Evaluating Generation of Paper Waste and its Appropriate Waste Management in Architectural Educational Campuses in India

Sub theme: Goal 4 – Quality Education, Goal 9 – Innovation & Infrastructure, Goal 11 – Sustainable cities & communities, Goal 12 – Responsible Consumption, Goal 15 – Life on Land

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Abstract

Educational campuses in India, especially the Architectural stream, are often faced with the challenges of **paper waste** generated through the academic curriculum requirements. Such generated waste produced as an outcome of the academic exercises, often leads to **waste management issues** at the campus level if not handled with care, leading to environmental concerns on life on land. With the growing amount of Govt. Initiatives with respect to **Digital India movement & technological implementation** in the higher education institutes to serve the students of digital era, transition into digital immersion of **paperless assignments** is the new domain to look at in future.

The research paper establishes attitudinal **change** as a key necessity towards **achieving net zero campus** along with effective **student engagement strategies** in waste reduction initiatives. The research paper aims to **evaluate the paper waste generated at an architectural campus and thereby recommend guidelines & strategies for the effective management of the same in future.**

A **qualitative approach** would be employed, combining literature reviews, case studies, observational studies & focus group discussions. The study findings should highlight the importance of **student engagement, awareness, and infrastructure in reducing waste generation.**

Keywords

net zero; paper waste; student engagement; guidelines

1. Introduction

With the advent of the late 20th Century & early 21st Century, the issue of the Waste generation along with its appropriate management has always been a concern for the "Environment consciousness" approach. With the rise in concern about the environment, everyone wants to do their bit to save the environment through various initiatives, campaigns & policies. It is important to note that the generation of waste is inevitable. One cannot stop it completely as it is a part of the daily process of Life on Land. With increasing population, waste management becomes a moral responsibility, which one can't ignore.

The world today is facing many challenges due to generation of wastes. Production of methane gas due to waste decomposition, contamination of soil, water, air, ecosystems & human health, destruction of many natural habitats, spread of diseases, affecting the mental & social wellbeing of the society to name a few. Wastes in the form of household wastes, food wastes, toxic & hazardous wastes, e-wastes, construction & demolition wastes, organic wastes, industrial effluents etc. are produced every day at the global level.

However it is worthy to note the amount of waste generated at the educational campuses at the global level as well as domestic levels has been significantly contributing to the landfills every year. Apart from the food wastes generated from canteens & hostels, plastic wastes generated in the form of water bottles & other packaging, e-wastes generated from various electronic equipment & devices, chemical wastes generated from laboratories, furniture wastes from the studios & classrooms, the generation of "Paper Wastes" has significantly contributed in harming the environment. The research paper specifically focuses on the wastes generated from the Architectural campuses across the country & its impact on the environment. If planned strategically, the paper waste management at such campuses could adopt the net-zero approach, could significantly reduce the greenhouse gas emissions, conserve natural resources & can promote sustainable practices for the future generation of the learners. The prime reason for the selection of an Architectural campus scenario is because without drawings or prints on the paper, the education in Architecture course seems impossible. The demand for the paper as a medium to communicate designs has been an age-old practice in the architectural curriculum for a long time now. However, very little has been done in terms of paper waste management at such campuses to curb the disposal of waste which eventually causes harm to the environment.

2. Aim, Objective and Scope

2.1 Aim

- To evaluate the paper waste in Architectural Educational campuses
- To optimize the process of education to minimize generation of paper waste.

2.2 Objective

- To measure the total amount of paper waste produced in the Architectural educational campus
- To analyse the types of paper products/assignments contributing most to waste within the campus
- To evaluate current recycling and disposal methods at the campuses.
- To survey student attitudes, knowledge, and habits regarding paper waste.
- To analyse differences in waste management among various architectural educational campuses in India.
- To investigate alternative teaching methods reducing paper usage
- To integrate sustainability and environmental education into the architectural curriculum.

2.3 Scope

- Create a comprehensive framework for reducing paper waste in architectural educational campuses.
- Engage all stakeholders such as administrators, faculty, students, and staff to understand their roles in paper waste management.

3. Methodology

3.1 SDG Goals & its relevance with the research paper

The UN SDG Goal no: 04,09,11,12 & 15 are interconnected with the paper waste management in architectural campuses. By addressing the paper waste management, the architectural campuses can contribute in achieving the UN SDG Goals by fostering the culture of sustainability & promoting environment conscious practices all throughout.

3.2 Literature Review

Conduct a comprehensive review of existing literature on paper waste management in educational settings in India. This study will review the literature to develop context-specific guidelines & solutions to address the effective waste management solutions for architectural campuses.

3.3 Case Studies

This research shall focus on waste management in architectural campuses, with a specific case study on an architectural educational campus in India. The selected campus would be studied in the form of observational studies with photo documentation to understand its current scenarios with respect to its current processes & practices.

3.4 Stakeholder analysis

A survey shall be conducted using a Questionnaire using Google Form, to understand the pulse of stakeholders with respect to the paper waste generation & management.

4 Limitations

- Non-accessibility to the following methodological tools such as Waste audits, Statistical software (SPSS, R, etc.), Survey and data analysis software (e.g., SurveyMonkey, Excel)
- The research component was purely studied based on the Literature reviews, case study & stakeholder analysis.

5 Literature Review

5.1 SDG Goals & its relevance with the research paper

5.1.1 **SDG Goal 4 Quality Education**- Imparting Quality education which is pro-environment & works on management of waste. The architectural campuses can integrate paper waste management and sustainability principles into their curricula, promoting environmental awareness and responsible practices among students.

5.1.2 **SDG Goal 9 Innovation & Infrastructure** - Existing infrastructure could be modified with required technology to manage wastes at campus level. Innovation in existing infrastructure for Teaching Learning methods & assignment deliveries can be organized. Disposal & segregation spaces, workshops, small machineries, etc.,

become a part of this goal. Architectural educational campuses can invest in sustainable infrastructure, such as recycling facilities, composting systems etc to minimize paper waste and promote environmentally friendly practices.

5.1.3 **SDG Goal 11 Sustainable Sites & Communities** - Architectural campuses could become sustainable models, where student communities play a vital part – This could be achieved gradually, by implementation of waste practices and the learner community shall be a part of the society & educate further – penetration of this adopted process into the society. Campuses can engage with local communities to promote sustainable practices, including paper waste management, and foster a culture of sustainability.

5.1.4 **SDG Goal 12 Responsible Consumption** - Stakeholders of the campuses need to have responsible consumption of all resources & thereby reduce carbon footprints. The implementation of this process will lead to changes in attitude of using the paper, learners would be more responsible, Activities & workshops, and responsible disposition shall be followed. This will considerably reduce the consumption at the resource level. Campuses can adopt sustainable procurement practices, sourcing products with minimal packaging, buying in bulk, and choosing products with high recycled content.

5.1.5 **SDG Goal 15 Life on Land** - The entire lifecycle of paper generation, usage, transportation to disposal needs to have minimal impact on the environment. By reducing paper waste, architectural educational campuses can help conserve natural resources, such as wood pulp, water, and energy.

Figure 1.The inter-connected UN SDG goals (4, 9, 11, 12 & 15) with the research component

SDG goals – a pictorial comprehensive

5.2 Management of Paper Waste

An efficient management of waste starts with regular collection of waste generated. This task has been made easier by placing a dustbin at appropriate places. A separate space for segregation of papers can be allotted. The frequency of waste generation depends upon the time at which the waste is generated which is mostly the concluding part of the semester.

Also, various different papers used by the learners demand man hours & hard work of labour to achieve the desired disposal of waste. The management of paper waste involves the basic paper grade categories such as old corrugated paper containers, mixed papers, old newspapers & high grade deinked papers.

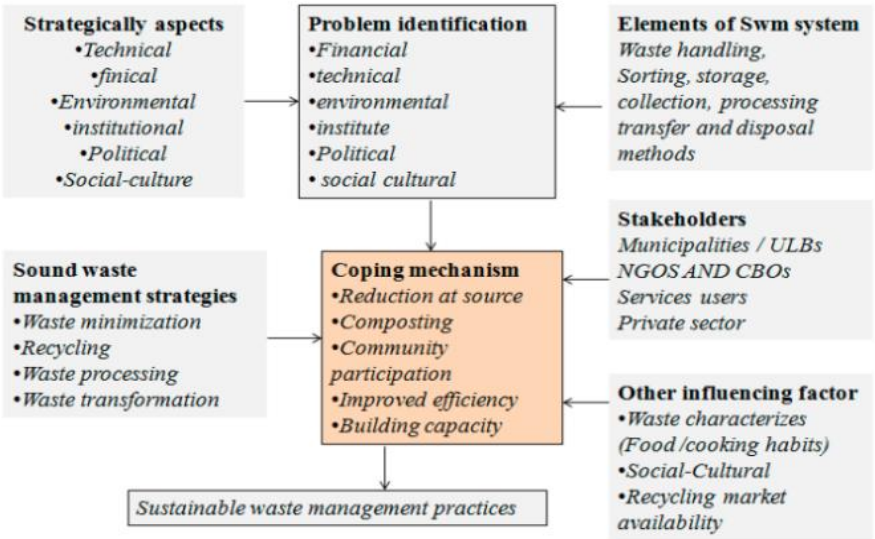
The type of conventional paper wastes which are recycled, involves the following:

- **Old corrugated paper containers** - Paper recycling mills use old corrugated containers to make new recycled content shipping boxes.
- **Mixed papers -** It's a broad category which includes discarded mails, paper board, magazines, catalogues etc. Mills use mixed papers to produce paper boards, tissues, as secondary fiber in newspapers, raw material for non-paper products
- **Old newspapers** - Mills use old newspapers to make new-recycled content newsprint, paper boards, tissues, etc.
- **High grade deinked papers** - It must be de-inked before it can be reprocessed into high grade paper products such as printing & writing papers or tissues etc.

The above recycling process requires transportation & disposal is done by using various machinery & industrial technology. This outcome of this research paper shall eliminate this chain & avoid this overhead expenses, by sorting the waste at the source itself at the architectural campus, shall help in effective waste management at the campus level without compromising on health & hygiene as well as easing the labor-intensive process of sorting post collection of wastes.

The figure below shows a similar process in a paper pulp making assembly line, which can be sometimes more expensive than the disposal itself.

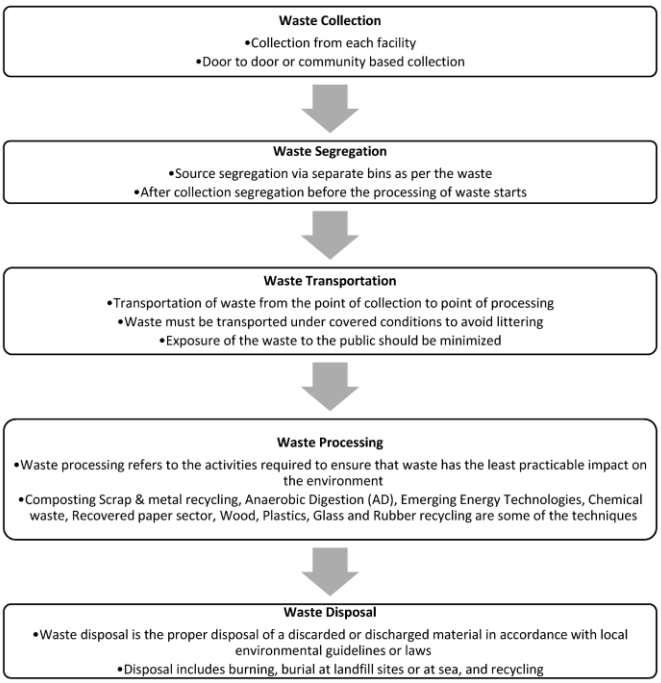
Figure 2.(Conceptual framework for solid waste management (SWM) sound practices coping Mechanism) Image Source : https://www.mdpi.com/2313-4321/4/3/28



The above figure shows reducing the waste at prime source is the first step of the waste hierarchy & coping mechanism.

Developing awareness by the institutes to all its stakeholders.
Hierarchy of the waste management needs to be strictly followed to focus on the long term environmental implications.
Understanding the process of waste management, interlinking of stakeholders etc.

Figure 3.The steps of Solid Waste Management as listed and advised by the Central Pollution Control Board (CPCB) in year 2000.) *Image Source :* ***https://www.mdpi.com/2313-4321/4/3/28***



The above figure shows the steps of Solid Waste Management as listed and advised by the Central Pollution Control Board (CPCB) in 2000. The architectural campuses in India can follow the same at institute level with following steps:

Waste collection - from individual classrooms,design studios, offices, stationary shops etc.

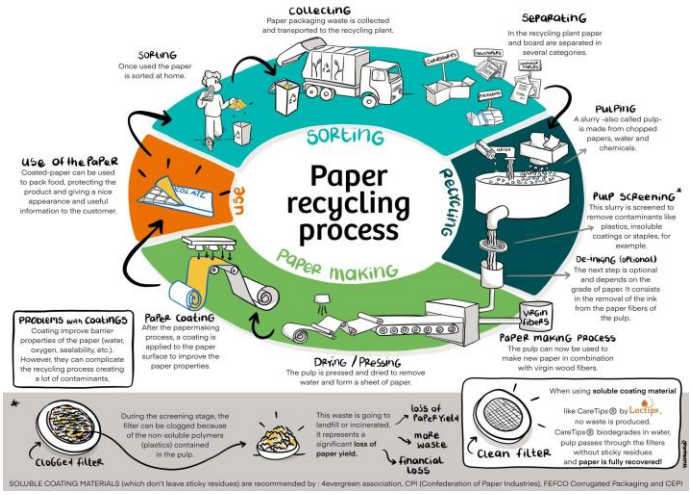
Waste segregation - in terms of loose papers, printed sheets, one-sided/both sided used papers, scrap papers, newspapers etc.

Waste transportation - recyclable waste to be transported to recycling units, other scrap paper can be reused at campus level.

Waste processing - ensuring minimal impact on environment by reusing or recycling papers

Waste disposal - minimal load on landfills, avoid burning & alternatives for recycling.

Figure 4. Image Source :https://www.lactips.com/news/what-is-the-paper-recycling-process/?lang=en



5.3 Digital Education

- The development of National Digital Education Architecture to enrich school learning is a part of overarching strategy to leverage digital technology, The digital access to education will help further the inclusivity & quality. It has awakened all stakeholders to immense possibilities of digital technologies to upgrade & rejuvenate Indian education.
- The Pandemic times brought all file work, assessments of students work to be carried out on online mode, Records' keeping using drive & cloud modes were being activated.
- Manual drafting found its way to software like AutoCAD, 3D Max, Google sketchup, etc. which considerably reduced dependency on papers, & lot of burden of stationery was reduced.
- Video conferencing platforms such as Google Meet , Zoom found its place in academics.
- Using various initiatives such as Digi locker (Digital lockers), e-paathshala & various SWAYAM courses, students can access various educational resources such as digital textbooks & academic research records.
- Subjects began to be taught on digital mediums – live cams in the studio, real time illustrations, presentations, simulations, etc.
- Administration process - CAP rounds in the institutions were online including payment of fees etc. thereby reducing the burden on transportation & physical presence to a larger extent along with stationary requirements at architectural campuses.

Figure 5. Digital India

5.4 Understanding Current Situation in Architectural Educational Campuses

- It is not debatable that education in architecture utilizes the most quantity & types of papers, may it be drafting, model making, printing of reports as assignments, model making, installations, etc.
- In terms of experimentation or Teaching learning, ancillary materials, like plywood, adhesives, metal, etc. are used. Per say, the assignment & the waste production, then the installation itself is replaced by a new one, adding to the Waste
- To achieve these products, energy is utilized, resources are consumed- Water, electricity, the proper products themselves are phenomenal.
- The printing, the stationery, which is imprinted on paper, the process, everything teaser calls for generation of Carbon footprint as well.
- The used & discarded paper contributes to already overwhelming landfill waste in our cities. (SDG Goal 15). Moreover, the decomposition of paper releases the methane gas, which is a potent greenhouse gas, causing environmental concerns. Moreover, when the used & discarded paper is not properly recycled or composted, it can clog the waterways, thereby harming the aquatic life below the water (SDG Goal 14).
- Inadequate waste management could also lead to soil & groundwater contamination, attracting pests & fostering unhygienic conditions. Thus, the unthoughtful paper waste dumping can lead to environmental degradation, undermining the campus sustainability efforts.

5.5 Case Study

Established in 2014, Thakur School of Architecture & Planning (TSAP) located in the Mumbai metropolis stands as one of the top architectural institutes across the city. Known for its comprehensive curriculum and robust academic framework, Thakur School of Architecture & Planning (TSAP) offers a range of degree programs tailored to meet the diverse needs of students. The B. Arch program here is meticulously structured to cover essential aspects of architectural education, blending theoretical knowledge with hands-on experience.

The current scenario pertaining to the paper usage & paper wastage at the campus highlights the use of paper into various academic & non-academic activities as well as the post-use scenario of papers.

Figure 7.Display of Students Academic projects in the form of printed sheets

Figure 8.Display of Teaching plans & timetable in the form of printed sheets, hand illustrated sheets

The paper is used by the students in the form of printed sheets (A4,A3,A2,A1,& A0 size) for their academic project work portfolios & reports. Often post assessment or juries, these printed sheets remain in the campus, if not taken back by the students leading into campus paper waste. It is observed the smaller the size of papers the more it is ignored & kept in campus, wherein larger portfolio sheets are collected by the students post juries. Apart from printed sheets, many hand illustrated sheets too are produced during class exercises, esquee & design submissions. Printed sheets of teaching plans, defaulter lists & time table as part of non-academic work related sheets too are produced in the campus. It is important to note, these printed sheets consume harmful inks for prints & can lead to environmental impact if left ignored.

Figure 9.Design juries & viva-voce with tracing sheets display

Figure 10.Design Process - using papers models

As a part of the design process many hands-on exercises of making paper models using cut sheets are used at the campus by the students. These process models have short life & are often seen dumped in the campus dustbins. The design juries are taken on either printed sheets or hand illustrated sheets (both cartridge & tracing sheets). Post juries these sheets are seen loitering in the studios.

Figure 11.Paper Waste generated everyday at design studios - in the form of sheets, cut papers strips, printed sheets, one-side/both side use sheets)

The waste generated at the end of each day at the studios have shown a mix of cut-sheets, cutouts of papers, printed sheets, rough worksheets, large paper rolls etc.

6 Stakeholder Analysis

6.1 Analysis of energy resource consumption before, during, and after paper usage in an architectural educational campus

- A comprehensive analysis of energy resource consumption before, during, and after paper usage in an architectural educational campus reveals a significant environmental footprint.
- **Before paper usage**, energy is consumed in pulp and paper production, involving processes like pulping, bleaching, and cutting. Good amount of energy is consumed in the paper production process in paper mills in the form of electricity, water & chemicals etc. The fuel consumption for the transfer of those papers to the stationeries at the campus is another form of energy resource consumption. The raw materials to produce paper are derived from the plant based materials. The paper manufacturing process includes several stages such as debarking, chipping, pulping, refining, screening, drying, pressing, bleaching, calendering along with cut-size production & shipment. This process generates a significant amount of waste including water, chemicals & paper sludge which has significant environmental impact, if not managed properly.
- **During usage,** energy is consumed in printing, copying, and transportation, contributing to the campus's overall energy consumption. The printers at the campuses consume electricity to print sheets or panels. The transportation of papers including printing paper, notebooks, and other paper-based materials, to the campus

involves energy consumption. Energy is consumed in shredding & disposing papers as well as storage & retrieving the paper documents.

- **After usage**, energy is required for waste management, including collection, transportation, and disposal or recycling of paper waste. This life cycle analysis highlights opportunities for energy conservation and sustainability initiatives, such as adopting digital alternatives, implementing recycling programs, and promoting environment conscious practices among campus stakeholders.

6.2 Statistical data of the paper usage by an architectural student

The following data represents the paper usage by a single architectural student over the course of one academic year. Based on the deliverables or mode of submission as prescribed by the statutory body (University of Mumbai)
This data provides valuable insights into the paper usage patterns of architectural students. By analysing these statistics, universities and educators can identify opportunities to reduce paper waste, promote digital submissions, and encourage sustainable practices among students.

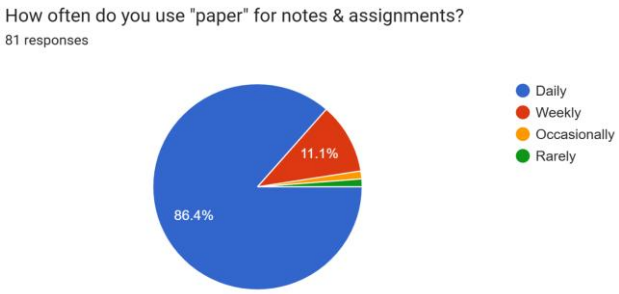
Table 1.Showing the paper usage by a single architectural student over the course of one academic year.)

Sr. No.	Semester	Subject	Tracing papers	Opaque A1 sheets	Opaque 8' x 4' Panels
1	1	Design	10	13	---
2		Technical	---	22	---
3	2	Design	14	13	---
4		Technical	---	22	---
5	3	Design	12	10	---
6		Technical	---	20	---
7	4	Design	13	10	---
8		Technical	---	20	---
9	5	Design	13	12	---
10		Technical	---	23	---
11	6	Design	15	14	---
12		Technical	---	34	---
13	7	Design	---	10	4
14		Technical	---	15	---
15	9	Design	---	---	3
16		Technical	---	15	---
17	10	Design	---	---	3
18		Technical			1
			77nos x 100 students	250nos x 100 students	11nos x 100 students
		Total Sheets	**7700**	**2500**	**1100**

Although the numbers presented above may seem substantial, they cannot be dismissed. Logistically, it is impractical to collect all tracings in one location, as they are often discarded by learners. The estimated number of opaque sheets is based on teaching plans and deliverables. Approximately 20% of the final work is showcased in exhibitions and display areas at the campuses, reducing the amount sent to landfills. Moreover, these displays are updated annually, ensuring a continuous cycle of reuse and reduction. The sheer volume of tracings generated underscores the importance of responsible waste management.

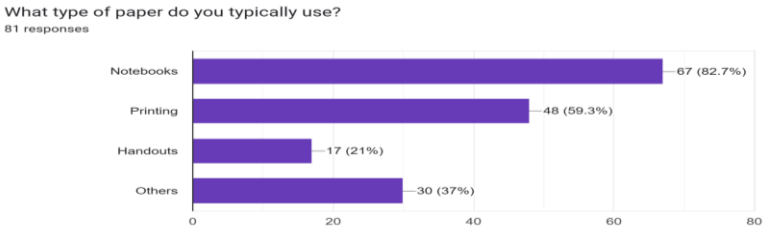
6.3 Survey form

A targeted survey was conducted to gauge the level of awareness and concern amongst architectural learners regarding paper waste management at the architectural campuses. These Google forms helped to quantify the learners' awareness about paper waste management, measure the level of concern amongst learners & explore the willingness of the learners to participate in paper waste management initiatives



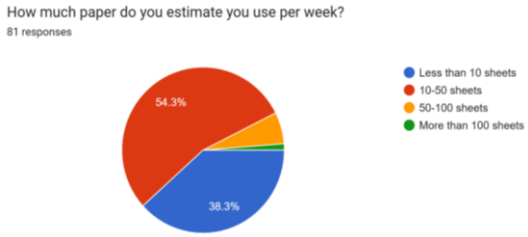
a) ***Figure 12***

Use of paper for academic notes & assignments is a daily practice in the architectural campuses. Hence the dependency on paper, followed by generation of paper waste seems to be a cyclic natural process.



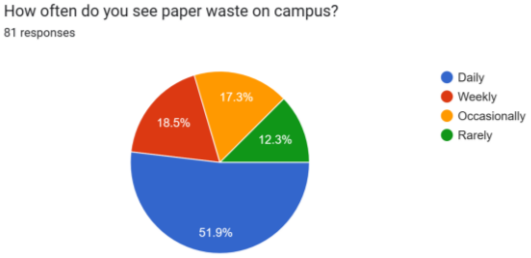
b) ***Figure 13***

Paper is consumed in a variety of forms at the architectural campuses such as notebooks, printed sheets, handouts & other materials used in model making etc. More preference is seen in the form of binded books for easy storage & maintenance purposes.



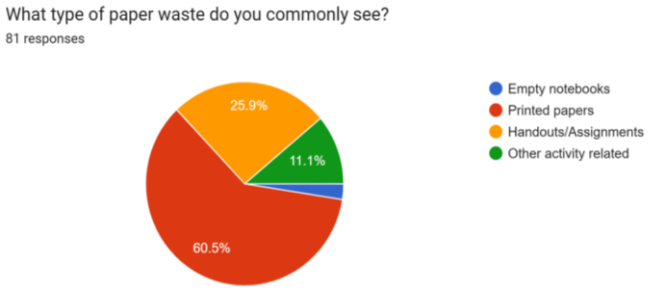
c) ***Figure 14***

The quantity of paper used by an average student of architecture is roughly around 10-50 sheets per week. This quantity multiplied per semester (16 weeks) of work by a student comes to around roughly 400 no.s of sheets per student.



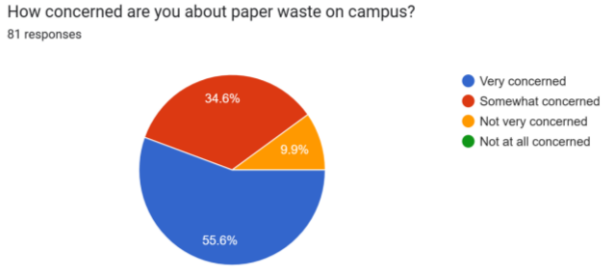
d) ***Figure 15***

Nearly 50% of the students at the architectural campuses see paper waste on a daily basis after the use. It is essential that we put forth the right message for the future generations of architects to learn responsible consumption & thereby reduce the dependency on the usage of papers. Change in the approach towards getting assignments at academic level, can bring the desirable outcome.



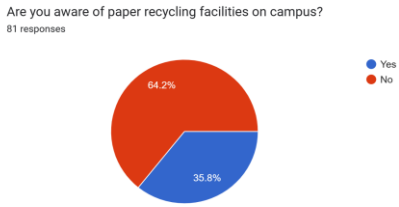
e) ***Figure 16***

The major contributor in the paper waste generated in architectural campuses is through the printed sheets or panels, often used during final portfolio submissions or jury viva-voce. Such printed sheets or panels often have a short life in itself & eventually end up in thrash & dumping yards. The inks on such printed sheets or panels are harmful for the environment. Effective waste management of such sheets is crucial in the long run.



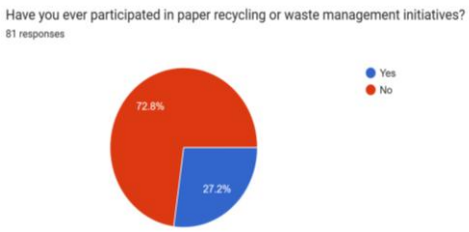
f) ***Figure 17***

The paper waste on the architectural campuses is a high concern for all the stakeholders & hence needs an effective action plan to treat the waste paper into something productive & creative. Policies to reduce paper usage could also be well thought off in the long run. The role of faculties, students, parents as well as management plays a vital role in this endeavor.



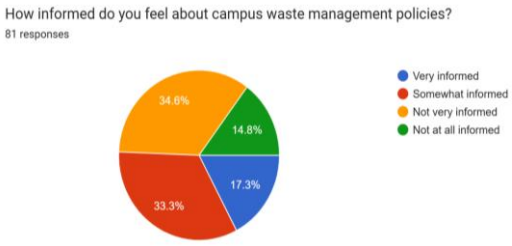
g) ***Figure 18***

The poor knowledge on paper recycling facilities on campuses, if any are, is another concern altogether. Creating awareness of paper waste & its disposal is the need of an hour.



h) ***Figure 19***

The participation of all stakeholders in the paper recycling process at the campus level seems to be a distant dream at many architectural campuses today in India. Innovative ways of reusing paper wastes could help engage students & other stakeholders to understand the cycle of waste management effectively.



i) ***Figure 20***

The mixed feedback on being informed on campus waste management policies altogether provides an opportunity to rework on the system/processes for the sustainable campuses in future.

7 Mitigation

7.1 Awareness & Education

Various workshops related to sustainable practices, waste management & environmental impact of paper waste could be conducted at the architectural institutions. Students could be made to research & evaluate their own practices of handling papers at the campus level & come up with solutions to reduce paper wastes. It would be crucial to incorporate sustainability into the curriculum which covers the areas of waste reduction strategies, environmental architecture & principles of sustainability right from the start of the courses. The campuses could also come up with informative posters, banners & other social media digital creatives which helps to raise awareness about paper waste & its consequences.

7.2 Encourage Active participation of Students

Various initiatives such as paper recycling drives could be arranged within the campuses, wherein students can collect the paper waste & recycle it appropriately. Through such initiatives, incentives could be given to students in their assessment & marking. By conducting regular feedback from students, the usage & wastage of paper can be assessed to identify the scope for improvement areas for future.

Figure 21.*Using waste paper into creative endeavors*

Figure 22.*Using waste news papers for making utility paper bags*

7.3 Implementation of sustainable practices

It would be wise to promote students to use digital tools & applications for note-taking, assignments & presentations instead of using papers. By implementing the paper-less policy within the architectural campuses, the colleges can slowly & effectively phase out the paper-based communication such as notices, reports & announcements etc. By installing paper recycling machines at the campus, it can provide regular collection & processing of recycled papers.

7.4 Lead by the example

By encouraging faculties & staff to model the sustainable behaviour & thereby reducing their own paper waste can greatly inspire students to practice the same in their life at the campuses. Students practicing sustainable behaviour in the campus, could be acknowledged & awarded to encourage other students to follow the path. Such role modeling exercises shall bring a positive outlook towards waste management amongst the students.

7.5 Monitor progress & evaluate impact

It is crucial to monitor & analyze the daily paper consumption & waste reduction strategies implemented at the campus level. Regular surveys & feedback shall help improve the process in the longer run.

7.6 Collaborate with local NGOs

By collaborating with the local NGOs working in the areas of waste management & awareness campaigns, the architectural campuses could help reach out to other resources to effectively reduce paper waste management. Community led development organizations such as the Gabriel Project Mumbai, which is working with the underserved informal urban settlements of Mumbai have started the initiative called “Naya” where a collective of women create paper products from recycled and virgin-sourced paper. The Naya initiative helps to provide livelihood to local women, reduces waste going to landfill and protects the environment while complying with the growing demand of plastic-free bags in India. The women employed in this initiative are trained in recycling waste paper, creating beautiful new pieces using their imagination and skills. Through the sales of these products they support the initiative, as well as develop facilities and awareness around waste and recycling within marginalized communities.

Figure 23.*Paper bag making workshops & donation of bags to local medical shops)*

7.7 Implementing Net zero practices in Architectural campuses

Collaborate with local NGOs and promote the workshops to the adoption of sustainable products and practices, such as:

- **Eco-friendly paper products:** Encourage the learners to repurpose the paper waste into use of paper bags, paper gift wraps, paper decorative items, and other sustainable paper products.
- **Reducing paper waste:** Avoid large paper panels, reuse papers for printing, and bind assignment papers into books using bookbinding techniques.
- **Sustainable alternatives:** Promote the use of paper dishes, paper art, sculptures, and handmade papers created from waste paper pulp.
- **Disposal machine availability:** Ensure disposal machines are readily available in college campuses to facilitate responsible waste disposal.

8 Conclusion

It is essential to recognize the waste as a resource & bring the attitudinal change in perception of waste management altogether. The perceived notion of the society towards waste needs to be relooked upon with creative measures. Disposal of paper waste is needed for an hour, if we want to protect our environment along with the responsible consumption of it as a resource in future. Shift in the perception of the society towards paper & its waste management is needed. By adopting the above mentioned mitigation strategies, India can effectively manage paper waste, reduce greenhouse gas emissions, conserve natural resources, and promote sustainable practices, contributing to a holistic net-zero approach.

9 Future recommendations

This research paper and its achievable goals were limited to evaluation of paper waste & its management. Further other arenas like waste due to model making & installations in Architectural campuses can be taken and a more sustainable community could be the desired goal.

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