Plastic waste menace in Ghana, a serious threat to marine ecological diversity

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Abstract. Plastic pollution is a major environmental concern due to the severe threats it poses to both terrestrial and marine ecosystems. The ocean health index for Ghana showed a consistent decline from 2017 to 2019 from a score of 63 to 59. Ghana is ranked 188th out of 221 exclusive economic zones worldwide. The annual imports of raw plastic materials are estimated to be 2.58 million metric tonnes and about 73% of the total plastic imports end up as waste materials. Plastic recycling represents an insignificant 0.1% while re-use plastics represent 19% of the total imported plastic materials. The analysis showed that the daily average solid waste generated per head in Ghana is 0.47 kg and it sums up to an estimated 12,710 tonnes per day for the population. In the marine ecosystem, plastics waste becomes entanglement capable of causing injuries and fatalities to some marine species. Low recycling techniques coupled with improper solid waste disposal by the populace in coastal communities contribute significantly to marine pollution.

1. Introduction
Plastic wastes pose severe environmental challenges to both terrestrial and marine ecosystems globally. As a result of the non-degradability of vast plastic materials, natural recycling via decomposition becomes virtually impossible, this leaves huge tonnes of plastic waste in the environment. Marine debris is defined as “any anthropogenic, manufactured, or processed solid material (regardless of size) discarded, disposed of, or abandoned in the environment, including all materials discarded into the sea, on the shore, or brought indirectly to the sea by rivers, sewage, stormwater, waves, or winds” [1]. Many countries around the world are battling with plastic waste or filth due to the increasing volumes of plastic waste materials disposed of in the environment. It is reported that the quantum of municipal solid waste (MSW) that is generated yearly globally amounts to 2.01 billion tonnes (Gt). A large chunk of this solid waste thus about 33% is not properly managed. At the global level, the open dumping method of solid waste disposal accounts for 33% however, the case is even worse when it comes to low-income countries. Whilst only 2% of high-income countries rely on open dumping methods for solid waste disposal, the situation is completely different in low-income countries, thus 93% of low-income nations depend on open dumping [2]. At present, the Pacific region and East Asia generate an overwhelming quantum of the world’s waste representing 23% but South Asia, Sub-Saharan Africa, North Africa, and the Middle East are the fastest growing solid waste generating regions by 2050. Plastic waste accounts for 12% of the global solid waste generated. In developing countries due to improper management, most of the solid waste that is dumped openly including the plastic component eventually finds its way into marine and freshwater bodies. The International Maritime Organization (IMO) as part of global efforts to prevent the pollution of marine resources
adopted the International Convention for the Prevention of Pollution from Ships (MARPOL) in November 1973 and MARPOL 73/78 later came into force in 1983. It is significant to note that, Annex V of MARPOL completely bans the disposal of ALL forms of plastics into the sea. It also mandates Ships to provide official records of disposals and incinerations (Garbage Record Book) for ships with capacities of 400 gross tonnages and over as well as every ship certified to carry 15 people or more onboard [3]. In Ghana, solid waste management is a serious challenge. Given that, a large chunk of solid waste generated ends up in open dumping grounds and landfills. Very little has been achieved in terms of recycling plastic waste materials in Ghana. Many solid waste recycling initiatives either do not receive the necessary funding supports from the appropriate quarters or they eventually fizzle out. The marine resources in many coastal areas are fast becoming recipients of some of the plastic waste that is dumped in the open gutters and open drainage systems or dumpsites. The occurrence is more prevalent during rainy season due to runoffs that virtually carry open dumped filth materials into the streams, rivers, lakes, and sea. This study seeks to highlight the growing menace of marine plastic pollution especially in coastal areas and to suggest possible interventions to help curb this menace to ensure healthy marine resource base.

2. Global scenario of plastic production and waste generation

In a period of 65 years (1950 to 2015), worldwide production of plastics increased by almost 200 times from about 2 to 381 million tonnes (Mt) annually respectively. The cumulative production of plastics within the same period amounted to 7.8 billion tonnes (Gt) [4]. Plastic waste accounts for a substantial amount of total solid waste generated globally. This poses severe challenges to both terrestrial and marine ecosystems given the time it takes to decompose in the environment. Plastic waste depending on the size could be categorized either as nano-plastics with diameter less than 0.0001 mm, small microplastics with diameter range 0.0001 to 1 mm, large microplastics with diameter range 1 to 4.75 mm, meso-plastics with a diameter range of 4.76 to 200 mm, and macro-plastics also with a diameter greater than 200 mm [5]. It is believed that if both macro and meso-plastics are exposed to the normal environment, ultraviolet (UV) radiation as well as collision with other objects physically, disintegration could occur resulting in smaller particle sizes. It is important to note that, small particles of plastics could be ingested by aquatic organisms and may end up in the food chain of humans if eventually consumed. The quantity of plastic waste generated in a year globally at the industrial level varies from one sector to the other. For instance, in 2015, the packaging sector generated the highest plastic waste in the world with 141 Mt. The textile sector generated the third-highest plastic waste (38 Mt) in the same year, while consumer and organizational products (37 Mt), transportation sector (17 Mt), building and construction (13 Mt) came 4th, 5th and 6th highest plastic waste generation sectors respectively. The sector which recorded the least plastic waste generation globally was the industrial machinery sector with 1 Mt [6]. Of the 242 Mt of plastic waste generated worldwide in 2016 which accounted for 12% of all MSW, three regional blocks such as East Asia and Pacific; Europe and Central Asia, and North America contributed 57 Mt, 45 Mt, and 35 Mt respectively [7]. In 2018, the total quantum of plastic waste generated globally increased to 250 Mt, out of which 69.2% representing 173 Mt of the plastics waste were retrieved for purposes of treatment while the remaining 30.8% representing 77 Mt of the plastics debris were left in the environment. In terms of the mode of disposal, 28.8% representing 72 Mt made of plastics waste was delivered in controlled dumpsites or sanitary landfills while 25.2% representing 63 Mt of plastics waste were inappropriately disposed of. A total of 5.6% thus 14 Mt of plastics waste got leaked. According to the World Bank, (2018) report, plastic waste was the 4th highest generated waste annually representing 12% of the total global waste composition. Sub-Saharan Africa generates significant quantities of waste. In 2016, the region alone generated 174 Mt, thus a proportion of 0.46 kg per capita per day. Given the fast rate of urbanization and rapid population growth in the region, the amount of waste generated is expected to increase three times by 2050. This even becomes more worrying given the fact that open dumping is the commonest method of waste disposal accounting for 69% while 24% of the waste is disposed of at landfills and only 7% is recovered or recycled [7].
2.1 Plastic products in Ghana

It is reported that Ghana’s annual imports of raw plastics amount to 2.58 Mt out of which 1,883,400 Mt representing 73% end up as waste materials. Only 490,200 representing 19% of total imported raw plastics are re-used while nearly 0.1% of the plastic waste is recycled [8]. The remaining larger chunk ends up in the open dumpsites in the environment as plastic litter. There are different brands of plastics however, the four main types of plastics that are usually recycled or reprocessed are polyvinyl chloride (PVC), polystyrene (PS), polypropylene (PP), and polyethylene (PE). These four broad categories could further be subclassified based on the manufacturing process, added additives, and their respective densities. The identification is necessary for plastic management especially during recycling to avoid defective outputs or products with poor properties and quality because not all plastic waste could be recycled [9]. Plastic waste in Ghana could be classified as primary or secondary. While primary plastic wastes are usually generated by companies that manufacture plastic products or goods, secondary waste, on the other hand, is generated through non-industrial sources. The main sources through which plastic waste is generated are municipal, industrial, and commercial.

It cost Accra Metropolitan Assembly about Ghc250,000 equivalent to US$44,220.47 (at an exchange rate of 5.65) to collect solid waste per month with an estimated Ghc6 equivalent to US$1.06 to collect one ton of waste in Accra Metropolis. The commercial sources are the supermarkets, shops and industrial sources are the plastic processing and packaging companies. Municipal plastic waste is the most common form of plastic waste in Ghana given that virtually every item or commodity sold to the people is kept often in plastic bags. Huge volumes of plastic waste are generated daily especially in the cities. A large chunk of this plastic waste is dumped on open dumpsites, gutters and streets. In 2015, the daily amount of solid waste generated by every individual in Ghana was 0.47 kg, and the total solid waste generated daily by Ghana was estimated to be 12, 710 tonnes [10].

2.2 Ghana’s coastal zones

Ghana is adjacent to the Gulf of Guinea with a coastal stretch of 550 kilometers (km) with about 90 lagoons and many wetlands. The lagoons are classified into either open or closed lagoons. The coastline in the country is divided into three major sections namely the Eastern section which covers areas such as Accra, Nungua, Tema, Prampram, Ningo, Ada, Keta, and Afao. The Central Section of the coastline covers areas such as Apam, Winneba, Saltpond, Cape Coast, Elmina, Aboadze, Takoradi and the Western section covers areas such as Axim, Essiama, Half Assini among others [11]. Some of the popular rivers in the coastal zones include River Volta, River Densu, River Kakum, River Pra, River Ankobra. The Western Coastal section spans approximately 95 km, thus between the Ankobra River estuary and Ghana-Ivory Coast border with about 49 lagoons with gentle sloppy sandy beaches. The Eastern Coastal section extends to the Ghana-Togo border from Tema with sandy shoreline prone to erosion while the Central Coastal section stretches from River Ankobra estuary to Tema characterized by sandbars and rocky surface [12]. Unfortunately, most of these lagoons and lakes especially in the cities are polluted with plastic filth, domestic sewage among others.

Ghana’s aquatic ecosystem is characterized by fauna and flora such as marine fish, lagoon fish, sea turtles, sea birds, shellfish, litoral invertebrates, macroalgae, plankton, seagrass bed [13]. The coastal habitats and biodiversity in the country are altered and destroyed due to many human activities such as illegal sand mining at the beaches by adjoining communities, conversion of wetlands to residential areas as a result of increasing urban population.

3. Sources of plastic debris and pollution

Ghana’s Ocean Health Index between 2015 to 2019 showed a consistent pattern of decline for three consecutive years since 2017. On a scale of 0 to 100 points, Ghana scored 64 in 2015, 64 in 2016, 63 in 2017, 62 in 2018, and 59 in 2019. In terms of the overall ranking, Ghana was ranked 188th out of 221 Exclusive Economic Zones (EEZs) globally [14]. EEZ is the zone in the sea where the adjacent
country has jurisdiction, demarcation of a sort not extending beyond 200 nautical miles from the territorial ocean baseline. Plastic materials are made up of various chemical constituents during their production. Depending on the particular type of plastic material, its chemical constituents could vary. Polyvinylchloride (PVC) mainly contains vinyl chloride which is a colourless gas that easily burns. PVC is produced by industries in commercial quantities for the manufacture of various plastic products such as wire or cable insulators, pipe, packaging materials, etc. When plastic wastes that contain vinyl-chloride are burnt and the smoke is released into the air, exposure to such contaminated air could lead to ailments such as lung cancer, lymphoma, liver cancer among others. Vinyl chloride is known to be carcinogenic to humans [15]. Besides the above-mentioned negative effects of plastic waste, many coastal areas like Accra have their drainage systems choked with plastic waste. Accra in recent years is known for its perennial flooding due to choked drainage systems. In June 2015, a devastating flood occurred in Accra which led to an explosion at a fuel filling station, over 150 lives were lost. Stagnant open drainage channels that have plastic waste virtually all year round include Odwana, Korle lagoon. According to UNEP (2005), the most dominant marine litter based on all surveys is plastic which accounts for 80% of total marine waste. More than 80% of marine debris is traced to land-based sources while the remainder comes from marine activities namely fishing, shipping, and cruise lines [16]. It is predicted that CO₂ emissions from plastic waste incineration activities could triple globally by 2030 [17]. An estimated 275 Mt of plastic waste was generated in 2010 by 192 coastal countries globally, out of which between 4.8 to 12.7 Mt was deemed to have found its way into the sea [18]. The surge in plastic waste at the beaches impacts negatively on tourism potentials as well as other recreational activities. This could negatively affect national revenue generation from the beaches and recreational parks. For instance, in Geoje Island, South Korea, the tourism industry lost between US$29-37 million in revenue due to pollution of beaches and recreational areas as a result of marine debris in 2011[19]. There is a direct relationship between beach patronage by tourists and marine debris on seashores and beaches. The influx of marine debris on beaches and coastal areas have greater tendencies to reduce patronage of beaches and recreational parks. A report by NOAA 2018 showed that when marine debris is reduced drastically to ‘virtually none’ at Alabama beaches, it resulted in an 8.1% increase in recreational days at the beaches translating into a change in recreation value by $10,051,517. For beaches in Ohio and Orange County, California, the change in recreational days increased by 35.4% and 9.5% correspondingly with an increase in recreational value by $88,006,606 for Ohio and $129,689,616 for Orange County. It also revealed that when marine debris doubled, change in recreational days decreased by -26.5% with a reduction in recreation value by $32, 347,029 for Alabama. For Ohio and Orange County, there were -35.6% and -20.9% reduction in visitor recreation days with the corresponding decrease in recreation value of -$83,935,614 for Ohio and -$275,077,340 for Orange County [20]. In terms of using the Ocean for tourism and recreation, Ghana’s score has consistently declined since 2016 from 17.48 in 2015 to 15.65 in 2016. It further declined to 14.47 in 2017 and it increased marginally in 2018 to 14.81 but still below the 2015 score. The pictorial evidence as illustrated in Fig. 1 showed the extent of marine plastic pollution as observed during this study on the coastal areas of Accra particularly along the eastern stretch of the Gulf of Guinea Ocean.
Authors’ field observation (June 2018)

Figure 1: Plastic debris washed into the sea (Gulf of Guinea), Accra

3.1 Degradation, fragmentation, and biodegradability of plastic waste

Many plastic wastes are generally non-biodegradable unlike other forms of solid waste materials such as paper bags, cardboard, newspaper, paper towel, banana, and orange peels.

To change or alter the properties of plastics, different compounds are used in the production of many plastic materials such as Ultraviolet (UV) protection, anti-oxidants, plasticizers, and fire retardants. Synthetic polymers consist of two main types namely thermoplastic and thermoset. While thermoplastic could be moulded several times after being formed, thermoset, on the other hand, cannot be remoulded through melting once it is produced such as epoxy resins (EP) or coatings [21]. The extent of the degradability of synthetic polymers is dependent on different factors such as the properties of the polymer as well as the environmental condition [22]. For biodegradation and fragmentation to occur, it will take multiple factors such as microbial action, UV, and thermal oxidation. UV radiation causes cracking, fragmentation, and embrittlement on plastics in the marine environment, thus the dominant catalyst in the production of microplastics. By this, it means when marine debris is more exposed directly to UV radiation with higher temperatures and high oxygen levels, the increase in fragmentation. Similarly, fragmentation reduces when marine waste is submerged or buried in the seabed or bottom [23]. Biodegradation as earlier stated involves a biological activity by microorganisms where the polymer is either partially or completely broken down into CO$_2$, O$_2$, and H due to photodegradation, hydrolysis, and microbial activity. Considering the long duration plastic wastes take in the environment before it can decompose, there is an urgent need for practical solutions and strategies to be adopted to reduce the high influx of plastic materials into
the sea and other water bodies. It estimated that whooping 104 Mt of plastic waste could leak into the environment by 2030 due to insufficient management of plastic waste globally [17]. Table 1 provides details on how long it takes some plastic materials to decompose.

| Marine waste       | Decomposition time |
|--------------------|--------------------|
| Banana peels       | 2-5 weeks          |
| Cigarette filter   | 1-50 years         |
| Coffee cup         | 30 years           |
| Coffee pod         | 500 years          |
| Disposable diaper  | 500 years          |
| Leather            | 50 years           |
| Newspaper          | 6 weeks            |
| Paper towel        | 2-4 weeks          |
| Plastic bag        | 20 years           |
| Plastic cup        | 450 years          |
| Plastic straw      | 200 years          |
| plastic toothbrush | 500 years          |
| Plastic water bottle | 450 years      |

Authors compilation (Source: The Ocean Conservancy & US National Park Service) [24]

4. Alternative interventions
With the complexity regarding the time required for plastic waste to breakdown, it is in Ghana’s interest to come out with a suitable and practical solid waste management model to curb the menace. Plastic waste has become one of the major environmental problems in the country. For illustration, in Western Australia, initiatives such as Adopt-a-Spot Programme (ASP), Tidy Towns Sustainable Communities Awards (TTSCA), Container Deposit Scheme (CDS) community grants up to $2000 and Clean Clubs among others are practical measures put in place by the Government to deal with solid waste. The TTSCA is categorized into seven different award schemes which include Environmental Education Awards (EEA), Litter Prevention and Waste Management Awards (LPWMA), Environmental Sustainability Awards (ESA), Litter Report Scheme (LRS), and Community Action and Wellbeing Awards (CAWA). These are practical models that could work in Ghana. For instance, the LRS could be done using a mobile app, dialing hotline, and online. As of February 2020, Western Australia had a total of 15,250 litter reporters [25]. In 2014, the Government of Ghana launched National Sanitation Day (NSD) in response to the sanitation challenges in the country. The 1st Saturday of every month was set aside for nationwide voluntary clean up exercises. This initiative even though it was good but unfortunately got truncated after a change of government in 2017. An estimated $4 billion could be saved by consumer goods manufacturing companies globally in a year through proper management of plastics [26]. This underscores the need for good management of plastic waste through recycling and reusing to ensure environmental health and sustainability.

5. Conclusion
The plastic pollution of Ghana’s marine resources has been examined. The disposal of municipal solid waste which includes plastic filth at open dumpsites and open gutters and drainage systems poses severe environmental challenges in the country. Perennial flooding in Accra and other coastal
communities in Ghana is largely attributed to choked gutters and drainage systems mostly by plastic debris. The outbreak of communicable diseases such as cholera has been associated with unsanitary conditions, especially in densely populated cities. The ocean health index for Ghana continues to deteriorate since 2017 and given the alarming increase in non-reusable plastic materials in the country especially in the urban areas, urgent steps must be taken to curb the menace. The presence of marine debris in the ocean does not only pollute the water but also entangles marine species such as fishes, shrimps, crabs and could sometimes result in fatalities. Tourism and recreational activities at beaches are negatively affected by marine debris which could lead to potential revenue losses. There must be a total paradigm shift in policy and practice by the central government and other relevant stakeholders to ensure sustainable and efficient management of municipal solid waste through rigorous recycling and reuse. It will be useful to conduct an additional in-depth investigation to ascertain the various categories of marine plastic debris that enter the sea and to possibly quantify the amount of plastic debris that enters the sea from ashore. This would help in both policy formulation and putting in place practical steps to address the menace.

6. References

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