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REVIEW ARTICLE

Sustainable Solid Waste Management Practices in Higher Educational Institutions

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ABSTRACT
Any nation at large has to deal with many challenges such as poverty, malnutrition, inequality, terrorism, political instability, ethics, environmental degradation, sustainability and quality of higher education. These challenges are crucial for the nation and can be addressed through higher education, which in a present-day context, holds immense potential to cultivate a knowledge-based society. Higher Educational Institutions (HEIs) of any nation can play a pivotal role in solving such problems as they accommodate young adults of that nation who will be the future leaders or torchbearers. Institutions, especially HEIs, are high population density areas and generate a large volume of waste which needs to be managed efficiently to maintain the campus cleanliness and hygiene. The major waste categories in HEIs are packaging papers, notebooks, plastic containers, vegetable waste, leaf litter, etc. This paper reviews the importance of sustainability in the HEIs, with special reference to solid waste management. The paper also highlights some Indian institutes adopting sustainable practices for managing their waste and moving towards zero waste campus. Some sustainable practices that can be adopted by the HEIs are recycling of paper, vermicomposting, rain water harvesting, utilizing renewable resources, conserving existing resources, and promoting environmental awareness through education.
***Key Words**: Higher Educational Institutions (HEIs), Solid Waste Management, Sustainable Development*

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INTRODUCTION

India has an education system that holds a prominent position and is recognized globally in terms of the network of higher education. "Education" in the Indian context is post-secondary education, which is given following a 12-year educational journey consisting of two years of secondary schooling and ten years of basic education. HEIs or Higher Education Institutions, provide secondary education through undergraduate, graduate, and even doctorate programmes.

India's higher education landscape offers a diverse range of institutions including Central Universities, State Universities, Private Universities, Deemed Universities, and Institutes of National Importance (INI). Higher education in India has achieved rapid growth. By the end of 2020, there were a total of 1043 universities, 42343 colleges and 11779 Standalone institutes in India with 38.5 million students consisting of 19.6 million boys and 18.9 million females [1]. HEIs have a critical place in society, shaping future leaders and innovators. The pressing need for sustainable solutions presents a golden opportunity for HEIs to step up and fulfil their leadership role by tackling this global challenge. The campus of the HEI resembles the characteristics of a city on a small scale, thus resulting in similar impacts on the environment; as a result, they can be identified as mini-cities [2]. These campuses can inspire and motivate local communities to effectively implement green sustainable practices.

By 2050, the world population is estimated to be 9.7 billion and it would take around 2.3 Earth-sized planets to sustain the current rate of consumption of resources, use of energy, and trash production [3]. To tackle this issue, more knowledge must be produced and effectively disseminated to the general population for practical implementation. Various scholars, such as Cordero et al. [4] and Simsar [5], emphasize the importance of environmental subjects in lowering the ecological footprint [4], [5], while others, like Moser and Kleinhückelkotten (2018), doubt its effectiveness [6]. Despite opposing viewpoints, it is clear that education plays a crucial role in attaining sustainability [7]. Numerous scholars have proposed that the most effective means of maintaining a clean environment is through education [8], [9]. Educational institutions can serve as a bridge between various stakeholder groups. Higher education establishments bear a special duty to develop future professionals and put ideas and knowledge into practice.

SUSTAINABILITY AND HIGHER EDUCATION

For a long time, schools, businesses, governments, and even non-profit groups have been grappling with how to use resources responsibly, considering the impact on people, the planet, and the economy [10]. The Stockholm Declaration in 1972 marked a turning point. It sparked a wave of pronouncements, both within countries and internationally, that highlighted the importance of sustainability in universities and colleges[11] & [12]. The Stockholm Conference in 1972, even though it didn't directly addressed sustainability on campuses but established the framework for future discussions. The declaration highlighted the importance of interdependence of human beings and the environment, and recognized education as a key factor in this relationship. In 1990, the Talloires Declaration became a turning point for universities, marking the first official commitment by university leaders to incorporate sustainability into higher education and outlined a set of guiding principles that urge HEIs to serve as an example of environmental responsible organization by reduction of waste, recycling, and resource conservation [12]. It further highlighted the crucial role of universities in both research and education for a sustainable future. Finally, the Talloires Declaration called for the implementation of programs that foster skills in environmental management, sustainable economic development, and social justice, assuring future generations have the knowledge and tools to tackle complex sustainability challenges [13] & [14].

Building on the momentum of the Talloires Declaration, the 1991 Halifax Declaration emerged from an international conference specifically focused on universities' role in sustainable development. This conference, "University Action for Sustainable Development," underscored the critical leadership position of universities in achieving a sustainable future. The Halifax Declaration emphasised the issue of ecologically sustainable development, further solidifying universities' commitment to environmental responsibility as a cornerstone of a broader movement towards a more sustainable world [11]. Through the Halifax Declaration, universities were challenged to "re-think and re-construct their environmental policies and practices to contribute to sustainable development on local, national, and international levels" [12]. The movement towards sustainability in higher education gained further recognition in 2005 when the United Nations launched a Decade of Education for Sustainable Development. This decade-long initiative aimed to weave the principles and practices of sustainability into the very core of education, transforming not just knowledge but also values and attitudes to enable a more sustainable and just society for all. These developments have been the source of momentum and have pushed sustainability in higher education into the mainstream [16].

HEIs aren't just places to learn and conduct research. They're also major employers, economic drivers, and cultural hubs that provide recreational facilities and infrastructure. This unique position gives them immense power to accelerate society's shift towards a more sustainable future. Sustainability in HEIs can be achieved by offering courses in sustainability or environmental studies, green building, use of more renewable resources such as solar energy, energy management, water conservation and solid waste management (SWM). Waste management systems pose a significant challenge for HEIs' pursuit of sustainable development [17]. The core principle of sustainability on a university campus revolves around managing waste responsibly. It prioritizes the principles of generation of waste at the source, reusing resources, recycling and composting organic matter – all while ensuring the safety of human health and the environment [18] & [19].

Sustainable waste management practices in HEIs require a holistic approach involving the entire campus community. By adopting green practices, institutions can reduce their environmental footprint, instil a culture of responsibility among students and staff, and contribute to a more sustainable future. One possible theme for student activities is cutting down on trash production as one of the main goals of waste management is waste minimization. Student organizations can also help to minimise the amount of garbage that has to be treated if they organise to help the less fortunate by giving clothing and other reusable accessories, reusing papers, and providing extra meals to those in need.

For effective and sustainable SWM with reference to HEIs, we need to know the amount and type of solid waste generated. Different researchers categorized solid waste in HEIs into different types (Table 1).
Waste categorization in HEIs as per the literature reviewed is as follows:

Table 1: Waste Categories in the Educational Institutions (references Missing)

S. No.	Waste Categories in the Educational Institutes	Researchers
1.	Paper and cardboard, Plastics, Organics, Metals, Glass, Construction & demolition, Hazardous and Others	**[4]**
2.	Paper, cardboard, Disposable cups and containers, Plastics, Glass, packing paper, Organics matter, Ferrous metals, Non- ferrous metals, Hazardous waste, Electronic waste and Others	**[20]**
3.	Paper and its products, Organics matter, Plastics, Glass, Metals, Textiles, Wood, E-waste, Hazardous waste, Construction & demolition, and Others	**[18]**
4.	Hot beverage cups, Cardboard, Plastics, Glass, Metals, Paper, Yard waste, Food, Foil and Others	**[21]**

Solid waste management is gaining more seriousness in detailing and and analysing resource recycling and recovery opportunities in HEIs [20]. Adopting a zero-waste strategy among HEIs is feasible but demands mass cooperation.
Zero waste can be described as a set of guiding principles aimed on waste prevention, emphasizing the restructuring of resource life cycles to promote the extensive reuse of all products. In the paradigm of zero waste, a product deviates from the traditional cycle of usage. Unlike conventional products, items aligned with the zero-waste philosophy have the potential to be recycled, repaired, or transformed into something new in their subsequent cycles [21] & [22]. The essence of the zero waste concept rejects practices such as burning waste or adhering to a throwaway society. Instead, it advocates for the establishment of a sustainable society [23].
The zero-waste program and environmental management structures at Massey University campus were reviewed by Mason et al. (2003). The research concluded that such programs necessitate the participation of various parties at various university levels. It was obvious that an institutional-level plan for sustainable, integrated solid waste management with fully developed recycling programs was needed. Currently, Recycling has been used as a powerful tool by the HEIs to demonstrate their dedication to environmentally responsible activities [24].
Rajamanikam and Poyyamoli (2014) quantified waste at the staff quarters of Pondicherry Engineering College (PEC) in India. They segregated waste into compostable food waste, dry recyclables waste and hazardous waste. The study found that kitchen waste made up the biggest portion of the total trash. Furthermore, the researchers concluded that by segregating waste at the source, they could recover up to 95% of the waste generated [25].
To ensure the sustainability of a green campus, the optimal waste management approach should be straightforward, affordable, easily scalable, and compliant with the 5 R's rules of waste management. The sustainable 5 R rules of waste management are Refuse, Reduce, Reuse, Recycle and Rot. According to Hui *et al* 2006 , the 5 R's (Refuse, Reduce, Reuse, Repurpose, Recycle) are a powerful tool for achieving sustainability [26]. This approach offers a three-pronged benefit:

1. Conservation of resources
2. Prevention of environment degradation
3. Energy Optimization

In 2017, Dangi and Agarwal conducted research to enhance waste management at MITS Gwalior. For effective waste management, their strategy entails segregating waste at the point of disposal (source segregation) and then dealing with each category in an environmentally beneficial manner that includes composting of food waste, vermicomposting or converting trash into fuel briquettes (biomass or charcoal). They also proposed making briquettes using refuse-derived fuel (RDF). Another advantage is that recyclable items may be sold to create revenue for the school [27].
A large amount of waste generated in HEIs is organic waste such as food waste, paper waste, yard waste, leaf litter, etc. It can be managed by the cost-effective method of composting and resulting in the recovery of value-added products. Composting is a natural process where tiny organisms decompose organic materials, transforming them into a safe, pathogen-free soil amendment called compost that's rich in nutrients.
Training and capacity building should be implemented at all levels to train students in India to create awareness about the need for waste management, its significance, adverse effects on public health and

the environment. This strategy will encourage the growth of conscientious citizens who will see waste as a potential resource [28].

Sustainable Practices in some Higher Educational Institutions in India

Many HEIs around the world are embracing sustainability and implementing practices to reduce their environmental footprint on campus by waste minimization, use of renewable resources, conservation of resources and education and awareness. Here are some examples (Table 2) of how institutions practice sustainability in their campus:

Table 2: Sustainable Practices in some HEIs in India

S.No.	HEIs	Sustainable Practices	References
1	**LadyIrwin College, New Delhi**	**-**Collaborated with "**Jaagruti – Waste Paper Recycling Services**" to manage its paper waste -Collaborated with the **Indian Pollution Control Association (IPCA)** to introduce Aerobins on campus to facilitate aerobic breakdown, releasing nutrients into the soil -Manure contributes to maintaining the campus landscape and supports organic farming and surplus compost is sold	[29]
2	**Hans Raj Mahila Maha Vidyalaya (HMV), Jalandher, Punjab**	**-**Installed a **waste paper recycling machine** to recycle paper waste -Students are selling the recycled products and effectively benefiting from the **'Earn while you learn'** initiative -Established a **vermicompost unit** to manage waste in an efficient, eco-friendly, and productive manner -College has adopted the tradition of **gifting plants** instead of plastic-wrapped bouquets -Plastic bottles are being recycled to create bird feeders and bird splashes	[30]
3	**Jawaharlal Nehru National College of Engineering or (JNNCE), Shimogga, Karnataka**	**-**Installed a **Sewage Treatment Plant (STP)** to treat the sewage and use cleaned water for lawns inside the campus -Solid sludge obtained is used as manure for gardening -**Pilot Plant Phytoremediation System** to treat the sewage -**Rainwater** is collected in a huge reservoir and treated using an indigenously developed water treatment system which is used for in-house consumption other than drinking & cooking purposes -Established a **Solid Waste Management System** comprising a Shredder Machine and a Chopper Machine. -Installed a **biodiesel production unit that** produces biodiesel using pongamia seeds and cooking oil	[31]
4	Indian Institute of Technology Roorkee, Uttarakhand	**A sewage Treatment Plant** has been constructed that treats about 2MLD sewage -Waste is segregated by using **colour-coded bins** -NSS carries out services to collect old used clothes and distribute them among the needy -**Eco Group** is a group of enthusiastic trendsetters working together to integrate sustainability in IIT Roorkee and inculcate Green Living in the campus community.	[32]

CONCLUSION

Higher education institutions (HEIs) in India have immense potential to be leaders in sustainability. The vast amount of waste generated on campuses necessitates effective Solid Waste Management (SWM) strategies. This paper reviews sustainability in HEIs in India, specifically focusing on waste management. It also analyzes the challenges and opportunities HEIs face and emphasizes the importance of sustainable waste management. This paper explores successful practices adopted by several Indian HEIs, highlighting a shift towards a zero-waste approach. From paper recycling and vermicomposting to rainwater harvesting and biodiesel production, these institutions are demonstrating exemplary environmental responsibility. The secret weapon for conquering waste is the 5 R approach: Refuse, Reduce, Reuse, Recycle, and Rot. By adopting these principles and fostering a culture of mindful consumption within

their communities, HEIs can become beacons of sustainability, inspiring future generations and contributing to a greener India. Imagine campuses not just educating future leaders, but also leading the way towards a more sustainable future for India. This requires collaboration, innovation, and a commitment to building a greener tomorrow.

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