Marine Debris Accumulation on the Big Island of Hawai‘i

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English 225

Introduction

Since the dawn of the industrial era, human effect on biodiversity and the environment has been detrimental. Human-generated pollution has globally established itself. One of the most predominant forms of pollution found is plastic. Since the start of commercially made plastic products in the 1950s, in just a few decades these same plastics can be found worldwide (Barnes et al., 2009). Plastics are an incredibly versatile item, and they have evolved over the past half-century to be used in our everyday lives (Laist, 1987). They are a resilient and long-lasting material that can be made at cost effective prices (Laist, 1987). Due to this, plastic usage has increased tremendously since its introduction. With no other alternative for plastic, the quantity of its waste from land to the ocean is projected to increase annually (Jambeck et al., 2015). The consistent input and collection of plastics into the marine environment has a detrimental effect to the Earth. The oceans consist of five major marine debris gyres: in the Indian Ocean, the North and South Atlantic, and the North and South Pacific. The numerous currents that push and pull the debris throughout the oceans facilitate the trash accumulation in these generalized areas. According to the location of the North Pacific gyre and the combination of the various North Pacific currents, more marine debris accumulation should be located along the southeastern side of Hawai‘i Island.

Background

Global Effects of Pollution

Plastics in the marine environment have collected for quite some time. Although plastic makes their way around the world and in far to reach places, such as the middle of the ocean, estimates can still be made. The first aspect of plastic having an effect on a global scale starts with the amount of its waste that is generated. In a 2010 study based on data collected from 192 coastal countries, an estimated 275 million metric tons of plastic waste was gathered (Jambeck et al., 2015); though only about 4.8 to 12.7 million metric tons are expected to make it into the ocean (Jambeck et al., 2015). This constant downpour of plastic waste has now been continuing since it originated over half a century ago. Over time, plastics of all sizes have spread onto the land, horizontally across oceans and vertically into the deep sea.

As the tides and currents change throughout the day the plastic pieces are pushed and pulled down into the abyss. Most of the plastic that sinks to the sea floor ends up on the continental shelf since it is more shallow and likely to settle there first (Cauwenbergh et al., 2013). Researchers for the first time have discovered plastics in the deep-sea sediment. Microplastics, which are small plastic particles less than 1mm, were tested at a few locations between 1000m to 5000m; the results showed on average that 1 microplastic was detected every 25cm³ (Cauwenbergh et al., 2013). Nearly all microplastics eventually settle into the sediment, whether at the bottom of the deepest part of the ocean or even at the surfaces of beaches.

Beach sediment can contain numerous materials, from regular sand, organic material, to even microplastics. It is inevitable that with the daily amount of plastic waste produced and put into the ocean, that there is a great possibility for it to end up in the sediment of beaches, especially those most frequented in densely populated areas (Jambeck et al., 2015). This is because of the possibility of pollutants being directly deposited on the beaches from its visitors. In a study conducted on Kamilo Beach, known for its high concentrations of plastic waste accumulation on the southern side of Hawai‘i Island, sediment cores detected several plastic materials. The implications of such data imply that more plastic in the sediment causes more permeability (Carson et al., 2013) Effects of this can cause small beach organisms in the sand to be flooded out and even reduce subsurface temperatures (Carson et al., 2013). The effect of plastics in sediment creates a threat to the biological life that it comes into contact with.

The biological effect of plastic concentrations in beach sediment starts off unnoticed. Reduced subsurface temperatures affect temperature-dependent organisms such as turtles, causing an influx of males to females (Carson et al., 2013). Other organisms that are interconnected to beach sediment such as seabirds are at harm (Blight and Burger, 1997). From surface feeding birds to diving birds, plastic was recorded in the stomachs of both types (Blight and Burger, 1997). Small fragments of plastic find their way into food sources of many organisms and have also been recorded in zooplankton. After being ingested by the zooplankton, the microplastic particles were seen to have attached themselves to the bodies of the organism, causing reduced fitness ability in the zooplankton (Cole et al., 2013). With a negative decline in the population of zooplankton, other organisms such as fishes or marine mammals that are above them in the food chain can become seriously in danger of perishing as well. Many places have flourishing water filled with biodiversity, but at this rate, it is hard to see them flourish much longer.

Local Consequences in Hawai‘i Due to Pollution

Hawai‘i is home to many beautiful creatures both on and off the land. Marine debris is detrimental to the biodiversity within the island chain. In a remote location, in the middle of the Pacific Ocean, Hawai‘i is sensitive to changes in environment. The majority of globally documented extinctions since the 1500s have occurred most commonly on islands (Baillie et al.,
Apart from the destruction on the biological side, the degradation of beaches is apparent as well. In Kauai, approximately 500 pieces of plastic debris are making their way on to the beaches every day by people and currents (Cooper and Corcoran, 2010). At this rate, the chances of contamination rise drastically. Not only does the chance of contamination affect the beaches, but the size and shape of the debris do as well. Some pieces according to their shape can scrape and drag the beaches, which in turn causes it to deform its natural structure (Cooper and Corcoran, 2010). The same way if an object is dragged over the beach, it creates a deformation of the sediment behind leaving it susceptible for more degradation to occur. The overall destruction these pieces cause is damaging towards all it encounters.

For removal of debris within sediment, there is elutriation. This process that separates particles based on physical characteristics in a stream of gas or liquid. Mostly used for small particle collecting, sediment can be separated from the plastics and extraction can begin (Claessens et al., 2013). Another form of debris collection includes beach cleanups, where annually, specifically on Hawai‘i Island, 16 metric tons of debris is collected over a 15km coastline (Carson et al., 2013). Plastic pollution is apparent based on collected data and computer estimates and the effects of this accumulation of plastic is obvious as well. The importance of plastic debris clean up is vital to overall health of the ecosystem by which the human population lives off of.

Site Descriptions & Methods
A total of six beach locations around Hawai‘i island were surveyed in three districts: Kona, Ka‘u, and Hilo. In the Kona district, Hapuna Beach and Kua Bay were chosen because they are both popular beaches that have dozens of daily visitors and locals. Punalu‘u Beach of the Ka‘u district usually has sea turtles which draws people to visit, and Green Sands is an isolated beach which requires a hike or 4WD to reach it. Hilo Bay sits alongside the district of Hilo and is used and visited for recreational activities such as sailing or rowing, and Richardson’s Beach is quite popular where dozens of locals and some tourists visit daily.

Upon arrival at the beaches, a random location just offshore was chosen. Two 30m transect line were laid in parallel approximately 3m apart from each other. Within this area now enclosed, a survey was conducted taking note of pieces of any marine debris detectable by the human eye no deeper than 4in. The debris collected was placed in three basic categories.

Categories of marine debris:
- a) Small: 0-3in
- b) Medium: 3.1-8in
- c) Large: >8.1in

Results

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<thead>
<tr>
<th>SITE</th>
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<th>COUNTS</th>
</tr>
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<tbody>
<tr>
<td>Hilo Bay</td>
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<td>15</td>
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<tr>
<td></td>
<td>Medium</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Large</td>
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</tr>
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</tr>
<tr>
<td></td>
<td>Medium</td>
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</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>Punalu‘u Beach</td>
<td>Small</td>
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</tr>
<tr>
<td></td>
<td>Medium</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Large</td>
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</tr>
<tr>
<td>Green Sands Beach</td>
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<tr>
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<tr>
<td></td>
<td>Medium</td>
<td>3</td>
</tr>
<tr>
<td></td>
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Figure 1: All recording were placed into a spreadsheet that was color coded to represent different districts. (Orange = Hilo, Green = Ka‘u, Blue = Kona).

New Methods for Ratification
The distribution of plastic debris is sporadic across the oceans. Wind and water currents vary everywhere. The abundance of plastic in a location can vary from 0 to 7300 pieces per hectare (Barnes et al., 2009). The importance of the knowing about the accumulation of plastics is essential because they have a wide variability as to the damages they can cause. Through a complex modeling system to estimate plastic accumulation as of today, an estimated 5 trillion tons of plastic, weighing about 270,000 tons has been collected (Eriksen et al., 2014). More precise methods for understanding the amount of plastic debris out there can help provide solutions for removal.

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The data collected were put into separate charts to show the correlation between debris size and location. These divisions provided a clearer understanding of how the debris was distributed across the island.

**Findings**

Observations made from the data conclude that the debris accumulation did not depend on the currents that move through the island. Of the beaches that were tested, the greatest accumulation of debris was shown in areas that have the highest population density. Beachgoers tend to pollute these beaches rather than the debris coming in from the water. Most commonly found were paper-like materials (wrappers, napkins, cardboard, etc.) and plastic bottles and bags. All of these constituents are most likely caused by human pollution that occurs directly on the beach. Overall, not much debris was observed throughout all of the test sites. The small pieces were primarily wrappers or paper-like materials and the larger items were either plastic bottles or bags. The low number of debris at such popular beaches show that these pollutants are probably picked up and thrown away in order to keep these beaches clean and visitors coming.

Between the three districts that the beaches were tested in, Hilo showed the greatest amount of pollutants. This also coincides with the previous assumption that more populated beaches tend to have the most trash. Hilo is the most populated city on the big island and therefore would make sense to have the most pollutants on its popular beaches. Following were Kona and then Ka’u, respectively. Kona has many tourists come visit its beaches and therefore that adds to debris accumulation on the western side of the Big Island. As for Ka’u, the southern side showed relatively clean beaches.

**Discussions**

The experiment tested only three districts and six beaches. Overall there are six districts and countless beaches. A better understanding of the accumulation of debris should include many more beaches and all districts around the island. The data collected showed the beaches in Hilo to have the most debris. This may be the case, however Kamilo Beach which is located in Ka’u, where the experimental data showed that this area had the cleanest beaches, is known as one of the worst trash filled beaches in the world where approximately 90% of the beach is debris (Carson et al., 2013). The structure of the beach and the path of the currents make this place a prime dumping spot for marine debris. This beach was not chosen to exclude any bias.

The data collected also excluded any debris that was below 4in. Many pieces of debris can become covered over time and be placed deeper in the sediment, due to lack of research tools, this could not be assessed. Sediment cores, which pull out layers of sediment could have produced more effective results because this would
show a longer time span as new sediment is placed on top of the older. Another aspect of the experiment is that storms or other natural events also impact the amount of debris accumulation. Runoff and strong winds, in conjunction with changing currents, move debris all around. Therefore debris can easily be transferred from one place to the next. A better understanding of the accumulation of debris should be taken over a length of time and using tools to show the previous history as well.

Conclusion

Marine debris, both on and off the beaches, has a broad impact on the environment. The many animals that interact with these pollutants are, majority of time, negatively affected. This poses an enormous threat to world ecosystems, as all animals in one way or another are interconnected in an environment. More efforts should be made to eliminate the use of plastics and all other non-biodegradable pollutants. The life expectancies of these materials are unreasonably long and with that the build up of these plastics and other items will just keep accumulating for many generations to come. Based on the data observed, most places will most likely have a correlation between population and pollution. The efforts of the community must come together to solve this ongoing problem. Ultimately, this problem lies at the source and the constant on pour of millions of metric tons of plastics into the environment must stop and the communities, along with the business men and women must learn to take care of the place they call home, Earth.

References


Cooper, A D, Corcoran, L P. (2010). Effects of mechanical and chemical processes on the degradation of plastic beach debris on the island of Kauai, Hawai‘i. Marine Pollution Bulletin. 60(5).


