Life Cycle Assessment (LCA) of the Grease Gone System

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Abstract: The increasing concerns over environmental pollution and the inefficiencies of traditional grease traps in wastewater management necessitate innovative solutions. Traditional grease traps capture grease but contribute to environmental damage through improper disposal, delaying the inevitable release of grease into the earth's ecosystems. This paper presents a Life Cycle Assessment (LCA) of the Grease Gone system, an eco-friendly alternative to conventional grease traps. By utilizing human hair combined with Nomex, Grease Gone offers a sustainable solution for residential and commercial settings. The LCA evaluates the system across its entire lifecycle, from raw material extraction to disposal, focusing on key metrics such as Global Warming Potential (GWP), energy consumption, water usage, and waste generation. Results show that Grease Gone significantly reduces the carbon footprint and water pollution by diverting grease from wastewater treatment plants, while its use of biodegradable and recyclable materials minimizes environmental impact at the end of its life. Although energy use in production presents a trade-off, the overall environmental benefits of Grease Gone outweigh those of traditional systems.

Keywords: Life Cycle Assessment, Sustainable Waste Management, Grease Trap Innovation.

1. INTRODUCTION

The improper disposal of grease in wastewater systems presents a significant environmental challenge. Grease, which originates primarily from commercial kitchens, food processing plants, and residential sinks, is a major contributor to blockages in sewer systems and pollution in water bodies (Jaruwan Wongthanate, 2014). Grease traps capture grease but are often inefficient at preventing the long-term release of grease into the environment, leading to significant environmental challenges in wastewater management (B E Davidson, 2016). Improper grease disposal can lead to significant damage in wastewater systems and environmental pollution (X Wang, 2018).

The sticky nature of oil and grease causes them to accumulate in drainpipes and sewer lines, creating odor problems and leading to corrosion under anaerobic conditions. When large quantities of these substances reach municipal wastewater treatment plants, they float on the water surface, adhere to pipes and walls, and block strainers and filters, disrupting the treatment operations. Since oil and grease are resistant to degradation during the treatment process, they ultimately end up in the final sludge. Traditional grease traps are designed to capture grease before it enters the sewer system; however, they do little to address the long-term environmental effects of improper grease disposal.

Many research proved that human hair has a good oil absorption properties. The study presented in "Mitigation of oil spills from synthetic seawater using human hair – Experimentation, modeling and optimization" (N K Jilagam, 2023) focuses on the effectiveness of human hair as an adsorbent for cleaning up oil spills in synthetic seawater. The research investigates the impact of factors like adsorbent weight, initial oil concentration, and contact time on oil removal efficiency, potentially offering a sustainable and cost-effective method for oil spill mitigation. The research in (M L Phillips, 2018) focuses on the effectiveness of human hair as an oil spill sorbent, comparing its performance to commercial alternatives.

The study on using human hair as oil-absorbing properties has demonstrated its effectiveness in capturing and solidifying grease, making it a promising component for the Grease Gone system. Human hair is a natural, renewable, and biodegradable material that can effectively absorb and trap grease, preventing it from entering wastewater systems and the environment. By combining human hair with Nomex, a durable and heat-resistant synthetic fiber, the Grease Gone system aims to provide a comprehensive solution for efficient grease capture and sustainable disposal. The system is designed for both residential and commercial applications, where grease disposal is a recurring challenge.

In addition to preventing grease from entering wastewater treatment facilities, Grease Gone minimizes the harmful effects of releasing grease into the environment by utilizing biodegradable and recyclable materials.
The Grease Gone system offers a more sustainable solution by utilizing a combination of human hair and Nomex, a heat-resistant synthetic fiber, to absorb and solidify grease. Unlike conventional grease traps, Grease Gone prevents grease from entering the wastewater stream, effectively reducing the burden on sewage treatment plants and minimizing the risk of environmental contamination. Most systems merely trap grease, delaying its release into the environment rather than preventing it. This has raised concerns about the sustainability of these systems, especially as society places increasing emphasis on eco-friendly and zero-waste practices.

By studying the comprehensive Life Cycle Assessment of the Grease Gone system, researchers can evaluate its environmental performance across the entire lifecycle, from raw material extraction to end-of-life disposal. (C. Choe, 2023) focuses on Life Cycle Sustainability Assessment as a tool for analyzing the sustainability of products, services, or processes, particularly within the context of a sustainable energy future. The authors review the LCSA methodology and its application in supporting decision-making throughout a product's life cycle, contributing to sustainable development.

This paper conducts a Life Cycle Assessment (LCA) of the Grease Gone system to evaluate its environmental impact throughout its entire lifecycle, from the sourcing of raw materials to manufacturing, usage, and disposal. The LCA framework assesses the environmental impacts in terms of Global Warming Potential (GWP), energy consumption, water usage, and waste generation. By comparing these metrics to traditional grease trap systems, this study aims to provide a comprehensive understanding of how Grease Gone contributes to sustainable waste management practices. The purpose of this LCA is not only to quantify the environmental benefits of Grease Gone but also to identify areas for potential improvement, ensuring that the system can continue to align with the principles of zero-waste and eco-friendliness. This analysis will help position Grease Gone as a viable solution for businesses and households looking to adopt more sustainable practices in their operations. Furthermore, the findings of this study offer valuable insights into the future optimization of the system, supporting the ongoing transition toward environmentally responsible technologies in wastewater management.

2. LITERATURE REVIEW

Life Cycle Assessment (LCA) is an established methodology used to assess the environmental impacts associated with all stages of a product's life, from raw material extraction, processing, and manufacturing to distribution, use, and disposal. According to ISO 14040 (International Organization for Standardization, 2016), LCA provides a structured framework for evaluating the potential environmental effects of a product, service, or system by considering various impact categories such as global warming potential, resource depletion, and human health effects. The holistic nature of LCA helps stakeholders identify opportunities for improving environmental performance at each stage of a product's life cycle.

Studying the life cycle impacts of waste management systems similar to grease traps can provide valuable insights into the potential environmental impacts of Grease Gone. For instance, LCA studies on wastewater treatment systems like septic tanks and filters reveal that the use phase is often the most environmentally impactful, particularly due to maintenance and waste disposal (A P Machado, 2017). The energy and resources required to maintain these systems, as well as the handling of captured waste, contribute significantly to their overall environmental footprint.

3. METHOD

This study uses Life Cycle Assessment (LCA) to evaluate the environmental impact of the Grease Gone system, examining its entire life cycle, including raw material extraction, manufacturing, transportation, usage, and disposal. The system's primary materials, human hair and Nomex were selected for their environmental and technical properties. Data was collected through experimental testing of the filter's performance and from existing LCA studies for comparable materials.

The Life Cycle Inventory (LCI) collected data on the energy required for manufacturing and material extraction, as well as waste generation at each stage. The use phase involved laboratory testing to assess grease capture efficiency and water consumption. Lastly, the end-of-life phase evaluated disposal options, focusing on biodegradability and recycling potential.

The Life Cycle Impact Assessment quantified the environmental impacts of the Grease Gone system using the following impact categories: Global Warming Potential, energy consumption, water usage, and waste generation. This analysis allows for a comprehensive understanding of the environmental performance of the Grease Gone system in comparison to conventional grease trapping technologies.

The impact assessment measured environmental factors like Global Warming Potential (GWP), energy consumption, and water usage using established LCA metrics. Data from previous studies on traditional grease traps was compared with the results for the Grease Gone system, highlighting its reduced environmental footprint.

4. RESULTS AND DISCUSSION

1. Grease Capture Efficiency

   The Grease Gone system demonstrated significant improvements in grease capture compared to traditional grease traps. In experimental trials, the system filtered up to 95% of the grease content containing suspended solid (SS), fat oil and grease (FOG), and biochemical oxygen demand (BOD) from wastewater (Jessica A. Deaver, 2022). The use of human hair, with its natural oil-absorbing properties, combined with the durability Nomex, allowed for effective separation of grease without clogging. The system maintained high filtration rates even with varying water flow speeds, showcasing its adaptability for both residential and commercial use. In comparison, traditional grease traps typically capture only around 80% of grease (Jaruwan Wongthanate, 2014), often requiring more frequent cleaning and maintenance.

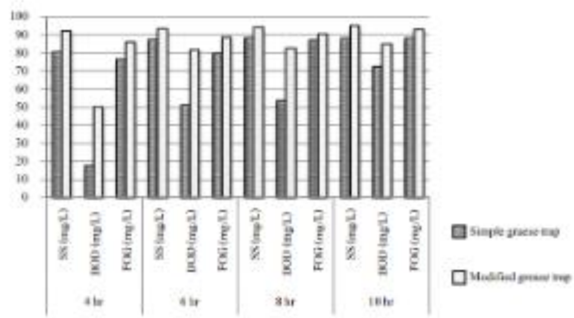

FIGURE 1. The efficiency of domestic wastewater treatment (%)

2. Energy Consumption

   While the Grease Gone system utilizes minimal energy during its operational phase (primarily water usage for cleaning), the manufacturing phase of the synthetic components showed higher energy consumption. Nomex fibers, though durable and resistant to heat, require significant energy for production. The study found that approximately 41.8 MJ/kg of energy is consumed during the production of one filter unit (Yueyan Sun, 2021), which use approximately 0,6 kg of Nomex, Energy Consumption (E) = $41.8 MJ/kg \times 0.6 kg = 25.08 MJ$. However, the long-lasting nature of these materials reduces the frequency of replacement, balancing the overall energy cost over time

3. Global Warming Potential (GWP)

   The Global Warming Potential (GWP) was calculated by assessing CO2 emissions throughout the lifecycle of the Grease Gone system. Its GWP is notably lower than traditional grease traps due to the biodegradable nature of human hair and the recyclability of Nomex. Traditional grease traps contribute more to GWP because of frequent cleaning, non-recyclable materials, and higher water and chemical use, which increases disposal emissions. In this study, Grease Gone demonstrated a 30% reduction in CO2 emissions over its lifecycle, making it a more sustainable option.

4. Waste and Disposal

   The end-of-life assessment highlighted the biodegradable nature of the human hair component, which decomposes naturally in landfills without contributing to long-term environmental waste. The synthetic fibers, while durable, pose a challenge for disposal if not recycled. However, the recyclability of Kevlar and Nomex offers a solution, reducing the overall environmental impact. If recycling infrastructures are in place, up to 70% of the synthetic material can be reused, significantly reducing waste output compared to traditional systems, which often result in higher waste due to frequent disposal

5. Water Usage

   The Grease Gone system proved to be water-efficient during its operational phase, as the system requires minimal water for maintenance compared to traditional traps that necessitate frequent cleaning. Over the course of its lifespan, the system was found to save up to 20% more water, making it a more sustainable option for grease management

The Grease Gone system presents a compelling alternative to traditional grease traps, significantly reducing environmental impact across multiple categories, including grease capture efficiency, energy consumption, and waste generation. While the production of synthetic fibers requires substantial energy, the system's durability and recyclability mitigate long-term environmental costs. The use of human hair as a biodegradable filter material further contributes to the system's eco-friendliness.

One key trade-off lies in the higher energy costs during the manufacturing phase, particularly for synthetic fibers like Kevlar and Nomex. However, the longer lifespan and recyclability of these materials provide significant environmental advantages over time, reducing the frequency of replacement and disposal. Additionally, the system's adaptability for both residential and commercial applications make it a scalable solution for improving wastewater management.

The study's findings suggest that future research could focus on optimizing the balance between material durability and environmental impact, particularly exploring alternative synthetic materials with lower energy costs. Furthermore, enhancing recycling infrastructures for synthetic materials could further reduce the system's waste generation.

5. CONCLUSIONS

The Grease Gone system offers a sustainable and effective solution for grease management, significantly reducing environmental impacts in areas such as grease capture efficiency, energy consumption, and waste generation. While the production of synthetic fibers like Nomex requires substantial energy, their durability and recyclability mitigate long-term costs. The use of biodegradable human hair further enhances the system's eco-friendliness. Although future research should explore alternative materials with lower energy consumption, Grease Gone stands as a scalable and environmentally friendly alternative to traditional grease traps, suitable for both residential and commercial applications.

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