Title: Balancing The Plastic See-Saw

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(PAPER343) **ABSTRACT:**

Globally, plastics are a widespread consumer product and, due to inappropriate disposal and accidental losses, are now found ubiquitously in the marine environment. Recently, however, there has been a growing interest in plastic pellets, or nurdles, following a spate of losses from shipping vessels during transshipment. Over the last five years, ITOPF has been heavily involved in five spills of plastic pellets, including incidents in Sri Lanka, South Africa and Spain.

Due to their size and mobility, once lost, plastic pellets can spread extensively and rapidly become buried and mixed with sediments, natural debris and other plastics on the shoreline. Past experience has shown that subsequent clean-up operations are laborious, protracted and costly.

The goal of pollution response is to reduce potential damage to sensitive environmental or economic receptors, and to enable the continuance of normal functions. Responders have long recognised the importance of retaining a holistic sense of this goal, systematically balancing the impact of response operations against the potential damage caused by a pollutant. As such, with an increasing focus on the climate change agenda, broader environmental consequences such as greenhouse gasses may need to be considered during the assessment process.

Utilizing data from three plastic pellets spills in South Africa, Sri Lanka, and Spain, life cycle analysis was carried out to look at plastic spills through the lens of the climate change agenda. This paper proposes that more consideration could be given to ensure that the balance is correct for ship-source plastic pellet pollution, and alternative strategies are discussed which could maximise the overall environmental benefit and minimize greenhouse gases emitted during a response.

Results of this study indicate that overtime, the efficiency of focusing on the recovery of plastic pellets diminishes greatly over time and emissions per kilogram of collected waste significantly increase. Pilot studies carried out in South Africa demonstrated that the collection of other background plastics can offer a more efficient solution to the recovery of plastic pellets and mitigating potential environmental impacts. The conclusions of this paper offer considerations for relevant stakeholders involved in post plastic pellet spill clean-ups and may provide value when deciding clean-up strategies.

INTRODUCTION

Globally, plastics have become a ubiquitous and widespread consumer product, with production levels in 2021 reaching around 391 million tonnes per year (PlasticsEurope, 2022). It is estimated that around 4.8 – 12.7 million tonnes of plastic is introduced into the marine environment annually (Jambeck et al., 2015) via a number of different terrestrial and marine sources.

Plastic debris is typically defined and described by its shape and size (Napper and Thompson, 2020). The three main classes used to describe the size of plastic contamination are macroplastic (>20mm diameter), mesoplastic (5 – 20mm), and microplastic (<5mm) (Barnes et al., 2009; Thompson et al., 2009). A fourth class – nanoplastics (<0.001 mm) is more frequently being used (Napper and Thompson, 2020).

Macroplastic pollution is typically most encountered due to its size and visibility (Ryan et al., 2009). Recently however, focus has shifted to microscopic plastic debris given the growing evidence of its abundance and impacts, particularly within biota (Napper and Thompson, 2020; Andrady, 2011). Two main classifications of microplastics exist: primary and secondary. Primary enter the marine environment less than 5mm in size (Napper and Thompson, 2020) and consist of plastic production feedstock (i.e., flakes, powders and pellets) (Turner & Holmes, 2015), items in cleaning products (Cole et al., 2011), cosmetics (Napper et al., 2015) or air-blasting (Gregory, 1996). Secondary microplastics exist via the fragmentation of larger plastic items, or from product use (e.g. tyre wear or washing clothing) (Cole et al., 2011; Napper and Thompson, 2020). Over time, it is likely the abundance of smaller plastics will increase as large items degrade and fragment (Ryan et al., 2020).

In the marine environment, organisms at every level of the food chain are reported to ingest or interact with plastics (Bucci et al., 2020). Interaction with plastic exposes marine organisms to both direct physical and indirect toxicological effects (Alimba and Faggio., 2019). Current research is beginning to elucidate the variety of lethal and sub-lethal effects of marine plastic pollution (Rochman et al., 2016). Although this research continues to demonstrate fatal interactions with macroplastics in marine organisms (Alomar et al. 2017, Franco-Trecu et al. 2017), consensus regarding the toxicity of microplastics has not been reached (Bucci et al., 2020). In a review by Bucci et al. (2020), data from 139 laboratory and field studies were compared, these test 577 independent effects (e.g., mortality, mobility, reproductive output), across a variety of taxonomic groups, and with various types, shapes and sizes of plastic. Overall, 59% of the tested effects were detected. Of these, 58% were due to microplastics, and 42% were attributed to macroplastics. Of the effects not detected, 94% were from microplastics and 6% were from macroplastics. In the review, Bucci et al. (2020) found that, whether an effect was detected, as well as the severity and direction of that effect, the causal factors were the dose, the particle shape, polymer type and particle size.

The environmental relevance of the dose and size of microplastics used in the experimental studies is regularly brought into question, with concentrations and forms often disproportionate to those found in nature. Bucci et al. (2020) examined the similarity of studies with environmental plastics and determined that only 17% of concentrations used in experimental studies have been observed in the field. Further, 80% of the particle sizes used in experiments fall below the size range found in most environmental sampling.

Recently, there has been growing concern microplastics entering the marine environment in the form of plastic pellets, or ‘nurdles’. Plastic pellets serve as the foundation material for nearly all plastic products. They are typically < 5mm in diameter and are manufactured by petrochemical companies for shipment to plastic manufacturing facilities. Perkins et al. (2023) estimated that of the 390 MT of plastic produced in 2021, the primary form was pre-production plastic pellets.

Maritime transport is the primary mode for global distribution and millions of tonnes of primary plastics are transported annually. Throughout the handling and transportation process, accidents, poor handling, or loss of cargo during transit can lead to significant, instantaneous losses of plastic pellets. These can find their way to the marine environment. It is estimated, based on the size of the current global plastic industry, that between 2.2 and 22.5 trillion plastic pellets are released to the environment annually across various stages of the supply chain (Perkins et al., 2020), equivalent to between 2,500 and 22,500 containers. It is important to note that only a tiny fraction of these are estimated to come from container losses at sea.

Within the maritime industry, stack collapses or vessel fires can result in losses of plastic pellet containers. Since 2011, ITOPF is aware of twelve shipping incidents involving the loss of plastic pellets. Since 2017, ITOPF has been involved in five notable incidents (Figure 1), including the X-PRESS PEARL in Sri Lanka, considered to be the greatest single loss of plastic pellets recorded to date.

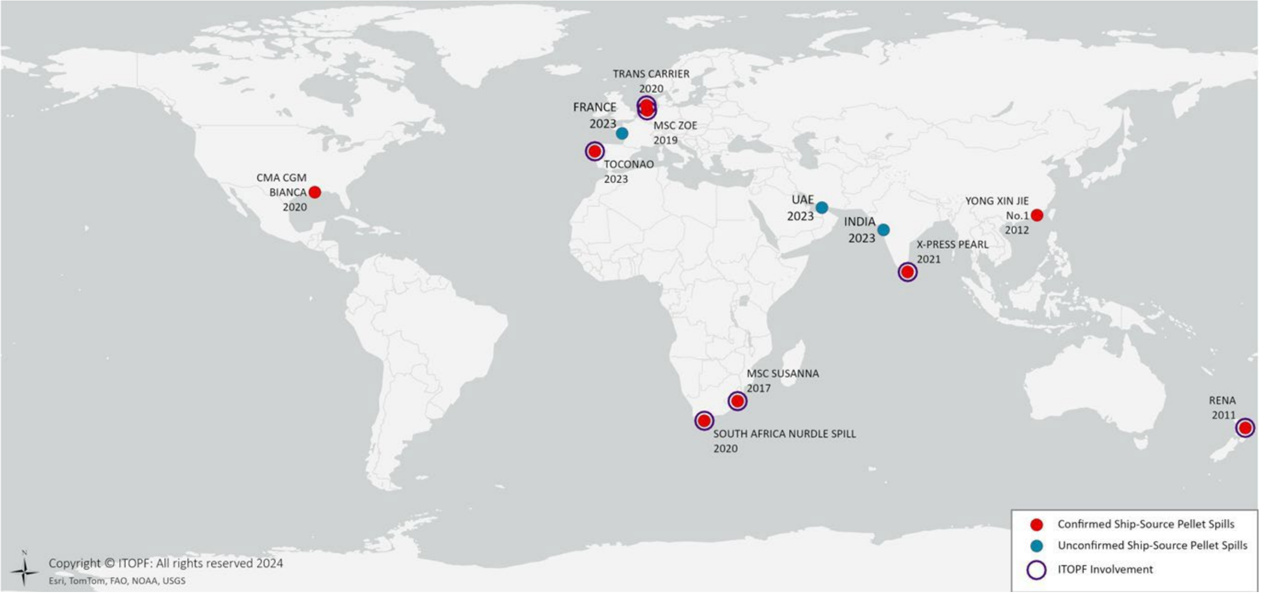

Figure 1: Reported plastic pellet Spills from Ships (2011 – 2024).

The circumstances and location of each incident varies, resulting in different extents and forms of contamination. The extent of contamination can range from hundreds to thousands of kilometres per incident, and the cleanliness of the affected shores can vary. Once lost to the environment, plastic pellets are highly mobile and readily influenced by prevailing meteorological and oceanic conditions. The subsequent shoreline responses are typically laborious and protracted, involving months to years of predominantly manual shoreline cleaning. The dynamic nature of plastic pellets and the type of affected shorelines exacerbates the response timeframe.

Plastic pellet cases attended by ITOPF have demonstrated varying levels of background contamination. The presence of chronic background plastic contamination has caused challenges for shoreline clean-up, and has also raised questions about the appropriateness of focussing entirely on collecting the ship-sourced plastic debris (i.e., plastic pellets) whilst significant quantities of pre-existing macro and micro plastics are also present on the shores.

In each case, the main concern of relevant government agencies has been the environmental impacts of stranded plastic pellets. In addition, however, the aesthetic impact on amenity beaches can also be a significant concern, particularly in pristine locations frequented by members of the public. As a result, although it is generally agreed that recovery of the entire lost cargo is impossible, the expectation is for the responsible party to remove plastic pellets to a ‘satisfactory’ level. Because pellets are so mobile, and pre-existing plastic so common, this expectation leads to difficulties in defining suitable endpoints.

Nevertheless, the goal of any post-incident pollution clean-up is to minimise the overall impacts to natural and economic resources. The response strategy therefore must consider both the impact of the pollutant and the impact of the response techniques, including the option of no intervention or ‘natural recovery’. When considering all the options, the response strategy that best reduces negative impacts, and enhances positive impacts, should be selected. This assessment process is well established in oil spill response and is referred to as Net Environmental Benefit Analysis (NEBA). Typically, the assessment is conducted on a relatively local scale, focussing on the extent of pollution and damage caused by cleaning, rather than considering broader environmental consequences such as Greenhouse Gasses (GHG) emitted during a response. However, with increasing focus on the climate change agenda, perhaps this should be reconsidered.

Plastic pellet spills pose different challenges to oil spills due to the persistence of plastic in the environment. This means that ‘natural recovery’ does not apply. The application of NEBA principles therefore shifts to question whether the level of plastic remaining is more or less harmful than the clean-up options available. If the answer is less, the clean-up should stop. With uncertainty around the environmental impacts of freshly spilt plastics, especially within the context of ubiquitous chronic plastic pollution, assessing the broader environmental consequences of a protracted clean-up (in terms of GHG emissions) should be a consideration. This paper therefore examines GHG emitted during recent plastic pellet spill responses to consider whether alternate strategies should be applied for responding to ship-sourced plastic pollution to minimise the net environmental damage of spill and response.

METHOD

ITOPF has been involved in seven separate incidents where plastic pellets have entered the marine environment. For this paper, only three case studies have been used to examine the GHG emitted during a response due to lack of detailed data for the others. The three cases examined cover a broad geographic spread, including countries in Africa (South Africa, 2020), Asia (Sri Lanka, 2021) and Europe (Spain, 2024).

Data Collection

Operational data for all three cases contains detailed data sets including; all daily effort exerted (in the form of manpower, equipment and vehicles deployed); all waste recovered (in the form of segregated waste collected), and is extended over significant timeframes. Unfortunately, the operational data does not cover the entire response period for all cases due to the difficulties of establishing precise data collection systems, especially during Covid. Consequently, the first 12 months of data is unavailable for Sri Lanka, however, reliable datasets exists for three, eleven and one month after the start of incidents in South Africa, Sri Lanka and Spain, respectively.

It is important to note the three incidents are not similar. The South African case is older, but also more ‘mature’, i.e. the volume of plastics remaining is less concentrated in the environment than at the start of the incident. Furthermore, a longer data set exists for the South African case, 29 months of information, rather than 19 and 1 month, for Sri Lanka and Spain, respectively.

Data has been collected in three ways. In South Africa, daily operational data has been recorded for each worksite by the lead response agency ‘SpillTech’. The 29-month data set includes 870 working days and includes over 16,000 individual beach clean-ups. In Sri Lanka and Spain, operational details are recorded via a bespoke digital questionnaire on the ESRI Survey123 platform created by ITOPF. A questionnaire is submitted by independent surveyors or shipowner contractors for every clean-up site. These records are substantiated by their own visual observations and records. In Sri Lanka, reports run from April 2022 to October 2023 and include 445 days of active response and 3,943 individual beach clean-up operations. In Spain, reports run from January to February 2024, and includes 27 days of active response and 375 individual beach clean-up operations.

An additional dataset has been collected, one which is experimental in nature. This data was collected by SpillTech and details trial plastic collections conducted in an area of natural plastic collation in Cape Town, South Africa (Moule Point, 33°53'57.1"S 18°24'28.7"E). The trial adopted the same work model to the spill response, i.e. a 10-man team operating for 7 hours (1 hour for lunch) collecting plastics from the shoreline. 3 hours (½ day) was spent focusing solely on microplastics (plastic pellets and any plastic < 5mm diameter), the other 3 hours (½ day) was spent collecting all observable plastic including macroplastics.

Analysis

All incident response operational data was collated by ITOPF into monthly totals. To enable comparison in the subsequent sections, the macroplastic collection trial conducted in South Africa has been extrapolated to a monthly collection figure. This extrapolation presents a limit to the strength of any discussions and conclusions but is indicative.

To understand the net environmental impact of the operational footprint, operational data has been converted to GHG emissions using ITOPF's GHG calculator. The calculator has been developed with SimaPro – a Life Cycle Analysis (LCA) company – to calculate the footprint of incident response operations. All life-cycle impacts are converted into a single metric of kilograms of carbon dioxide equivalent (kg CO_2e) for ease of communication and direct comparison. Probability analysis of linear regression has been conducted using a Tukey test (T-test). The environmental footprint of the response effort and the recovered plastics is expressed as:

- environmental footprint of effort (GHG (kg CO_2e) / labour day)
- environmental footprint of plastic recovered (GHG (kg CO_2e) / kg of plastic pellets recovered).

Information regarding the number of vehicles and mechanical assets used per day is recorded, however their precise usage is not. Certain assumptions (Table 1) have therefore been incorporated to allow this information to be used in a meaningful way. The assumptions made are based on intimate knowledge of the work operations by ITOPF and the contractors involved. All estimates are conservative to avoid over-reporting.

Table 1: An overview of assumptions made for operational use in plastic collection responses.

Case	Response Element	Assumption
South Africa	Backpack Hoovers ('Nu-Vacs' (Nurdle Vacuums))	Used for collection of plastic pellets. Utilise approximately one litre of petrol per machine per day.
	Light Delivery Vehicle (LDV)	Used for operational support in South Africa, assumed to drive an average of 59 km roundtrip / day.
	Worker Transportation	Shoreline worker transport minibus daily roundtrip is estimated based on the approximate round trip distance for each worksite when visited. (Estimated distances available upon request).
	Waste Storage	Usage of black polyethylene (PE) rubbish sacks are estimated at six bags per team of ten workers per day of operation in South Africa. Jumbo (one tonne) storage bags are estimated to be used at one jumbo bag per 120 PE sacks in South Africa.
Sri Lanka	Personnel Vehicles	All Buses / vans / cars / pickup trucks and 4-seater pickup) are assumed, when engaged for a day, to drive 30 km roundtrip / day, this is based on detailed knowledge of worksite geographic layout and general staff movements.
	Work Machines	All tractors, JCBs, loaders, excavators, flatbed trucks, water trucks, lorries and forklifts are assumed for the days they have been engaged, to operate for three hours per day. This is based on operational awareness.
	Work Boats	All outboard motorboats, when utilised, are assumed to travel approximately 15 km per day. This is based on awareness of the operational area.
Spain	Personnel Vehicles	All equipment and personnel vans / flatbed trucks / worker cars are assumed to drive 36 km day based on the geographic spread and frequency of sites visited.
	Work boat	Work boats are estimated to cover 40 km a day when used. This is based on awareness of the operational area.
	Waste storage	Usage of black PE refuge sacks are estimated at six bags per team of ten workers per day.

RESULTS

Results have been presented for response effort, rates of recovery, and the overall efficiency of recovering plastic pellets and other plastics. Only one month of data exists for the Spanish spill, so inclusion of the results is primarily anecdotal.

Response Effort and Rates of Recovery

In South Africa and Sri Lanka, the level of collected plastics declines over time (Figure 2). In South Africa, a distinct decline occurs from a high of ~5,000 kg month in response month 10 (July 2021), steadily reducing to ~1,000 kg / month by month 29 (March 2023) (Figure 2). Sri Lanka falls from ~8,000 kg / month in month 14 (June 2022) to ~ 2,000 kg / month by month 30 (October 2023).

The level of clean-up effort exerted is variable between cases. The rate of employed labour per month declines over time in Sri Lankan by approximately 1,000 / month (a decision of the national authority leading the response). In South Africa, the level of effort almost doubles in month 5 (February 2021) and then declines again in month 26 (December 2022), a decision made in relation to decreasing rates of material collected.

Response Footprint

Variations in response organisation exist between case studies, including the use of mechanical assets, PPE and refreshments provided for labour. However, as demonstrated (Figure 3) plastic recovery operations are generally labour intensive and low tech, with the majority of GHG emissions caused by transport of workers and waste. This allows for similarities to be drawn between the cases. However, it should be noted in the Spanish case, workers drive their own cars to site, whilst in South Africa and Sri Lanka, shoreline workers are bussed to work sites.

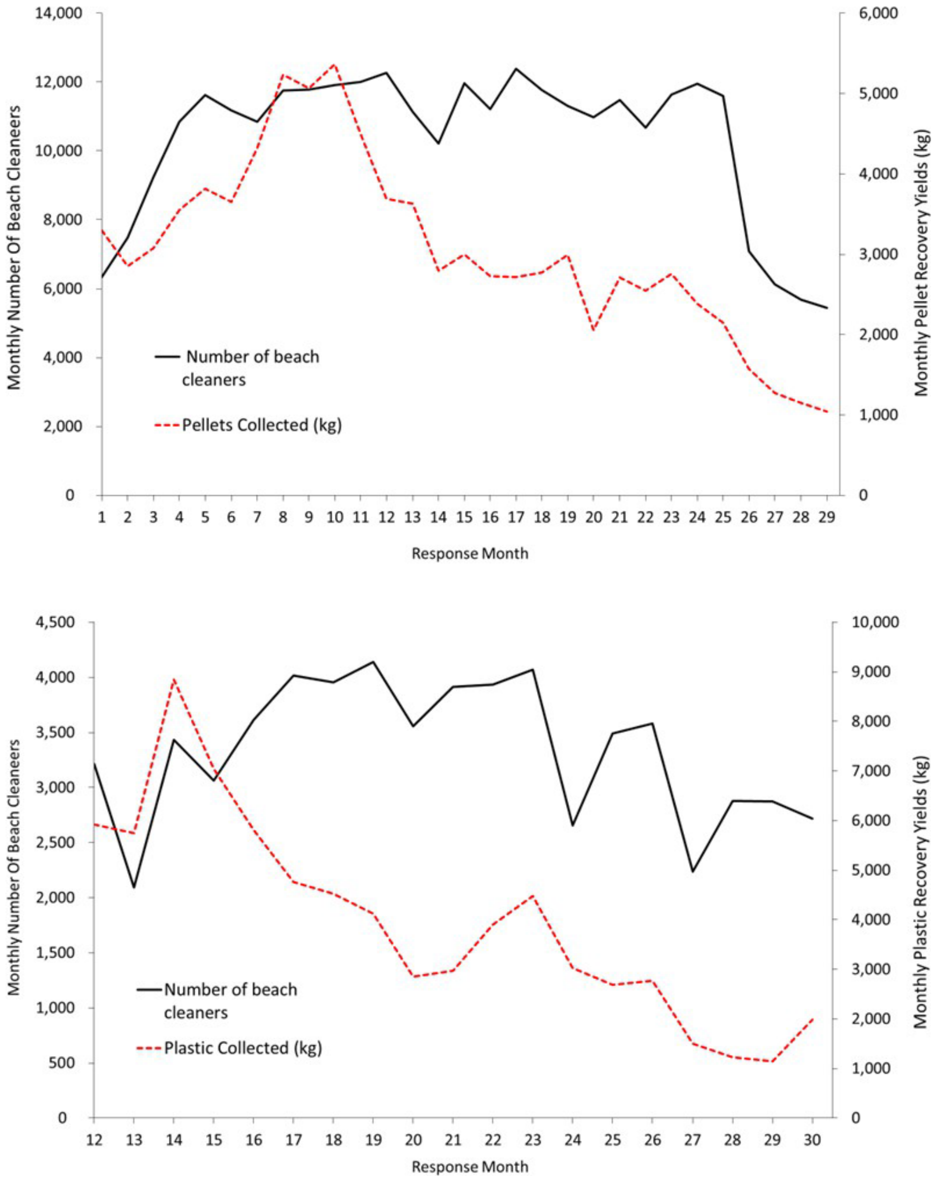

Figure 2: Monthly clean-up footprint and plastic pellet recovery yields during South African (top) and Sri Lanka (bottom) incidents.

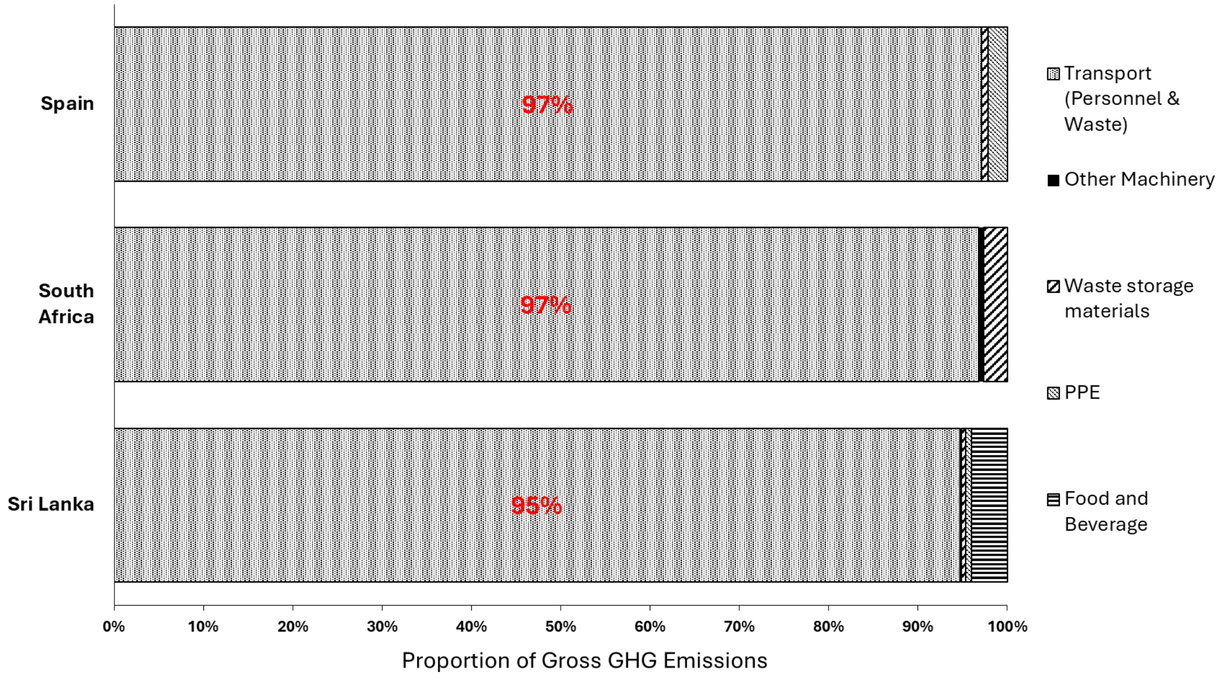

Figure 3: Division of gross GHG emissions (kg CO_2e) by operational sector for 1 month of operations in Spain, 19 months in Sri Lanka and 29 months in South Africa.

The monthly and cumulative GHG emissions in South African and Sri Lanka is shown in Figure 4. The mean monthly GHG footprint in Sri Lanka was approximatley 10,500 kg (10.5 MT) CO_2e for 19 months of operations with a cumulative total of approximately 200,000 kg CO_2e, (200 MT). The mean emissions per month in South Africa was 1.6 times greater at approximately 17,300 kg (17.3 MT) CO_2e, with a cumulative total of about 500,000 kg CO_2e (500 MT) for 29 months of operations. It should be noted that, in South Africa, the response footprint was greater than Sri Lanka, with approximately 2.4 times the number of clean-up workers employed a day in South Africa (n=344) compared with Sri Lanka (n=142). In addition, the overall extent of contamination in South Africa (n = ~2000km) was around 6.6 times bigger than Sri Lanka (n = ~ 300 km).

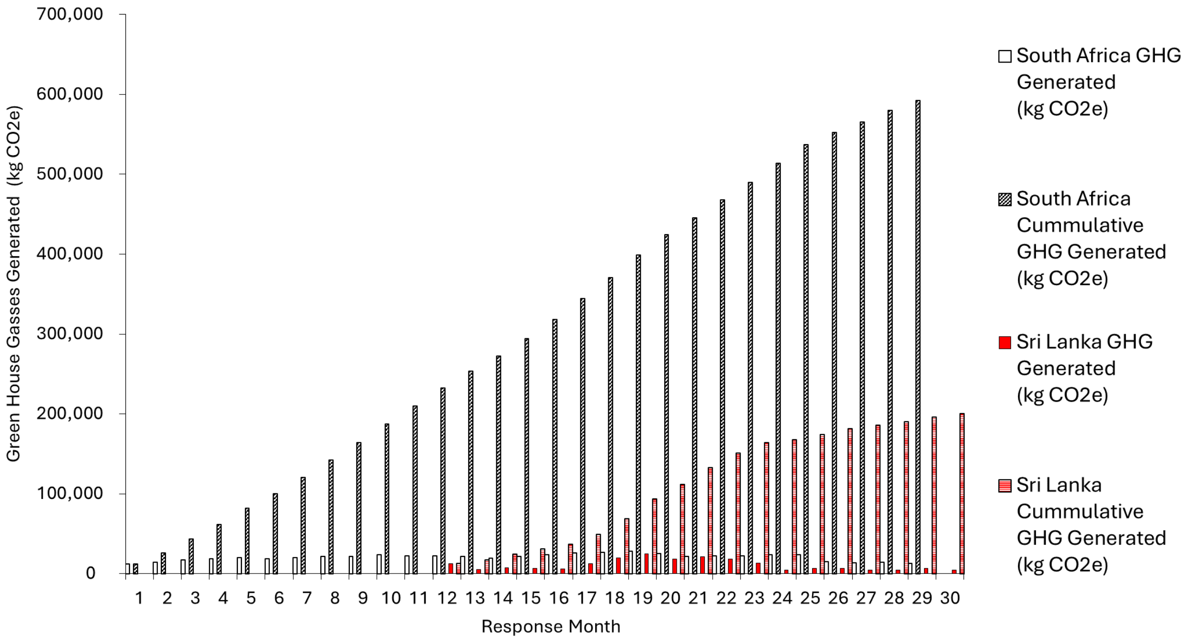

Figure 4: Monthly and cumulative GHG production (kg CO2e) for 29 months of plastic pellet recovery operations in South Africa (November 2020 - March 2023) and 19 months in Sri Lanka (April 2022 - October 2023).

Environmental Efficiency of The Response

A reoccurring question within the response industry is whether the environmental efficiency of response operations remains consistent over time. For this paper, environmental efficiency is viewed in two ways:

- The amount of plastic recovered per unit effort (kg plastic recovered / labour day).
- The GHG footprint of recovered plastic (kg CO_2e / kg plastic recovered).

GHG figures used for this analysis only considers labourers, excluding additional personnel such as supervisors or support staff (e.g. drivers, cooks etc.) to avoid disparities in organisational setup. The results are shown in Figure 5.

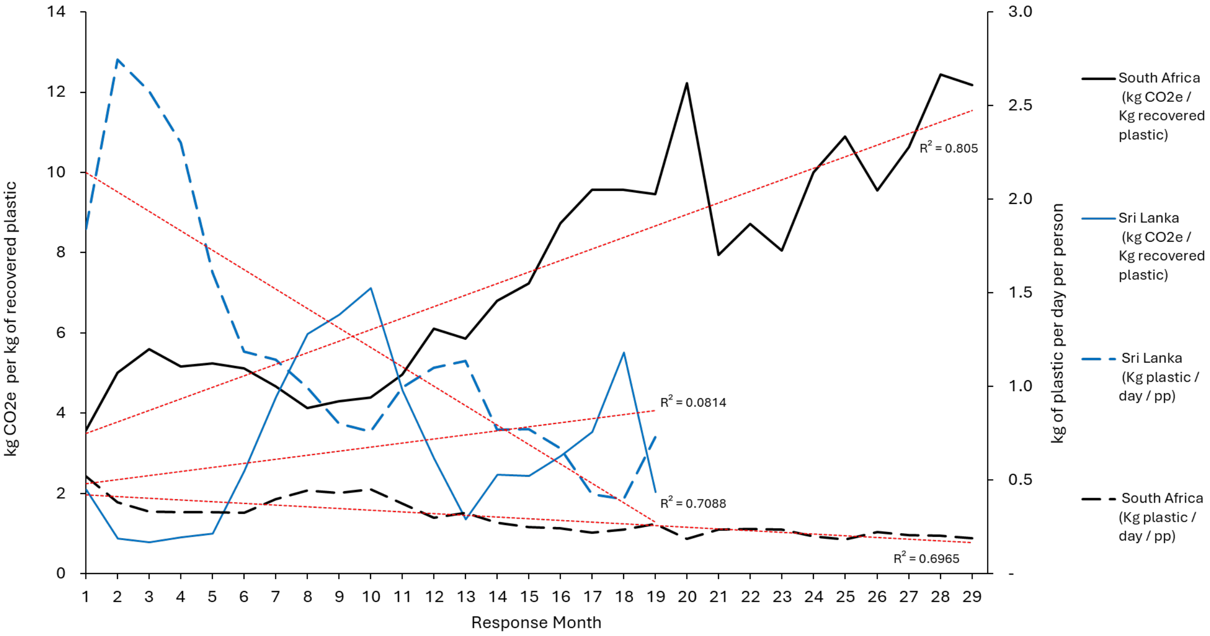

Figure 5: Daily waste collections per cleanup personnel per day, and GHG produced per clean-up personnel per kg of plastic pellets collected in Sri Lankan and South African operations.

Both cases exhibit reduced efficiency of plastic waste recovered per unit effort. In Sri Lanka, the rate falls from 1.9 kg plastic / pp / day in the second month, to around 0.2 kg / pp / day by month 18. The relationship however is not statistically significant ($R^2 = 0.7088$, $p > 0.05$). In South Africa a significant decline can be observed across the 29 months of operation ($R^2 = 0.6965$, $p < 0.01$). Results also indicate that the amount of GHG emitted per kg of recovered plastic waste increases over time for both cases, suggesting both an operational and environmental efficiency decrease (Figure 5). In South Africa, there was approximately a 400% increase in GHG emissions per kg, from ~3 kg CO_2e to ~12 kg CO_2e / kg of plastic waste over 29 months of operation. This relationship is significant ($R^2 = 0.805$, $p < 0.01$). In Sri Lanka, although we see a linear relationship, the data is too scattered to be statistically significant ($R^2 = 0.0814$, $p > 0.05$).

Collection Of ‘Other' Background Plastic

Whereas both the South African and Sri Lankan incident response operations focus solely on recovery of spilt plastic pellets – as instructed by the relevant authorities – this paper highlights two alternate models wherein collection of existing background plastics is undertaken.

The first example model is in Spain, where response teams have collected ‘other’ plastics encountered whilst collecting pellets spilt from the ship. Workers do not search the wider area for other plastic, but recover plastic within the direction and area of travel. At the time of writing, in one month of operations for which data is available a, 9,600 kg of debris has been collected. Of this 656.5 kg is plastic pellets (6.8%), 2,007.5 kg is other plastic (21%), and 6,936 (72.2%) is natural debris removed in the process of pellet recovery. All natural debris was returned to the same location it was recovered from following pellet sorting and segregation.

The other two examples were developed by the South African clean-up contractor SpillTech who conducted a pilot study to investigate how much general plastic could be collected from a shoreline by a dedicated, experienced response crew. One half-day of 10 workers and a support vehicle was dedicated to each of two studies undertaken at a South African beach where waste plastic naturally accumulates in the environment:

> Test 1: Half a day collecting all available plastic on the shore including macroplastics. Test 2: Collecting all available microplastics, including nurdles.

To normalise the results (Figure 6), half day totals have been extrapolated to one full day of labour. All values have been compared to average daily values of response operations in Sri Lanka and South Africa. The GHG emissions per worker and per kg of collected waste in the SpillTech two test scenarios were disproportionately high because the supporting waste collecting vehicle was being used by one clean-up operation and 10 workers, rather than the normal scale of South African response (1 vehicle / 344 workers). All results have been normalised by removing waste collecting vehicles to avoid the results being skewed.

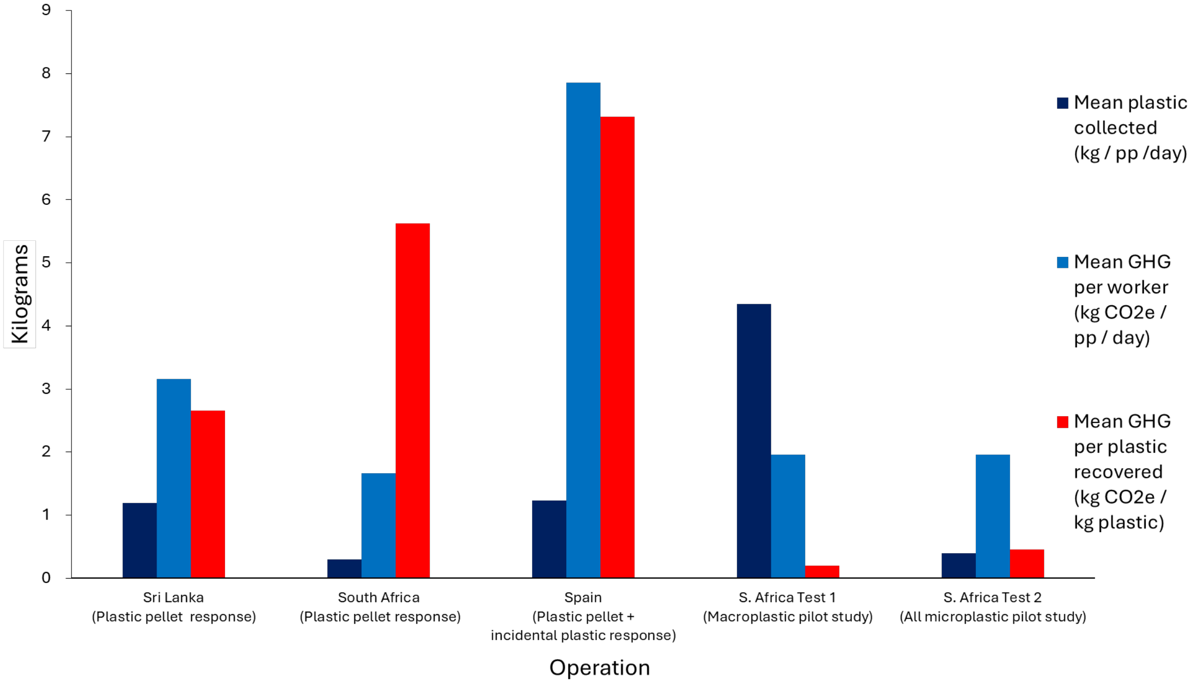

Figure 6: Recovery efficiency and normalised GHG emissions compared across response operations.

It's worth noting that if the Spanish spill response was only collecting pellets, their operational efficiency would be a staggering 29.7 kg CO_{2e} / kg plastic pellets collected. This is primarily because workers drive their own vehicles.

DISCUSSION

The recovery of plastic pellets and their segregation from other background material is laborious and requires a large response effort which, as shown, rapidly sees diminishing returns. A plastic pellet spill response is relatively rudimentary, however large quantities of GHG emissions can occur due to the protracted nature. In the cases shown, over a combined period of 48 months response period in South Africa and Sri Lanka, around 700,000 kg (700 MT) CO_2e was emitted. This is equivalent to approximately 140 U.S. homes total energy use for a year (EPA GHG Equivalencies Calculator, 2023).

As analysis demonstrates, over time the quantity of recovered plastic reduces while the response footprint and GHG emissions remain relatively consistent. This is reducing efficiency, both in terms of recovery yields and GHG emissions. In South Africa, a significant 400% increase in GHG emissions per kilogram of waste collected occurred over 29 months. In Sri Lanka, although changes were not significant, a trend is observed, and as the response continues further reductions in efficiency are expected as pellets become less concentrated and require more effort to recover. As the data set increases, we would expect to see a statistically significant trend occur that overreaches operational variability, or seasonal changes.

If spill managers follow the principles of NEBA (i.e., to seek a Net Environmental Benefit, or at least to reduce negative environmental benefits) related to plastic pellet spills, a more holistic response paradigm should be considered. One in which a broader approach to waste plastic removal from the environment is considered.

To elucidate this point, the results of the South African trial have been transposed over the course of the actual South African response timeline. This includes a significant assumption, that the level of recovered background, non-ship related plastic would be maintained every day. This scenario may be unrealistic, however, it indicates the potential of reconsidering the goal of a response. Two opposing environmental paradigms are offered, firstly focussing on minimizing GHG emissions (Model A), and secondly, focussing on removal of as much plastic from the environment as possible (Model B). The results are shown in Figure 7.

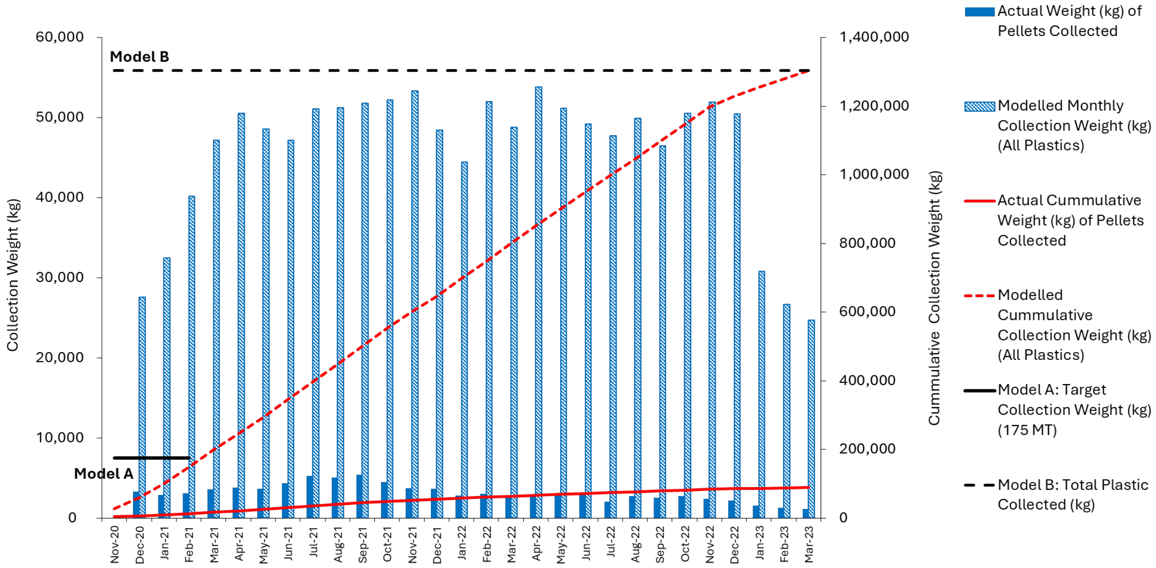

Figure 7: Potential response outcomes based on two different models involving the recovery of all plastic waste. Model A – reduction of GHG emissions. Model B – maximising plastic recoveries.

If Model A is followed, 79,702 kg CO_{2e} would be emitted before reaching the target recovery weight of 175 MT of plastic – the equivalent of what was originally lost to the environment – reducing total GHG emissions during the response by 87%. Conversely, if Model B is followed, utilising the same labour days (299,920 days) and GHG emissions to date to recover any plastic from the shoreline environment, 1,304 MT would be recovered. Based on this analysis, if recovery of waste plastic from the environment is the only concern, responders can potentially achieve this relatively quickly by focusing on plastics beyond spilt pellets - ~20 weeks in Model A). If maximising plastic recoveries is the goal, the same effort and GHG footprint can be used to capture greater volumes of environmental plastic (almost 15 times more in Model B). Response decisions, however, are not that simple and are complicated by a variety of social, environmental and governance (ESG) pressures, in addition to the unknown impacts of a nurdle versus an existing piece of micro, or macroplastic. However, including an assessment on GHG emissions within the decision framework may help to achieve a more balanced array of response benefits. The approach adopted in Spain is a hybrid approach, collecting any plastic encountered during the targeted plastic pellet search. The result is a four-fold increase in recovered plastics for the same environmental footprint, with 656.5 kg and 2,007.5 kg of plastic pellets and other plastics being recovered in 27 days of response, respectively.

Concerns over plastic pellets by government agencies and other stakeholders centre around both the perceived environmental impacts and the aesthetic of millions of plastic pieces scattered along their coastlines. The expectation for the responsible party to remove plastic pellets to a ‘satisfactory’ level has led to difficulties in defining suitable end-points. This is particularly true in the absence of conclusive research about the short, medium and long-term impacts of plastic pellets at the population level, and comparisons of impacts between freshly released microplastics and pre-existing ones. This challenge can lead to a highly drawn out, costly and sometimes inefficient responses, lasting many months, or even years.

Given the uncertainties around environmental impacts, when major releases of plastic pellets occur, the swift and focused recovery of concentrated pellets is advisable. However, as the response progresses, consideration of alternate response strategies should be considered to ensure efficacy and efficiency remain, and to minimise holistic negative environmental impacts. It is noteworthy that further research is required to fully understand the risks to the environment presented by ‘fresh’ plastic pellets. In some circumstances, however, ship-sourced pellets may not share the same risk profile as background plastics. For example, fire damaged plastic released from the X-PRESS PEARL may present a different toxicological profile than virgin pellets released in South Africa. However, equally important is the recognition that not all shorelines are equally sensitive or pristine. Plastic waste is regularly burnt on Sri Lankan beaches by local residents, and it is critical that the context where a spill occurs must be correctly evaluated to maintain good scientific practice.

Understanding the background conditions within which plastic is spilt is critical when considering the aim of targeting plastic pellets or other background debris. Some locations have limited presence of background plastic, whereas other areas have chronic plastic pollution problems (Figure 8). Therefore, the feasibility of an alternative collection strategy must be considered on a case-by-case, and location-by-location basis. It is important to note that, if size of the plastic pellets is the main concern, evidence has shown that pre-existing background plastic will eventually fragment into micro and nano plastics if left in the environment. Therefore, recovery of macroplastic may not only be the most efficient, but also provide the greatest long- term net environmental benefit.

Figure 8: Environmental plastic pollution, both ship-source and background, varies and the relative impact of spilt pellets changes within those contexts. The left image shows ship-source spilt pellets on pristine South African beaches, the right image shows pellets amidst background pollution on Sri Lankan beaches.

CONCLUSIONS

The overarching goal of any response to a ship-source pollutant should be to mitigate long- term damages and expedite the natural recovery process. The principles of NEBA are relatively easy to apply when dealing with pollutants where threats to the environment are known, however during spills where the risks of the pollutant is less understood, their application could be more challenging.

Overtime, clean-up of ship-sourced plastic pellets has been shown to become increasingly inefficient once concentrations diminish. During these cases, considering the operational GHG footprint can help determine the most effective approach to mitigating damage. This study provides the basis for a more holistic approach to plastic pellet spills by considering more efficient recovery strategies where feasible. Importantly, these strategies must be considered within the wider context of the spill, however collection of ‘other’ plastic concurrently with spilt pellets may yield a more expeditious net-environmental and social benefit, compared with recovery of only lost ship-sourced plastic pellets.

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