve as a reference for the development of effective policies and regulations for waste management and the protection of the marine and coastal environment in the Indian ocean reigon.

Based on the results of the study, several recommendations can be made, to mitigate the issue of TBML of Sri Lanka.

Raise Awareness: One of the primary causes of TBML is lack of awareness among general public. There is a timely need to educate the general public on the aftermath of littering in to the ocean, choosing products with eco-friendly packaging and the necessity of preserving the marine environments. This can be done through both conventional (e.g.: mass media, social media campaigns, workshops, school programs etc.) and non-conventional media (e.g.: ambient advertising, art, theatre etc.)

Improve waste management: Sri Lanka needs to develop its waste management infrastructure to prevent litter from reaching the ocean. This can include increasing the waste collection points, improving transportation and proper disposal of solid waste.

Implementation of regulations: The government of Sri Lanka should implement regulations to prevent dumping of litter into the ocean and enforce penalties for those who violate those regulations.

Encourage the involvement of private sector: Industries that produce a large amount of waste should adopt practices that minimize the impact on the marine environment.

Strengthen monitoring and enforcement: The government should attentively monitor beaches and coastal areas to prevent illegal dumping of waste into the ocean. This can be done by having dedicated individuals & resources for the cause.

Community involvement: The local communities can play an important role in reducing the amount of TBML. Community-based clean-ups, volunteer initiatives can raise awareness & increase the contribution of individuals, towards reducing TBML.

Collaboration with neighboring countries: As TBML is a transboundary issue, it is important for Sri Lanka to collaborate with neighboring countries. Joint initiatives and agreements can help lessen the flow of litter across international borders and reducing the overall amount of TBML in the region.

Based on the results of the study, the following recommendations can be made to address the issue of TBML with regards to its country of origin and relevant companies.

Awareness Campaigns: Governments of the countries that were identified as having a high contribution to TBML, such as Tamil Nadu, Maharashtra, Karnataka, should raise awareness, and educate the public on the dangers of littering and the necessity of proper waste management.

Increased Monitoring and Enforcement: The relevant authorities should increase monitoring and enforcement of littering laws, especially in areas identified as having high TBML accumulation, such as Maggona Beach. This will help to reduce the amount of litter entering the ocean.

Industry Collaboration: Companies involved in industries that produce high volumes of packaging and single-use products, such as the fast-food and beverage industry, should collaborate with governments and NGOs to reduce their waste footprint and find more sustainable packaging alternatives.

Zero-Waste Initiatives: Governments should encourage and support the implementation of zero-waste initiatives, such as waste reduction, reuse, and recycling programs, to reduce the amount of waste generated and prevent it from ending up in the ocean.

International Cooperation: TBML is a global issue that requires international cooperation to address. Governments and organizations from different nations must work together to implement coordinated effective measures to reduce the amount of litter entering the ocean.

Research and Development: Further research and development should be conducted to better understand the sources, pathways, and impacts of TBML in the long term. This will help to develop more effective strategies to reduce its occurrence and mitigate its impacts on the ocean environment and marine life

It is recommended to extend this study island-wide in order to get a comprehensive understanding of the distribution and temporal variation of TBML in Sri Lanka. This will help to determine the sources of TBML and the areas that are most affected by it.

By doing so, the data collected will provide a map of areas that need immediate attention and help to prioritize action in the most impacted areas. Expanding the study island-wide will also provide information on the sources of TBML which can be used to work with relevant organizations and governments to implement measures to reduce the amount of TBML entering the ocean and to develop programs to clean up existing marine litter as well.

6 Annexure- Case Studies

Floating toys Incident

A prominent case of the floating toys of the Pacific Ocean has been of scientific and oceanographic discussion. A container vessel carrying a cargo of bath toys met with an accident during a storm where boxes carrying 28,800 bath toys in the form of rubber ducks spilled onto the ocean near the International Date Line (44.7 N, 178.1 E) on 10th January 1992. The cargo vessel heading from China to the United States destined to be delivered to 'The First Year Inc.' met with the abrupt storm which led to the spillage.

Since the spillage of the bath toys, many beachcombers, oceanographers and environmentalists have spent over a decade collecting the ducks from various coastlines across the world. First accounts of these rubber ducks appeared on the coast of Alaska after 10 months at sea on 16th November 1992. During early 1995, floating rubber ducks started appearing in North America and Hawaii. During 1995 and 2000, these floating toys started travelling through the Bering Strait to the cold waters of the Arctic Sea and started travelling eastwards. In 2000, the floating rubber ducks started appearing in the North Atlantic Ocean where sightings were reported from Massachusetts to Maine. The rubber ducks were reported from the sea where the Titanic sank in 2001. Subsequent reports of these ducks appearing in the coasts of New England, Canada, Iceland and even in Britain were recorded during 2003. The company 'The First Year Inc.' issues a cash reward of $100 for a wayward branded rubber duck returned to the company. It is estimated that 19,000 of

the floating toys have moved to the south of the Pacific Ocean washing up in Australia, Indonesia & South American coasts.

This case highlights how the floating objects moved through various oceans by the phenomenon known as **Coriolis Effect.** This effect explains the movement and the pattern of objects not physically connected to the ground which makes the object move long distances around the world. Due to the unequal movement of the earth's rotation compared to the poles with the equator, fluids tend to move faster closer to the equator. The Coriolis Effect appears to turn to the right in the Northern Hemisphere of the earth while turning the opposite way in the Southern Hemisphere. Depending on the velocity of the earth's rotation, its impact can be measured significantly with the speed or the distance. The Coriolis Effect is responsible for many large-scale weather and wind patterns seen across the globe.

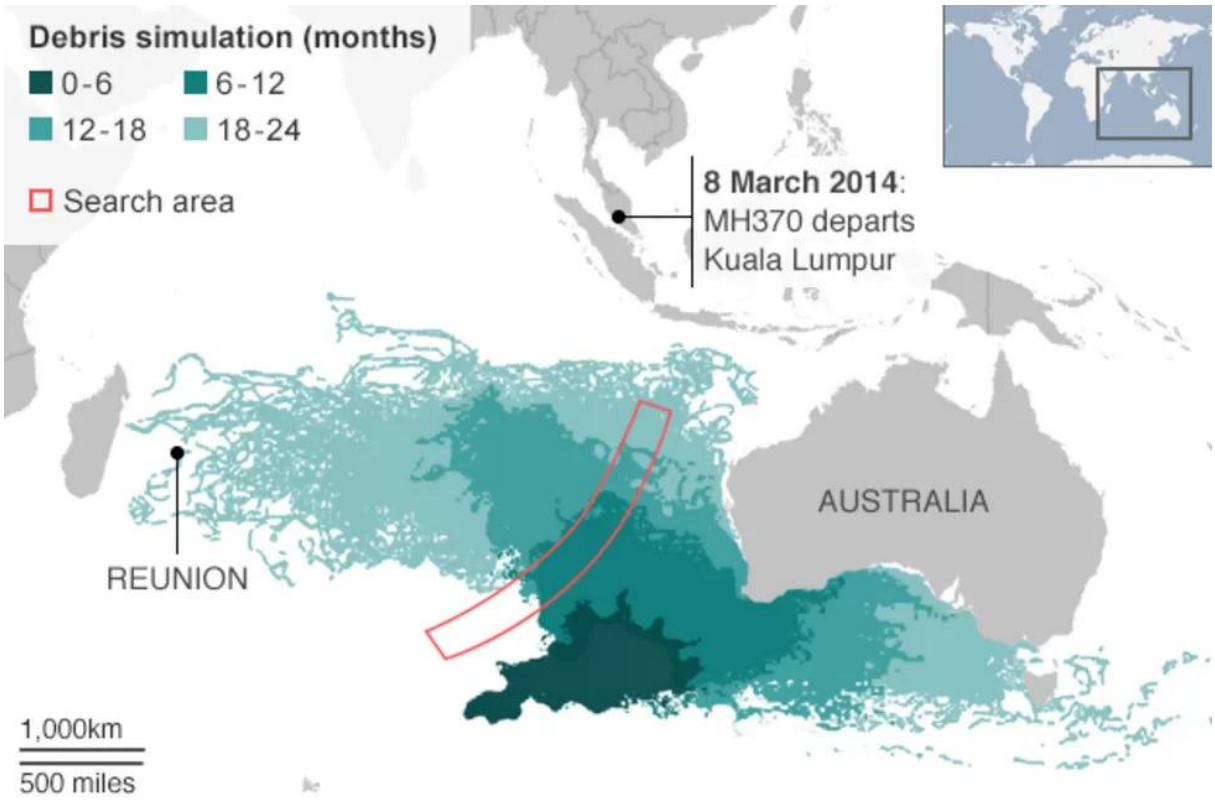
MH 370 Incident

On 7th of March 2014, flight 370 of Malaysian Airlines (MH370) disappeared off all radars and was believed to have crashed into an unknown location in the Indian Ocean. The transponder of the flight had been manually switched after the pilot had informed the passengers to have a good night. The flight was a scheduled passenger flight from Kuala Lumpur (Malaysia) to Beijing (China). The Boeing 777-200ER aircraft with 239 passengers and crew disappeared less than an hour after take-off. Air traffic control (ATC) lost both voice and radar contact with the flight while the aircraft was flying over the Gulf of Thailand. During initial reports, it was assumed the flight had crashed at sea, but a separate military radar located the aircraft as being deviated from its original flight path and flying towards Malaysia. Although there was no communication with the lost aircraft, the flight path was tracked by the aircraft's satellite terminal. Based on this data, it was ascertained that the aircraft changed course towards the south and continued in this direction until fuel ran out.

Based on the above information and criteria, scientists have mapped several key locations in the southern Indian Ocean in an effort to locate the aircraft wreck. The main criteria for the mapping were based on the constant distance to the satellite at the time of the final

communication with the aircraft. Yet the mapped area was significantly large and was deemed too difficult for a full-scale search. Extensive searches of the seabed were conducted based on the map created, however, the aircraft wreck has not yet been located.

New information of the location of the aircraft started emerging after parts of the aircraft have been recovered from the following sites; a flaperon, part of the right wing of the aircraft, found on the coast of Reunion in July 2015; a flap fairing from the right wing, found in Mozambique in 2015, and reported in March 2016; part of an engine cowling, found in South Africa in March 2016; part of the horizontal stabilizer, discovered off the coast of Mozambique in February 2015; a cabin interior panel, found on Rodrigues Island (Mauritius) in March 2016. Based on these findings, oceanographic modelling was used to predict the near exact location of the aircraft wreck. Using long-term global ocean and weather reconstructions, the super ensemble drift model was used to produce probability distributions for the surface drift of aircraft debris originating from the accident in southern Indian Ocean. Based on the information gathered through oceanographic data modelling simulations, new aircraft wreck searches are planned to be conducted in the near future.



Source: Professor of Coastal Oceanography, Charitha Pattiaratchi
School of Civil, Environmental and Mining Engineering & UWA Oceans Institute

BBC

7 References

Bergmann, M., Gutow, L., Klages, M. (2015) Marine anthropogenic litter, *Marine Anthropogenic Litter*. https://doi.org/10.1007/978-3-319-16510-3

Borrelle, S. B., Ringma, J., Law, K. L., Monnahan, C. C., Lebreton, L., McGivern, A., ... & Rochman, C. M. (2020). Predicted growth in plastic waste exceeds efforts to mitigate plastic pollution. *Science,* 369(6510), 1515-1518.

Clerkin, B. (2007, June 27) *Thousands of rubber ducks to land on British shores after 15 year journey*. Mail Online. https://www.dailymail.co.uk/news/article-464768/Thousands-rubber-ducks-land-British-shores-15-year-journey.html

Dauvergne, P. (2018). The power of environmental norms: marine plastic pollution and the politics of microbeads. *Environmental Politics,* 27(4), 579-597.

De Vos, A., Pattiaratchi, C. B., & Wijeratne, E. M. S. (2014). Surface circulation and upwelling patterns around Sri Lanka. *Biogeosciences,* 11(20), 5909-5930.

Duhec, A. V., Jeanne, R.F., Maximenko, N., Hafner, J.(2015) Composition and potential origin of marine debris stranded in the Western Indian Ocean on remote Alphonse Island, Seychelles. Mar. Pollut. Bull. 96, 76–86. https://doi.org/10.1016/j.marpolbul.2015.05.042

Edwards, K.F. and Stachowicz, J.J. (2010), Multivariate trade-offs, succession, and phenological differentiation in a guild of colonial invertebrates. *Ecology,* 91: 3146-3152. https://doi.org/10.1890/10-0440.1

Follow the Friendly Floatees. National Geographic Society (2020). https://www.nationalgeographic.org/activity/follow-friendly-floatees/

Gabrys, J., Hawkins, G., & Michael, M. (Eds.). (2013). *Accumulation: The material politics of plastic.* Routledge.

Galgani, F., Leaute, J. P., Moguedet, P., Souplet, A., Verin, Y., Carpentier, A., & Nerisson, P. (2000). Litter on the sea floor along European coasts. *Marine pollution bulletin,* 40(6), 516-527.

Galgani, F., Souplet, A., & Cadiou, Y. (1996). Accumulation of debris on the deep sea floor off the French Mediterranean coast. *Marine Ecology Progress Series,* 142, 225-234.

Galil, B. S., Golik, A., & Türkay, M. (1995). Litter at the bottom of the sea: a sea bed survey in the Eastern Mediterranean. *Marine pollution bulletin,* 30(1), 22-24.

Geyer, R., Jambeck, J.R., Law, K.L. (2017) Production, use, and fate of all plastics ever made - Supplementary Information. Sci. Adv. 3, 19–24. https://doi.org/10.1126/sciadv.1700782

Gibb, B.C. (2019) Plastics are forever. Nat. Chem. 11, 394–395. https://doi.org/10.1038/s41557-019-0260-7

Jansen, E., Coppini, G., Pinardi, N., (2016). Drift simulation of MH370 debris using superensemble techniques. *NHESS.* 16(7) https://doi.org/10.5194/nhess-16-1623-2016

Krakstad, J.O., Jayasinghe, P., Totland, A., Dalpadado, P., Søiland, H., Cervantes, D. et al., (2018) Survey of regional resources and ecosystems of the Bay of Bengal: part 1 Sri Lanka, 24 June- 16 July 2018. NORAD-FAO programme GCP/GLO/690/NOR, Cruise reports Dr. FRIDTJOF NANSEN, EAF-Nansen/CR/2018/8 162 pp

Mitchell, J.T., Hance, D. (2014). Map skills, Ocean currents, Pollution, and a Rubber Duck? *The Geography Teacher.* 11(3). https://rb.gy/mniehm

Rathnasuriya, M. I. G., Mateos-Rivera, A., Skern-Mauritzen, R., Wimalasiri, H. B. U., Jayasinghe, R. P. P. K., Krakstad, J. O., & Dalpadado, P. (2021). Composition and diversity of larval fish in the Indian Ocean using morphological and molecular methods. *Marine Biodiversity*, 51, 1-15.

South Africa. Department of Agriculture, & Muir, J. (1937). *The seed-drift of South Africa and some influences of ocean currents on the strand vegetation.* Government Printer, South Africa.

Subarna, D. (2018, March). The effect of monsoon variability on fish landing in the Sadeng Fishing Port of Yogyakarta, Indonesia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 139, No. 1, p. 012027). IOP Publishing.

The Coriolis Effect: Earth's Rotation and Its Effect on Weather. National Geographic (2023). https://education.nationalgeographic.org/resource/coriolis-effect

Thiel, M., Hinojosa, I. A., Miranda, L., Pantoja, J. F., Rivadeneira, M. M., & Vásquez, N. (2013). Anthropogenic marine debris in the coastal environment: a multi-year comparison between coastal waters and local shores. *Marine pollution bulletin,* 71(1-2), 307-316.

Topçu, E. N., Tonay, A. M., Dede, A., Öztürk, A. A., & Öztürk, B. (2013). Origin and abundance of marine litter along sandy beaches of the Turkish Western Black Sea Coast. *Marine environmental research,* 85, 21-28.

8 Summary

Transboundary marine litter (TBML) refers to any persistent manufactured or processed solid waste that ends up in the marine environment, crossing international borders. These marine debris made up of materials such as plastic, metal, and rubber and can come from various land based activities, shipping and fishing.

The movement of TBML can have serious consequences for marine ecosystems and wildlife, human safety and economy as well. In order to mitigate these impacts, it is crucial to understand the forms in which TBML occurs, their sources and pathways. This study was conducted to address a knowledge gap regarding TBML in the Indian Ocean region, and to establish a baseline for comprehending the accumulation of TBML along the Western Province coast of Sri Lanka over time.

The study was conducted in two components; the main survey and Citizen Science survey.

Main Survey: Nine locations from the districts of Kalutara, Colombo, and Gampaha were selected for the survey based on the accessibility, visibility, and prevalence of marine litter in the area. At each location, an area of 200m length and width from the tide line to a maximum of 10 meters inland, was surveyed. In this study, foreign marine debris which cannot be purchased locally is considered TBML and the focus of the survey was on stranded liquid containers. The accumulation of TBML was analyzed according to the country of origin, location, and monsoon season.

Citizen science survey: The citizen science program was aimed at involving students from academia, coastal communities, and beachgoers in research. An online data gathering platform accessible to the general public was established. Participants, known as citizen scientists, were requested to provide metadata about themselves, the exact location of the TBML found, and clear images of the TBML (including the country of origin and brand name). Data collected through the main survey and the citizen science survey was analyzed separately and the followings results stand out as key points for concern.

> During the survey period from May to December, a total of 6057 PET bottles were collected from the Western Province coast. Out of these, 780 bottles were identified as **TBML which is 13% of the total bottles surveyed.**
>
> **When looking at the origin countries of TMBL and their contribution as a proportion (Figure 8), India is the major contributor (66.79%) of TBML, followed by China (14.62%).**

The TBML originating from India was traced back to 11 states (Figure 10). The majority of the TBML was recorded from Tamil Nadu, with 145 instances and the least contribution was from Madhya Pradesh, with 1 recorded instance.

When considering the continent-wise contribution, (Figure 9) Asia is the major contributor (90.4%) of the TBML. Out of 780 records, 7.7% were categorized as unidentified as their origin was ambiguous.

When looking at the spatial variation of TBML along the Western Province coast (Figure 11), the **highest concentration of TBML was recorded at Maggona Beach, with 139 items and the lowest concentration was at Negombo Beach Park, with 19 items recorded.** The temporal variation of TBML was characterized by fluctuations in the number of records during different months (Figure 12).**The number of TBML peaked in July, August and October and declined towards December.** As the temporal variation of TBML has multiple variables further research is needed to understand the causes of the fluctuations.

The results of the citizen science survey (Figure 14) also revealed that the **India being the largest contributor, accounting for 59.4% of the litter, followed by China at 22.8%.** 13 Indian states were found to be responsible for the litter (Figure 15).Tamil Nadu, located on the southeastern coast of India, was the major contributor to TBML, accounting for 27.7% of the total TBML identified. Kerala and Gujarat followed closely, with contributions of 24.3% and 22.8%, respectively.

Other countries such as Turkey, Myanmar, Bangladesh, Vietnam, Thailand, the USA, and Switzerland contributed up to 0.3%, while Iran and Singapore contributed up to 0.6%. The remaining contributions were reported from Malaysia (8.9%), UAE (2.5%), Indonesia (1.2%), and Maldives (1.8%). Accordingly, **99% of TBML were reported from Asian continent, while Europe and North America had a contribution of 1%.**

As found in the study, TBML can result from the dumping of litter into the ocean by foreign countries , discarded or lost gear during fishing activities, waste generated in freight, runoff from land-based sources & coastal communities, marine debris from natural disasters and by transport via marine animals through ingestion etc. With multiple sources contributing in various ways, further research is needed to better understand the causes and the scope of the issue of TBML.

This study also highlights the diverse and extensive impacts of TBML. To name some, TBML can entangle, suffocate and otherwise harm marine animals, settle underwater and degrade the quality of marine habitats, and often act as a carrier for invasive species. TBML can travel from areas of high abundant pollution to areas of less pollution making any ecologically sensitive areas vulnerable. Litter of peculiar characteristics than those of local

litter can impose additional risks on environment and human health. It can be challenging to collect and remove marine litter due to its widespread distribution, inaccessibility to some marine environments, its presence in large quantities and physical & chemical weathering over time. It can equally be hard to trace back to the source of TMBL, making it difficult to understand the cause of litter and to take targeted measures to minimize them ending up in the ocean.

Several recommendations that can be made to mitigate the issue of TBML in the region are as below. Raising awareness of the general public on the aftermath of littering in to the ocean, Implementation of regulations to prevent illegal dumping of waste into the ocean, Improve waste management infrastructure, Strengthening the monitoring & enforcement by having dedicated individuals & resources for the cause, Encouraging the involvement of private sector, Collaborating with neighboring countries on joint initiatives and agreements can help lessen the flow of litter across international borders reducing the overall amount of TBML in the region, Collaborating with Industries to reduce their waste footprint & to opt for more sustainable packaging alternatives etc.

It is clear that TBML is a complex and far-reaching problem that requires a multifaceted approach to mitigate its impacts. Further research is needed to better understand the different forms and origin of TBML and, to develop strategies for reducing the amounts of litter entering the ocean, as well as improving the removal and recycling of existing litter. The findings of this study will contribute to the development of effective strategies for addressing TBML in the Indian Ocean region. It is a timely need to actively address the issue of TBML and protect our oceans, marine life, and ecosystems for future, and for all.

8.1 සාරාංශය

සීමාන්තර සාගර අපද්‍රව්‍ය හෙවත් Transboundary marine litter (TBML) යනු ජාත්‍යන්තර දේශසීමා තරණය කරමින් සමුද්‍ර පරිසරයට එකතු වන, නිෂ්පාදිත හෝ සකසන ලද ඝන අපද්‍රව්‍ය වේ. මෙම සාගර සුන්බුන්, ප්ලාස්ටික්, ලෝහ සහ රබර් වැනි ද්‍රව්‍ය වලින් සෑදී ඇති අතර, ගොඩබිම් ආශ්‍රිත විවිධ මිනිස් ක්‍රියාකාරකම්, නාවික කටයුතු මෙන්ම ධීවර කර්මාන්තය මගින් මුහුදට එක්විය හැකියි.

TBML වල එක්රැස් වීම සහ සංචලනය මගින්, සාගර පරිසර පද්ධති, සමුද්‍ර ජීවීන්, මානව ආරක්ෂාව මෙන්ම ආර්ථිකය වෙත නොයෙකුත් අහිතකර බලපෑම් ඇති විය හැකිය. මෙම බලපෑම් අවම කිරීම සඳහා, TBML වල විවිධ ස්වරූප, ඒවායේ මූලාශ්‍ර සහ ඒවා සංචලනය වන මාර්ග අවබෝධ කර ගැනීම අත්‍යාවශ්‍ය වේ. ඉන්දියානු සාගර කලාපයේ TBML සම්බන්ධව දැනට ඇති දැනුමේ මද බව පිරවීටත්, කාලයත් සමඟ ශ්‍රී ලංකාවේ බස්නාහිර පළාත් වෙරළ තීරයේ TBML එක්රැස් වීම අවබෝධ කර ගැනීම සඳහා මූලික දැනුමක් ඇති කිරීමටත් මෙම පර්යේෂණය සිදු කරන ලදී.

මෙම පර්යේෂණය; ප්‍රධාන සමීක්ෂණය සහ පුරවැසි විද්‍යා සමීක්ෂණය යන ක්‍රම දෙක මගින් සිදු කරන ලදී.

ප්‍රධාන සමීක්ෂණය: ප්‍රදේශයේ සාගර අපද්‍රව්‍යවල දෘශ්‍යතාව, බහුලත්වය, සහ ප්‍රවේශ වීමේ හැකියාව මත පදනම්ව, සමීක්ෂණය සඳහා කළුතර, කොළඹ සහ ගම්පහ දිස්ත්‍රික්කවලින් ස්ථාන නවයක් තෝරා ගන්නා ලදී. සෑම ස්ථානයකම, මීටර් 200 ක් දිග සහ වඩදිය රේඛාවේ සිට ගොඩබිම දෙසට උපරිම වශයෙන් මීටර් 10 ක් දක්වා පළල ප්‍රදේශයක් තුල සමීක්ෂණය කරන ලදී. මෙම අධ්‍යයනයේදී දේශීයව මිලදී ගත නොහැකි විදේශීය සමුද්‍ර සුන්බුන් TBML ලෙස සලකනු ලබන අතර සමීක්ෂණයේ වැඩි අවධානය යොමු වූයේ ගොඩගසන ලද ද්‍රව්‍ය බහාලුම් කෙරෙහිය. එක්රැස් වූ TBML වාර්තා වූ ස්ථානය, නිෂ්පාදිත රට සහ මෝසම් සමය අනුව විශ්ලේෂණය කරන ලදී.

පුරවැසි විද්‍යා සමීක්ෂණය: පුරවැසි විද්‍යා වැඩසටහනේ අරමුණ වූයේ සිසුන්, වෙරළබඩ ප්‍රජාවන් සහ වෙරළ සැරිසරන්නන් පර්යේෂණ සඳහා සම්බන්ධ කර ගැනීමයි. පොදු ජනතාවට දත්ත ඇතුළු කර හැකි පරිදි දුරස්ථ මාර්ගගත දත්ත රැස් කිරීමේ වේදිකාවක් ස්ථාපිත කරන ලදී. පුරවැසි විද්‍යාඥයන් ලෙස හඳුන්වනු ලබන සහභාගිවන්නන්ගෙන් ඔවුන් පිළිබඳ පාරදත්ත, සොයාගත් TBML හි නිශ්චිත ස්ථානය සහ TBML හි පැහැදිලි ජායාරූප (නිෂ්පාදිත රට සහ වෙළඳ නාමය ඇතුළුව) ලබා දෙන ලදී. ප්‍රධාන සමීක්ෂණය සහ පුරවැසි විද්‍යා සමීක්ෂණය හරහා එකතු කරන ලද දත්ත වෙන වෙනම විශ්ලේෂණය කරන ලද අතර පහත ප්‍රතිඵල අවධානයට ලක්විය යුතු කරුණු ලෙස කැපී පෙනේ.

> මැයි සිට දෙසැම්බර් දක්වා වූ සමීක්ෂණ කාලය තුළ බස්නාහිර පළාත් වෙරළ තීරයෙන් PET බෝතල් 6057ක් එක්රැස් කර ඇත. ඉන් බෝතල් 780 ක් TBML ලෙස හඳුනාගෙන ඇති අතර එය සමීක්ෂණයට ලක් කළ මුළු බෝතල්වලින් 13% කි.
>
> වාර්තා වූ TMBL නිෂ්පාදිත රටවල්, සහ එම රටවල දායකත්වය ප්‍රතිශතයක් ලෙස බලන විට (රූපය 8), ඉන්දියාව ප්‍රධාන ලෙස වගකිව යුතු අතර (66.79%), චීනය (14.62%) ඉන්දියාවට පමණක් දෙවැනි වේ. ඉන්දියාවෙන් වාර්තා වූ TBML ප්‍රාන්ත 11 කට අයත් වේ.(රූපය 10). බහුතරය තමිල්නාඩුවෙන් (අවස්ථා 145ක්) සහ අවමය මධ්‍ය ප්‍රදේශ් වෙතින් (අවස්ථා 1ක්) වාර්තා වී ඇත.

මහාද්වීපය අනුව දායකත්වය සලකා බැලීමේදී, (රූපය 9) TBML වලින් 90.4% ක්ම වාර්තාවන්නේ ආසියාවෙනි. වාර්තා වූ TBML 780 න් 7.7%ක් ඒවායේ නිෂ්පාදිත රට අපැහැදිලි බැවින් හඳුනා නොගත් ඒවා ලෙස වර්ග කරන ලදී.

බස්නාහිර පළාත් වෙරළ තීරයේ TBML හි අවකාශීය විචලනය දෙස බැලීමේදී (රූපය 11), වැඩිම TBML සාන්ද්‍රණය මග්ගොන වෙරළ තීරයේ ද (අවස්ථා 139) අඩුම සාන්ද්‍රණය මීගමුව වෙරළ උද්‍යානයේ ද (අවස්ථා 19) වාර්තා වී ඇත. TBML හි කාලානුරූප විචලනය විවිධ මාසවල වාර්තා සංඛ්‍යාවේ උච්චාවචනයන් මගින් හඳුනාගන්නා ලදී (රූපය 12). TBML සංඛ්‍යාව ජූලි, අගෝස්තු සහ ඔක්තෝබර් මාසවල ඉහළ ගොස් දෙසැම්බර් දක්වා ක්‍රමයෙන් අඩු විය. TBML හි කාලානුරූප විචලනය, විචල්‍ය කිහිපයක් ඇති විෂය කොටසක් බැවින් මෙම උච්චාවචනයන්ට හේතු අවබෝධ කර ගැනීමට වැඩිදුර පර්යේෂණ අවශ්‍ය වේ.

පුරවැසි විද්‍යා සමීක්ෂණයේ ප්‍රතිඵල මගින්ද (රූපය 15) හෙළිදරව් වූයේ, ඉන්දියාව TBML වලින් වැඩි කොටසකට 59.4% හේතුවන බවයි. ඉන්දියාවේ ප්‍රාන්ත 13 කට අයත් TBML සොයා ගන්නා ලදී. (රූපය 15). ඉන්දියාවේ ගිනිකොනදිග වෙරළ තීරයේ පිහිටා ඇති තමිල්නාඩුව, එම TBML වල බහුතරය නිපදවා ඇති අතර එය මුළු TBML වලින් 27.7% ක් විය. කේරල සහ ගුජරාටය ද පිළිවෙලින් 24.3% සහ 22.8% ලෙස සමීප අගයන් දක්වයි.

මේ අතර චීනය ද මුළු TBML වලින් 22.8% අගයක් දක්වයි. (රූපය 14). මීට අමතරව මැලේසියාව (8.9%) ලෙසද, එක්සත් අරාබි එමීර් රාජ්‍යය (2.5%), ඉන්දුනීසියාව (1.2%) සහ මාලදිවයින (1.8%) ලෙසද ඉරානය සහ සිංගප්පූරුව 0.6% බැගින් ද දක්වයි. ඉතිරි දායකත්වය තුර්කිය, මියන්මාරය, බංග්ලාදේශය, වියට්නාමය, තායිලන්තය, ඇ. එක්සත් ජනපදය සහ ස්විට්සර්ලන්තය වැනි අනෙකුත් රටවල් වලින් 0.3% ක් බැගින් වාර්තා විය. මේ අනුව TBML වලින් 99% ක් ආසියානු මහාද්වීපයෙන් වාර්තා වූ අතර යුරෝපයේ සහ උතුරු ඇමරිකාවේ දායකත්වය 1% කි.

අධ්‍යයනයෙන් සොයා ගන්නා ලද පරිදි, TBML වල මූලාශ්‍ර විවිධාකාර වේ. විදේශ රටවල් විසින් සාගරයට අපද්‍රව්‍ය බැහැර කිරීම, ධීවර කටයුතු වලදී ඉවතලන හෝ නැතිවූ ආම්පන්න, මුහුදු මගින් භාණ්ඩ ප්‍රවාහනයේදී ජනනය වන අපද්‍රව්‍ය, ගොඩබිම සිදුකරන මානව ක්‍රියාකාරකම් සහ වෙරළබඩ ප්‍රජාවන්ගෙන් අපද්‍රව්‍ය එක්වීම, ස්වාභාවික විපත් වලින් එක් වන සමුද්‍ර සුන්බුන්, සහ සාගර සතුන් ආහාරයට ගැනීම හරහා ප්‍රවාහනය වීම යනාදිය දැක්විය හැකියි. විවිධ මූලාශ්‍ර මගින්, විවිධාකාරයේ TBML ජනනය කිරීම නිසා, ඒවා එකිනෙක සාගරයෙන් අවසන් වීමට හේතු වඩාත් හොඳින් අවබෝධ කර ගැනීම සඳහා වැඩිදුර පර්යේෂණ අවශ්‍ය වේ.

මෙම අධ්‍යයනය මගින් TBML ඇතුළු සාගර අපද්‍රව්‍ය වල සංකීර්ණ බලපෑම් ද අවධානයට ලක් කෙරෙයි. අපද්‍රව්‍ය කොටස් වල මුහුදු ජීවීන් පැටලීම, හුස්ම හිරවීම සහ වෙනත් ආකාරවලින් හානි වීම සිදු වෙයි. මුහුදු ජීවීන්ගේ ආහාර ගැනීම, චලනය, ප්‍රජනනය ආදී ක්‍රියාකාරකම් වලට බාධා වෙයි. අපද්‍රව්‍ය දිය යට තැන්පත් වීමෙන් කොරල් පර, මුහුදු තෘණ බිම් ආදියට හානි වීම, හිරු එලිය සහ වාතාශ්‍රය නොලැබීම සහ අපද්‍රව්‍ය නිසා ජලයේ සංයුතිය වෙනස් වීමෙන් සමුද්‍ර වාසස්ථානවල ගුණාත්මක භාවය පිරිහීම සිදුවේ. TBML වෙරළට ගසාගෙන ආ පසු වෙරළාශ්‍රිත පරිසර සහ සතුන්ටද බලපෑම් කල හැකියි. TBML බොහෝ විට ආක්‍රමණශීලී විශේෂ සඳහා වාහකයක් ලෙස ක්‍රියා කල හැකිය.

TBML වල වඩාත් අවධානය යොමු වන ලක්ෂණයක් නම්, එක් රටක ජනතාවගේ පරිභෝජන රටාව සහ දුර්වල අපද්‍රව්‍ය කළමනාකරණ නිසා තවත් රටක පරිසරය සහ ජනතාව අවධානමට ලක් වීමයි. TBML, සමුද්‍ර දූෂණය වැඩි ලෙස පවතින ප්‍රදේශ වල සිට පරිසර විද්‍යාත්මකව සංවේදී ප්‍රදේශද අවධානමට ලක් කරමින් සමුද්‍ර දූෂණයක් ඇති ප්‍රදේශ දක්වා ගමන් කළ හැකිය. දේශීය අපද්‍රව්‍ය වලට වඩා වෙනස්, නුපුරුදු භෞතික සහ රසායනික ගුණ සහිත විදේශීය අපද්‍රව්‍ය පරිසරයට සහ මිනිස් සෞඛ්‍යයට අමතර අවදානමක් ඇති කළ හැකිය. දිරාපත් නොවන ද්‍රව්‍ය වලින් සෑදී ඇති TBML, පාරිසරික තත්ව මත ඉතා කුඩා ප්ලාස්ටික් කොටස් දක්වා බිඳවැටෙන අතර සතුන්ගේ ආහාරයට එක්වීමෙන් ආහාර දාම වල ඉහලට ගමන් කරයි. TBML කෙතරම් හානිදායක වුවද, ඒවායේ පුළුල් පැතිරීම, විශාල ස්කන්ධයන් ලෙස පැවතීම, සමහර සමුද්‍ර පරිසරයන්ට ප්‍රවේශ විය නොහැකි වීම, සහ කාලයත් සමඟ භෞතික හා රසායනික කාලගුණික තත්ත්වයන් හේතුවෙන් විපරීත වීම යනාදී හේතූන් නිසා TBML එකතු කිරීම, ඉවත් කිරීම, සහ ප්‍රතිචක්‍රීකරණය කිරීම අභියෝගාත්මක විය හැකිය. අනෙක් අපද්‍රව්‍ය මෙන් නොව සමහර TMBL වල මූලාශ්‍රය හඳුනා ගැනීමට නොහැකි වීම, ඒවා සාගරයට එක් කිරීමේ/ එක් වීමේ හේතුව තේරුම් ගැනීමත් එහි බලපෑම අවම කිරීම සඳහා ඉලක්කගත පියවර ගැනීමත් දුෂ්කර කරයි.

මෙම පර්යේෂණයේ නිර්දේශ ලෙස, කලාපයේ TBML ගැටළුව අවම කිරීම සඳහා ශ්‍රී ලංකාව තුල අන්තර්ජාතිකව ක්‍රියාත්මක කළ හැකි යෝජනා කිහිපයක් පහත දැක්වේ. සාගරයට අපද්‍රව්‍ය දැමීමෙන් සිදුවන දිගුකාලීන අහිතකර ප්‍රතිඵල පිළිබඳව සාමාන්‍ය ජනතාව දැනුවත් කිරීම, නීතිවිරෝධී ලෙස සාගරයට අපද්‍රව්‍ය බැහැර කිරීම වැළැක්වීම සඳහා නීති රෙගුලාසි ක්‍රියාත්මක කිරීම, ඝන අපද්‍රව්‍ය කළමනාකරණය සඳහා ඇති යටිතල පහසුකම් වැඩිදියුණු කිරීම, ඒ සඳහා කැපවූ පුද්ගලයින් සහ සම්පත් ලබාගෙන අධීක්ෂණය බලාත්මක කිරීම, පුද්ගලික අංශයේ මැදිහත්වීම සිදු කල හැකියි. TBML යනු කලාපීය මෙන්ම ගෝලීය ගැටළුවක් වන බැවින් අසල්වැසි රටවල් සමඟ ඒකාබද්ධ මුලපිරීම් සහ ගිවිසුම් මත සහයෝගයෙන් කටයුතු කරමින් ජාත්‍යන්තර දේශසීමා හරහා අපද්‍රව්‍ය සංචලනය අඩු කිරීමෙන් කලාපයේ සමස්ත TBML ප්‍රමාණය අඩු කිරීම අත්‍යාවශ්‍ය වේ. කර්මාන්ත සහ නිෂ්පාදන සමාගම් (විශේෂයෙන් ආහාර පාන, පානීය ජලය, බෙහෙත්, පිරිසිදුකාරක සහ රුපලාවන්‍ය ද්‍රව්‍ය) සමග සාකච්ඡා කිරීමෙන් ඔවුන්ගේ අපද්‍රව්‍ය ප්‍රමාණය අඩු කිරීමට සහ වඩාත් නිරසාර විකල්ප ඇසුරුම් ක්‍රම සහ ඇසුරුම් ද්‍රව්‍ය තෝරා ගැනීමට යෝජනා කිරීම අතිශය වැදගත් වේ.

මේ අනුව TBML යනු එහි බලපෑම් අවම කිරීම සඳහා බහුවිධ ප්‍රවේශයක් අවශ්‍ය වන සංකීර්ණ විෂයක් බව පැහැදිලිය. TBML හි විවිධ ස්වරූපයන් සහ සම්භවය වඩාත් හොඳින් අවබෝධ කර ගැනීමට සහ සාගරයට නිතිපතා ඇතුළු වන අපද්‍රව්‍ය ප්‍රමාණය අඩු කිරීම සඳහා උපාය මාර්ග සැලසුම් කිරීමට මෙන්ම දැනට පවතින අපද්‍රව්‍ය ඉවත් කිරීම සහ ප්‍රතිචක්‍රීකරණය කිරීම සඳහා වැඩිදුර පර්යේෂණ තුලින් ලබාගන්නා දැනුම අත්‍යාවශ්‍ය වේ. මෙම පර්යේෂණයේ සොයාගැනීම් ඉන්දියානු සාගර කලාපයේ TBML ගැටලුව සම්බන්දයෙන් ඵලදායී උපාය මාර්ග සැලසුම් කිරීමට දායක වනු ඇති අතර, අපගේ ජීවයෙන් පිරුණ සාගර අප සියල්ලන් සහ අනාගතය වෙනුවෙන් රැක ගැනීම අපගේ අපේක්ෂාවයි.

8.2 சுருக்கம்

எல்லை - கடந்த கடல் கழிவுகள் (TBML) என்பது தொடர்ந்து தயாரிக்கப்பட்ட அல்லது பதப்படுத்தப்பட்ட திண்ம பொருளைக் குறிக்கிறது.சர்வதேச எல்லைகளைக் கடந்து கடல் சூழலில் சேரும் கழிவுகள். இந்த கடல்குப்பைகள் பிளாஸ்டிக், உலோகம் மற்றும் ரப்பர் போன்ற பொருட்களால் ஆனவை மற்றும் பல்வேறு நாடுகளில் இருந்து வரக்கூடியவை. கப்பல் போக்குவரத்து மற்றும் மீன் பிடி காரணமாக இவை கடலில் சேர்க்கப்படுகிறது

TBML இன் இயக்கம் கடல் சுற்றுச்சூழல் அமைப்புகள் மற்றும் வனவிலங்குகள், மனித பாதுகாப்பு மற்றும் பொருளாதாரத்திற்கும் கடுமையான விளைவுகளை ஏற்படுத்தும். இந்த தாக்கங்களைத் தணிக்க, TBML ஏற்படும் வடிவங்கள், அவற்றின் ஆதாரங்கள் மற்றும் பாதைகள் ஆகியவற்றைப் புரிந்துகொள்வது அவசியம். இந்த ஆய்வு இந்தியப் பெருங்கடல் பிராந்தியத்தில் TBML தொடர்பான அறிவு இடைவெளியை நிவர்த்தி செய்வதற்கும், காலப்போக்கில் இலங்கையின் மேற்கு மாகாண கடற்கரையோரத்தில் TBML திரட்சியை புரிந்துகொள்வதற்கான அடிப்படையை நிறுவுவதற்கும் நடத்தப்பட்டது.

ஆய்வு இரண்டு கூறுகளாக நடத்தப்பட்டது; பிரதான கணக்கெடுப்பு மற்றும் குடிமக்கள் அறிவியல் கணக்கெடுப்பு

பிரதான கணக்கெடுப்பு: களுத்துறை, கொழும்பு மற்றும் கம்பஹா மாவட்டங்களில் இருந்து ஒன்பது இடங்கள், கடல்சார் குப்பைகளின் அணுகல், பார்வை மற்றும் பரவல் ஆகியவற்றின் அடிப்படையில் கணக்கெடுப்புக்கு தேர்ந்தெடுக்கப்பட்டன. ஒவ்வொரு இடத்திலும், 200மீ நீளமும் அகலமும் உள்ள அலைக் கோட்டிலிருந்து அதிகபட்சம் 10 மீட்டர் உள்நாட்டில் உள்ள பரப்பளவு கணக்கெடுக்கப்பட்டது. இந்த ஆய்வில், உள்நாட்டில் வாங்க முடியாத வெளிநாட்டு கடல் குப்பைகள் TBML ஆகக் கருதப்படுகின்றன, மேலும் கணக்கெடுப்பின் கவனம் கரைந்த திரவ கொள்கலன்களில் இருந்தது. TBML இன் திரட்சியானது பிறந்த நாடு, இருப்பிடம் மற்றும் பருவமழைக் காலத்தின் அடிப்படையில் பகுப்பாய்வு செய்யப்பட்டது.

குடிமக்கள் அறிவியல் கணக்கெடுப்பு: குடிமக்கள் அறிவியல் திட்டம் கல்வியாளர்கள், கடலோர சமூகங்கள் மற்றும் கடற்கரைக்கு செல்பவர்களை ஆராய்ச்சியில் ஈடுபடுத்துவதை நோக்கமாகக் கொண்டது. பொது மக்களுக்கு அணுகக்கூடிய ஆன்லைன் தரவு சேகரிப்பு தளம் நிறுவப்பட்டது. குடிமக்கள் விஞ்ஞானிகள் என அழைக்கப்படும் பங்கேற்பாளர்கள், தங்களைப் பற்றிய மெட்டாடேட்டா, கண்டுபிடிக்கப்பட்ட TBML இன் சரியான இடம் மற்றும் TBML இன் தெளிவான படங்கள் (பிறந்த நாடு மற்றும் பிராண்ட் பெயர் உட்பட) ஆகியவற்றை வழங்குமாறு கோரப்பட்டது. பிரதான கணக்கெடுப்பு மற்றும் குடிமக்கள் அறிவியல் கணக்கெடுப்பு மூலம் சேகரிக்கப்பட்ட தரவு தனித்தனியாக பகுப்பாய்வு செய்யப்பட்டது மற்றும் பின்வரும் முடிவுகள் கவலைக்குரிய முக்கிய புள்ளிகளாக உள்ளன.

மே முதல் டிசம்பர் வரையிலான கணக்கெடுப்பின் போது, மொத்தம் 6057 PET போத்தல்கள் இருந்தன.இவற்றில், 780 போத்தல்கள் TBML என அடையாளம் காணப்பட்டது, இது கணக்கெடுக்கப்பட்ட மொத்த பாட்டில்களில் 13% ஆகும்.

TMBL இன் தோற்ற நாடுகளையும் அவற்றின் பங்களிப்பையும் ஒரு விகிதத்தில் பார்க்கும்போது (படம் 8), TBML இன் முக்கிய பங்களிப்பாளராக இந்தியா உள்ளது (66.79%), அதைத் தொடர்ந்து சீனா (14.62%). இந்தியாவில் இருந்து உருவான TBML 11 மாநிலங்களில் கண்டறியப்பட்டது (படம் 10)

கண்டம் வாரியான பங்களிப்பைக் கருத்தில் கொள்ளும்போது, (படம் 9) TBML இன் முக்கிய பங்களிப்பாளராக ஆசியா உள்ளது (90.4%). 780 பதிவுகளில், 7.7%அவற்றின் தோற்றம் தெளிவற்றதாக இருந்ததால், அடையாளம் காணப்படாதவை என வகைப்படுத்தப்பட்டுள்ளன.

மேல் மாகாணக் கரையோரத்தில் உள்ள TBML இன் இட மாறுபாட்டைப் பார்க்கும் போது (படம் 11), TBML இன் அதிக செறிவு மகொன கடற்கரையில் பதிவாகியுள்ளது, இதில் 139 பொருட்களும், குறைந்த செறிவு நீர்கொழும்பு கடற்கரை பூங்காவில் 19 பொருட்களும் பதிவு செய்யப்பட்டுள்ளன. TBML இன் தற்காலிக மாறுபாடு வெவ்வேறு மாதங்களில் பதிவுகளின் எண்ணிக்கையில் ஏற்ற இறக்கங்களால் வகைப்படுத்தப்பட்டது. TBML இன் தற்காலிக மாறுபாடு பல மாறிகளைக் கொண்டிருப்பதால், ஏற்ற இறக்கங்களின் காரணங்களைப் புரிந்து கொள்ள மேலும் ஆராய்ச்சி தேவை.

குடிமக்கள் அறிவியல் கணக்கெடுப்பின் முடிவுகள் (படம் 14) இந்தியா மிகப்பெரிய பங்களிப்பாளராக உள்ளது, இது 59.4% குப்பைகளை கொண்டுள்ளது, அதைத் தொடர்ந்து சீனா 22.8% ஆக உள்ளது. 13இந்திய மாநிலங்கள் குப்பைகளுக்கு பொறுப்பாக இருப்பது கண்டறியப்பட்டது (படம் 15).இந்தியாவின் தென்கிழக்கு கடற்கரையில் அமைந்துள்ள தமிழ்நாடு, TBML க்கு முக்கிய பங்களிப்பாளராக இருந்தது, மொத்த TBML இல் 27.7% ஆகும். கேரளா மற்றும் குஜராத் ஆகியவை முறையே 24.3% மற்றும் 22.8% பங்களிப்புகளுடன் நெருக்கமாகப் பின்தொடர்ந்தன

துருக்கி, மியான்மர், பங்களாதேஷ், வியட்நாம், தாய்லாந்து, அமெரிக்கா மற்றும் சுவிட்சர்லாந்து போன்ற பிற நாடுகள் 0.3% வரை பங்களித்தன, ஈரான் மற்றும் சிங்கப்பூர் 0.6% வரை பங்களித்தன. மீதமுள்ள பங்களிப்புகள் மலேசியா (8.9%), ஐக்கிய அரபு எமிரேட்ஸ் (2.5%), இந்தோனேசியா (1.2%), மற்றும் மாலத்தீவுகள் (1.8%) ஆகியவற்றிலிருந்து பதிவாகியுள்ளன. அதன்படி, TBML இன் 99 ஆசிய கண்டத்தில் இருந்து பதிவாகியுள்ளன, அதே நேரத்தில் ஐரோப்பா மற்றும் வட அமெரிக்காவின் பங்களிப்பு 1% ஆகும்.

ஆய்வில் கண்டறியப்பட்டுள்ளபடி, வெளிநாடுகளால் கடலில் குப்பைகளை கொட்டுவது, மீன்பிடி நடவடிக்கைகளின் போது அப்புறப்படுத்தப்பட்ட அல்லது இழந்த மீன்பிடி வலை

உபகரணங்கள், சரக்குகளில் உருவாகும் கழிவுகள், கரை பிரதேசத்திலிருந்து சேர்க்கப்படும் கழிவு போன்றவற்றால் TBML ஏற்படலாம்.

இந்த ஆய்வு TBML இன் மாறுபட்ட மற்றும் விரிவான தாக்கங்களையும் எடுத்துக்காட்டுகிறது. அவற்றுள் சில: TBML கடல் விலங்குகளை சிக்க வைக்கலாம், மூச்சுத்திணறலாம் மற்றும் வேறுவிதமாக தீங்கு செய்யலாம், நீருக்கடியில் பதிக்கப்படலாம் மற்றும் கடல் வாழ்விடங்களின் தரத்தை குறைக்கலாம், மேலும் பெரும்பாலும் ஆக்கிரமிப்பு உயிரினங்களுக்கு கேரியராக செயல்படலாம். TBML அதிக அளவு மாசு உள்ள பகுதிகளிலிருந்து குறைந்த மாசு உள்ள பகுதிகளுக்குச் சென்று சுற்றுச்சூழலியல் ரீதியாக உணர்திறன் வாய்ந்த பகுதிகளை பாதிக்கக்கூடியதாக மாற்றும். உள்ளூர் குப்பைகளை விட விசித்திரமான குணாதிசயங்களைக் கொண்ட குப்பைகள் சுற்றுச்சூழலுக்கும் மனித ஆரோக்கியத்திற்கும் கூடுதல் அபாயங்களைச் சுமத்தலாம். அதன் பரவலான விநியோகம், சில கடல் சூழல்களுக்கு அணுக முடியாத தன்மை, அதிக அளவில் இருப்பது மற்றும் உடல் ரீதியாக இருப்பதால் கடல் குப்பைகளை சேகரித்து அகற்றுவது சவாலானது.

பிராந்தியத்தில் TBML இன் சிக்கலைத் தணிக்கச் செய்யக்கூடிய பல பரிந்துரைகள் கீழே உள்ளன. கடலில் குப்பை கொட்டுவதால் ஏற்படும் விளைவுகள் குறித்து பொதுமக்களுக்கு விழிப்புணர்வு ஏற்படுத்துதல், கடலில் சட்டவிரோதமாக கழிவுகள் கொட்டப்படுவதை தடுக்கும் வகையில் விதிமுறைகளை அமல்படுத்துதல், கழிவு மேலாண்மை கட்டமைப்புகளை மேம்படுத்துதல், கண்காணிப்பை பலப்படுத்துதல்.

TBML என்பது ஒரு சிக்கலான மற்றும் தொலைநோக்கு பிரச்சனை என்பது தெளிவாகிறது, அதன் தாக்கங்களைத் தணிக்க பன்முக அணுகுமுறை தேவைப்படுகிறது. TBML இன் பல்வேறு வடிவங்கள் மற்றும் தோற்றத்தை நன்கு புரிந்துகொள்வதற்கும், கடலுக்குள் நுழையும் குப்பைகளின் அளவைக் குறைப்பதற்கான உத்திகளை உருவாக்குவதற்கும், அத்துடன் இருக்கும் குப்பைகளை அகற்றுதல் மற்றும் மறுசுழற்சி செய்வதை மேம்படுத்துவதற்கும் மேலும் ஆராய்ச்சி தேவை. இந்த ஆய்வின் கண்டுபிடிப்புகள், இந்தியப் பெருங்கடல் பகுதியில் TBML-ஐ நிவர்த்தி செய்வதற்கான பயனுள்ள உத்திகளை உருவாக்குவதற்கு பங்களிக்கும். TBML இன் சிக்கலைத் தீவிரமாகக் கையாள்வது மற்றும் நமது பெருங்கடல்கள், கடல்வாழ் உயிரினங்கள் மற்றும் எதிர்கால சுற்றுச்சூழல் அமைப்புகளைப் பாதுகாப்பது சரியான நேரத்தில் தேவை.

Amila Sumanapala
Survey Advisory

Muditha Katuwawala
Survey Advisory | Author

Shalanka Ranjula
Project Lead | Author

Bimali Keerthisinghe
Project Coordinator | Author

Samudra De Silva
Author | Data visualization

Dimashi Sathsara
Research assistant

Vishadi Wijenayake
Research assistant

Suyama Sanjunee
Research Assistant

Hashani Senavirathna
Research Assistant

Lochana Amandi
Research Assistant

Dineshi Gunawardana
Research Assistant

Isuru Kularathna
Research Assistant

Shalini De Silva
Research Assistant

Rashmi Bandara
Research Assistant