## Task 1: Notes of Key points

Notes:

- Total losses of microplastic is estimated to be around 3.2 million tons per year (Full range is 1.8 to 5.0)
- Total release of microplastic into oceans is estimated to be around 1.5 million tons per year. (Full range of estimates is 0.8 to 2.5 million tons depending on optimistic or pessimistic estimate)
    - This is a world equivalent per capita release of 212 grams or the equivalent of one empty conventional plastic grocery bag thrown into the ocean per person per week worldwide
    - Shows how severe this issue is
        - This is an example of the interaction between 2 different systems, the ecosystems and the human world
        - Also shows the input, process and output of the ecosystem
            - Input: Waste materials from humans
            - Process: Pollution
            - Output: Damage to the ecosystem, death of aquatic life
- The laundering of synthetic textiles and the abrasion of tyres while driving are the largest proportion of the loss of plastic microplastics
- Showcases effects of bioaccumulation and biomagnification
    - The chemicals and toxins from the microplastics cannot be easily excreted by organisms

- Such toxins will bioaccumulate in organisms and will biomagnify from one trophic level to the next, affecting all the species in the food web

## Task 2: Microplastics from Tyres and Shoes

**Main Scientific Investigation:**

**Compare the amount of microplastics from car tyres with the amount from shoe wear.**

a) What are some questions you have about the inquiry question? What are your answers to those questions?

| Questions | Answers |
|---|---|
| Which has a higher plastic content, car tyres or shoes? | Car tyres composition<br>43% plastic<br>24%natural rubber<br>19% synthetic rubber<br><br>Shoes<br>47% rubber or plastic |
| Which releases more microplastics through wear and tear?<br>(We can only find the results for the losses/release by tyres) | Tyres: abrasion while driving<br><br>Activities and losses are computed in two ways.<br>The first approach combines the estimated driven distance covered by all vehicles in a region with reported particulate matter emissions from tyres per km per type of vehicle.<br><br>The second approach combines data on yearly global and regional sales of synthetic rubber for tyres with the typical particulate matter |

| | |
|---|---|
| | emissions over the lifecycle of a tyre.<br><br>Approach 1<br>Based on calculations, the results are as follows: Optimistic/central/pessimistic: 0.033/0.051/0.178 gram per tyre-km for cars, light and heavy trucks from (GRPE, 2013; Lassen et al., 2015; Sundt et al., 2014).<br><br>Approach 2<br>Losses: Optimistic/pessimistic: 10/25 % of microplastics loss over the lifecycle (Essel et al., 2015; Magnuson et al., 2016; Sundt et al., 2014). The central value is set to 20%, which is equivalent to the global apparent loss of rubber (quantity of synthetic rubber losses computed in approach 1 over the global sold quantity of synthetic rubber for tyres). |

# Report

**Research Question**: To find out whether shoes or tyres produce more microplastics after wear and tear

**Hypothesis**: An equal mass of tyres will produce more microplastics than shoes after wear and tear of a week

**Literature Review**

Section 1: Background Information

- **Total losses** of microplastic are estimated to be around 3.2 million tons per year
- Total release of microplastic into **oceans** is estimated to be around 1.5 million tons per year. This is a world equivalent **per capita release of 212 grams** or the equivalent of one empty conventional plastic grocery bag thrown into the ocean per person per week worldwide
- The **laundering of synthetic textiles** and the **abrasion of tyres** while driving are the largest proportion of the loss of plastic microplastics

Section 2: Composition of testing target

Most of those shoes are partly, or in many cases completely, fabricated from plastic and plastic-like materials, from the squishy soles to the pointy heels to the knit polyester uppers to the brittle eyelet holes.

Car tyres composition is 43% plastic, 24% natural rubber, and 19% synthetic rubber. Synthetic rubber are a close neighbour of plastics, made from treated petroleum and about 70 per cent of all rubber used in manufacturing is synthetic, according to the American Chemical Society.

**Methodology**:

Equipment required

- Running shoes
- Car tyre
- Electronic Balance
- Scotch Tape

Steps:

1. Cut the scotch tape into lengths of 5cm
2. Stick the sticky side of scotch tape on the part of the car tyre **that is in contact with the road**
3. Press down firmly on the scotch tape to ensure that the scotch tape is able to collect any microplastics present
4. Slowly peel off the scotch tape
5. Place the scotch tape on a petri dish with strong lighting
6. With the aid of the ruler, count any microplastics present on the scotch tape
7. If needed, use a microscope or a magnifying glass
8. Record the sizes of the different microplastics into different categories (0.1- 1 mm, 1- 3 mm, 3- 5 mm)
9. Repeat Steps 1 to 8 on 2 different car tyres that are in contact with the road and calculate the average number of microplastics for each category of size present for all 3 tyres.
10. Repeat steps 1 to 9 for all 3 different types of running shoes.
11. After 1 week of wear and tear, repeat steps 1 to 10, to find out if the amount of microplastics released has changed

Data to be collected

We are able to find the **surface area of the scotch tape** which is the fixed width of the scotch tape multiplied by 5cm length.

We are also able to find the **surface area of the tyre** in contact with the ground, which to measure the diameter of the tyre (*d)* and the breadth of the tyre (*b)* and putting it in the formular: $\pi d \times breadth$

- **Note: The tyres are of different surface areas, as we took different tyres to ensure the reliability of the test (same goes for the shoes)**

To measure the **area of the sole of the shoe** trace the outline on a 0.5cm by 0.5cm grid. Then count the number of full squares and multiply by 0.5, adding this derived value to the area of the number of incomplete squares.

To find the **total number of microplastics on the tyre** use the following formula:

$$\frac{Area\ of\ Tyre}{Area\ of\ Scotch\ Tape} \times Average\ number\ of\ microplastic\ on\ the\ scotch\ tape$$

To find the **total number of microplastics on the shoe** use the following formula:

$$\frac{Area\ of\ Shoe}{Area\ of\ Scotch\ Tape} \times Average\ number\ of\ microplastic\ on\ the\ scotch\ tape$$

**Results**

| Tyre | | | | | | |
|---|---|---|---|---|---|---|
| Week 1 (Before use) | | | | | | |
| Tyre used | Surface area of scotch tape used/ $cm^2$ | Surface area of tyre in contact with ground/ $cm^2$ | Number of microplastics on scotch tape | | | Estimated total number of microplastics on the tyre |
| | | | Size is small (0.1 - 1 mm) | Size is medium (1 - 3 mm) | Size is large (3 - 5 mm) | |
| 1 | 10 | 3012.5 | 0 | 1 | 2 | 904 |
| 2 | 10 | 2835 | 2 | 1 | 3 | 1701 |
| 3 | 10 | 2908.5 | 2 | 2 | 3 | 2036 |
| **Average** | **10** | **2918.7** | **1.6** | **1.3** | **2.6** | **1547** |
| Week 2 (After use) | | | | | | |
| Tyre used | Surface area of scotch tape used/ $cm^2$ | Surface area of tyre in contact with ground/ $cm^2$ | Number of microplastics on scotch tape | | | Estimated total number of microplastics on the tyre |
| | | | Size is small (0.1 - 1 mm) | Size is medium (1 - 3 mm) | Size is large (3 - 5 mm) | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 10 | 3012.5 | 5 | 7 | 8 | 6025 |
| 2 | 10 | 2835 | 7 | 4 | 6 | 4820 |
| 3 | 10 | 2908.5 | 5 | 7 | 4 | 4654 |
| **Average** | **10** | **2918.7** | **5.7** | **6** | **6** | **5166.3** |

# Shoe

Week 1 (Before use)

| Shoe used | Surface area of scotch tape used/ $cm^2$ | Surface area of shoe in contact with ground/ $cm^2$ | Number of microplastics on scotch tape | | | Estimated total number of microplastics on the shoe |
|---|---|---|---|---|---|---|
| | | | Size is small (0.1 - 1 mm) | Size is medium (1 - 3 mm) | Size is large (3 - 5 mm) | |
| 1 | 10 | 450 | 0 | 1 | 2 | 135 |
| 2 | 10 | 425.5 | 0 | 1 | 3 | 170 |
| 3 | 10 | 400 | 0 | 2 | 3 | 200 |
| **Average** | **10** | **425.2** | **0** | **1.3** | **2.6** | **168.3** |

Week 2 (After use)

| Shoe used | Surface area of scotch tape used/ $cm^2$ | Surface area of tyre in contact with ground/ $cm^2$ | Number of microplastics on scotch tape | | | Estimated total number of microplastics on the shoe |
|---|---|---|---|---|---|---|
| | | | Size is small (0.1 - 1 mm) | Size is medium (1 - 3 mm) | Size is large (3 - 5 mm) | |
| 1 | 10 | 450 | 2 | 5 | 3 | 450 |
| 2 | 10 | 425.5 | 4 | 2 | 2 | 340 |
| 3 | 10 | 400 | 3 | 5 | 4 | 480 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Average** | **10** | **425.2** | **3** | **4** | **3** | **423.3** |

Table of comparison for shoes and tyres

| | Shoes | Tyres |
|---|---|---|
| Average surface area | 425.2 | 2918.7 |
| Average number of microplastics in week 1 | 168.3 | 1547 |
| Average number of microplastics in week 2 | 423.3 | 5166.3 |
| Average number of microplastics/ $cm^2$ area for week 1 | 0.396 | 0.530 |
| Average number of microplastics/ $cm^2$ area for week 2 | 0.996 | 1.77 |
| Percentage increase from week 1 to week 2 / % | 151 | 234 |

**Data Analysis**

As can be seen from the data, after one week of usage and wear and tear, the tyres release more micro plastics than a pair of shoes. In fact, the general size of the micro plastics released are much larger, with many more pieces being of the largest size. This is also consistent with the findings for the release of micro plastics from the shoes, with most of the plastics released being of the largest size.

Considering the percentage increase in micro plastics release after one week of wear and tear, it suggests that tyres are more susceptible to releasing more plastics after wear and tear, with a 2.34 times increase in micro plastics released compared to only a 1.51 times increase in release from shoes. Considering the ratio of the amount of

microplastics to the surface area, tyres also prove to have released more plastics, with a release of around 5170 in an area of about 2900 square centimetres, while shoes only released 420 in about an area of 425 square centimeters. After comparing the release of microplastics per $cm^2$ of surface area for both the tyres and shoes before and after the week of usage, it is evident that tyres release more microplastics both before and after use, with an average of 0.530 per $cm^2$ in the first week and 1.77 per $cm^2$ in the second week compared to the shoes, with an average of 0.396 per $cm^2$ in the first week, and 0.996 per $cm^2$ in the second week. This suggests that tyres are generally more susceptible to releasing plastic when compared to shoes, being more dangerous than the shoes in this aspect.

A possible explanation could be that the tyres are put through more wear and tear than shoes, with more pressure being put on to it due to the weight of the vehicle. In contrast, shoes are only pressed down by humans which exert much less force and hence pressure, and this could have an impact on the release. The number of microplastics on the tyre or the shoe is also very dependent on the usage of that particular tyre/shoe. With a rarely used tyre/shoe, there will be very little microplastics found on the tyre/shoe compared to a shoe that is used oftenly. In this case, it is possible that the tyre was used much more often than the shoe, resulting in the differences in the amount of microplastics released.

**Conclusion**

The main findings of this experiment show that the tyres produce more micro plastics when compared to shoes, making them a more potent pollutant than shoes. With micro plastics polluting our rivers and oceans, it will endanger the lives of various species living in the rivers and oceans as microplastics can lead to indigestion and suffocation of various fish and animals in the oceans and rivers. Hence, it is crucial to reduce microplastic pollution to ensure the continued survival of aquatic life.

Based on research, it has also been found that microplastics can act as a channel through which PBTs (Persistent, Bioaccumulative and Toxic chemicals) can bioaccumulate. Microplastics act as a sink for such toxic substances. In fact, because they are split into such small parts, they have a much larger combined surface area compared to a plastic bag of the same volume. This means that more toxic chemicals can be ingested via microplastics, which can absorb/carry more of such chemicals. Organisms that consume food and drink water that contains these microplastics then consume the toxic chemicals that come along with it. Over time, because such chemicals are difficult to degrade and be excreted, bioaccumulation occurs in the organism and the toxic chemicals accumulate in the organism. These toxins and chemicals are also passed on to the next trophic level. When the organism is eaten by a predator, the chemicals end up in the predator as well. When the predator eats more of such organisms that are poisoned, the chemicals accumulate in their bodies over time, to a much higher level than the previous trophic level. This is a result of biomagnification, where the levels of such toxic chemicals increase as we move up the food chain. When this process is repeated, not only does this poison the entire community and ecosystem, but this can also affect humans, as humans are one of the most significant final consumers in many food chains. If such poisoning is extensive, it may result in humans getting poisoned by the plastic that we created.

Therefore, the release of microplastics is a pressing issue, and we should find solutions to the release of microplastics as soon as possible to prevent further serious problems, especially for tyres, such as making tyres out of less plastic or making roads less abrasive.

**Limitations**

This experiment has some limitations. One of them is that the area tested may not be representative of the whole surface. Some parts of the surfaces may have more or less plastics, and we are only able to come up with an estimate with this method.

Another limitation is that this experiment is also based on the assumption that all particles found on the tape are microplastics. However this is not the truth. In actuality dirt and dust particles can be stuck to the tape. Also, tiny rubber bits can also be stuck. This experiment could lead to a gross exaggeration of the number of plastics as a result.