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Paper Cup Waste Disposal

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CHAPTER ONE

INTRODUCTION

1.1 GENERAL INTRODUCTION

A paper cup is a disposable made out of paper and after lined with plastic or wax prevent liquid from leakage out or soaking by paper. Paper cups are made from

renewable resources. The cups should be made from food grade paper which is hygienic in nature. It is capable for holding both hot & cold liquid for longer time. The uses of paper cups have wide range. Give the rapid changes in life style; it is the right time to enter the consumer segment to popularize the home consumption of paper cups.

There are several inherent advantages in using Paper Cups as compared to cups of other materials. These Paper Cups are gaining popularity all across the globe as a beautiful and stylish way of minimizing exposure to food borne infections.

Paper Cups have numerous advantages like; they are manufactured in a very simple process using Food Grade Raw Materials with least waste and are easiest to recycle. They are ideal for individual servings at all kinds of parties, functions, picnic occasions, marriages, chat, tea & food joints, etc. Non-toxic in nature, the shapes and surface designs on these paper cups are attractive and present an inviting look. These paper cups can also be custom printed with an outlet's logo, brand punch line or advertising message.

Among the post-consumer waste, paper cup becomes a widely used commodity all over the world. Though paper is recyclable, paper cups are coated with polyethylene plastic to prevent damage of the cups from hot beverages. A recent survey reveals that, consumption of paper cup in the country is around 1 Crore per day (Think beyond world, 2013). By this way paper cups generate about 253 million pounds

of solid waste per year (Whirley, 2008). Unfortunately, these paper cups were reported to be very complicated to recycle. The polyethylene terephthalate (PET) coated inside the paper cups prevents the cups from being recycled or degraded (Bijayani et al., 2013). While trying to recycle the paper cup waste, it is true that the process will lead to several complications. Times of India, Bangalore, 2008 reported that for recycling 6000 paper cups, around 12 trees, 26,000 litres water, 1750 litres of oil were required which would create 250 kg of air pollutants thereby consuming 4100 kilo watts hours of energy. Moreover, the recycling process was unable to separate the polyethylene lining. So, without proper disposal the paper cups end up in landfill and get eventually decomposed by releasing greenhouse gas. Hence, it is worthwhile for researches to pay attention on managing the paper cup waste generation.

To get control over the critical issue, we have opted vermicomposting technology for managing the paper cup waste generation. Vermicomposting involves the bio-oxidation and stabilization of organic matter through joint action of earthworms and microorganisms to transform its physicochemical and biochemical properties (Dominguez, 2004). It is an ecofriendly, cheap and rapid technique suitable for Indian conditions (Amit et al., 2013). Nevertheless, disposing the solid waste by land filling and open burning leads to air and soil pollution. Vermicomposting is an established field in waste management, converting the waste into high quality organic fertilizer. This process is performed in an aerobic environment with optimum biological activity and symbiotic interaction between earthworm and microorganism (Katrina et al., 2014). In a recent study, it was reported that vermicomposting of paper cup waste using earthworm required 19 weeks for conversion into a nutrient rich and stable product (Karthika et al., 2015). Vasanthy et al. (2017) results demonstrate that the microorganisms present in the vermicompost of paper cup wastes were effective in cellulase degradation and it can be used to reduce the period required for the degradation of paper cup waste.

Figure 1.1: paper cup waste Disposal

CHAPTER TWO

LITERATURE REVIEW

2.1. LITERATURE REVIEW

Most disposable paper cups (DPCs) end up being incinerated like most household waste due to high costs and technical limitations in China. And this has raised concerns due to potential environmental and health hazards. A combination of thermogravimetric analysis, Fourier-transform infrared spectroscopy and mass spectrometry (TGFTIR-MS) was employed to analyse the combustion process and identify the emitted gases during DPCs burning in this study. The combustion kinetics were elucidated through the Flynn–Wall–Ozawa (FWO) and Kissinger–Akahira–Sunose (KAS) methods. The physicochemical characterization revealed remarkably high volatile matter (94.51 wt.%) and an impressively high heating value of pistachio shell (19.54 MJ/kg). The relative concentration of the main volatile products was in the order of CO > H O > C = O > aromatic compounds > C-O > CO > C-According to TG-MS. This study provided a comprehensive understanding of the combustion behaviour of DPCs and highlighted the importance of proper waste management to mitigate the environmental impact of DPCs. This study examined what happens when disposable paper cups (DPCs) are burned. In China, most DPCs end up being burned with household waste, causing environmental and health concerns. The researchers used various analyses to understand the combustion process and identify the gases emitted. They found that DPCs burn in four stages, with the most significant weight loss occurring between 210 and 520 degrees Celsius. The combustion produces gases like carbon monoxide (CO), water (H2O), carbon dioxide (CO2), and various organic compounds. The study emphasizes the need for proper waste management to reduce the environmental impact of burning DPCs. The disposable paper cup industry has grown due to the demand for convenient and hygienic beverage containers. In India alone, 11.5 million paper cups are used annually. However, these cups, coated with materials for durability, pose environmental concerns as they end up in landfills and oceans after brief use. Recycling DPCs is challenging, and incineration, a common disposal method in China, has drawbacks such as emitting greenhouse gases. Some studies explore alternatives like vermicomposting and extracting new materials from Pastis study aims to analyse the combustion process of DPCs for sustainable waste management. Using advanced technology (TG-FTIR-MS), the researchers examine the combustion kinetics, emission characteristics, and potential by-products. This comprehensive analysis helps optimize incineration, recover energy, and develop eco-friendly waste management strategies. The research fills a gap in understanding DPC combustion, providing insights into environmental impact, energy recovery, and improved waste management. (Wang et al.2023)

Microplastics (MPs) have been found in many packaged food products such as salt, tea bags, milk, and fish. In a previous study by this group, MPs were found to leach into hot water from the plastic lining of disposable paper cups. No studies were found in the literature quantifying health risks or lifetime intake of MPs. At present, it is not possible to quantify health risks due to MPs because dose-response and toxicity assessments are not available. Therefore, the objective of the current study was to assess the intake of MPs and associated contaminants like fluoride that are released into these hot beverages. This study aimed to

understand the potential health risks associated with the intake of microplastics (MPs) and fluoride released from hot beverages, such as tea and coffee, due to plastic packaging. The researchers converted the previous particle count data of MPs into mass and calculated the chronic daily intake (CDI) and lifetime intake (LTI) through ingestion. Using Monte Carlo simulations to consider variable factors, they estimated an average CDI of 0.03 mg of microplastics per kg of body weight per day and 7.04 μg of fluoride per kg of body weight per day. While health risks from MPs are not fully understood, this study takes a step toward assessing human health risks associated with the ingestion of microplastics and other contaminants in food and beverages. In simple terms, the study highlights concern about the health and environmental risks associated with using disposable crockery and cutlery, particularly paper cups lined with high-density polyethylene (HDPE) films. The research found that these disposable items can release microplastics, ions like fluoride (F), and harmful contaminants into hot beverages Microplastics, which are tiny plastic particles, are known to carry harmful substances. The study points out that microplastics can be released from various sources, including disposable items like face masks post-COVID-19. These tiny particles can enter the human body and potentially cause health issues such as diabetes, disruptions to the endocrine system, cardiovascular problems, and developmental complications. The research also emphasizes the presence of microplastics in food and water, raising concerns about their potential impact on human health. For example, the study found microplastics in canned fish, bottled water, and even human faces. The ingestion of microplastics, especially those smaller than 10 μm, can lead to stress in the digestive and circulatory systems, posing a direct threat to health. Furthermore, the study discusses the release of fluoride ions from disposable items. While fluoride is essential for a healthy diet, excessive intake can be harmful. The research notes that paper cups, in addition to other sources like water and tea, can contribute to elevated fluoride levels, potentially leading to health issues such as dental or skeletal fluorosis. To better understand and estimate the risks associated with microplastics and fluoride intake, the study proposes the use of Monte Carlo simulation. This simulation helps assess both daily and lifetime intake of these substances through the consumption of hot beverages in disposable paper cups lined with HDPE films. Overall, the study aims to contribute to the risk assessment of microplastics and fluoride exposure from disposable items, highlighting the need for standardized protocols in scientific research to better understand and address these health risks. This research aims to figure out how much microplastic we might be swallowing every day and over our lifetime. While previous studies have told us how many tiny plastic particles we could be getting from our food, they often leave out the actual weight of these microplastics. This study uses simulations to estimate the mass of microplastics we could be taking in, giving us a clearer picture of the potential impact on our bodies. (Joseph et al.2023)

Microplastics (MPs) have become widespread in the modern world posing a hidden threat to the global environment. However, growing accumulation and devastating impact of MPs on human health and the environment have received least attention. In the current investigation, for the first time MPs have been identified which are released from the daily usable materials like polythene bags (PB) and paper cups (PC) in response to hot and cold-water exposure at different time intervals. The impact of these MPs has been assessed on the major antioxidant enzyme, bovine liver catalase (BLC).In simple terms, this study looked

at tiny particles called microplastics that come from everyday items like plastic bags and paper cups. When these items are exposed to hot or cold water, they release these microplastics. The researchers found that these microplastics can affect an important enzyme (a type of protein) called catalase, which helps protect our bodies. The microplastics change the shape of the catalase, making it less effective. It's like if you have a tool that's supposed to do a job, but when it gets altered, it doesn't work as well. The study showed that the catalase's ability to do its job was reduced by about 40%. This is concerning because catalase plays a role in protecting our bodies from damage. The researchers also suggested that using materials like glass, porcelain, stainless steel, or high-grade plastics instead of plastic bags and paper cups could be better for the environment and potentially avoid these harmful effects. So, it's like saying, "Hey, these common items we use every day might be releasing harmful particles, and we should consider using more eco-friendly materials. “Microplastics (MPs) are tiny particles from plastic products that have become a widespread concern due to their accumulation in the environment, posing threats to both human health and the global ecosystem. Household items like plastic-laminated cups and baby feeding bottles have been identified as significant sources of MPs, releasing millions of particles into the water. These MPs resist breaking down and can cross biological barriers, leading to contamination in terrestrial and aquatic ecosystems. The atmospheric presence of MPs has also been recognized as a potential global threat. The small size and mobility of MPs allow them to reach areas previously untouched, interacting with atmospheric layers and cellular environments. The impact of MPs on living organisms is concerning, as they can be ingested or inhaled, affecting organs such as the gastrointestinal tract, lungs, liver, kidneys, and circulatory system. Human stools have been found to contain MPs, indicating their potential absorption into the bloodstream. MPs binding to cellular proteins can reduce their activity The physiological accumulation of MPs in various organs can lead to blockages, structural deformities, changes in metabolism, genotoxicity, DNA damage, inflammation, and oxidative stress. Antioxidant enzymes like catalase, crucial for breaking down harmful substances, may be affected by MPs. Catalase deficiency is associated with various degenerative disorders. Infant feeding bottles containing MPs raise concerns about potential health impacts, especially in infants during critical development stages. To address this, sensitive techniques like Nile red staining are used to detect and identify MPs. Disposable plastic and paper cups commonly used for hot and cold beverages release MPs, especially when exposed to hot water. Harmful elements leach from the inner surface due to mechanical and thermal stress. Glass, steel, high-grade plastic, and porcelain cups are suggested as alternatives for consuming beverages and food items without the risk of MPs. In conclusion, this study highlights the need to reconsider the use of modern plastic and paper cups in Favor of traditional carriers and containers to minimize exposure to harmful microplastics. In simpler terms, this communication highlights that microplastics (MPs) not only contribute to deoxygenation in the ocean due to human activities but also negatively impact the enzyme responsible for producing oxygen. Specifically, the enzyme catalase, which plays a role in breaking down hydrogen peroxide into water and oxygen, experiences compromised structure and function in the presence of MPs. The study suggests that everyday materials like polyethylene (PB) and polycarbonate (PC) release MPs, further emphasizing the significant role of microplastics in the cellular deoxygenation process. (Samal et al.2023)

The study compared the release of tiny particles, called microplastics, from single-use paper cups lined with either traditional plastic (polyethylene or PE) or a biodegradable plastic (polylactic acid or PLA) when used for hot beverages. Surprisingly, the biodegradable PLA cups released more particles than the traditional PE cups. Top of Form The use of single-use plastic cups, especially those lined with polyethylene (PE), contributes significantly to plastic pollution. Efforts are being made globally to replace these with biodegradable options like polylactic acid (PLA)-lined cups. However, recent studies suggest that PLA cups may release high levels of microplastics (MPs), posing environmental and health risks. LA, while considered a biodegradable alternative, can release more MPs than conventional PE cups. The degradation of PLA is influenced by temperature, and the common use of these cups for hot beverages may accelerate the release of MPs. A study compared PE and PLA cups and found that PLA cups released 3.6 times more MPs, with 22,000 particles per Liter. The released MPs from biodegradable plastics, including PLA, can have similar toxicity to conventional plastics, affecting marine life. Additionally, by-products from the degradation of biodegradable plastics may pose risks to biodiversity and ecosystems. The study also highlighted the presence of cellulose microfibers in PLA cups, which were not found in PE cups. This raises concerns about the overall impact of biodegradable plastics on the environment. In conclusion, while there is a global push to replace conventional plastic cups with biodegradable options, the study emphasizes the need to reconsider the environmental and health implications of biodegradable plastics. Policymakers and consumers should be aware of these findings to make informed decisions about plastic alternatives. This study focused on comparing a biodegradable plastic called PLA SUPC with the traditional plastic PE SUPCs. The researchers looked at the number of tiny particles released when both types of plastics were exposed to hot water, simulating beverage preparation. The results showed that when PLA SUPCs were exposed to 95°C water, they released 4.2 times more tiny particles compared to traditional SUPCs. These particles included a significant number of additives. The study also found that treating the plastics with ethanol was effective in separating microplastics (MPs) from additive particles. It's important to note that the study may have underestimated the total number of particles, as the method used may have missed nano-sized particles. The research suggests that the approach can be used to study other biodegradable plastics and assess potential exposure trends to microplastics and additives. The paper concludes that while there's a detailed investigation into biodegradable plastics, it's too early to say if they are a better alternative to traditional plastics in terms of human and environmental health. There's still a need for more research on the potential harm of biodegradable microplastics and additives to human health, which should be a focus in future studies. (Yang et al.2023)

Researchers have found a way to tackle the environmental issue of disposable cups by recycling them into new materials. Most disposable cups are made of a mix of paper and plastic, which is hard to recycle. In this study, they shredded these cups into small pieces and used them to strengthen a type of plastic called polypropylene, creating a new material called paper plastic composites (PPCs). To make this happen, they mixed the shredded cup material with polypropylene, turned it into pellets, and melded it into various shapes at low temperatures to avoid damaging the paper fibres. They also experimented with adding different amounts of shredded cup material and using a special agent to improve the connection between

the paper and plastic. The results showed that by adding 40% of shredded cup material and using the special agent, they could significantly enhance the strength of the plastic. The new material had 50% higher tensile strength (the ability to withstand stretching), the stiffness increased, and it became more resistant to breaking. This study suggests that we can give a second life to disposable cups by turning them into a useful material, reducing waste and environmental impact. They also examined how well the cellulose fibres hold up under high-temperature processing using a method called thermogravimetric analysis. In simpler terms, the researchers are trying to find a practical way to recycle disposable cups and electronic waste plastic together to create a new, useful material. They've tested its strength and flexibility to see if it can be used for various applications. Disposable paper cups pose a big problem for the environment because they are challenging to recycle. However, a promising solution involves turning these cups into plastic composites that enhance the strength of materials. Essentially, up to 40% of the cup material (polypropylene or PPL) can be recycled and added to new plastic products, improving their overall strength. The recycling process includes breaking down the disposable cups into PPL flakes, which are then mixed with regular polypropylene (PP). The mixture undergoes extrusion and injection moulding to create composite materials with better mechanical properties. It's crucial to carefully control the processing temperatures and times to prevent damage to the cellulose fibres in the PPL flakes. To ensure the success of this recycling method, a coupling agent is needed. In this case, adding 3% of maleic anhydride grafted polypropylene has been found to be the best option. This coupling agent improves the properties of the resulting composite materials. When examining the fractured surfaces of these materials, it's clear that adding the coupling agent at the right level causes the PPL flakes to break instead of just pulling out. This approach of using recycled PPL flakes from disposable cups to reinforce plastics is not only resource-efficient but also has the potential to significantly benefit the environment. (Mitchell et al.2014)

The study focuses on improving the egg-laying process of the tasar silkworm (Antheraea mylitta) reared by tribal farmers in India. Currently, the moths lay eggs in earthen cups, but the process is not well-organized. The researchers experimented with a method involving cutting the wings and legs of the moths (W–L–) to control the oviposition frequency. They compared this new method with the traditional one (W–) in earthen cups and also tested oviposition on plain paper sheets. The results showed that moths with wing and leg cuts (W–L–) laid more eggs (72–80% in earthen cups and 74–83% on paper sheets) compared to moths with only wing cuts (W–). Additionally, the W–L– moths laid a higher percentage of eggs within the first four hours. The study suggests that using paper sheets for oviposition is a fast and efficient alternative to earthen cups. The findings indicate that the new method is comparable to the silk moth (Bombyx mori) in terms of egg-laying efficiency. This could be a beneficial and scalable approach for tsar silk production. The text talks about a type of silkworm called Antheraea mylitta, which produces tsar silk in several states in India. This silkworm is found in tropical forests and is raised by tribal farmers. Taser culture, or the practice of rearing these silkworms, is significant for rural livelihoods. The silkworm is categorized into different groups based on its adaptation to specific environmental conditions. The Daba ecotype is commonly used for tasar culture due to its suitability for semi-domesticated operations. The life cycle of the silkworm varies, with some completing it once a year (univoltine), twice a year (bivoltine), or

thrice a year (divoltine). The success of the tasar culture depends on factors like climate, presence of pests, and predators. The text also mentions challenges in tasar culture, such as the impact of yellow fly and uzi fly during the spinning stage, as well as threats from fungal, viral, and microsporidia infections. The latter can be transmitted from the parent to offspring. In the process of obtaining eggs for tasar silk production, female moths are allowed to mate, and their wings may be amputated. However, the timing of egg laying is not consistent, affecting hatchability. Eggs laid on the first day are known to have higher hatchability. Comparisons are made with Bombyx mori, a domesticated silkworm that undergoes grainage and rearing operations indoors. Unlike Antheraea mylitta, Bombyx mori has specific setups for egg production that involve keeping moths indoors, performing pebrine testing, and using plastic trays or sheets for egg laying. The text discusses the practice of bodily amputation, such as removing antennae and legs, in both Antheraea mylitta and Bombyx mori. However, detailed analysis and data on the effects of amputation on egg laying frequency are lacking. The paper aims to provide insights into the egg laying frequency and performance of Antheraea mylitta, specifically the Daba divoltine variety, after amputating wings and wings & legs. Additionally, it explores the use of paper sheets as an alternative to earthen cups for egg laying. This study found that a specific type of amputation, known as W–L– amputation, significantly increased the number of eggs laid by tasar silk moths. The moths laid a large number of strong eggs within the first four hours after amputation. When placed on paper sheets in favourable conditions, up to 83% of the eggs were laid on the first day and 92% within two days. This suggests that the process of tasar silk production could be shortened to just two days. Additionally, the study showed that there was no significant difference in egg laying between moths placed in earthen cups and those on paper sheets. This implies that traditional earthen cups used in tasar silk production could be replaced with PVC cellules and paper sheets as new and more efficient devices for egg laying. In summary, the research introduces a simple and scalable method of encouraging tasar silk moths to lay eggs on paper sheets. This innovation has the potential to modernize tasar silk production, making it more efficient and beneficial for tribal farmers. (Soundappan et al.2021)

Disposable paper cups that we commonly used for hot beverages have a plastic coating inside. A recent study looked at how this coating breaks down when exposed to hot water (85-90°C). The findings revealed that as the plastic breaks down, it releases tiny particles called microplastics and ions like fluoride, chloride, sulphate, and nitrate into the drink. The study found that in just 15 minutes of hot water exposure, about 25,000 tiny plastic particles were released into a standard cup of 100 mL. When examined more closely, scanning electron micrographs showed a whopping 102 million microplastic particles per millilitre in the liquid. Moreover, the plastic coating also contains harmful heavy metals like lead (Pb), chromium (Cr), and cadmium (Cd), which can transfer into the hot beverage. The analysis of the plastic composition showed a decrease in the percentage of elements like carbon (C), hydrogen (H), and nitrogen (N) due to exposure to hot water. In simpler terms, when we use these cups for hot drinks, the plastic inside breaks down, releasing tiny plastic particles and harmful substances into our beverages. Regularly consuming these microplastics, ions, and heavy metals with our tea or coffee might pose health risks in the long run. In simple terms, disposable paper cups, commonly used for drinks like coffee and tea, are made mostly from paper with a small amount of plastic lining to make them waterproof. However, there's a concern that

certain chemicals and plastic particles from the cup can end up in the drink. The plastic layer in the cup contains additives like phthalates and antioxidants, which can potentially leach into the beverage. Additionally, the waterproofing process involves using substances like perfluoroalkyl substances (PFAs). Some studies have shown that harmful chemicals from paper-based food packaging can transfer to the food or drink, including heavy metals and even tiny plastic particles called microplastics. This study aimed to figure out the types of plastic used in these cups and how they change when in contact with hot liquids. The researchers also measured the amount and size of microplastics that might end up in the drink. This is important because disposable paper cups are widely used, and understanding the potential health impact of these materials is crucial. Some disposable paper cups (A, B, D, E) have HDPE liners, while cup C has a liner with lots of cellulose. Pouring hot water into plastic-lined paper cups for 15 mins releases microplastic particles – about 25,000 per 100 ml cup. Scanning electron microscope (SEM) images show even smaller particles released – about 10.2 billion per 100 ml cup after 15 mins. Plastic liners change when exposed to hot water – surface roughness increases, strength decreases, and carbon percentage reduces. Ion Chromatography shows more ions in liquid from paper cups, possibly from microplastic release. Heavy metals are found plastic liners through ICP-MS – microplastic release may increase heavy metal concentration in liquid. Future studies can explore how quickly the plastic liners break down in paper cups. (Ranjan et al.2020)

Every year, more than 64 billion paper-plastic laminate (PPL) coffee cups are used in the United States and Canada, and most of them end up in landfills because they have a plastic lining that makes them hard to recycle. Recycling these cups can help the environment and create economic value from reused materials. However, the usual recycling methods don't work well for these cups. So, we tried a different approach. We shredded the PPL coffee cups and compared them to regular paper (Kraft eucalyptus sheets) using a machine. We wanted to see how much energy it takes to separate the paper fibers from the plastic in the cups and how it affects the quality of the recycled fibers. We used different amounts of the shredded material and passed it through the machine three times to increase the recycling process's strength. The energy needed to recycle the PPL cups was relatively low, especially at 2% and 3% consistency. Most of the paper fibers (around 72-87%) from the PPL cups could be recovered, which is good for recycling. The quality of the recycled fibers from the PPL cups was slightly affected, with the formation of small particles called fines. The length of the recycled fibers from PPL cups decreased a bit, but their strength improved. The freeness, which is a measure of how well the fibers separate, decreased only in the PPL cup samples with higher consistency. In simpler terms, we found that it doesn't take much energy to recycle the paper and plastic in these cups using existing technology. The recycled fibers are mostly recovered, with only a small impact on their quality. This information can help estimate the cost of local recycling efforts for these types of cups. In 2016, a significant portion of the world's waste paper and plastic was exported to China for recycling. However, in 2018, China stopped accepting such imports, leading to a shift in waste trade to Southeast Asia and increased recycling efforts in North America and Europe. The burning of plastic waste contributes to pollution and greenhouse gas emissions. Disposable paper coffee cups, with a plastic lining, add to the plastic waste problem. Despite efforts to recycle them, most end up in landfills or incinerators,

releasing harmful gases. Challenges in recycling include the difficulty of separating the plastic lining from the paper. Recent research addresses these challenges, suggesting technological solutions like automatic sorting systems and public awareness programs. However, recycling PPL cups faces hurdles due to the cost of recycling and the ease of using new materials. Efforts to make sustainable products and circular economies are gaining popularity, driven by consumer preferences and environmental regulations. The market for recovered paper fibers is well-established, but recycling PPL cups remains costly, requiring further innovation. One potential solution involves using mechanical refiners to separate plastic and paper fibers efficiently. This process, known as low consistency refining, could be energy-efficient and easily integrated into existing recycling systems. However, there's limited research on this method's feasibility for PPL cups. The study's goals are to determine the energy needed for this refining process, quantify recovered fiber and plastic, and describe the resulting paper's properties. This information aims to guide industry professionals and inspire further innovations in recycling technologies. (Bilek et al.2021)

The demand for high-quality coffee is increasing worldwide, leading to a need for better ways to assess coffee quality. Currently, assessments rely on subjective and time-consuming methods, making them costly and sometimes unreliable. To address this, we aimed to create a quick, affordable, and reliable method to evaluate the quality of green coffee beans. In our study, we analysed near-infrared (NIR) spectra from 86 samples of green Arabica beans with varying quality. We used a statistical method called Partial Least Squares (PLS) regression to build a model that correlates the spectral data with the cupping scores, which measure the cup quality of the coffee. The developed PLS model showed good predictive ability for overall cup quality and specific attributes like overall preference, acidity, body, and aftertaste. The correlation between the measured and predicted scores was high for 20 out of 86 samples. The results indicated that the NIR spectra of green coffee beans could effectively predict coffee quality, including different aspects like taste preferences and acidity. The model's accuracy was measured using root mean square error of prediction (RMSEP), which was reasonably low for total specialty cup quality and its attributes. This suggests that NIR spectra can be a valuable tool for quickly and accurately assessing coffee quality, enabling the classification of green coffee beans into various specialty grades. However, further testing is needed, especially with coffee samples from different regions in Ethiopia, to determine if a single model can be used for all regions or if region-specific models are necessary. Overall, our findings indicate that NIR spectra have great potential for enhancing the efficiency and reliability of coffee quality assessment. The specialty coffee market is growing because people prefer high-quality coffee with specific characteristics. Specialty coffee includes beans that are certified organic, fair trade, and rainforest alliance. These certifications ensure quality and sustainable practices. Quality coffee has minimal defects, a unique flavour when roasted, and high taste scores. The demand for specialty coffee is increasing, creating opportunities for coffee-producing countries like Ethiopia. Specialty coffee often commands higher prices, with premiums for certifications like organic and fair trade. Ethiopia, a major coffee producer, can further increase its share in the global market. Evaluating coffee quality is crucial for setting prices and determining export potential. Currently, physical and cup quality analyses are used, but they are subjective, costly, and time-consuming. A need exists for a faster, cheaper, and more objective method. Near-infrared

spectroscopy (NIRS) is a promising alternative. It's quick, reliable, and cost-effective, requiring minimal sample preparation. Previous studies have shown NIRS's potential in analysing coffee quality attributes. However, most focus on roasted beans, and there's a lack of research on predicting cup quality from green coffee beans. This study aims to develop a NIRS-based model for predicting coffee cup quality using green coffee beans. The goal is to provide a reliable and efficient method for assessing coffee quality from the early stages of production. (Tolessa et al.2015)

The focus on environmentally friendly packaging in the foodservice industry is growing, and one area of concern is paper coffee cups. These cups often have polyethylene liners, making recycling challenging. To address this, new materials without polyethylene are emerging. This paper explores current and upcoming technologies for making paper coffee cups that can be easily recycled with other paper. Many of these materials are also compostable. The use of bioplastics is gaining traction, but challenges exist. Various efforts are underway to create more eco-friendly paper cups. However, widespread adoption of these solutions requires a collective commitment to circular economics. This involves changes in consumer behaviour, brand initiatives for sustainability, government policies against fossil-based cups, and accessible systems for collecting and processing biodegradable cups at the consumer level. The love for coffee shops worldwide has led to a huge increase in the use of disposable coffee cups. Currently, about 118 billion single-use paper cups are used each year, and this number is expected to grow to 294 billion by 2025. The United States uses the most, with 136 million cups a day. Despite efforts to make these cups eco-friendlier, they're not easily recyclable. Most end up in landfills, where they don't break down. While the paper part is often made from sustainable sources, the cups are lined with a plastic coating (polyethylene) to resist heat and liquid. This makes recycling difficult, and less than 1% of these cups are recycled globally. The issue is that many communities and venues lack effective recycling systems, and people think these cups are hard to recycle because of the mix of paper and plastic. Also, recycling facilities struggle to process cups contaminated with food. Plastic-coated cups take over 20 years to decompose, contributing to pollution. Younger generations, like Millennials and Generation Z, are more aware of environmental issues. This has pushed companies to find better ways to handle the disposal of coffee cups. Unfortunately, most cups still end up in landfills, and the plastic-coated ones are especially problematic. In short, the convenience of disposable coffee cups is causing an environmental problem. Efforts are being made to improve recycling, but it's still a big challenge. Composting bioplastic coffee cups in the US is a challenge because most composting facilities don't accept them due to contamination concerns with traditional plastics. Only a few hundred out of 4,000 composting sites in the US accept foodservice packaging, and even fewer accept bioplastics. Chulalongkorn University in Bangkok, Thailand, has a successful "zero-waste cup" initiative. They collect almost 2 million coffee cups annually, lined with a special bioplastic coating called bioPBS™, which can be processed in their central composting facility. These cups biodegrade in soil even at normal temperatures. Starbucks is testing cups lined with BioPBS™ in selected stores. Chula Zero Waste in Thailand and Silapakorn University also use bioPBS™-lined cups, which completely biodegrade in industrial compost within three months. The newer version can biodegrade at ambient temperatures without the need for an industrial composting facility. However, bioPBS™

production is not yet economically feasible on a large scale globally, limiting its use outside Thailand and Southeast Asia. Several companies are working on recyclable and biodegradable coffee cups, with QR codes on cups by Huhtamäki to guide consumers on recycling options. Recyclable cups can be processed in paper mills, while biodegradable ones are over 90% compostable in industrial facilities. Still, an increase in compostable cups may disrupt existing composting processes, emphasizing the importance of reducing and reusing instead. (Koukoulas 2020)

Researchers improved the water resistance of paper cups by combining sodium alginate (NaAlg) and gellan gum, followed by a crosslinking treatment. These materials were blended and tested under various conditions. The study found that the combination of NaAlg and gellan gum produced water-resistant films suitable for coating paper cups, especially for hot drinks. This is important given the environmental impact of disposable plastic cups. The optimal conditions for the blend included a specific concentration of the mixed solution, a particular ratio of components, glycerol content, calcium ion concentration, crosslinking time, and drying temperature. The resulting films showed a synergistic effect between NaAlg and gellan gum, providing improved water resistance. Sodium alginate, extracted from brown algae, forms a film that becomes insoluble in the presence of calcium ions. However, to enhance water resistance further, it is combined with gellan gum, a microbial polysaccharide known for its stability and gel-forming properties. The combination is crosslinked with calcium ions to create a stable structure with barrier properties suitable for paper cups. Unlike traditional water-resistant films made of non-biodegradable materials like polystyrenes, the polysaccharide-based films are more environmentally friendly. Polysaccharides can degrade in soil, reducing environmental impact. Additionally, the study considered factors such as glycerol as a plasticizer and calcium ions for crosslinking, optimizing the film's performance for hot drinks. In summary, the research focused on creating water-resistant films from natural polysaccharides for coating paper cups, providing an eco-friendlier alternative to traditional materials. The study explored the synergistic effects of combining sodium alginate and gellan gum under specific conditions to achieve optimal water resistance for hot beverages. They bought a substance called NaAlg from a company in China. This substance helps in making films and getting rid of air bubbles. The NaAlg had a certain thickness and properties. They also got another material called low-acyl gellan gum. They used calcium chloride and glycerol too. They had a machine to spread the liquid on paper, and they used special cups for this. To test how well the films stop water, they put the films on paper. The liquid used to make the films was prepared by mixing NaAlg, gellan powder, and glycerol in water. They heated it, stirred it until it was clear, and removed air bubbles with a vacuum pump. Then, they poured it on paper using a machine. The wet film on the paper was dried and sprayed with a calcium solution. After some time, the film was ready and attached to the paper. They did this multiple times for accuracy. In short, they made films that stop water from going through, tested it on paper, and did the process several times to be sure it works. (Zheng 2016)

In simpler terms, this study looked at how plastic cups, plastic lids, and paper cups used for drinks like hot and cold beverages can affect the environment. They tested how these materials release chemicals

when they're left in water or soil for up to four weeks. The researchers used small insects called Chironomus repairs to see how these chemicals affected them. They found that all the materials they tested (plastic cups, plastic lids, and paper cups) had negative effects on these insects. When the insects were exposed to water or soil contaminated by these materials, they didn't grow properly, took longer to develop, and sometimes had deformities in their body parts. Female insects also took longer to grow up when they were in soil contaminated by paper cups. The study showed that these packaging materials release harmful substances, and these substances can cause problems for insects that live in water and soil. It suggests that when we throw away these materials, they can harm the creatures living in these environments. The study revealed that disposable cups used for take-away beverages, regardless of the material they are made of, can harm small insects like midges. The liquids that come in contact with these cups release substances that can negatively affect the growth and development of these insects. These effects were observed both in water and sediment, which are important habitats for many aquatic creatures. The species they tested, Chironomus riparius, is used in studies because it represents a larger group of water organisms that are crucial for keeping ecosystems healthy. The findings of this study emphasize that if we don't manage waste properly, it can seriously harm aquatic life. Another study by Gallo et al. in 2018 highlighted that the production and use of plastics, along with wasteful habits, have damaging effects on the environment and can become even worse if we don't take immediate actions to prevent it. Simply swapping one material (like plastic cups) for another (such as paper-based products) isn't enough. Instead, it's crucial to reduce our overall use and consumption of single-use products to address these issues effectivel. (Almroth et al.2022).

The coffee industry in the UK is growing quickly. Almost half of all hot drinks are served in disposable cups, and there are way more coffee shops now than there were in 2000. These cups are made of paper lined with plastic for waterproofing, which makes them hard to recycle. Each year, about 2.5 billion coffee cups are used in the UK, but less than 1 in 400 is recycled. Around 500,000 cups are littered daily, causing harm to the environment. The best way to manage waste follows the Waste Hierarchy - reduce, reuse, recycle. It's important for those who create pollution to take responsibility for managing it. This principle is part of EU laws and global sustainable development goals the UK has committed to. Many people wrongly believe that disposable cups are widely recycled and put them in street recycling bins. But there isn't enough infrastructure to recycle them properly, leading to a costly problem for local authorities and taxpayers who cover most waste management costs. While some cup manufacturers and coffee shops have promised to recycle cups, their efforts lack consistency and clear goals. To raise awareness and tackle the issue, the government should set a target for recycling all single-use coffee cups by 2023. If this isn't achieved, they might need to consider banning disposable cups. Encouraging the use of reusable cups would significantly reduce waste, lessening the burden on local authorities and cutting costs for coffee retailers. Though coffee shops offer a discount for customers who bring their own cups, not many people take advantage of this. Evidence suggests that people respond better to a charge for disposable cups, which could reduce their use by up to 30%. We propose that the Government should impose a minimum charge of 25p on disposable cups. The money collected from this charge should be invested in facilities to recycle

the remaining disposable cups. Disposable coffee cups represent just one aspect of a larger issue regarding recycling packaging. Presently, businesses only cover about 10% of the cost of waste disposal, with taxpayers bearing the majority of the expense. To align with the principle that those who produce waste should pay for its management, the UK should hold producers and retailers of disposable cups more financially accountable for their waste. We suggest that the Government establishes a system with varying fees to ensure compliance from these businesses. This system would reward packaging designs that are easily recyclable or made from recycled and compostable materials while increasing fees for packaging that is hard to recycle. Additionally, reducing the minimum threshold for companies covered by waste management schemes would incentivize the industry to produce and use packaging that aligns better with the UK's recycling capabilities. (Ordered by the House of Commons to be printed 2017).

In this study, the focus was on managing paper cup waste, which poses a threat to the environment due to its composition of 90% high-strength paper and a 5% coating of polyethylene. This polyethylene layer prevents the cup from breaking down in soil. The researchers conducted experiments using two different methods of vermicomposting technology. They set up two plastic reactors: Vermicompost (VC) and Vermicompost with bacterial consortium (VCB). These reactors contained mixtures of cow dung, paper cup waste, earthworms (Eudrillus eugeinea), and a microbial consortium including various bacteria such as Bacillus species and Lactobacillus pantheries. After the treatment process, they analysed various physicochemical parameters. The results showed a reduction in TOC (Total Organic Carbon), TOM (Total Organic Matter), and C/N (Carbon-to-Nitrogen) ratio in both VC and VCB. However, values for pH, EC (Electrical Conductivity), TP (Total Phosphorus), TMg (Total Magnesium), TCa (Total Calcium), TNa (Total Sodium), and TK (Total Potassium) increased. The study highlighted that adding the microbial consortia helped in speeding up the degradation process, reducing the treatment time from 19 to 12 weeks in the VCB reactor. Characterization of the vermicompost produced from paper cup waste using FT-IR (Fourier Transform Infrared Spectroscopy) revealed higher degradation of carboxylic and aliphatic groups. SEM (Scanning Electron Microscopy) analysis demonstrated the breakdown of cellulose and lignin, while XRD (X-Ray Diffraction) showed the degradation of cellulose. These analyses supported the faster degradation of paper cup waste with microbes (VCB). Overall, this study emphasizes a more efficient way to manage paper cup waste in a shorter period, highlighting the effectiveness of using a microbial consortium in the vermicomposting process. The management of solid waste is a significant environmental concern worldwide, especially in urban areas of India. India produces approximately 1,88,500 tonnes of municipal solid waste daily, posing health hazards and environmental issues without effective waste management. Post-consumer waste, which includes materials discarded by end-users, constitutes about 35% of municipal solid waste in landfill sites. To address this problem, it's essential to minimize waste generation by recycling discarded materials in a safe, efficient, and cost-effective manner. Paper cups, commonly used globally, are a notable part of post-consumer waste. Despite paper being recyclable, paper cups are coated with polyethylene plastic to protect them from hot beverages. In India, consumption of paper cups is estimated at around 1 crore per day, contributing to roughly 253 million pounds of solid waste annually. (Karthika et al.2014)

The growing emphasis on environmentally friendly and sustainable foodservice packaging remains a key concern for stakeholders in the foodservice industry. Paper-based coffee cups represent a segment where efficient recycling of waste cups remains a challenge. To address this issue, material alternatives to polyethylene liners are emerging, aiming to facilitate the recycling of paper-based coffee cups. This paper reviews current and emerging commercial material technologies used in the production of paper-based coffee cups that can be easily recycled alongside other paper grades. Many of these material solutions are also compostable. A particular focus is placed on the rapidly evolving production of bioplastics as an alternative on a larger scale. The paper also examines various efforts aimed at developing more environmentally friendly paper cups. It's evident that the widespread adoption of proposed solutions will require a comprehensive commitment and approach to circular economics. This encompasses changes in consumer behaviour, initiatives by brand owners to meet sustainability objectives, governmental policies that limit or prohibit the use of fossil-based cups, and the establishment of easily accessible infrastructures at the consumer level for the collection, separation, and processing of biodegradable cups. These factors are crucial for successful implementation and uptake of eco-friendly alternatives in the foodservice industry. The global demand for out-of-home (OOH) coffee and coffee beverages has surged, resulting in an exponential increase in the consumption of single-use hot paper coffee cups. Estimates suggest the market size for these cups is currently at 118 billion units annually, with projections to reach 294 billion units by 2025. This growth is propelled by the convenience sought by consumers leading busy lives, with the number of coffee shops increasing notably in countries like the US and UK. Despite efforts to use sustainable materials in the paperboard cupstock and sometimes incorporating recycled wood fiber, these cups typically have a polyethylene (PE) coating to provide essential barrier functionalities. However, most used coffee cups end up in landfills due to ineffective recycling schemes, the perception of difficulty in recycling the mix of paper and plastic in these cups, and the incapacity of recycling facilities to handle food-contaminated waste streams. Less than 1% of used paper coffee cups are estimated to be recycled globally. In contrast, plastic-coated cups take an extensive period of over 20 years to decompose in landfills, contributing significantly to environmental pollution in land, rivers, and oceans. (Koukoulas 2020).

After conducting a comprehensive review of the project's objectives, methodologies, and outcomes, several valuable insights and recommendations have emerged. The cooperation, interest, and willingness of the participants, primarily students and Second Cup customers, were noted and appreciated throughout the study. The suggestions gathered from surveys and interviews were particularly insightful, representing a representative sample of the Dalhousie University student body and signalling their inclination towards fostering a more sustainable campus environment. Notably, suggestions gathered from students at different Second Cup locations, especially the Killam Memorial Library, were more prevalent, likely due to higher foot traffic in that central and multidisciplinary building. Implementing suggestions such as banning disposable cups or introducing a stamp card system at the Killam's Second Cup might find more success, considering the higher willingness among customers in that area. Conversely, addressing waste concerns at the Second Cup in the Computer Science building would require initial awareness-raising measures such

as informative posters, reduced pricing, and enhanced availability of mugs. To further explore sustainable options, it is recommended to conduct a cost-benefit analysis regarding the implementation of compostable cups on campus. Additionally, soliciting feedback from Second Cup customers via a survey about their willingness to pay extra for coffee served in compostable cups could provide valuable insights into consumer preferences and readiness for sustainable practices. the promotion of reusable travel mugs, targeting the entire student population based on their existing knowledge about sustainability is deemed crucial. Tailoring awareness campaigns to various levels of understanding on the subject across campus can significantly contribute to waste reduction and the overall greening of the Dalhousie campus. After conducting a comprehensive review of the project's objectives, methodologies, and outcomes, several valuable insights and recommendations have emerged. The cooperation, interest, and willingness of the participants, primarily students and Second Cup customers, were noted and appreciated throughout the study. The suggestions gathered from surveys and interviews were particularly insightful, representing a representative sample of the Dalhousie University student body and signalling their inclination towards fostering a more sustainable campus environment. (Fairbairn et al.)

Simulators used in palatal surgery, as found in existing literature, tend to be costly or demand extensive preparation of the simulator device [1-7]. Our investigation aimed to explore the development of a rapid, cost-effective simulator using easily accessible materials. This setup enables trainees to cultivate advanced, specialized surgical skills efficiently." We made a simulator using a plastic cup with tape inside, allowing trainees to practice suturing under a microscope in a confined space. Two groups of surgeons in training (Junior and Senior) practiced interrupted sutures on this simulator, with 20 attempts on three different occasions. We collected data on knot completion time, knot quality, and instrument handling. Our findings revealed that both groups improved knot completion time, knot quality, and reduced the number of instrument exchanges across the training sessions. Although senior trainees performed better overall, both groups showed similar levels of improvement." We have shown that a simple and cheap simulator can be used to allow trainees to develop specific surgical skills required for palatal surgery. Although higher fidelity simulators exist, we feel that’s surgeons in the earlier years of training require specific skills acquisition where ease of accessibility is more important than fidelity. (Ioanna Dimasi et al.)

One million paper coffee cups are sent to a landfill from Toronto each day (Entec, 2009). This amount of waste from a single-use disposable item is not sustainable. This study reviews the recyclability of the industry standard polyethylene lined paper coffee cup by studying various Solid Waste Management Systems in Ontario, including jurisdictions where coffee cups are accepted in blue bin and green bin organics collection systems. In both these cases coffee cups are treated as contaminants of the collection stream and are discarded during the recycling process. Biodegradable cups, Styrofoam cups and reusable mugs are evaluated, using life cycle assessment methods, to determine alternatives to current industry standard disposable cup. The target population of the proposed waste reduction strategy is frequent coffee buyers, understood to mean those who buy their coffee in disposable cups as part of their routine. This target population was identified through the use of IPSOS Reid survey data collected in 2008 for 700

representative residents from Toronto. The recommended policy option and accompanying implementation considerations were developed in conjunction with a series of eleven interviews conducted in October of 2009 with independent coffee shop owners in Toronto. The policy consists of three behaviour change tools; a prompt, a sign and an available alternative. These tools are described as policy recommendations. It seems like you're asking for a summary or a simpler version of the text provided regarding disposable coffee cup waste in Toronto. Here's a simpler version: Toronto throws away over a million disposable coffee cups every day, and these cups end up in landfills. This practice is harmful to the environment. It's not just Toronto—similar waste happens across the USA, with billions of cups discarded yearly. The problem is that the real cost of these disposable cups isn't reflected in their price. People don't realize the environmental impact because the cost of the cup is included in the coffee's price. Producing, shipping, and disposing of these cups uses a lot of energy and resources, causing environmental harm. (Ziada 2009)

The European Union (EU) emphasizes considering a product's environmental impacts throughout its entire life cycle, including production, use, and disposal. Understanding and adopting this life cycle thinking is becoming increasingly important for industries. A study used a life-cycle assessment method to analyse the environmental effects of an industrial disposable cup. The goal was to gain new insights into the cup's life cycle impacts, focusing on material choices and various disposal scenarios. The study mainly examines the cup's contribution to global warming. The cups were made from carton, coated with either polyethylene or polylactide. The study compared the environmental impacts of these carton-based cups with polymer-based cups made from polyethylene terephthalate. The findings indicate that selecting materials wisely and optimizing disposal methods can lead to significant environmental improvements in the cup's life cycle. The study used life-cycle assessment (LCA) to analyse the environmental effects of a disposable product, specifically focusing on carton-based cup concepts. The aim was to understand their life-cycle impacts and aid in better managing the product's life cycle. Comparisons were made regarding different materials used and end-of-life scenarios, aiming to highlight the potential environmental improvements achievable through optimized material choices and disposal methods. This paper specifically discusses the assessed global warming potential of these products. It compares carton-based cups, covered with either polyethylene (PE) or polylactide (PLA), to polymer-based cups made of polyethylene terephthalate (PET). Both types of cups have the same capacity and function. The environmental impact was calculated based on 100,000 pieces of cups over a specific timeframe. (Häkkinen et al.2010)

Disposable cups, mostly made from paper plastic laminates (PPL), have few recycling options, leading to them becoming problematic waste. This study explores repurposing shredded disposable cups, creating PPL flakes used to reinforce polypropylene in novel paper plastic composites (PPCs). By mixing, extruding, pelletizing, and injection moulding the PPL flakes and polypropylene at low temperatures to preserve cellulose fibers, this approach aims to create new materials. The research examines the impact of PPL flake quantity and a coupling agent on the composite's properties. Testing reveals that adding 40% PPL flakes, along with a coupling agent, increases the tensile strength of polypropylene by 50% to 30 MPa.

Moreover, the Young's modulus rises from 1 to 2.5 GPa, and the work to fracture improves fivefold. This work demonstrates the potential to beneficially reuse PPL disposable cups by incorporating them into polypropylene composites, enhancing their mechanical properties. Disposable cups used by popular retail outlets are constructed with high-quality virgin cellulose fiber board and a thin internal polyethylene (PE) coating, forming paper plastic laminates (PPLs). These cups, along with various PPL products, are challenging to recycle due to the strong bond between the cellulose fiber board and the polyethylene coating. In the UK alone, leading coffee chains use an estimated 500 million disposable cups yearly, amounting to approximately 6250 tonnes of waste, mostly disposed of in landfills or incinerated. Waste electrical and electronic equipment (WEEE) is also increasing globally, with the EU generating around 8.3–9.1 million tonnes annually, containing significant amounts of engineering plastics like polypropylene (PP). PP extracted from WEEE might not have ideal mechanical properties for certain high-volume reuse applications. (Mitchell et al.2013)

The study focuses on addressing the growing concern regarding the disposal of Used Disposal Paper Cups (UDPCs), which have become an issue in solid waste management. Scientists are aiming to develop a solution for this problem. The study specifically highlights the isolation of innovative bio-eco-based Cellulose Nanocrystals (CNCs) from UDPCs using citric acid hydrolysis. The research delves into understanding the impact of acid concentration on the microstructure and yield of CNCs. It found that an optimized yield of 55% was achieved, resulting in rod-like structures measuring approximately 13.7 ± 0.6 nanometres in width, primarily due to 76% acid-hydrolysed CNCs. Various techniques such as zeta potential, X-ray diffraction (XRD), conductometric testing, and Fourier-transform infrared spectroscopy (FTIR) were utilized to evaluate the colloidal stability, crystallinity index, presence of functional groups, and elemental composition in the CNCs (76%). Additionally, thermo-gravimetric analysis was conducted to assess the thermal stability of these CNCs. Overall, the study aims to explore the potential of deriving Cellulose Nanocrystals from UDPCs using citric acid hydrolysis, evaluating their properties and characteristics for potential applications. The global issue of unbalanced natural processes and waste disposal is garnering significant attention due to its adverse impact on the environment. Solid waste mismanagement leads to the continuous deposition of toxic and non-biodegradable materials, urging researchers to explore harmless, easily biodegradable materials and decrease reliance on fossi fuels. (Nagarajan et al.2020)

The study aimed to address the environmental threat posed by disposable paper cups, primarily composed of 90% high-strength paper and 5% polyethylene, preventing their degradation in soil. Two distinct vermicomposting approaches were investigated: Vermicompost (VC) containing Cow dung, Paper cup waste, and Earthworms (Eudrillus eugeinea), and Vermicompost with a bacterial consortium (VCB) involving Cow dung, Paper cup waste, Earthworms (Eudrillus eugeinea), and a Microbial consortium. Upon treatment, various physicochemical parameters were analyzed. The findings revealed reductions in Total Organic Carbon (TOC) (26.52% and 37.47%), Total Organic Matter (TOM) (36.01% and 33.13%), and C/N ratio (15.02 and 11.92%) in both VC and VCB. Conversely, pH levels (8.01 and 7.56), Electrical

Conductivity (EC) (ranging from 1.2–1.9 ms1 to 1.4–1.9 ms1), Total Phosphorus (TP) (46.1% and 51%), Total Magnesium (TMg) (50.52% and 64.3%), Total Calcium (TCa) (50% and 64%), Total Sodium (TNa) (1.39% and 1.75%), and Total Potassium (TK) (1.75% and 1.86%) were observed to increase. The study demonstrated that the inclusion of microbial consortia in the VCB reactor expedited the degradation process, reducing the duration from 19 to 12 weeks. Moreover, the characterization of the resulting vermicompost from paper cup waste via FT-IR revealed significant degradation of carboxylic and aliphatic groups. Scanning Electron Microscope (SEM) analysis depicted cellulose and lignin disaggregation, while X-ray Diffraction (XRD) showed cellulose degradation. These analyses collectively support the accelerated degradation of paper cup waste, particularly when aided by microbes (VCB). Thus, this study emphasizes a more efficient management approach for paper cup waste within a relatively shorter timeframe. The issue of solid waste management is a critical concern globally, particularly in urban areas like India. The country generates a massive amount of municipal solid waste daily, contributing to health hazards and environmental degradation. Post-consumer waste, representing approximately 35% of municipal solid waste, has become a significant component in landfill sites. An effective approach to mitigate this issue involves recycling discarded materials in a safe, cost-effective, and environmentally friendly manner. (Arumugam et al.2017)

This report highlights the pervasive issue of single-use beverage cups littering beaches globally, mainly made of polystyrene (PS) or polymer-lined paperboard. With approximately 500 billion of these cups consumed annually and often ending up as litter due to inadequate recycling and waste management, they pose a significant threat to marine ecosystems, impacting biodiversity, tourism, fishing, and shipping industries. The forecasted increase in the use of disposable beverage cups, particularly in middle- to low-income countries, necessitates immediate action at multiple levels—policy, business, and individual—to explore sustainable alternatives for consuming beverages outside the home. Several alternatives have been proposed, including reusable cups and enhanced end-of-life management. However, these options come with their own set of challenges. This report provides a meta-analysis of ten Life Cycle Assessment (LCA) studies, categorizing them into three groups: studies comparing single-use beverage cups, studies comparing single-use and reusable cups for hot drinks, and studies comparing single-use and reusable cups for cold drinks. The summary of these studies and their key findings is presented in the table in the Executive Summary section. The analysis underscores that various factors impact the environmental footprint of beverage cups, whether single-use or reusable. In general, reusable cups appear to be a better choice under specific conditions. In regions with a high proportion of renewable electricity in the grid mix, low recycling rates, and responsible consumer practices regarding washing and reuse, reusable cups emerge as the preferable option. Due to the significant variability observed in the studies, it's crucial for policy solutions to be context-specific, taking into account local relevance and human behaviour. There is no universal solution applicable to all situations. Policymakers are encouraged to adopt adaptable best practices that suit their country and population for effective implementation. (Lewis et al.2021)

2.2. OBJECTIVES OF STUDY

- To collect the paper cup waste from NKOCET college campus.
- To determine physical characteristics of paper cup waste.
- To determine properties of cement, coarse aggregate and fine aggregate.
- To prepare paver blocks by blending paper cup waste.
- After the paver blocks keep for curing in water tank.
- To determine compressive strength of paver blocks.

CHAPTER THREE

MATERIALS AND METHODS

3.1. MATERIALS

- **CEMENT: -**

  Brand name of cement: - Zuari Cement (Purchased from market in Solapur)

  Grade of cement: - 53 Grade

  Type of cement: - Ordinary Portland Cement

- **SAND: -**

  Type of sand: - Plaster Sand (Purchased from market in Solapur)

  Size of sand: - 0 to 2.36 mm

- **COARSE AGGREGATE: -**

  Size of aggregate: - 4.75 to 20 mm (Collected and purchased form local market hipparga Solapur)

- **WATER: -** Tab water is used to casting of Pevar blokes.
- **PAPER CUP WASTE**: - The waste of paper cup is collected from NKOCET collage canteen.

3.2. METHODS

Cement was tested for following properties as indicated in table no. 3.1.

Table 3.1: Testing on cement

Sr. No.	Name of test	BIS code
1	Fineness test	IS 4031
2	Standard consistency test	IS 4031 Part 4 1988

Coarse aggregate was tested for following properties as indicated in table no. 3.2

Table 3.2. Testing on coarse aggregate

Sr. No.	Name of test	BIS code
1	Flakiness and elongation index	IS 2386 Part 1 1963
2	Impact test	IS 2386 Part 4 1963

3.3. TEST ON PAPER CUP WASTE

Following physical properties determined on paper cup waste.

1. Density
   - Take empty box. Measure its length, width and hight of box. And calculate the volume.
   - Take weight of empty box(w1). After box fill with paper cup waste and weight the box(w2). After box fill completely drop the box from hight 1m. Take trial 3 times and calculate density.
   - Formula density calculation: - Density = Mass/Volume.
   - Formula mass calculation: - Mass = w1-w2
   - Formula volume calculation: - Volume = length*width*height.
2. Moisture content
   - Take the empty crucible and clean the crucible. Take the empty weight of crucible(w1).
   - Take the specimen of the sample in the crucible and weight(w2).
   - Keep the crucible in the oven and maintaining the temperature 105˚ C for a period of 1 hr.
   - After 1 hr. remove the crucible form oven and weight(w3).
   - Calculate the moisture content using formula.

     Moisture content (W) = ((w2-w3)/(w3-w1)) *100
3. Ash content
   - The crucible removed from oven is keep in muffle furnace.
   - Keep at temperature 550 ˚C for 45 min.
   - After 45 min. remove crucible from muffle furnace and weight(w4).
   - Calculate the ash content using formula.

     Ash content = ((w2-w4)/(w2)) *100

3.4 COMPRESSIVE STRENGHT

Trials were conducted for replacing fine aggregate with paper cup waste pieces.

Table 3.4: Trials

Trial No.	% of paper cup waste	Cement in (kg)
1.0	0%	7.34
1.1	1%	7.34
1.2	2%	7.34
1.3	3%	7.34
1.4	4%	7.34
1.5	5%	7.34
1.6	6%	7.34
1.7	7%	7.34

Figure shows blended paper cup waste using in dry mix concrete

Figure 3.4: Sample of blended paper cup waste

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. PROPERTIES OF PAPER CUP WASTE

Table 4.1 shows results for tests carried on paper cup waste.

Table 4.1. Testing on paper cup waste

Sr. No.	Parameters	Average value
1.	Moisture content	2.826 %
2.	Density	29.67 kg\m^3
3.	Inorganic content	4.17 %
4.	Organic content	95.823

It was observed that moisture content of paper cup is very less. Organic content was 95.823% and inorganic content was 4.17% for paper cup waste.

4.2. PROPERTIES OF CEMENT

Table 4.2 shows results for tests carried on cement.

Table 4.2. Testing on cement

Sr. No.	Parameters	Average value
1.	Fineness of cement	4.2 %
2.	Standard consistency test	7 mm

Fineness of cement is less than 5 %. Standard consistency of cement as per BSI requirement 5 to 7 mm

4.3. PROPERTIES OF COURSE AGGREGATE

Table 4.3 shows results for tests carried on coarse aggregate.

Table 4.3. Testing on coarse aggregate

Sr. No.	Parameters	Average value
1.	Impact value test	25 %
2.	Flakiness and elongation index	20%

Impact value of aggregate is 25% is satisfactory for surface. Flakiness and elongation index of aggregate not less than 15% and not more than 25%

4.4. COMPRESSIVE STRNGHT OF PAVER BLOCK

Table 4.4 shows results for testing carried on Pevar blocks.

Table 4.4: Testing on Pevar blocks

Trial No.	% of paper cup waste (gm)	Cement in (kg)	Sand (kg)	Aggregate (kg)	Water (kg)	Comp. strength After 3 days N/mm^2	Comp. strength After 7 days N/mm^2	Comp. strength After 28 days N/mm^2
1.0	0 %	7.34	11	22	4.45	11.5	21.01	23.95
1.1	1 %	7.34	10.890	22	4.45	13.5	20.46	22.89
1.2	2 %	7.34	10.780	22	4.45	15.8	22.45	23.85
1.3	3 %	7.34	10.670	22	4.45	17.91	26.65	25.10
1.4	4 %	7.34	10.560	22	4.45	16.36	13.59	
1.5	5 %	7.34	10.450	22	4.7	5.93	6.33	
1.6	6 %	7.34	10.340	22	4.8	5.62	6.65	
1.7	7 %	7.34	10.230	22	4.8	5.85	5.01	

Figure 4.4.1 shows compressive strength after 3 days in graphical format.

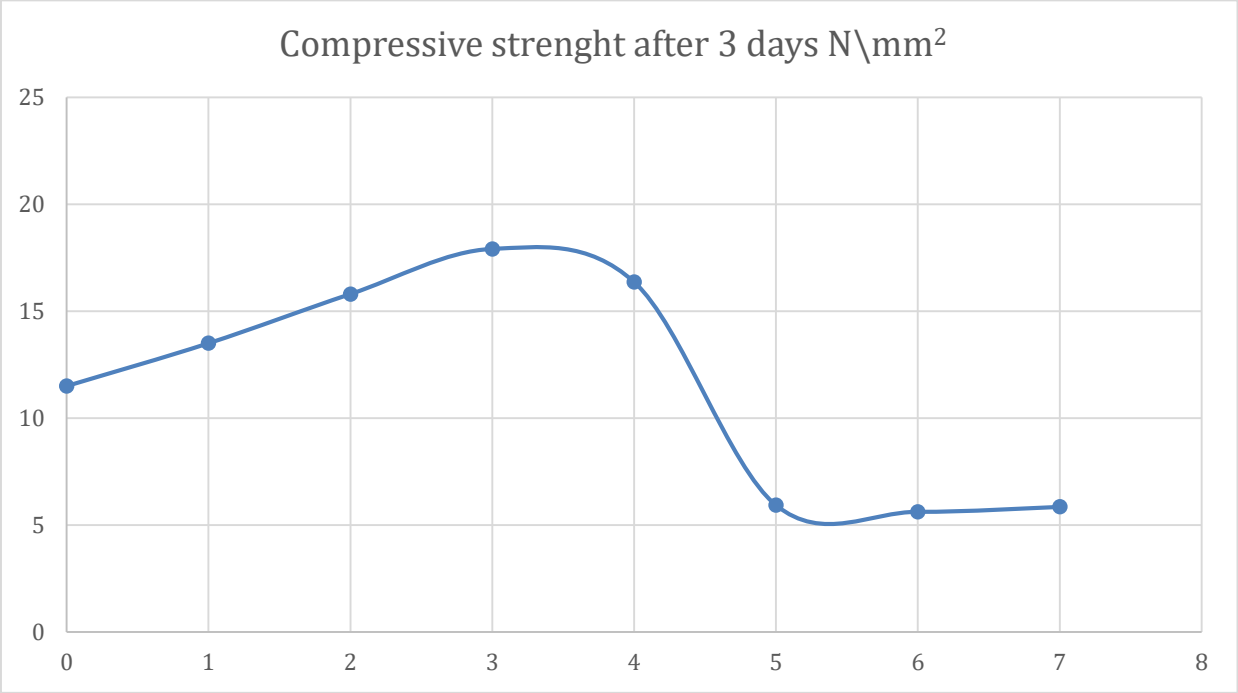

Figure 4.4.1: - Comp. strength after 3 days

Figure 4.4.1 shows compressive strength after 7 days in graphical format.

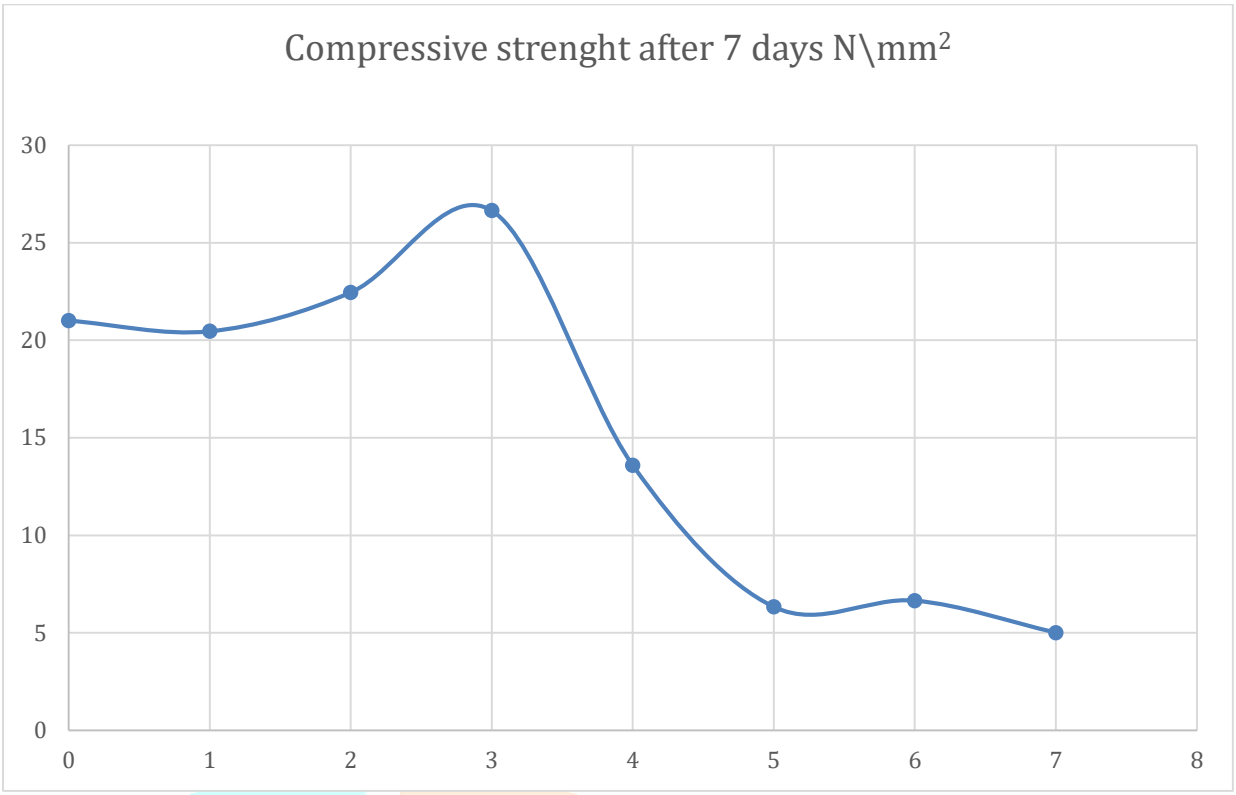

Figure 4.2: - Comp. strength after 7 days

Figure 4.4.1 shows compressive strength after 28 days in graphical format.

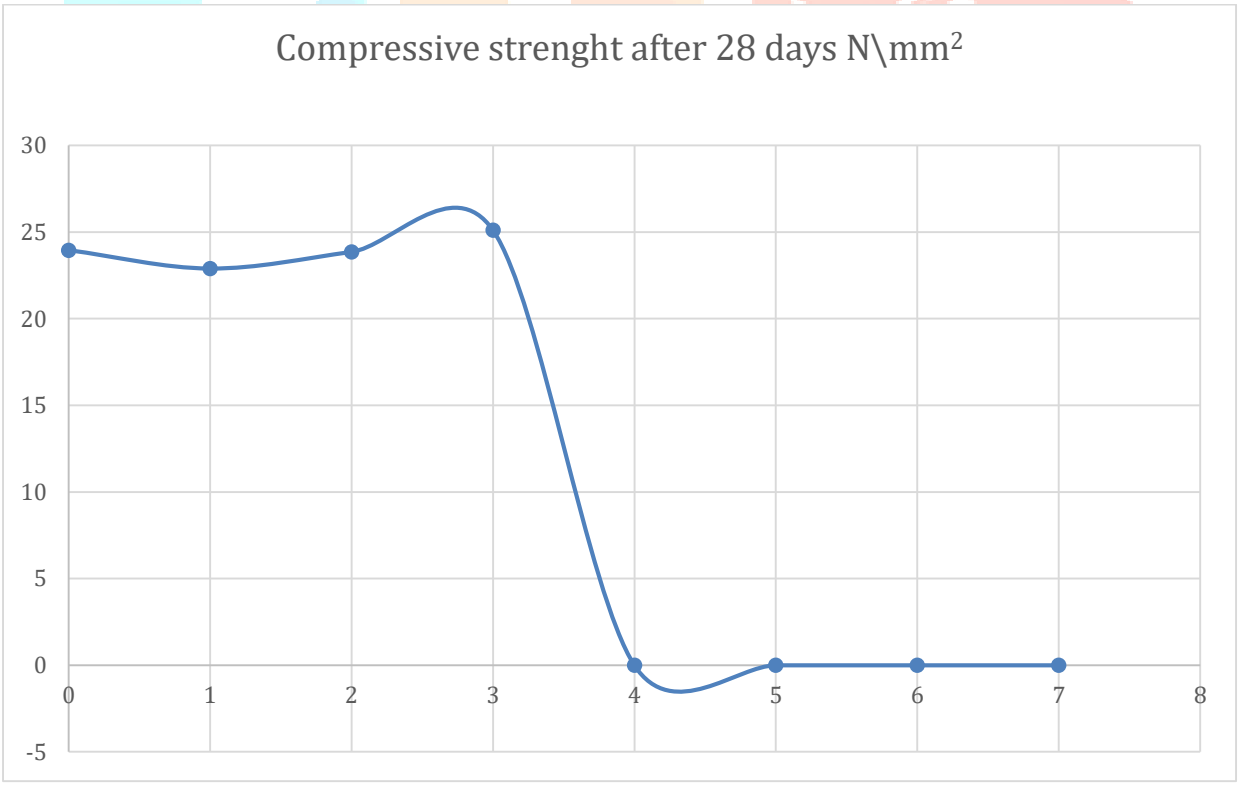

Figure 4.3: - Comp. strength after 28 days

Figure 4.1 to 4.3 shares compressive strength of paper cup blended paver blocks. From above graph it is clear that compressive strength increases with in paper cup waste pieces up to 3%. Later it was seen that compressive strength reduces drastically with increase in paper cup waste pieces.

CHAPTER FIVE

CONCLUSION AND FUTURE SCOPE

5.1: CONCLUSION

Following conclusions were drawn from the study

i. Paper cup waste could be used for replacement of sand in paving block manufacturing.
ii. Compressive strength increased with addition of paper cup waste.
iii. Up to 3% paper cup waste could be blended to replace sand. After increasing the [a[er cup waste beyond 3% compressive strength reduces. This might be because of lack of binding between paper cup waste and cementitious material.
iv. Blending of paper cup waste in manufacturing of paving blocks could help to solve problem of waste disposal.

5.2: FUTURE SCOPE

i. Paper cup waste fibres may be used in different building materials such as Concrete, paver block, bricks etc.
ii. Paper cup waste ash cam be used in making of burnt clay bricks.

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