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Implementing Sustainable Waste Paper Recycling Techniques in Academic Institutions: A Review

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Abstract— This review on the research paper on sustainable waste paper recycling techniques for academic institutions is conducted with the objective to provide an overview of various recycling techniques. The ultimate aim of this review is to analyze the area of waste paper recycling in academic institutions and provide the problems involved in it. Further, the problems and challenges accepted in waste paper recycling were identified for future sustainability, and a comprehensive review on sustainable waste paper recycling techniques for academic institutions was covered in this paper. With these objectives, a review covering the various recycling techniques used in the market was conducted and observed in this manuscript. In the end, the importance of the recycling was shown, and information collected from this review was summarized. This entire process could be adapted for recycling the vast quantities of waste paper produced by students, an initiative which often fails due to the high cost of disposal. This could be achieved through urged use of the same paper disposal methods already in use, with the paper being collected and pulped once a week directly from the student paper waste bins.

Keywords— Recycling paper waste, Sustainable Techniques, Academic Institutions, and Environmental impact.

1. Introduction

The increasing amount of unutilizable waste poses a major challenge to environmental managers. Hence, the need to take necessary and appropriate steps to protect the environment from harmful effects of waste products is not negotiable. Among the wastes usually found in academic institutions is paper, which is also a dominant component of municipal solid waste worldwide. Waste paper recycling techniques, when appropriately implemented, can lead to environmental stewardship and cost savings for the institution. In the educational institution, the teaching and training received by the students on recycling processes can be fully actualized if there are models of sustainability before them. Ironically, very few academic institutions practice recycling as much as they teach and discuss it.

Comparable to other academic institutions worldwide, Nigerian academic institutes are significant producers of different categories of waste, and waste paper makes the greater proportion of the solid waste generated in these institutions. There is an increasing need for changes in attitude and actions on the part of the leadership, taxpayers, learning systems, curriculum, students, faculty, and external stakeholders in these institutions. Management principles on paper recycling practices can be integrated and sustained effectively using business process improvement techniques. Sustainable waste paper recycling techniques include the use of recycling baskets, donation to non-governmental organizations, selling waste paper, integration of entrepreneurial activities into the academic program, and the establishment of a recycling factory on campus. Even major challenges posed by legislation, management support, and the capacity to manage paper recycling operations can be overcome with the joint realization that a deep partnership between the institution's management and the community brings about a desired change [1].

1.1. Background and Rationale

Academic institutions produce huge amounts of wastepaper which can be used as a secondary fiber for the

recycling of paper. By doing so, the colleges can save on the costs of purchasing white paper for the photocopying and printing of academic documents. The focus of this paper is to create awareness among academicians on the three sustainable techniques they can use in their respective institutions to recycle the wastepaper. These techniques will inspire departments, centers of excellence, etc., to produce their academic materials in-house by using newspaper cuttings, waste notebook sheets and other printed matter that lie idle as such in waste paper bins in colleges [2]. The composting of organic materials in the academic institution envisages the recycling of the residual compost for academic activities while setting an example for implementation of sustainable recycling techniques.

The objective this review tries to accomplish is to demonstrate the sustainable waste paper recycling in academic institutions by amalgamating the principles of three basic techniques from the scientific perspective and awareness of the biogas technology, which involves the disposal of organic waste by carrying out a clean sustainable process in a confined system and utilizing the biogas produced. These three techniques, known as valley, nanofibril and biochemical, sustain the principles of waste paper recycling by the action of balling, ultra-fine grinding and pulping, respectively. The awareness of the Waste Management Hierarchy illustrated in the review could motivate academicians to part with conceptual knowledge, case studies, experimental results and experience in the implementation of these same to others. Inspiration can be drawn from some positive real life situations to encourage voluntary set up of such low tonnage waste paper recycling units close to academic institutions [3]. An understanding of these various benefits can tempt college managements to view colleges as special learning centers/competition entrants to create a sacred administrative environment while tapping hidden sources of revenue.

Figure 1: Classification of different types of waste [2]

1.2. Research Aim and Objectives

This review on the research paper on sustainable waste paper recycling techniques for academic institutions is conducted with the objective to provide an overview of various recycling techniques. The ultimate aim of this review is to analyze the area of waste paper recycling in academic institutions and provide the problems involved in it. Further, the problems and challenges accepted in waste paper recycling were identified for future sustainability, and a comprehensive review on sustainable waste paper recycling techniques for academic institutions was covered in this paper. With these objectives, a review covering the various recycling techniques used in the market was conducted and observed in this manuscript. In the end, the importance of the recycling was shown, and information collected from this review was summarized.

2. Current State of Paper Recycling in Academic Institutions

The success of waste paper recycling programs implemented in academic institutions depends on how much information the administrators have regarding both the waste paper generated and paper recycling activities. Several socioeconomic barriers exist that cause the failure of these programs to be effectively implemented [4]. The most cited reasons are that such institutions do not have a clear understanding of the costs and the payback associated with these systems, the lack of support and commitment by the administrators, and these institutions consider it inappropriate to implement expensive, cumbersome, and obsolete paper recycling programs. In addition, the difficulty in finding solutions for the small physical footprint in waste separation centers, unwanted waste paper collection and transport systems, or including upgrades to waste paper collection equipment pose additional problems in implementing this program. Penalties imposed if recycling targets are not met may also serve as a disincentive [5].

Furthermore, understanding the recycling infrastructures such as policy-makers at different government levels, non-governmental organizations, academic institutions, paper collection and recycling centers, and waste paper dealers either promoting or involved are other critical factors that may impede how institutions deconstruct the current systems and suggest the best frameworks for waste paper recycling programs. Researchers do not have a concrete biomethodic framework to suggest to these institutions. Their studies succeed because they spent several decades reworking and identifying opportunities, but sometimes do not transmit the results of their

discoveries to academic institutions. The literature review of waste paper recycling in academic institutions shows a wide range of surveys that identify potential interventions undertaken to solve the problems encountered with the use of the photocopying paper of students, but the management and organization methodology of these studies are based on basic interventions.

2.1. Challenges and Opportunities

The previous section elaborated on challenges and opportunities for waste recycling in general. Recycling paper in academic institutions presents a number of challenges and at the same time provides a genuine opportunity as a platform for showcasing best practices in recycling. Generating waste paper is becoming an established culture in learning institutions. Used paper such as past exam papers, coursework notes, and draft work contribute substantially to the recycling basket. However, academic institutions themselves are not without challenges regarding their recycling processes. The academic environment serves several functions that may not support an efficient and effective recycling agenda [6]. The Green Office Model initiated at Ms-en-scene campuses of the University of Pretoria, South Africa, suggested that the Green Office aspects may, in certain instances, be repressive and restrictive of other personalized features of office living.

On the global scenario, the Bert H in 2007 revealed a rather shaky ground with regard to the ability to cope with glocalization and the increasingly green society. The realization that the European Union was passing through a deep societal crisis would engender the courage for multifaceted strategies towards sustainable development in Europe. In Brussels, the European Commission had in 2006 developed a strategy to make Europe more eco-efficient by improving implementation of its social and environmental rules; the integration of competitiveness and environmental sustainability; and to enhance citizen-centric benefits in terms of health and quality of life [7]. Likewise in Maastricht, the Netherlands, the INTEC Community program would initiate eco-industrial park development without downgrading the quality of life.

3. Techniques for Sustainable Waste Paper Recycling

Waste paper can be broadly categorized into the following basic paper grades: office paper, newsprint, packaging board, and sanitary paper. These different paper grades consist of fibers (cellulose), fillers, coating, and in specific cases, the single components of the waste paper mixture, the quantities thereof can be calculated. Each waste paper grade can be theoretically recycled without its quality being influenced by other paper grades included in the mixture. As long as the above-mentioned prerequisites are fulfilled, recycling solely by considering the waste paper mixing ratios is termed strictly selective recycling (SRSR). The main advantage of SRSR is that customers of a paper product receive a product that includes exact features determined by the respective formulation and these are not 'diluted', which might happen when atypical additional components are added to the product. Characteristics, such as printability or strength, are mainly influenced by the fillers used.

The glue components of the waste papers, which consist of starch, casein, or melamine, have to be removed completely by uncontaminated water. The greatest advantage of SRSR cannot always be provided by the paper recycling industry, as the paper sorting industry is not always in the position to separate the different paper masses completely from each other [8]. The weaknesses associated with the use of this technique concern the production problems resulting from the influence of the various operation materials. Thus, impurities and contraries activate the production problems such as folds or streaks and soiling of rolls, and further, they result in diminution of production. Besides, waste paper inclusions lead to a lessening of the treatable quantity of the mixture components. Not least, the use of atypical components within the recycling of paper significantly influences the final product.

Table 1 Wood chemical composition contents determined by wet chemistry analysis

Sample	Extractives	Lignin	Holocellulose	Cellulose	Hemicelluloses	Total
1	1.18	27.03	75.53	47.55	27.98	103.75
2	2.92	26.66	75.16	48.88	26.28	104.73
3	2.17	27.49	71.65	43.19	28.46	101.30
4	2.82	26.71	72.82	46.59	26.23	102.35
5	2.47	26.47	71.87	47.30	24.58	100.81
6	2.25	29.43	71.25	46.09	25.16	102.93
7	1.35	26.35	71.85	44.87	26.98	99.54
8	0.75	28.89	73.14	46.01	27.13	102.77
9	3.24	24.61	71.02	46.71	24.32	98.88
10	1.17	27.79	71.39	45.57	25.82	100.35
11	2.63	26.21	71.15	45.24	25.91	100.00
12	2.69	26.94	68.73	44.64	24.09	98.36
13	2.36	26.65	73.49	48.86	24.63	102.50
14	1.49	25.80	72.88	48.07	24.81	100.18
15	1.83	26.51	72.44	48.27	24.17	100.78
16	3.07	25.19	76.07	50.57	25.50	104.33
17	1.69	26.64	71.17	45.46	25.71	99.50
18	2.17	26.86	71.10	46.39	24.71	100.14
19	1.23	28.07	71.78	46.27	25.51	101.08
20	2.36	25.90	74.14	48.23	25.91	102.40
21	2.80	26.68	74.69	48.83	25.85	104.17

3.1. Mechanical Recycling Techniques

The process of recycling paper is facilitated by the deterioration and loss of quality of fibers in used paper. There are various recycling technologies designed to recover useful cellulose fibers without complete degradation, resulting in recycling paper with different properties. Mechanical techniques reuse paper by agitating it in water and use of chemicals to remove

contaminants and improve the quality of the product. Mechanical recycling can be performed by three techniques: repulping, deinking flotation, and cleaning.

The most widely used methods to remove ink from the paper are de-inking with chemicals and de-inking with foams. The process reduces the costs of paper production by recycling paper fiber that would be lost if paper were remanufactured from virgin material as it removes most of the ink from paper fibers [9]. This important de-inking is part of the recycling process that treats and separates unwanted materials during recycling. The de-inking process transforms the paper into pulp by loosening and detaching the ink from the paper fibers, enabling them to be removed from the liquid pulp. The secondary fiber production grows in the United States and uses long fibers from cardboard, old magazines and colored papers with wood papers. The problem of colored papers and wood chips is the low quality of the slurry and sheets produced, which receives decreased prices. The high content of dyes does not look attractive to potential secondary fiber buyers. High-end mixed papers are related to dye bleed and decreased brightness. The secondary fiber price continues low as virgin fiber.

3.2. Chemical Recycling Techniques

This category includes processes that use chemicals to break down the complex structures of cellulose and hemicellulose macromolecules into monomeric forms. The most widely used chemicals in this category are methanol, ethanol, and sulfuric acid, or enzymes that can help in breaking down complex cellulose molecules into smaller substitutes that can be transformed into pulp. The depolymerization of these monomeric subunits usually occurs by two chemical processes that are carried out under specific conditions and/or a combination of high temperature and pressure. Two main types of chemical recycling are hydrolysis and solvolysis. Contamination problems and the production of hazardous by-products are among the ecological implications of the chemical recycling technique carried out.

Hydrolysis process this method relies on the use of mineral acids such as sulfuric acid (H2SO4), nitric acid (HNO3), or phosphoric acid (H3PO4) to catalyze depolymerization of cellulose and derived nanofibrils into monomeric sugars (glucose) in the presence of water, a process termed hydrolysis [10]. The two main hydrolysis techniques used in cellulose hydrolysis are dilute acid hydrolysis and hydrolysis by enzymes. Using the dilute acid hydrolysis process removes most of the non-cellulosic materials and therefore 'cleans' the feedstock. Other advantages include the ability to use steam stripping to recover and reuse the acidic catalyst and subsequent steps for separation of components such as the sugars. However, disadvantages of the dilute acid technique are that it often requires high pressures and high temperatures for operation and may unexpectedly produce degradation products such as furan dialdehyde and hydroxymethylfurfural. Mistreatment of the cellulose feed will further internally degrade the polymer, so that the cellulose degradation is dependent on factors including the quantity, distribution, functionalization of polysaccharides in cellulose feedstock, as well as the reaction conditions. Conversely, enzymes are proteins that serve as biologic catalysts used to initiate chemical reactions in cellulose hydrolysis and advance the complete depolymerization of crystalline nanofibrils and nanocrystalline cellulose substrates [11]. However, the process of enzymatic hydrolysis is limited by the inefficiency of the use of the proteinaceous catalysts, high sensitivity of the enzymes to reaction conditions (e.g., temperature, pH, permeation, and the substrates preparation), and the limited access of enzymes to cellulose substrates. On a positive note, environmental pollution in terms of by-product generation is minimal for both dilute acid and enzyme hydrolysis. When compared to other methods of aerobic degradation, enzyme hydrolysis is believed to have advantages in terms of lower cellulose decomposition duration and higher conversion efficiency.

3.3. Biological Recycling Techniques

Biological recycling techniques include the use of enzymes, whole microbial cells or even groups of microbial cells to treat the materials. Plant materials are being constantly reprocessed in nature by the action of fungi, bacteria, invertebrates, and vertebrates to return them to their inorganic minerals. These natural systems are being duplicated on a smaller scale in laboratories or in larger complex industrial bioreactors to assist in recycling and composting. The major advantages of using whole cells over individual or groups of enzymes are the ability to express a variety of enzymes with defined activity in a single cell, and cell membranes allow localized action of the enzymes and cycling of enzymatic intermediates.

The most famous example of the use of microorganisms in materials recycling is sewage treatment. Approximately three grams of active microorganisms may be involved in processing one liter of sewage. The next most famous example is how mushrooms are produced. The substrate, in this case horse manure, is heat-treated to kill all other microorganisms so that they

do not compete with the mushroom mycelium for nutrients [12]. Alternatively, a number of fungal species are much more efficient at processing certain chemicals enough so that these chemicals are not excreted into the surrounding environment. The fungal mycelium produces the chemical enzymes which break down the chemicals, which by transforming the chemicals into a form of energy that the cell can use in further cell growth.

Figure 2: represents the process of sorting and collecting paper waste from other waste [12].

4. Case Studies of Successful Waste Paper Recycling Programs

Recycling in the faculty has been a long process. The recycling process is done through various efforts such as marketing recycling to the community and gathering waste paper to be worked on to become a new product. Clarity of the process in waste paper collection, initial choices in this process can provide the right recycling conditions. The determination that the internal recycling of waste paper for more than a dozen academic faculty offices is part of one important pre-policing stage. This paper describes the efforts involved in drafting these rules and implementing programs at both the faculty and departmental levels. The programs have met with considerable success in their first year.

Post-consumption waste materials are potentially an important source of secondary fibers for paper and paperboard production. Academic institutions in general and faculty in particular can place large volumes of waste paper suitable for recycling. The proposed recycling strategy can serve as a model for other faculty recycling efforts. Implementation of recycling programs is typically considered among the easier programs to initiate. However, successful recycling programs require careful planning, good relationships among the various individuals involved, and a large degree of time, money, and energy to be raised. Despite the media reports that imply recycling is simple and straightforward, in the end, excellent guidance on recycling paper in academic institutions is difficult to find.

4.1. University X Case Study

Upon establishing the waste management system, both dry waste and wet waste can be segregated properly. The wet waste is being composted on campus to support the greening efforts near the academic buildings. The resultant compost is used by the university on the grounds. Paper is collected to such an extent that with the implementation of a paper recycling machine, recycled paper is produced. This paper is then printed with university logos and used for internal clerical works. The business units within the university are responsible for managing these initiatives. Due to the incentives program provided by the Council to support these initiatives which collectively aim in recycling, moving forward in areas to zero landfill waste and the circular economy, the business units gain prominence. The Vice President's Office served as the lead department in implementing these waste recycling initiatives.

The structural plan, information and awareness, incentives, and management involvement have played a key role in contributing to the enhancement of sustainable waste recycling in Academic Institution X. Although starting from the year 2012, the internal business unit plan was earlier decided and implementation informed to the staff in the year 2009 to kick off the dry waste recycling [13]. Subsequently, assessments on the outcome for incentive, waste type, and source were refined and improved from time to time. The plan runs biannually by monitoring and fine-tuning initiatives for ongoing improvements, upgrading the recycling of separated waste to zero waste landfill, and improving the overall campus sustainable recycling.

4.2. College Y Case Study

The experience of College Y in paper recycling is actually an experience developed in two academic courses, in which students from College Y were actively integrated in the development of an innovative proposal. In 2013, the rehabilitation of an abandoned textile factory in Guimaraes, Portugal was proposed in the subject of Waste Recovery and Rational Use of Resources, offered in the M.Sc. in Civil Engineering Materials at College Y. The rehabilitation proposal included the concept of sustainability and the principles of Sustainable Engineering. Part of the rehabilitation project focused on addressing the main characteristics and qualities of the existing ruins, transforming them into attractive and pleasant places that could be visited by those who worked at the future newly constructed building fitted out for a hotel purpose [14].

To support society and ensure a circular economic system, environmental education was planned to be provided by an open classroom inside the ruins. The teaching tactics consisted basically of working on a theme of the Ruins Park. As Ruins Park, the students considered the room in which most of the machinery, essential to the production of goods, was located. This classroom had a placement where the outdoor pool was. This structure was erected with the purpose of reusing treated gray waters from the hotel. When the students registered the machinery and the other contents present in the classroom, they found that the majority of its contents were made of wood and paper. At the same time, they realized that they also generally wore simple ideas, such as lighting the classroom with paper ceiling light fixtures [15]. The work developed for the Ruins Park gave new light to attitudes in relation to the classroom and took advantage of six competitive advantages inherent to the classroom. Five are due to specific issues related to inherent sustainability, and the last is due simply because it was part of a rehabilitation project. The competitive advantages that the Ruins Park had in relation to paper were: (i) global reuse potential; (ii) CO2 storage by the material; (iii) a low environmental impact; and both (iv) its initial and (v) final economic value. Additionally, human beings were more receptive to the classroom delivery due to its increase in height and greater volume.

5. Environmental and Economic Benefits of Paper Recycling in Academic Institutions

5.1. Environmental Benefits

Using recycled paper products can directly influence the cost associated with the disposal of paper products. In a recirculation scheme, the cost of disposal can be directly transferred to the user of the paper. In turn, less waste paper at collection sites within the academic institution means less frequent collection of waste paper materials, releasing transport and environmental pressures due to reduced demand for haulage and reduced greenhouse gases generated by landfill sites at treatment facilities. In addition, the waste paper recycling loops divert material from the broader waste stream and associated costs of general waste disposal or incineration compared to the economic benefits resulting from the sale of recovered waste paper, which reduces potential emissions and impacts throughout the materials life cycle [16].

Recycling paper extends the life of forest resources and preserves the world's natural plant and animal diversity. Thus, the number of trees in the natural environment, or that must be planted to replace those lost, is minimized. The energy required to produce virgin pulp is significantly reduced through the use of recycled pulp, either in the production of deinked or non-deinked recycled pulp, as indicated in several LCA studies. Consequently, the landfill spaces required to accept the waste paper during their life cycles are decreased. The reduction in the dependent valuation of trees and required energy has a critical impact on global climate change and lowers the embodied energy of paper products. Even the recycling process requires much less energy than the original manufacturing of paper and potentially creates a higher volume of waste per tonne of paper sludge than paper produced from virgin pulp. Consequently, the need for forest harvesting, deforestation activities, and the repetition of waste paper materials has driven a great emphasis on restoring, maintaining, and conserving the Earth's forests and reducing soil erosion in some of the world's most effective carbon traps, attracting interest and protection from regulatory or adaptive decision-making.

Every year, one tonne of waste paper collected is repurposed and recycled into 900 kg of new paper products that would otherwise go to landfill. Paper products are sent to landfill at a rate of 2.5% of all waste deposited. This leads to paper and pulp waste occupying 7.2% of all landfill space, while paper products generate an unreasonable level of methane gas and contribute to global warming. Landfill sites are the most sustainable source in climate cascading emissions on the planet, and their complex engineering and leachate management are environmental nightmares [17]. Large amounts of hazardous materials in food waste and factory productions are known to infiltrate their way through the landfill into groundwater and nearby rivers, creating environmental problems that pose serious risks to human health. The preservation or recovery of raw materials such as glass, steel, aluminum, plastic, and paper through different recycling schemes can significantly reduce the associated cost pressure if material-specific collection systems can be tailored directly to the available infrastructure, thus reducing leachate products and potentially delaying soil contamination.

6. Barriers to Implementing Sustainable Paper Recycling Techniques

Barriers are constraints or lack of resources or planned approaches that inhibit the adoption or use of a sustainable system. To be successful, any change process in the institutional set-up generally requires at least minimal understanding and acceptance of the involved stakeholders and sufficient interest in participating in the process. In the case of waste recycling in educational sectors, several barriers have been identified: lack of

information, economic barriers, policy barriers, technical barriers, social barriers, and the lack of cooperation [17].

The problem also arises due to the reluctance of management and staff to engage in a separate waste-sorting system with economic consequences, especially at the favor of a concern for global environmental quality. In this respect, public stakeholders, such as national or local authorities, should have a strong political commitment to waste recycling and support the establishment of a comprehensive and effective region-based recycling program. The enforcement of financial or particularly effective legal attrition policies or specific economic incentives in compliance with waste recycling plants can benefit the development of recycling systems in academic institutions. These barriers not only hinder the full implementation of sustainable waste paper recycling practices in comprehensive institutions, which in turn could lead all these institutions to sorely need access to open landfill sites, but also are a sole malaise to address the environmental discharge problems from landfills.

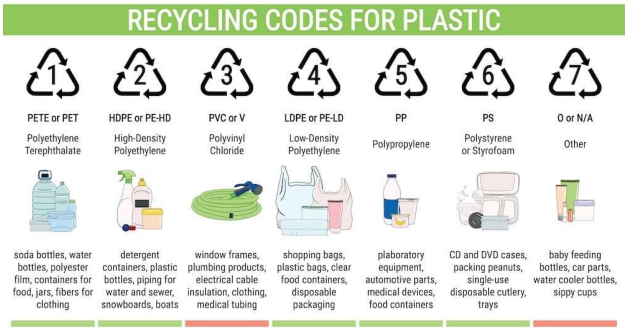

Figure 3: highlights the types accepted for use in the recycling process [17]

7. Policy Recommendations for Promoting Paper Recycling in Academic Institutions

Recycling industries and the government should let the public acknowledge the economic and environmental benefits of recycling waste papers by offering motivating remuneration to institutions. Recycling industries should sign a contract with educational institutions to guarantee the prioritized procurement of recycled papers. In turn, educational institutions should expand the application scale according to the contract terms. By increasing the knowledge of recycling industries and the purchase of recycled papers, recycling industries are sponsored with the capability of processing more waste papers, and the ultimate disposal cost of the educational institutions is reduced. The recycling industries are able to affirm the direction of research and development. Lab-scaled enterprises usually lack the confidence in their ability to substitute the virgin pulps produced through chemical pulp selection. They refuse to purchase the recycled papers, and the lack of purchasers leads to low value of recycled paper and a lack of motivation to work. It is suggested that paper and pulp mills should alter their inherent prejudice against using recycled paper from the purchasing point of recycled paper.

The government should organize public awareness activities and subsidize the waste paper de-inking process researches in terms of technological and economic initiatives. The government can fundamentally improve the de-inking environment by organizing a publicity campaign. Schoolmasters are then encouraged to pay attention to the color of handouts. Depending on the required printing quality, they are required to control the paper produced in each batch. Meanwhile, educational institutions should participate in waste paper collection programs, as this old paper collection is challenging for local infrastructure because the purchase of recycled newspapers supports collection activities. For about 10 years, the rest of the waste paper collection systems and the strategic plans initiated by the government were unable to solve the problems, including fermented and spoiled odors from collected waste paper. Finally, the government selected tenders to upgrade the advanced de-inking technology on a large scale for complete de-inking and odor removal [18]. Since the government has provided financial support through subsidies, the educational institutions complete their increased application rates for recycled paper batch by batch.

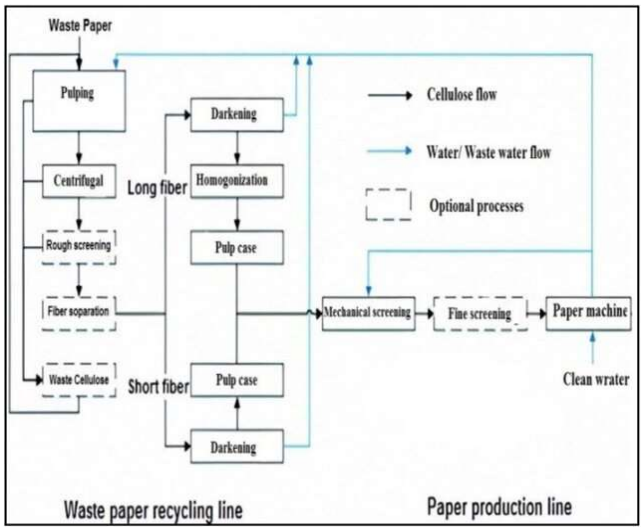

Figure 4: Steps for recycling waste paper and the production process [18]

8. Future Research Directions

Despite significant research in many areas of waste management and in the paper recycling industry, there is relatively little research into the problems involved in the sustainable implementation of effective waste paper management processes in academic institutions. Though, previous studies have addressed different waste management problems, in fact, the waste management problem as a whole is very complex and involves ethical, economic, social, and environmental issues, as well as different scale and size problems. Clearly, future research may assist in the solution of the specific and complicated problem of the sustainable implementation of the most appropriate and effective waste paper management practices in academic institutions [19]. Hence, based on the System Analysis stage of the Soft Operational Research Methodology used in this study, ten of the different categories of research problems identified earlier are proposed for future examination and are briefly presented below.

Firstly, in relation to social problems, questions may be asked about why academic institutions, academic staff, and students either contribute to the waste or why they are indifferent to recycling programs in their academic institutions and communities. How can management and staff encourage students and other office users to embrace recycling in the institutions, changing the attitudes of their staff and students to make them more supportive of the environmental initiatives that institutions are introducing? Can behavior towards sustainable waste paper management in academic institutions be induced through persuasion, and what motivates waste paper recycling in academic institutions? [20] What characteristics of human behavior are necessary for the implementation and effectiveness of the adopted sustainability management practice? Can coaction and personal commitment orchestrate the adoption of waste paper recycling technologies? Upon addressing the above, institutions will be able to coordinate corporate social responsibility and personal cultural change in doctoral programs. Furthermore, could the development of public policy in the area of waste paper recycling reduce the cost of paper recycling, thus creating less system-related hassle and inconvenience for office workers in academic institutions? What kind of support needs to be put in place by the institution to ensure that recycling is being carried out effectively?

9. Conclusion and Key Findings

The use of paper in secretarial offices and institutions generates a large amount of waste paper annually. The supply of waste paper for recycling is sufficient to meet the needs of any existing paper or cardboard recycling plant in the United States. This means that besides the office data processing and academic institutions sector contributing substantially to the serious solid waste problem of today, it also offers an opportunity for recycling practices. In the course of research, a number of factors were identified which could enable paper recycling practices in offices and academic institutions.

The organizations studied were found to be doing a poor job in waste paper recycling. Waste paper generation in academic institutions is slightly different from that in business offices and institutions due to their nature and location. To implement effective waste paper recycling techniques in academic institutions, it is necessary to be effective in providing increased public awareness. Academic secretaries, as the main parties with control of the majority of waste paper, should be involved. It is hoped that research will help to improve the waste paper recycling situation in secretarial offices and academic institutions in the United States and elsewhere.

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تنفيذ تقنيات إعادة تدوير النفايات الورقية المستدامة في المؤسسات الأكاديمية: مراجعة

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الخلاصة – أجريت هذه المراجعة على ورقة البحث حول تقنيات إعادة تدوير النفايات الورقية المستدامة للمؤسسات الأكاديمية بهدف تقديم نظرة عامة على تقنيات إعادة التدوير المختلفة. والهدف النهائي من هذه المراجعة هو تحليل مجال إعادة تدوير النفايات الورقية في المؤسسات الأكاديمية وتقديم المشاكل التي ينطوي عليها. علاوة على ذلك، تم تحديد المشاكل والتحديات المقبولة في إعادة تدوير نفايات الورق من أجل الاستدامة المستقبلية، وتم تناول مراجعة شاملة لتقنيات إعادة تدوير نفايات الورق المستدامة للمؤسسات الأكاديمية في هذه الورقة. ولتحقيق هذه الأهداف، تم إجراء مراجعة تغطي تقنيات إعادة التدوير المختلفة المستخدمة في السوق ولاحظتها في هذه المخطوطة. وفي النهاية، تم توضيح أهمية إعادة التدوير، وتم تلخيص المعلومات التي تم جمعها من هذه المراجعة. يمكن تكييف هذه العملية برمتها لإعادة تدوير الكميات الهائلة من نفايات الورق التي ينتجها الطلاب، وهي المبادرة التي غالبًا ما تفشل بسبب التكلفة العالية للتخلص منها. ويمكن تحقيق ذلك من خلال الاستخدام المستحث لنفس طرق التخلص من الورق المستخدمة بالفعل، مع جمع الورق وتقطيعه مرة واحدة في الأسبوع مباشرة من صناديق نفايات الورق الخاصة بالطلاب.

الكلمات الرئيسية – إعادة تدوير نفايات الورق، والتقنيات المستدامة، والمؤسسات الأكاديمية، والتأثير البيئي.