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DESIGN AND DEVELOPMENT OF SOLAR POWERED VERMICOMPOSTING BIN FOR ACCELERATED DECOMPOSITION OF GARDEN WASTE: A REVIEW

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ABSTRACT

Solid waste management is a global issue that is getting more difficult to solve every day as a result of population growth, industrialization, and lifestyle modifications. Although there are several ways to get rid of solid waste, including land filling, incineration, turning into biogas, recycling, and composting, their overproduction has resulted in improper disposal methods like applying them carelessly and at the wrong time to agricultural fields, which pollutes the water and soil. Nevertheless, if managed appropriately, these organic wastes can be utilized for vermicomposting, a highly efficient recycling technique that enhances the quality of the resulting goods by disinfecting, detoxifying, and enriching them with valuable nutrients. The procedure is an inexpensive and environmentally-friendly method of waste management that involves the employment of earthworms and microorganisms to transform biodegradable garbage into organic fertilizer. Vermiast, the excreta of earthworms, is a highly nutritious organic fertilizer that contains abundant humus, NPK, micronutrients, and beneficial soil microbes. These microbes include nitrogen-fixing bacteria, phosphate solubilizing bacteria, actinomycetes, as well as growth hormones such as auxins, gibberellins and cytokinins. Vermicast serves as a viable substitute for chemical fertilizers and acts as an exceptional promoter of growth and protector of crop plants. Therefore, vermiculture not only facilitates the control of solid waste, but also yields high-quality vermicompost that is rich in nutrients. Vermicompost is advantageous for promoting sustainable organic agriculture and preserving a harmonious ecosystem.

Key words : Vermicompost, Compost, Compost Bin, Earthworms, Decomposition.

Introduction

The waste generated by society has been traditionally disposed of in landûlls, which accounts roughly 60% of all waste generated (Al-Maaded *et al.*, 2012). Landfills are large-scale dumping sites where waste continues to remain for an indeûnite period of time. Unfortunately, this process has been consistent over the last four decades, resulting in an exponential increase in landfill citation and size.

With the growing population, the world generates 2.01 billion tonnes of municipal solid waste annually, with a minimum of thirty-three percent of the aforementioned not being managed in an environmentally safe and economically just manner (Akai-Tetteh, 2021). The waste generated by households is often left uncollected, particularly in rural areas, which causes various types of pollution such as air and water pollution, soil pollution and the aesthetic degradation of the landscape. Additionally, this approach has led to an estimated average garden waste generated rate of 0.68kg per household per day, which is a signiûcant amount (Eades *et al.*, 2020).

It is imperative to recognize that waste can be a valuable resource if managed properly. For instance, some waste, such as food waste, can be used to generate energy through anaerobic digestion. Furthermore, recycling and up cycling waste can help to reduce the amount of waste that is sent to landûlls, which in turn can reduce the negative effects on the environment. By diverting waste from landûlls, we can reduce the creation of greenhouse gas eûects and prevent signiûcant harm to marine and wildlife.

By the same token, it is crucial that we adopt a more sustainable approach to waste management. This includes reducing the amount of waste generated, reusing and recycling materials and properly managing waste that cannot be recycled or reused. By doing so, we can reduce the negative effects on the environment and preserve the planet for future generations.

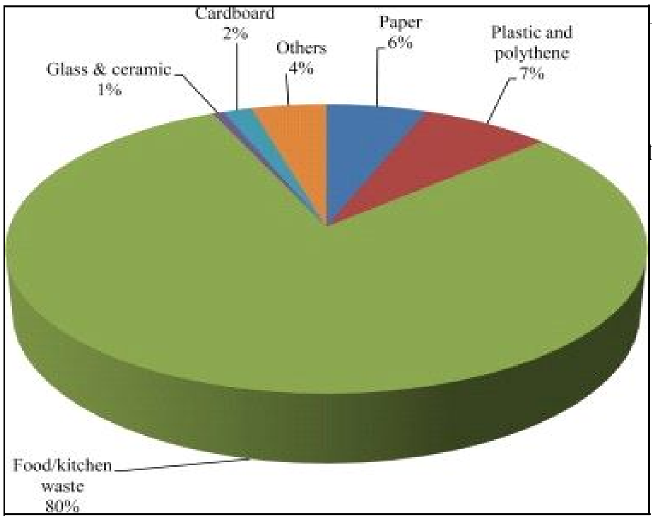

Fig. 1 : Percentage distribution of waste generated.

Waste management is a complex issue that aûects both local and global environments. Improper waste disposal facilities are a major contributor to this problem. When waste is dumped outside of designated sites, it can create serious environmental problems that have wide-ranging impacts. For example, a simple landfill site that does not meet environmental standards can adversely affect soil quality, contaminate groundwater, pollute the air and damage the local landscape (Zhengfu *et al*., 2010).

Fig. 2 : Landûll in Ghazipur, Bhalswa, Delhi.

This research paper aims to exhibit the situation of local waste management and its environmental influences in various areas. In doing so, emphasizing on the current state of waste management, and to identify areas where improvements can be made. Ultimately believing that by taking a more proactive approach to waste management, society can work collaboratively to meet the demands of the current generation; albeit without compromising the ability of future generations.

Value Added Product-Compost

Organizations might choose to create compost out of various forms of garbage as opposed to simply disposing of items as was described previously in landfills. The natural process of turning organic waste, such leaves and food scraps, into a beneficial fertilizer that can improve soil and plants is known as composting. Due to its potential to lessen landfill methane emissions, which play a large role in climate change, this procedure may be very advantageous to the environment and society.

Composting merely expedites the decomposition process by creating the perfect habitat for bacteria, fungi and other decomposing creatures (such as worms, sowbugs and nematodes) to carry out their functions (Weindorf *et al*., 2011). Everything that develops eventually decomposes. Compost is the term used to describe the final decomposed material, which frequently resembles fertile garden soil. Composting may aid society and the environment in a multitude of approaches. The ideal method to recycle organic waste produced at households is by composting. More than 28% of all discarded waste is made up of food and garden waste. Processing food waste has a negative economic impact in addition to being a huge environmental burden. Composting, however, can offer a more afordable option to conventional waste disposal techniques. Municipal solid waste disposal is expected to cost $55 per ton on average in 2020 (Chintapalli and Vakharia, 2023).

Fig. 3 : Vermicomposting Site.

Every year, large proportions of fiscal allocations are spent on waste management, with the globe producing more than 267 million tons of municipal waste and sending two-thirds of that to landfills and incinerators (Lee and Lee, 2022). Composting enables society to remove the vast majority of garbage from landfills and recycle it into useful products for gardens and yards, which can lower the cost of waste management and provide a useful resource for home owners.

Large amounts of crop leftovers are produced and sugarcane, cereals crops account for 75% of the total (Venkatramanan *et al*., 2021). These residues typically comprise 0.5% nitrogen, 0.2% phosphorus pentoxide and 1.5% potassium oxide. The broad C:N (Carbon to Nitrogen) ratio of agro-residues, when applied directly presents nutrient management concerns. However, obtaining such materials is incredibly efficient and productive because they are abundant in ideal qualities that support the creation of compost with added value. Utilizing these materials will increase the effectiveness and efficiency of composting and improve the quality of the compost that is produced.

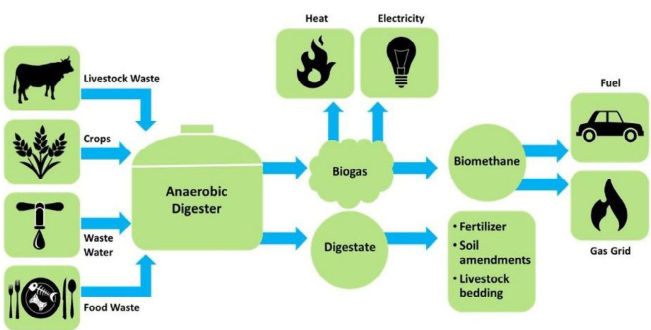

Fig. 4 : Flow of Anaerobic Decomposition.

Additionally, when organic matter decomposes, oxygen-dependent microbes break it down. This process is known as aerobic decomposition. Compostable garbage is buried behind a mountain of other waste when it is dumped in to a landfill, preventing decomposers from getting a steady supply of oxygen.

Anaerobic decomposition is the process by which organisms that cannot breathe oxygen break down such waste. Biogas is produced as a by-product of the process. Methane and carbon dioxide, which make up nearly half of this biogas are both powerful greenhouse gasses, with methane having a 28–36 times greater ability to trap heat in the atmosphere than CO_2 (Mulu *et al*., 2021). Composting regularly can help reduce landûll methane emissions, while recovering more oxygen for use in other processes. Composting can therefore play a significant role in a sustainable waste management approach that lowers greenhouse gas emissions while producing useful resources for society.

Post Harvesting issues

Post-harvest management is a key stage of crop production immediately after harvest, which consists of a series of activities such as cooling, cleaning, sorting and packaging (Kiaya, 2014). When a crop is removed from the ground or parent plant, its quality begins to deteriorate. Therefore, post-harvest activities, including harvesting, handling, storage, processing, packaging, transport and marketing, are essential to minimize losses of horticultural products. Unfortunately, losses of such crops are a serious problem in the post-harvest chain and can be attributed to a wide range of factors, such as growing conditions, harvesting methods, transportation and handling at the retail level.

Quality loss is one of the major concerns in developed countries, affecting the nutritional /caloric composition, acceptability and edibility of a given product. On the other hand, in developing countries, volume loss is more frequent, resulting in product volume loss. Globally, high-income regions have been reported to experience more food loss and waste downstream in the food chain, while low-income regions have experienced more food loss and waste upstream. It is worth noting that the major contributors to post-harvest losses of fruits and vegetables are mainly due to mechanical and / or environmental factors. These verities of the damage became more apparent as the severe weather conditions became more apparent.

Overall reduced availability of such crops and properties results in an increased demand with less supply, but also a considerable amount of residue waste that cannot be accounted for. Reduction of post-harvest losses can increase food availability to the growing world population, decrease the area needed for production and conserve natural resources.

Solar Powered Compost Bin

Conventional strategies for preparing compost require a significant amount of manpower and oversight, making it a labor-intensive process. However, through innovative and mechanical applications, organizations can create a composting bin that requires less human intervention, while still being sustainable.

To achieve this, the apparatus would consist of four main components: a 12V DC motor, a 330 Ω resistor, a PMax 10V solar panel and a generic 9V battery (Duffy, 2011). The DC motor used in the apparatus would be small-capacity to ensure energy efficiency, making it a more sustainable option compared to using larger motors. With the gear motor within the apparatus having a gear ratio of slightly over 6000:1, it will have a higher speed and more rotations per minute (RPMs) from the motor to torque, making the composting process faster and more efficient.

Fig. 5 : Sample Solar Panel Information.

Additionally, the solar panel would be placed in a location relatively close to the main components to enhance the voltage capacity, while also being placed in a location with ample sunlight for assimilation (Li *et al*., 2021). This ensures that the solar panel will provide enough energy to power the apparatus and maintain the sustainability of the composting process, while also reducing the need for human intervention. Overall, the use of these innovative and sustainable components in the composting process can signiûcantly reduce manpower and oversight while still producing high-quality compost.

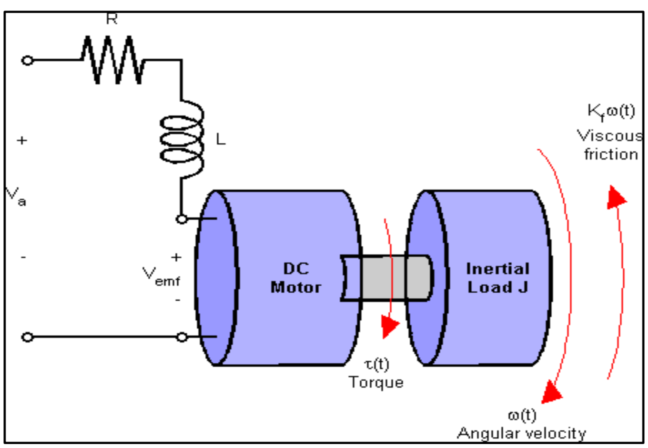

Fig. 6 : "DC Motor Control". DC Motor Control-MATLAB & Simulink.

Advantages of Vermicomposting

As demonstrated in the apparatus (Fig. 2), the mechanism is an accessible scale which can be exploited on all fronts. In doing so, rural areas are able to utilize such a mechanism to sustainably repurpose the large volumes of waste produced, whilst being performed in both a sustainable and equitable manner.

- One of the key benefits of vermicomposting is that it can be done on a small scale, making it a viable option for households in urban areas. By using a small bin and a small number of earthworms, households can process their organic waste and produce high-quality compost that can be used to grow plants and vegetables. This approach not only reduces the amount of waste that is sent to landfills, but also improves soil quality and promotes urban agriculture (Cofie *et al*., 2006).

Disadvantages of Vermicomposting

On the other hand, the mechanism warrants large parsecs of land, wherein preempted sites are allocated for the mechanism; whilst also being observed by a set of individuals. Despite its applications in small spaces and rural areas, situating the scheme in a lower economically developed country may prove to be challenging, due to the lack of an active workforce given the possibility of a largely dependent population; or, the lack of economically active individuals within the agricultural sector of an urbanized conurbation; whose residents primary engage in non agricultural tasks with administratively deûned boundaries.

Conclusion

The waste generated by society has become a major problem due to traditional disposal methods that rely on landûlls, which account for roughly 60% of all waste generated. Landfills are large-scale dumping sites where waste remains for an indefinite period of time, resulting in an exponential increase in landfill size and citation over the last four decades. With the growing population, the world generates 2.01 billion tonnes of municipal solid waste annually, with a minimum of thirty-three percent of the aforementioned not being managed in an environmentally safe and economically just manner. The waste generated by households is often uncollected, particularly in rural areas, leading to various types of pollution such as air and water pollution, soil pollution and landscape degradation. Additionally, this approach has led to an estimated average garden waste generated rate of 0.68kg per household per day, which is a signiûcant amount.

It is critical to recognize that waste can be a valuable resource if managed properly. For example, some waste, such as food waste, can be used to generate energy through anaerobic digestion. Furthermore, recycling and up cycling waste can help reduce the amount of waste that is sent to landûlls, which in turn can reduce the negative effects on the environment. By diverting waste from landûlls, we can reduce greenhouse gas emissions and prevent signiûcant harm to marine and wildlife.

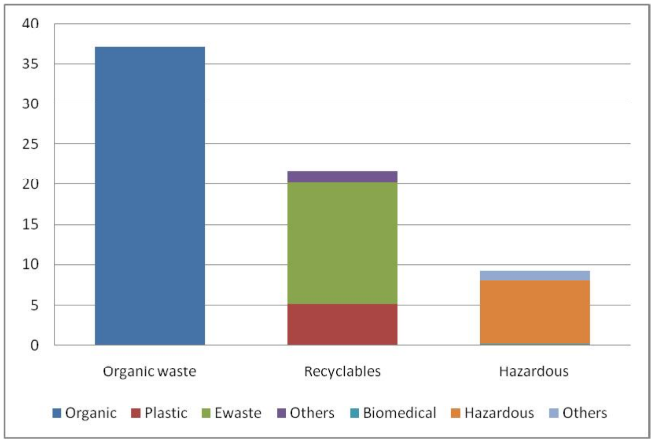

Fig. 7 : Household Waste Statistics.

To achieve a more sustainable approach to waste management, it is essential to reduce the amount of waste generated, reuse, recycle materials and manage waste that cannot be recycled or reused properly. By doing so, we can reduce the negative eûects on the environment and preserve the planet for future generations.

Composting is one way to turn waste into a valuable resource. It is a natural process that turns organic waste, such as leaves and food scraps, in to a beneûcial fertilizer that can improve soil and plants. Composting can expedite the decomposition process by creating the ideal habitat for bacteria, fungi and other decomposing organisms to carry out their functions. The ûnal decomposed material, called compost, frequently resembles fertile garden soil. Composting can be an affordable option to conventional waste disposal techniques, as processing food waste has a negative economic impact while being a huge environmental burden. Municipal solid waste disposal is expected to cost $55 per ton on average in 2020.

In conclusion, waste management is a complex issue that affects both local and global environments. Proper waste disposal facilities are essential to managing waste electively and it is critical to adopt a sustainable approach to waste management. By doing so, we can reduce the negative effects on the environment and preserve the planet for future generations.

Vermicomposting, a type of composting that uses earthworms to break down organic waste, has been gaining popularity as a sustainable method for addressing household waste in cities. Unlike traditional composting methods that rely on bacteria and fungi to break down waste, vermicomposting utilizes earthworms to process organic matter, resulting in nutrient-rich compost that can be used to enrich soil and plants. This process not only reduces the amount of waste that is sent to landfills, but also produces a valuable resource that can be used to improve urban agriculture and green spaces.

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