European Journal of Sustainable Development (2022), **11**, 4, 211-216 ISSN: 2239-5938
Doi: 10.14207/ejsd.2022.v11n4p211

Mathematical Analysis of the Environmental Impact of Throwaway Fashion

By Mukta Mithra Raj[1], Priti Bajpai[2]

Abstract
The Fast Fashion industry is the second largest polluter in the world. The clothes we wear are impacting the environment during and after use. The amount of clothes discarded each year has increased tremendously. A staggering quantity of around 100,000,000 tons of collective apparel ends up in landfills. Most of the textiles are not disposed of in an eco-friendly way, causing the release of pollutants and greenhouse gases. In some countries, discarded clothes are incinerated to avoid piling up in landfills. Incineration releases toxins from the dyes and chemicals used in the clothing. This study focuses on analysing the money spent on each sector (Landfill, Incineration, Reuse and Recycle) and minimising the costs involved in a particular sector by first forming a mathematical model, and then solving it using Diophantine Equations. Waste management of textile waste has become an issue of major concern since the consumption of fast fashion is skyrocketing each year. Disposal methods like incineration and landfill are taking a heavy toll on the environment. The paper makes some recommendations on how the environment can be saved by reducing the costs. The objective of this study is to create awareness among consumers of the environmental impact their purchases are causing.

Keywords: Diophantine Equation, Fast Fashion, Environmental Impact

1. Introduction

Fashion labels entice us with advertisements, and the availability of choices in fashion at such affordable prices, makes us buy more and more. Today, an average consumer buys 60% more clothing than they purchased 15 years ago. Millions of people buy clothes every day without considering the environmental consequences. Textile manufacturing requires a huge amount of chemicals, water, energy, and natural resources. In fact, as consumers we have little knowledge about the entire production process; it has little to no impact on us. Fast fashion clothing is made of low-cost, low-quality materials and has a low price tag. Each year, washing garments release 500,000 tons of microfibers into the ocean, mostly made of polyesters. Laundry accounts for 40% of domestic water footprints. In recent years, the amount of clothing discarded has grown significantly due to changing trends in fashion and poor garment quality that wear out rapidly. When consumers discard clothing in the garbage, not only do they waste money and resources, but the materials might take more than 200 years to degrade in landfills.
The rate of landfill waste and incineration rises as the consumer demand for fast fashion increases. In the United States, 85 % of discarded textiles are disposed of in landfills or burned. i.e., approximately 13 million tons in 2017. This equates to a truckload full of

| [1]UnderGraduate, B.E.Computer Science, Birla Institute of Technology and Science Pilani, Dubai Campus
[2]PhD, Professor of Mathematics and Dean of Student Welfare, Birla Institute of Technology and Science Pilani, Dubai Campus

clothes per second according to the study by the Ellen MacArthur Foundation. According to estimates, every year, an average American throws away about 37 kilograms of clothes. In Europe, clothing waste is typically disposed of in landfills or incinerated. 5.6% of the total waste in Europe is burned and converted into energy. This corresponds to more than 80 million tons of waste. However, it is not as amazing as it seems. Incineration causes more CO2 emissions than power generated by the combustion of coal. Globally, 92 million tons of textile waste are generated every year. The global textile industry is expected to discard over 134 million tons annually by the year 2030.

Worldwide, the fashion industry accounts for 10% of total greenhouse gas emissions, and it is estimated that 1.2 billion tons of greenhouse gas emissions are released into the atmosphere each year from cloth production alone. Landfills are required for the effective disposal of solid waste. They keep communities clean by reducing the quantity of garbage. Nevertheless, they impact the environment considerably. The decomposition of textiles in landfills releases greenhouse gases and causes toxic chemicals and dyes to seep into soil and groundwater. When clothes get incinerated, it emits carbon dioxide, methane, and other greenhouse gases, diminishing air quality and contributing to the growing climate crisis. Toxins from the dyes and chemicals used in the garments are also released during incineration. Even the most advanced technologies cannot filter these pollutants that contaminate the air.

The world's natural resources simply cannot match our demand for throwaway fashion – it is not a sustainable system due to landfills, pollution, and the rapid depletion of natural resources. An enormous quantity of water is needed to produce the clothes we wear, and the fashion industry accounts for 20% of the world's wastewater. The run-off dyes and chemicals are polluting the water ecosystems directly. Incineration rates have increased almost four times over the last decade as landfill sites are diminishing. At the same time, the recycling rate shows a mere 6% increase over the past decade. What is collected for recycling which is about 12% is likely to be shredded and used to stuff mattresses and the like. Less than 1% is used to make new clothing. These trends are harmful to the environment.

The advent of the pandemic has brought the fast fashion industry to a standstill. People led a simple life through stagnation, and now as the world opens up, it is time to rethink before reverting to old ways. Fast fashion has a huge environmental impact on our planet, and as responsible consumers, we should be aware of the repercussions our purchases are creating. Go green policy needs to be adopted and implemented in the fashion industry. This study aims to analyse the cost of each sector of clothing waste by employing the Linear Diophantine equation and make recommendations. The Diophantine equation is a polynomial equation, having two or more unknown variables, having integral solutions. The general form of the Linear Diophantine equation is $ax + by = c$, where a, b and c are integers. The linear Diophantine equation used in this paper is in 4 variables and of first order which gives integral solutions.

2. Data Collection

The data is taken from the studies conducted by Ellen MacArthur Foundation and Green America on the Fast Fashion Industry. To reflect the evolving analysis using

the Linear Diophantine equation, the percentage of discarded clothing in each sector is rounded off to the nearest integer.

3. Methodology

To determine the amount spent on landfills, incineration, recycling, and reuse, the Linear Diophantine equation in 4 variables is formulated using the total value of the wasted clothing in USD, and the quantity of clothing discarded in tons as given in Figure 1 and Table 1.

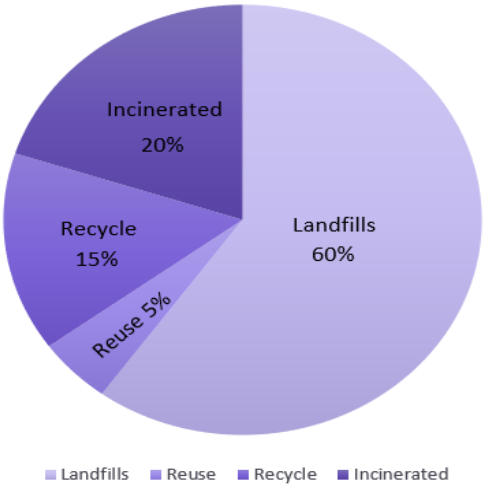

Figure 1: Percentage of discarded clothing in each sector, in tons

Table 1: Percentage and weight of discarded clothing in each sector

Sectors	Percentage	Weight of discarded clothing in tons
Landfills	60	60,000,000
Incineration	20	20,000,000
Recycle	15	15,000,000
Reuse	5	5,000,000

Facts: Total weight of discarded clothing in tons = 100,000,000
The total worth of discarded clothing = 500 billion USD
Formulation: Let x, y, z and w be the amount of money spent in USD per ton on incineration, recycling, landfills and reuse respectively.
The Diophantine equation formed is in 4 variables and is solved by taking two variables at a time**.**
(20% of 100,000,000) x + (15% of 100,000,000) y +(60% of 100,000,000) w + (5% of 100,000,000) z = 500,000,000,000
⇒ 20x+15y+60w+5z = 500,000
or 4**x + 3y + 12w + z = 100,000……** (1)
Solution: The equation has a solution as gcd (4,3,12,1) = 1 and gcd (4,3,12,1) |100,000

Taking 4x + 3y = u ----------(2)
and substituting (2) in (1) gives
u + 12w + z = 100,000 ……. (3)
Further, taking two terms,
u + 12w = v ----------(4)
and substituting (4) in (3), gives
v + z = 100,000…… (5)
Equation (5) is an equation in 2 variables v and z, which gives the general solution as
v = 200,000 + t
z = -100,000 – t ; t = 0, ±1, ±2, …
Substituting v in equation (4), gives
u + 12w = 200,000 + t
Solving u and w gives the general solution
u = -2,200,000 - 11t + 12t'
w = 200,000 + t – t' ; t, t' = 0, ±1, ±2,…..
Further, on substituting u in equation (2), gives
4x + 3y = -2,200,000 - 11t + 12t'…… (6)
The general solution of (6) is
x = -2,200,000 - 11t + 12t'+ 3t"
y = 2,200,000 + 11t - 12t'– 4t" ; t, t', t" = 0, ±1, ±2,…..
The general solution of (1) is:
x = -2,200,000 - 11t + 12t'+ 3t"
y = 2,200,000 + 11t - 12t'– 4t"
w = 200,000 + t – t'
z = -100,000 – t,
where, t, t', t" = 0, ±1, ±2, …

4. Results

The general values of x, y, z and w are calculated by substituting t= -101,000, t'= 98,000 and t" = -23,000 in the equations. The values obtained are as follows:
x = 18,000 USD/ton = 18 USD/kg,
y = 5,000 USD/ton = 5 USD/kg,
w = 1,000 USD/ton = 1 USD/kg,
z = 1,000 USD/ton = 1 USD/kg
Total expenditure for landfills:
➢ 60 w = 60*1,000 = 60,000 million USD
Total expenditure for incineration of clothes:
➢ 20 x = 20*18,000 = 360,000 million USD
Total expenditure for recycling:
➢ 15 y = 15*5,000 = 75,000 million USD
Total expenditure for reuse:
➢ 5 z = 5*1,000 = 5,000 million USD
When both investment and operational costs are considered, incineration is more

expensive than landfill. The cost of incineration remains high even if environmental costs are included.

5. Conclusion and Recommendations

Not all energy sources are sustainable. Although incineration produces some useful energy, it is not eco-friendly and causes more harm than good. Incineration releases harmful emissions that substantially impact climate change. Comparing the environmental costs of both landfills and incineration, the former is the lesser evil. When it comes to waste management, reuse and recycling should be prioritised.

The pandemic has shown the world that it is possible to survive on necessities. Pollution levels dramatically dropped globally during the lockdown. A conscientious choice must be made to advocate slow fashion. The transition from fast to slow fashion will make a huge difference and help reduce the carbon footprint. While buying apparel, one should go for brands that adopt sustainable practices and environmental policies. Garments that last longer should be purchased, and consumption should be minimised by buying less. Making the switch to sustainable practices will go a long way toward safeguarding the environment. The study largely focuses on worldwide post-consumption impacts on the environment. However, the country-wise role of the fast fashion industry in the escalating environmental catastrophe is not examined in this research. Furthermore, the actual environmental costs can be analysed only if the pre-consumer production stage of garments is also included. So, a study based on both pre-consumption and post-consumption environmental costs is planned as future work.

References

Abdulrab, H., & Maksimenko, M. (1995, April). General solution of systems of linear diophantine equations and inequations. In *International Conference on Rewriting Techniques and Applications* (pp. 339-351). Springer, Berlin, Heidelberg.

Bick, R., Halsey, E., & Ekenga, C. C. (2018). The global environmental injustice of fast fashion. *Environmental Health*, *17*(1), 1-4.

Binet, F., Coste-Manière, I., Decombes, C., Grasselli, Y., Ouedermi, D., & Ramchandani, M. (2019). Fast fashion and sustainable consumption. In *Fast fashion, fashion brands and sustainable consumption* (pp. 19-35). Springer, Singapore.

Blankenau, K. (2020). How is Fast Fashion Hurting the Environment and Why Should We Support Sustainable Brands?. *Best Text*, *1*(1), 6.

Brewer, M. K. (2019). Slow fashion in a fast fashion world: Promoting sustainability and responsibility. *Laws*, *8*(4), 24.

Buzzo, A., & Abreu, M. J. (2019). Fast fashion, fashion brands & sustainable consumption. In *Fast fashion, fashion brands and sustainable consumption* (pp. 1-17). Springer, Singapore.

Dhir, Y. J. (2021). Hazards of fashion and textile waste: Approaches for effective waste management. In *Waste Management in the Fashion and Textile Industries* (pp. 31-58). Woodhead Publishing

Ellen Macarthur Foundation.(2017). *A New Textiles Economy: Redesigning Fashion's Future*. Ellenmacarthurfoundation.Org. Retrieved January 5, 2022, from https://ellenmacarthurfoundation.org/a-new-textiles-economy

Kanaga Dhurga, C. (2021). A LINEAR DIOPHANTINE EQUATION AND ITS REAL LIFE APPLICATIONS. *Advances and Applications in Mathematical Sciences*, *20*(8),1389–1394. https://www.mililink.com/upload/article/1038216181aams_vol_208_june_2021_a5_p1389-1394_c._kanaga_dhurga.pdf

Meßner, F., Parsert, J., Schöpf, J., & Sternagel, C. (2018, July). A Formally Verified Solver for Homogeneous Linear Diophantine Equations. In *International Conference on Interactive Theorem Proving* (pp. 441-458). Springer, Cham.

Meyer, C., & Höbermann, C. (2021). From Fast Fashion to Slow Fashion–Raising Awareness of Young People for Sustainable Production and Consumption. In *Recontextualising Geography in Education* (pp. 167-183). Springer, Cham.

Miller, J. (2020). The Textile Industry: A Deep Look into the Environmental Impacts of Fast Fashion.

Moazzem, S., Crossin, E., Daver, F., & Wang, L. (2021). Environmental impact of apparel supply chain and textile products. *Environment, Development and Sustainability*, 1-19.

Moorhouse, D. (2020). Making fashion sustainable: waste and collective responsibility. *One Earth*, *3*(1), 17-19.

Quinlan, R., Shau, M., & Szechtman, F. (2022). Linear diophantine equations in several variables. *Linear Algebra and its Applications*.

Roy, U. N., Sah, R. P., Sah, A. K., & Sourabh, S. K. (2019). Linear Diophantine Equation: Solution and Applications. *International Journal of Mathematics Trends and Technology (IJMTT)*, *65*(1).

What really happens to unwanted clothes? (n.d.). Green America. Retrieved February 2, 2022, from https://www.greenamerica.org/unraveling-fashion-industry/what-really-happens-unwanted-clothes